FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

50-247

IN REPLY REFER TO:
PWR/ER

May 10, 1972

Mr. Lester Rogers
Director, Division of Radiological
and Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of April 14, 1972, requesting comments on the Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License to the Consolidated Edison Company of New York for the Indian Point Unit No. 2 Nuclear Generating Plant, dated April 13, 1972.

The Federal Power Commission's Bureau of Power has previously commented on the need for the Indian Point Unit No. 2 nuclear generating plant in its letter dated December 22, 1971. These comments were included in a Bureau of Power staff report made in response to AEC's letter dated December 7, 1971, requesting comments on the Consolidated Edison Company's application for interim authorization to operate the Indian Point Unit No. 2 at 50 percent of full power.

It is noted that the basic data included in the capacity-demand-reserve margin evaluation made by the FPC Bureau of Power staff in its December 1971 report is that used in Table X-1 of your April 13, 1972 Draft Detailed Statement; therefore, the following comments will update those made in our December 22, 1971 letter.

The FPC Bureau of Power staff completed an analysis of the 1972 summer load-power supply situation for the contiguous United States on April 17, 1972. As of that date, based on available data from the AEC, it appeared that the Indian Point Unit 2 might be able to achieve a significant level of power sometime in the summer, but would not be commercially available on May 31, 1972, our cut-off date for determination of firm summer resources.

The Company reported its expected June 1, 1972 power resources to be 9,293 megawatts (8,823 dependable generating capacity plus 470 megawatts firm purchases) and its estimated summer peak demand to be

Mr. Lester Rogers

8,400 megawatts. The resulting reserve margin is 893 megawatts, or 10.6 percent. This margin is less than the size of its largest unit, and only 45 percent of the median 1,977 megawatts of forced outages and deratings the Company experienced at the time of the weekly peaks for a fifteen week 1971 summer period. The Company expects to improve its position with the installation of 174 megawatts of barge mounted gas turbines in June and a like amount in July, but it also plans to retire 243 megawatts of old fossil fired capacity in July which, if carried out, would have an offsetting effect. The Company is also continuing its efforts to increase its firm purchases for the period.

For the New York Power Pool, including the Consolidated Edison Company, the situation is only slightly better. As of June 1, 1972, the Pool's resources are projected to be 22,474 megawatts with an estimated peak demand of 19,510 megawatts, resulting in a reserve margin of 2,964 megawatts or 15.2 percent. For the Pool, a median of 3,056 megawatts of forced outages and deratings at time of weekly peak was experienced for the 1971 fifteen week summer period.

In the light of the foregoing and even though the Indian Point No. 2 nuclear unit was not considered as firm capacity in the summer load forecast, the staff of the Bureau of Power concludes that all reasonable efforts should continue to bring this unit into service at the earliest possible date. The need for added capacity to safeguard against the contingencies of forced outages, as well as the desirability of implementing scheduled preventive maintenance programs, is self evident.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power

A REVIEW OF

CONSOLIDATED EDISON COMPANY

1972 SUMMER POWER SUPPLY PROBLEMS AND TWENTY-YEAR EXPANSION PLANS

BUREAU OF POWER
FEDERAL POWER COMMISSION
September 1972

FOREWORD

Following a series of problems affecting bulk power supply for the New York City area in the summer of 1969, the staff of the Federal Power Commission's Bureau of Power undertook a comprehensive review of the circumstances which had led to the conditions then existing and examined in detail the Consolidated Edison Company's plans for expanding its power supply facilities to meet projected demands for electric power in the Company's service area for the 10-year period ending in 1979.

A Bureau of Power staff report was published in December 1969 and distributed to members of the Congress, State and Federal agencies, New York City officials, and others having an interest in the power supply problems and plans affecting the New York City area. The report, which was also publicly available through the Commission's Office of Public Information, analyzed both the existing and future load-supply situations on the Consolidated Edison Company system; discussed the Company's operating policies, emergency plans, and maintenance practices; reviewed internal and external transmission capacities and interconnection capabilities as they related to the Consolidated Edison Company and its need for supplemental power; presented the history of events leading to the 1969 power shortages and reviewed problems related to plant sites and transmission line rights-of-way in terms of the future requirements of the Company and its interconnected systems; and made recommendations for enhancing the reliability of the bulk power supply of the New York metropolitan area.

Throughout the period since the 1969 report was issued, the staff has monitored the New York situation, and has periodically reviewed with the Company its modifications in future system expansion plans and projected means of meeting expected load requirements for the 10-year periods of the future. The staff has also obtained information on all of the major events affecting the New York area power supply, including equipment failures, shortages of capacity which necessitated voltage reductions or other measures for meeting peak loads, and service interruptions of sufficient severity to cause significant public notice.

Several relatively lengthy power interruptions affecting parts of the Consolidated Edison Company's service area in July and voltage reductions in July and August 1972 have led to considerable public concern and have prompted many questions about the reasons for the failures and measures to reduce the likelihood of other such failures in the future. These failures affected the distribution system of Consolidated Edison and not the bulk power supply, but many questions concerning them have been addressed to the Federal Power Commission by members of Congress and others. Although the failures have not been related in any way to shortages of bulk power supply, the staff has prepared the following report in an effort not only to present factual information about the particular failures but to update the information presented in 1969 and give a current picture of the present outlook for the New York area bulk powe supply throughout the next 10- to 20-year period. The Federal Power

Commission does not have jurisdiction over local power supply matters such as those involved in the July and August distribution system outages which affected sections of Brooklyn and Queens and smaller parts of some other Boroughs, but Consolidated Edison Company representatives have cooperated in discussing these problems with staff members and providing information concerning them.

The 1969 report pointed out unique characteristics of the Consolidated Edison service area, including both geographic features and load patterns, together with discussions of how these and other characteristics affect electric power requirements and services in the area. The descriptive information of this nature is not repeated in the current report, but the related comments and observations made in the earlier report are still applicable.

TABLE OF CONTENTS

1972 Summer Load Situation on the Consolidated Edison System

During the early spring of 1972, the staff of the Federal Power Commission's Bureau of Power analyzed the scheduled system capabilities and the projected peak loads for the summer of 1972 in each of the six National Power Survey regions. On April 21, the Commission issued a news release and the staff's report which summarized the anticipated conditions in each of the regions. The release also included information which indicated conditions pertaining to particular utility systems or groups of systems within each of the regions.

Information available at the time of the above report showed an expected total system capability for the Consolidated Edison Company, including purchased power under firm contract, of about 9,300 megawatts. This compared with a forecast 1972 summer peak load of 8,400 megawatts, or a reserve margin of a little less than 11 percent.

Since June 1, Consolidated Edison has been able to meet its peak demand for power throughout the summer without any curtailment actions due to bulk power limitations except for voltage reductions of three or five percent for periods of about four hours or less on three different days between July 12 and 20, and for 2 hours and 35 minutes on August 24 and for approximately 5 hours on August 25. The New York Power Pool and the New England Electric Exchange systems were participants in the August 25 voltage reduction. On one occasion voltage was reduced when heavy power flows on the west to east transmission circuits through New York State made it prudent to reduce system demands slightly to safeguard against possible threats to continuity of service in case there should be a loss of import capability through trouble on the external transmission network. On four occasions, voltage was reduced in order to provide a more safe reserve capacity margin during peak load periods.

There have been a few changes in Consolidated Edison's power supply conditions for the summer since the Commission's April report but the power outages which have attracted widespread attention both in New York and elsewhere have been the result of distribution system failures and not inadequacies of the bulk power facilities supplying the New York City area.

During the July heat wave, Consolidated Edison's load peaked at 7,872 megawatts on July 19 with a reserve margin of 301 megawatts or 3.8 percent of the peak. Although operating reserves on other occasions have been even lower, power supply has been sufficient to meet the demand.

Subsequent to our April report, Con Ed was successful in obtaining for additional firm purchases of 300 megawatts from Ontario Hydro and 150 megawatts from the Power Authority of the State of New York. During the most critical part of July, Con Ed received over 1,600 megawatts from outside sources at times. Availability of the Branchburg-Ramapo-Millwood 500/345 kV connection helped to make this possible. The Company is no longer using any sales promotion programs, and it attributes some reduction in peak demands to its Save-A-Watt program, a public appeals and customer education campaign to reduce non-essential use of electricity, and thus reduce the impact on the environment.

July 1972 Distribution System Problems

Early July was a period of unusually heavy rainfall in the New York City area, and the weather during the days which followed may have been more different to an average season than would be realized without an examination of the particular conditions which prevailed. Information supplied by the Company indicated that during the 15 days from July 11 through 25, the cooling/degree/days were greater than for any other 15-day period since 1938. Prior to that, the record was 25 days in 1908. Thus, it can be seen that conditions experienced this year represent more stringent requirements for the power system than are to be expected for most years.

The lengthy outages which affected parts of Brooklyn and Queens were the results of sequential failures of a number of 27-kV underground cables in the distribution networks supplying these areas. Cables may fail for many reasons but often the trouble starts from tiny holes in the cable sheaths which permit the entrance of moisture. This leads to a hot spot in the cable insulation which becomes more serious as heat, due to higher losses, increases under heavy loading conditions and leads to eventual failure. It is usually impossible to detect incipient trouble of this type until an actual failure has occurred. Loss of one cable in a parallel group proportionately increases the loading on the remaining circuits, thus increasing the stresses on them and the chances for their failure if any defects are present. In general, the Con Ed network is designed to withstand the simultaneous outage of any two feeder cables of the total number supplying a single network section without producing hazardous overloads on the remaining ones.

During the period of July 17-25, the Federal Power Commission received from Con Ed reports of 15 separate incidents of underground failures with customer interruptions ranging in duration from a minimum of almost two hours to a maximum of nearly 47 hours. Included in these were the extensive outages in the Bay Ridge area of Brooklyn and the Richmond Hill area of Brooklyn and Queens involving failures of both underground cables and some network transformers. Since these instances attracted much public attention, they are discussed in more detail in the following section of the report.

Bay Ridge and Richmond Hill Interruptions

On Sunday, July 16, all ten of the feeder cables which supply the Bay Ridge area were in service and there were no indications of the troubles which were to develop rapidly and disrupt service to this thickly populated section of Brooklyn. The area occupies relatively low-lying lands generally along and a few blocks east of the Upper New York Bay and as far south as the Narrows Bridge. By Monday morning, July 17, three of the ten 27-kV distribution cables supplying the area had failed, and this was the condition at the beginning of the high load period on that day. Subsequent failures reduced the number of cables still in service to four by about 9:45 p.m., at which time these were taken out of service to prevent further damage from overload and a further prolonging of the time which would be required to effect the necessary repairs to restore service to the affected area. The total number of customers affected by the interruption is not known precisely, but the Company estimates that it was approximately 100,000. Power was off in the Bay Ridge area from approximately 9:45 p.m. on July 17 until about 11:04 a.m. on July 18 (13 hours and 19 minutes).

The widespread interruption in the Richmond Hill area occurred in much the same manner in that sequential failures of seven cables reduced the remaining cable capacity to a value which required removal from service with consequent interruption of electric service to the entire area until repairs could be made to return the system to serviceable condition. The Company estimated that approximately 95,000 customers were interrupted in the Richmond Hill area. Power in that area was off from about 10:27 a.m. on July 24 until about 5:45 a.m. on July 25 (19 hours and 18 minutes).

Kennedy International Airport is adjacent to the interrupted area of Richmond Hill and is served from the same 27-kV area supply system, but service was not interrupted there because it is supplied from cables dedicated to that specific service and these remained in operation throughout the entire period.

Problems in Restoration of Service

The normal repair time for 27-kV distribution cable failures is about two days. As mentioned earlier, it is usually impossible to identify incipient cable failures until an electrical fault has occurred. It then becomes necessary to employ tracer current techniques to determine the approximate location of the fault with reference to the manholes which provide entry to the damaged section terminal points. Once this is done, it is often necessary to obtain police aid to remove cars that are parked over manhole covers. In Brooklyn, if gas is detected in the manholes, the Company must get in touch with Brooklyn Union to clear the manholes of the presence of gas.

In addition to the above hindrances, repair crews are frequently hampered in their efforts to expedite restoration of service for a number of other reasons. The secondary cable feeders associated with the network system are generally protected by current limiters, fuse-like devices, which blow and require time-consuming testing procedures in underground vaults. Where cables show signs of physical damage, or electrical failure, they are replaced. This requires their removal and replacement with new sections and attendant splicing. Where possible, the Company has been replacing faulted cable lengths with new types, employing cross-linked polyethylene insulation, which are more resistant to moisture than the earlier oil-impregnated paper-insulated types. The service record of these newer types of cables has been good, and they have been used for most of the replacements since about 1968. All of the cable failures in the Bay Ridge and Richmond Hill incidents described above were of the older oil-filled paper-insulated types and none involved the newer polyethylene designs. About 10 percent of Con Ed's primary underground distribution cable is now composed of the polyethylene type.

Working conditions in some instances further delay restoration of service beyond the times which otherwise would be required to actually perform the repair work. In high crime areas, the Company reports that repair crews have been subject to physical violence, thereby prolonging the time required for return of service to affected areas.

Conclusions Regarding Distribution System Problems

The New York City metropolitan area has the most extensive underground electric power distribution network in the world. It employs primary feeders which supply a total of some 48 secondary networks, each serving from 100 to 300 megawatts of load. Overall, the network system consists of some 8,000 miles of primary feeder circuits and over 70,000 miles of secondary circuits.

Correction and improvement of the underground system, where needed, should have a high priority. The task could be a very formidable one, however, when the vast extent of the total underground system is considered. Certainly any extensive modifications would entail long periods of time and large expenditures of money. Difficulties in obtaining sites for additional substation facilities create a major obstacle to splitting the distribution networks into smaller segments even if this should be found to be an otherwise desirable solution to some of the network problems. We understand that the Company has three outside consultants studying the problem in an effort to make an overall appraisal of the situation. Special investigations are also being made by the City of New York and the State Public Service Commission.

Review of Consolidated Edison's Bulk Power Program and Twenty-Year Expansion Plans

At the time of our 1969 review of Consolidated Edison's Ten-Year Expansion Plan, there were already indications of trouble in meeting schedules for some of the planned new facilities, but there have been a few slippages in schedules far beyond those envisioned at that time. Perhaps the most notable has been the continued delay in the 873-megawatt Indian Point No. 2 Nuclear Unit which was originally scheduled for 1969 and which has suffered several unexpected problems such as the fire which damaged cables and other equipment in the primary auxiliary building in November 1971, a prior accident involving the collapse of a crane inside the reactor vessel, and other delays that still have prevented the unit from becoming available for service. The new interconnection to PJM via the Branchburg-Ramapo 500-kV line and thence to Millwood which was originally planned for service in 1968 was finally completed early in 1972 and, as noted earlier, has been of significant help this summer in importing supplemental power into the New York City area. Construction is still unstarted on the Cornwall Pumped Storage Project, and various obstacles have been encountered in other areas of the future New York power supply. Con Ed has this year converted its last coal-burning unit for oil firing, and work is in progress on the new unit being added at the Astoria Plant. A very large part of the new capacity which has become available for meeting Con Ed's loads within the last three years is in the form of gas turbines, much of which is mounted on barges and connected to the system at peripheral points around the shoreline. Two 174-megawatt gas turbine barges, located at the Narrows Generating Station in Brooklyn, were placed in service in late May and early June 1972, over a month in advance of their previously scheduled initial service dates. Almost one-fourth of the Company's total generating capacity is now vested in gas turbine units. These and other situations are discussed in the following sections of this report.

Power Sources for the Future

Although it represents only a relatively small improvement, perhaps the most immediate prospect for an increase in the bulk power supply capability for the New York City area rests in the completion of the new 345-kV submarine cable circuit from Public Service Electric & Gas Company's Hudson Station to Con Edison's Farragut Station. This connection is virtually complete and is expected to be ready for service by year end as soon as a phase-angle regulator, damaged during construction and returned for factory repair, is received and reassembled for operation.

The next most imminent improvement appears to be the Indian Point No. 2 Nuclear Unit. Reactor fuel had been loaded earlier but had to be removed when rod drop tests did not yield satisfactory performance, and the control rods had to be removed and burnished to alleviate the difficulty. Continuing problems currently seem to preclude significant electrical output before early 1973.

After Indian Point No. 2, the planned capacity additions represent somewhat longer term considerations. Con Ed has for the last several years released relatively detailed information on its expansion plans, first for periods of 10 years into the future, and more recently, for periods of 20 years. The tabulation which follows delineates the expansion program as planned and envisioned by the Company's System Planning

Department at the end of December 1971. Naturally, there are changes in plans as time proceeds over such a planning period, and there have already been a number of developments which reflect themselves as changes in the Company's long-range plans for meeting future power supply requirements. These are discussed in the following paragraphs in terms of the basic plan presented in the December 1971 tabulation of future expansion.

The Bowline Point oil-fired Unit No. 1, being constructed jointly by Con Ed and Orange and Rockland Utilities at Haverstraw, New York, is nearing completion and has been in the early stages of operational testing since July 25. It had been hoped that this unit might be in service by July but that schedule was not met. Con Ed's share of the 600 megawatts of capacity is 400 megawatts but it has also contracted to purchase Orange and Rockland's 200-megawatt share through April 1973.

Two 600-megawatt, oil-fired units, jointly owned by Con Ed, Niagara Mohawk, and Central Hudson, are under construction at Roseton, near Newburgh, New York. Initially, Con Ed is entitled to a 40 percent share of each of these units. The first is scheduled for completion in the fall of 1972 and the second in the spring of 1973. Some changes in ownership of these units is contemplated in later years, but Con Ed will have long-term ownership rights to a portion of the plant output.

The December 1971 schedule showed the addition of 44 megawatts of gas turbine capacity at Kennedy Airport prior to the summer of 1973 and another 44 megawatts by the summer of 1974. The Company reports that difficulties in obtaining necessary clearances for these installations make it relatively clear that these expected additions will not be available by the summer of 1974.

The new 800-megawatt, oil-fired unit, under construction at Astoria Station, is scheduled for initial service in the spring of 1974.

The 965-megawatt Indian Point No. 3 Nuclear Unit is presently scheduled for completion in the fall of 1974.

Bowline Point No. 2 unit is scheduled for commercial operation in the spring of 1975, and Con Ed will be entitled to 400 megawatts of the 600-megawatt total capacity. This unit is jointly owned with Orange and Rockland, the same as the first unit at this plant.

In addition to the anticipated new generating capacity described above, Con Ed expects to purchase significant amounts of power from other systems throughout the foreseeable future. A new source expected to be available sometime next year is the FitzPatrick Nuclear Unit under construction by the Power Authority of the State of New York at Scriba, New York. Earlier this unit was scheduled for service in the spring of 1973 but it has now been delayed at least until October 1973. Final arrangements have not been completed but Con Ed expects to receive several hundred megawatts during the summer seasons, and lesser amounts in the winter.

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.
LONG RANGE ELECTRIC GENERATION PROGRAM

PLANNED CAPACITY, LOAD AND RESERVE - SUMMER PROGRAM

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Existing Installed Capacity	8469	8909	10205	10488	11150	11985	12720	12633	12508	13108	13542	14104	15059	15810	16060	17010	17410	18510	18510	19210
New Capacity and Retirements																				
Gowanus Gas Turbines	624																			
Indian Point No. 2		873	92	35	33															
Bowline Point No. 1		400																		
Narrows Gas Turbines		348																		
Roseton Nos. 1 & 2			480				-120				-120									
Indian Point No. 3					965 1/	35	33													
Bowline Point No. 2					400															
Astoria No. 6				800																
GT Peaking Plant-JFK Airport			44	44																
Gas Turbine Plants						700								400		400		400		400
Ossining Fossil									600	600										
Cornwall Pumped Storage											1000	1000								
Nuclear Nos. 4 & 5													1100		1100					
Base Load Plants																	1100		1100	
Retirements	-184	-325	-333	-217	-563			-125		-166	-318	-45	-349	-150	-150			-400	-400	
Total Installed Capacity	8909	10205	10488	11150	11985	12720	12633	12508	13108	13542	14104	15059	15810	16060	17010	17410	18510	18510	19210	19610
Firm Purchases	920	395	40	40	40	40														
Proposed Purchases 2/			1000	900	700	400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Total Capacity Resources	9829	10600	11528	12090	12725	13160	14033	13908	14508	14942	15504	16459	17210	17460	18410	18810	19910	19910	20610	21010
Steam Deratings	-200	-95	-40	-39	-27	-67	-46	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Capacity Resources	9629	10505	11488	12051	12698	13093	13987	13908	14508	14942	15504	16459	17210	17460	18410	18810	19910	19910	20610	21010
Estimated Peak Load	7950	8400	8850	9300	9750	10200	10650	11100	11550	12000	12475	12950	13450	13950	14500	15050	15600	16150	16750	17350
Reserve - MW	1679	2105	2638	2751	2948	2893	3337	2808	2958	2942	3029	3509	3760	3510	3910	3760	4310	3760	3860	3660
- %	21.1	25.1	29.8	29.6	30.2	28.3	31.3	25.3	25.6	24.5	24.2	27.1	27.9	25.2	27.0	25.0	27.6	23.3	23.0	21.1
Reserve with Latest Unit Delayed One Year - MW		1232	2398	1951	2465 3/	2543	2837 4/	2808	2358	2342	2529 5/	3009 5/	2660	3110	2810	3360	3210	3360	2760	3260
- %		14.7	27.1	21.0	25.3	24.9	26.6	25.3	20.4	19.5	20.2	23.2	19.8	22.3	19.4	22.3	20.6	20.8	16.5	18.8

Notes: 1/ Indian Point No. 3 operation at full power shown delayed beyond summer 1974 scheduled construction completion date to allow for potential AEC licensing delays.

2/ Proposed purchases include capacity which may be available from Rochester Gas and Electric (1973 and 1974), Niagara Mohawk (1973-75), Power Authority of the State of New York FitzPatrick Nuclear Unit (beginning in 1973) and Breakabeen Pumped Storage Plant (beginning in 1977), and Hydro Quebec (beginning in 1977). Purchase arrangements are in various stages of negotiation and no contracts have yet been signed.

3/ Assumes Indian Point No. 3 in operation at one-half of full power.

4/ Considers delay of 600 MW of proposed purchases.

5/ Assumes two Cornwall pump-turbines (500 MW) delayed.

System Planning Department
December 27, 1971

Looking further ahead, Con Ed has a letter agreement with Hydro Quebec for 800 megawatts capacity and initially 2.14 billion kilowatt-hours in 1977 and 3 billion kilowatt-hours annually for 19 years thereafter. There are also general plans for the addition of 700 megawatts of gas turbine capacity and 1,200 megawatts of oil-fired capacity in the last half of the 1970's and the early 1980's. The Ossining Plant shown in the schedule for 1979 and 1980 is still being studied but there are a number of problems which prevent the outlook from being encouraging. Other potential sites are being sought.

Con Ed still plans to build the Cornwall Pumped Storage Project whenever it appears feasible to undertake construction. Completion is expected to require about six years from the time construction is started. The Company's December 1971 tabulation indicates availability of 1,000 megawatts for summer 1981 and another 1,000 megawatts for the following summer.

In the latter part of the 20-year projection, all of the major capacity additions are shown as unidentified nuclear, other base load, and gas turbine installations. Arrangements have been made to extend the period for starting the development of David's Island through 1976 but it is envisioned that much of the new capacity in the 1980's might involve large generating complexes at sites under study.

Transmission Considerations

As load growth continues over the Consolidated Edison system, the transmission capacity to bring power into the concentrated load areas must be increased correspondingly since most of the new base load facilities are necessarily being constructed elsewhere. Frequently, in prior years when there were severe power shortages in New York City proper, it was reported that sufficient generating capability to relieve the shortages was available in other parts of New York or adjoining areas but certain transmission capability limitations prevented it from being brought into the areas of need at the time. To correct some of these problems, there is a program of transmission system strengthening even though progress has been somewhat slow because of delays due to environmental questions, rights-of-way problems, and related matters. As mentioned earlier, an extra-high-voltage tie to the PJM system was delayed from its planned initial service date in 1968 until early 1972 because of rights-of-way problems. Also mentioned earlier is the new 345-kV cable connection between Con Ed and Public Service Electric & Gas which is expected to be ready for service in the very near future.

An additional 345-kV circuit to connect with utilities in upstate New York, originally scheduled for initial service in January 1971, is still being held up by legal proceedings. Known as the Southern Tier Line, construction is expected to require some 18 months after a license is granted by the Public Service Commission.

A new 345-kV line from Ramapo Substation to connect to Public Service Electric & Gas Company's New Milford Substation, originally scheduled for service in May 1972, was not approved and licensed until March 1972. Construction was started soon thereafter, and the line is expected to be completed early in 1973.

Preliminary work, including footing and structure designs, has been done in connection with the rebuilding of two 138-kV lines for 345-kV operation between the Millwood and Dunwoodie Substations in Westchester County. These circuits follow the New York City Aqueduct right-of-way, and only a portion of the necessary approvals for the construction have been granted. The rebuilding for 345-kV operation was originally scheduled for completion in the spring of 1969, but it is now expected that completion will be before the summer of 1974.

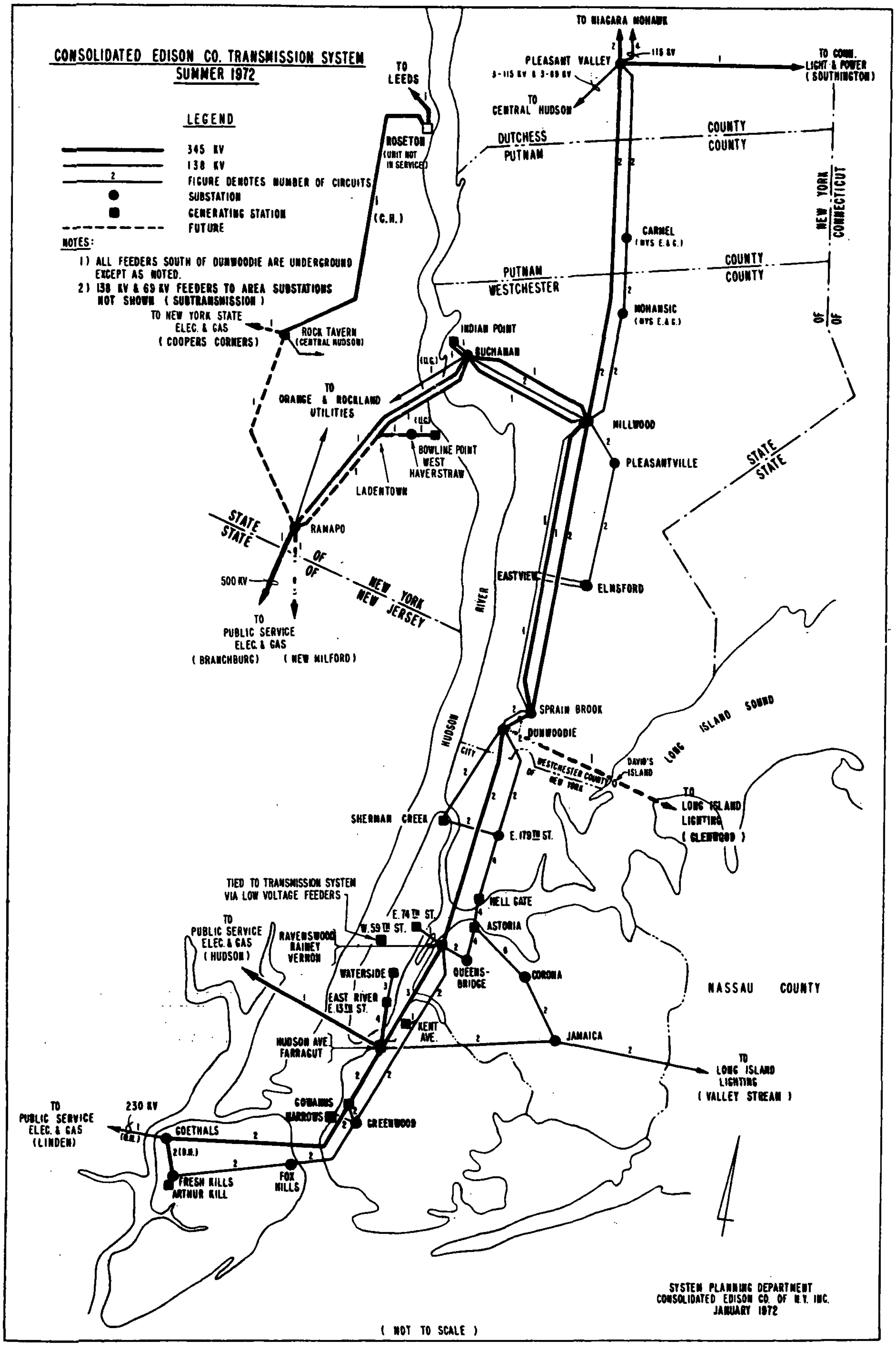
Application has been filed with the Public Service Commission for certification and approval of a 345-kV circuit from Dunwoodie Substation to Long Island Lighting Company's Glenwood Generating Station. Construction is presently scheduled to begin in the fall of 1973 and to be completed by spring of 1975.

Construction has been started on the installation of two 345-kV underground cable circuits from the Sprainbrook Substation in southern Westchester County to the East 13th Street Substation in Manhattan, and one 345-kV underground cable circuit from Sprainbrook Substation to Tremont Substation. These circuits are scheduled for completion by the spring of 1974 and will significantly improve transmission capability from the north into lower Manhattan.

Construction is scheduled to begin in the fall of 1972 on two new 345-kV underground cables from the Astoria Generating Plant to the East 13th Street Substation. This addition is scheduled for completion by the spring of 1974 to coordinate with the schedule for initial service of the new 800-megawatt generating unit at Astoria.

Longer range plans for new transmission are less definite but added generating capacity at Cornwall and other points farther north will require further strengthening of the transmission facilities into Con Ed's major service areas. The Cornwall Project is expected to require four 345-kV transmission cables under and near the Hudson River with overhead lines to extend these connections to a new switching station at Kent, and the rebuilding of existing 138-kV lines for operation at 345-kV from Pleasant Valley to Millwood. The accompanying area map shows the Con Ed transmission system as of summer 1972.

Completion of arrangements for large generating complexes, possibly in upstate New York, and deliveries of large amounts of power from Canada would require very substantial new construction of transmission facilities


CONSOLIDATED EDISON CO. TRANSMISSION SYSTEM
SUMMER 1972
LEGEND
345 KV
138 KV
FIGURE DENOTES NUMBER OF CIRCUITS
SUBSTATION
GENERATING STATION
FUTURE
NOTES:
1) ALL FEEDERS SOUTH OF DUNWOODIE ARE UNDERGROUND EXCEPT AS NOTED.
2) 138 KV & 69 KV FEEDERS TO AREA SUBSTATIONS NOT SHOWN (SUBTRANSMISSION)
TO NIAGARA MOHAWK
PLEASANT VALLEY
115 KV
TO CONN. LIGHT & POWER (SOUTHINGTON)
TO CENTRAL HUDSON
TO LEEDS
ROSETON (UNIT NOT IN SERVICE)
(C.H.)
DUTCHESS COUNTY
PUTNAM COUNTY
NEW YORK
CONNECTICUT
CARMEL (NYS E.& G.)
PUTNAM COUNTY
WESTCHESTER COUNTY
MOHANSIC (NYS E.& G.)
STATE OF
TO NEW YORK STATE ELEC. & GAS (COOPERS CORNERS)
ROCK TAVERN (CENTRAL HUDSON)
INDIAN POINT
BUCHANAN
TO ORANGE & ROCKLAND UTILITIES
MILLWOOD
BOWLINE POINT
WEST HAVERSTRAW
LADENTOWN
PLEASANTVILLE
STATE STATE
RAMAPO
STATE OF NEW YORK
STATE OF NEW JERSEY
500 KV
TO PUBLIC SERVICE ELEC. & GAS
(BRANCHBURG) (NEW MILFORD)
EASTVIEW
ELMSFORD
HUDSON RIVER
SPRAIN BROOK
DUNWOODIE
LONG ISLAND SOUND
CITY OF NEW YORK
WESTCHESTER COUNTY
DAVID'S ISLAND
TO LONG ISLAND LIGHTING (GLENWOOD)
SHERMAN CREEK
E. 179TH ST.
TIED TO TRANSMISSION SYSTEM VIA LOW VOLTAGE FEEDERS
HELL GATE
ASTORIA
E. 74TH ST.
W. 59TH ST.
TO PUBLIC SERVICE ELEC. & GAS (HUDSON)
RAVENSWOOD RAINEY VERNON
WATERSIDE
QUEENS-BRIDGE
CORONA
NASSAU COUNTY
EAST RIVER E. 13TH ST.
KENT AVE.
HUDSON AVE. FARRAGUT
JAMAICA
TO LONG ISLAND LIGHTING (VALLEY STREAM)
GOWANUS NARROWS
GREENWOOD
230 KV
TO PUBLIC SERVICE ELEC. & GAS (LINDEN)
GOETHALS
FRESH KILLS ARTHUR KILL
FOX HILLS
SYSTEM PLANNING DEPARTMENT
CONSOLIDATED EDISON CO. OF N.Y. INC.
JANUARY 1972
(NOT TO SCALE)

in both Canada and New York. Plans for facilities such as those are under study and it is anticipated that they would involve transmission facilities in the 700-kV class to economically transmit the anticipated amounts of power over the distances required.

Possible Problem Areas Affecting Future Power Supply

At the time of this review, there appear to be several problem areas which could create major obstacles in carrying out the planned expansion programs and providing the generation and transmission facilities expected to be needed to meet New York City's future demands for electric power.

The plans as outlined for furnishing the power requirements of the metropolitan area in the years ahead involve the timely completion of many new facilities if serious power shortages are to be avoided. It is noted in relation to this that for the last several years virtually every new facility has met with problems of delay which seem to be virtually unavoidable. Objection to many of the proposed installations, the multiplicity of procedures involved in the approval, certification, and licensing processes, and the sometimes seemingly endless delays associated with them, make it almost impossible to schedule and construct new facilities by the time they are needed. Regardless of the inefficiencies and frequent changes of plans which result, this demands that exceedingly long lead times be used in the planning of new installations and even then there may be no guarantee of successfully completing the projects on time.

Although work is underway and there is hope that Astoria Unit No. 6 may be finished and ready for operation in 1974, there are still unresolved issues which could prevent its operation and thereby provoke another season of jeopardy and uncertainty for the people of New York City as regards power supply in the summer of 1974.

In addition to the delays due to procedural problems and interventions on various grounds, some significant delays are reported to have resulted from strikes affecting some construction projects.

Recent problems with nuclear fuel assemblies at power plants outside the Con Ed area could have an impact on operation of the nuclear units of similar design at Indian Point and perhaps other locations which have a relationship to the overall power supply for the Northeast. Any severe restrictions in the operations of these units could seriously affect area power supplies, including New York City.

Although some of its older facilities have been retired in the past few years, Con Ed still experiences a relatively high forced outage rate and at times the equipment out of service and the capacity reductions together represent a substantial part of the total installed generating capability. The following table indicates the capacity losses during several weeks of the 1972 summer season.

Unavailable Capacity on Peak Day 1/

Week Ending	Install. Capabil. (MW)	Forced Outage (MW)	Derating Unit (MW)	Derating Steam (MW)	Total Unavail. Am't. (MW)	Total Unavail. %Inst.
June 3	9009	724	566	275	1565	17.4
June 10	9009	1001	1085	274	2360	26.2
June 17	9183	477	905	298	1680	18.3
June 24	9183	1364	522	236	2122	23.1
July 1	9183	1074	778	282	2134	23.2
July 8	9183	2134	470	409	3013	32.8
July 15	9173	878	686	437	2001	21.8
July 22	9173	1054	576	319	1949	21.3

Source: New York PSC weekly reports to Gov. Rockefeller.

1/ Exclusive of scheduled maintenance. The Company is conducting intensive maintenance to reduce the system capacity unavailability and will retire older units as soon as new capacity can be installed.

Recent Programs Related to Adequacy and Reliability of Power Supply

The New York Power Pool and the Public Service Commission have reached understandings about curtailment actions and emergency measures to be taken by the Pool in case of severe problems affecting power supply of the Pool or its member systems. These agreements facilitate actions to aid troubled areas by reducing services in adjoining areas if emergencies develop which can be mitigated in this manner.

The Consolidated Edison Company has a 26-point program of voltage reductions and progressively more stringent measures for dealing with emergency situations resulting from inadequate generating capability or related problems affecting the Con Ed system.

The Consolidated Edison Company has instituted conservation programs in the form of public education campaigns to encourage the reduction in non-essential uses of electricity through turning down air conditioners, turning off lights, and rescheduling the periods of use of high consumption appliances. Its Save-A-Watt program is believed to have been quite effective in times of serious need as a means of lowering peak demands.

The Association of Home Appliance Manufacturers has conducted programs of instruction for the public on how to purchase, operate, and maintain air conditioners in order to obtain optimum results in terms of electricity consumption.

Finally, the State of New York has enacted a new siting law which established a Board on Electric Generating Siting and the Environment. It is to review applications for the siting and construction of new steam-electric plants and issue certificates of environmental capability and public need before site work and facility construction can be started. It is hoped that this will make possible a practical means of resolving many of the problems which have been most difficult in some past experiences.

Conclusions and Recommendations

The many restrictions affecting the expansion programs and future sources of supply for loads of the Consolidated Edison Company leave little room for any substantial alternatives at any given time, and it remains incumbent upon the Company to continually review timely performance of all programs involving facilities to meet future power needs of the New York metropolitan area. Apparently, it will also continue to be necessary for the Company to diligently pursue practical means of providing for requirements many years into the future if the essential facilities and arrangements are to be available when needed.

Although some improvements in interconnection capability have been effected since 1969, the transfer capability into the Consolidated Edison system remains below 25 percent of peak load. We still consider 25 percent to be a realistic goal for added reliability in terms of the Con Ed system characteristics and forced outage rates experienced recently.

The increased efforts toward closer coordination of planning, construction, and operation of generation and transmission facilities have been noted. The continued need for such coordination is evident and is commended as an important element in the solution of future power supply problems.

The adoption of a longer range planning program and the publication of a 20-year planning base have been noted and the Company is commended for its action in this regard.

It appears that a program of improvements to alleviate some of the problems affecting the distribution network and local service areas is appropriate although the tremendous difficulties in obtaining additional substation sites in the highly congested areas are recognized.

Final

environmental statement

related to operation of

INDIAN POINT NUCLEAR GENERATING PLANT UNIT NO. 2

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

DOCKET NO. 50-247

September 1972
Volume I

UNITED STATES ATOMIC ENERGY COMMISSION

DIRECTORATE OF LICENSING

SUMMARY AND CONCLUSIONS

This Final Environmental Statement was prepared by the U. S. Atomic Energy Commission, Directorate of Licensing.

1. This action is administrative.

2. The proposed action is the issuance of a license to Consolidated Edison Company of New York, Inc., for the operation of the Indian Point Nuclear Generating Plant, Unit No. 2 (Docket No. 50-247), located in the State of New York, Westchester County, Village of Buchanan, 24 miles north of the New York City boundary line.

   The Indian Point Station will have three Units each with a pressurized water reactor. Although the present action is concerned with the proposed issuance of a license for Unit No. 2, this Statement considers the environmental impact of the simultaneous operation of Units Nos. 1 and 2 (265 and 873 megawatts electrical, respectively). In view of the proximity of Units Nos. 1, 2, and 3 and the similarity in design of the Units, it is reasonable to expect that any and all requirements placed on Unit 2 as a consequence of this Statement will apply as well to Units Nos. 1 and 3. Nevertheless, separate studies of the environmental impact of Units Nos. 1 and 3 will be made, in which the combined effects of the Units will be taken into account, and conclusions will be drawn and recommendations made based on those studies.

3. Summary of environmental impacts, including beneficial and adverse effects, follows:

   a. About 35 acres of 239 acres of land formerly used as an amusement park, and later zoned for heavy industry, have been converted to industrial use.

   b. The applicant's plans to develop an 80-acre forested park with a freshwater lake and to build a new visitors' center, nature trails, gardens and public facilities will enhance the value of the site to the general public. A 14-acre area, transferred by the applicant to the Village of Buchanan, will be developed into a marina.

c. A minimal land area was used for the right-of-way of the transmission lines from Unit No. 2 to the nearby Buchanan Substation from which the power is distributed to the applicant's system; no additional right-of-way was needed to distribute the electrical output of Unit No. 2. Transmission towers from Unit No. 2 to the Buchanan Substation were designed in accordance with Federal guidelines.

d. In constructing Unit No. 2, the change in pattern of land use was kept to a minimum; areas disturbed during construction will be improved by landscaping and planting.

e. About 2,650 cubic feet per second* of water for once-through cooling and service water systems will be withdrawn from the Hudson River and increased in temperature by about 15F° during passage through the steam condensers and heat exchangers of Units Nos. 1 and 2. This heated water from both Units will be combined in a common discharge canal and released into the Hudson River at a velocity of about 10 feet per second via a 270-foot long, submerged multiport discharge structure.

f. The applicant's conclusion that the thermal discharges from Units Nos. 1 and 2 will meet the New York State thermal standards throughout the entire year has not been confirmed by the staff's review and evaluation. Although the staff's assessment shows that the thermal discharges will result in a temperature of less than 90°F at the river surface, even during the summer months, and thus meet part of the New York thermal standards, the staff finds that the New York State standards for surface area and cross-sectional area enclosed within the 4F° isotherm may not be met. Under the severest anticipated operating conditions, the staff's evaluation indicates that the area included within the 4F° isotherm will be on a tidal average basis less than 50% of the vertical cross-sectional area of the river, but the increase in temperature at the surface of the river may be on a tidal average basis more than 4F° for more than two-thirds of the surface area of the river and may even extend across the whole width of the river. Under transient peak conditions of the tide, which are not analysed by the applicant, the results are expected to be more severe than the average conditions mentioned.

* 1 cubic foot per second (cfs) is equivalent to about 450 gallons per minute (gpm).

g. The dissolved oxygen concentration in the thermal plume on occasion may be reduced to levels detrimental to aquatic life, principally in late summer and early fall.

h. During the operation of Units Nos. 1 and 2 small quantities of phosphate, hydrazine, amines, boric acid, and chromate discharged into the Hudson River are not expected to produce important biological effects.

i. Chlorination of the once-through cooling system 3 times per week for a total of 6 hours per week may result in releasing cooling water containing up to 0.5 ppm of residual chlorine. This residual chlorine (and any chloramines formed from reaction with nitrogenous materials in the river water) may be toxic to aquatic life in the thermal plume and in the immediate vicinity of the cooling water outfall.

j. A detailed staff assessment of the biological impact of the once-through cooling system of Indian Point Units Nos. 1 and 2, using available information on the hydraulics and biota of the Hudson River estuary, shows that:

   1) Unless the applicant finds better means of preventing fish from entering the intake structure, fish, numbering between two to five million annually based on present population levels and composed mostly of young-of-the-year white perch and also large numbers of young-of-the-year striped bass and other fishes of about one to two inches in length, will be killed by impingement on the intake structure;

   2) Aquatic organisms including phytoplankton, planktonic crustaceans, larval stages of benthic invertebrates and eggs and larvae of many of the estuarine fishes such as striped bass, alewife, blueback herring, tomcod, American shad, bay anchovy, smelt, and white perch will be subject to entrainment in the cooling water and thereby exposed to mechanical, thermal, and chemical (chlorine) effects. The staff has estimated that during the summer months, an average of about 25% of those organisms passively drifting downstream will be entrained. The staff analysis further indicates that during June and July of most years from 30 to 50% of the striped bass larvae which migrate past Indian Point from upstream spawning areas are likely to be killed by entrainment. There is a high probability that the combined effects of entrainment and impingement will also result

I. INTRODUCTION

The Indian Point Nuclear Generating Plant Unit No. 2 (Indian Point Unit No. 2) (Docket No. 50-247), owned and operated by the Consolidated Edison Company of New York, Inc., (the applicant) is located on a 239-acre site on the eastern bank of the Hudson River in an industrial area, about 24 miles north of the New York City boundary line, at Indian Point, Village of Buchanan, in the upper Westchester County, New York State.

The applicant received a construction permit CPPR-21 for Indian Point Unit No. 2 on October 14, 1966. The applicant applied for an operating license on October 15, 1968 and obtained a Facility Operating License No. DPR-26 to load fuel in the core and conduct subcritical testing on October 19, 1971. An operating license to test up to 50% of rated power is pending before the Commission.

The Indian Point site has three nuclear generating Plants on the Station with the following thermal and electrical output expressed in megawatts thermal or megawatts electrical.

(1)	Unit No. 1 (In operation since 1962)	-	890 MW(t) (total) 615 MW(t) (nuclear) 275 MW(t) (fossil)	285 MW(e) (gross) 265 MW(e) (net)
(2)	Unit No. 2	-	2,758 MW(t)[a] 3,216 MW(t)[b]	873 MW(e)[a] (net) 1,069 MW(e)[b]
(3)	Unit No. 3 (Under construction until 1974)	-	3,025 MW(t)[a] 3,216 MW(t)[b]	965 MW(e)[a] 1,069 MW(e)[b]

[a]Initial output

[b]Design output

Each Unit utilizes the Hudson River as the water supply for a once-through cooling system.

The following chapters describe (1) the environment in the area, including the history, geography and geology, hydrology, climatology, ecology, land and water use including chemical characteristics, (2) the facility and its effluents, (3) the impacts from construction and operation of Unit No. 2 (Plant), (4) alternatives to the proposed action, (5) irreversible and irretrievable long-term commitments of resources from effects of the Plant operation, (6) need for power, and (7) the benefits-cost accrued from the proposed issuance of an operating license. Wherever possible, the Statement takes into account the combined impacts from operation of Unit No. 1 and Unit No. 2. The applicant shall be required to release all discharges to the environment in accordance with Federal and State regulations. Comments from Federal, State and local agencies, the applicant, interested persons and groups, some of which are parties in the proceeding of the Licensing Hearing before the Board, have been taken into account in the body of the text under the appropriate subject and further detailed in Chapter XII of this Statement.

A. SITE SELECTION

The selection of a site for construction of an electrical-generating facility depends on many factors. The generating capacity of the power plant is a primary factor. Large generating units (which are more economical than smaller units) place restrictive requirements on prospective plant sites. Power plants using fossil fuel (coal or fuel oil) must have available the means, such as railroads or navigable waters, of transporting bulk materials in large quantities. In addition, each fossil- or nuclear-fueled power plant requires a large volume of water for dissipating the waste heat inherent in the steam-electric cycle.

Another consideration in the selection of plant sites is the distance to the load centers, since transmission losses increase with distance. Nearness to existing transmission facilities decreases the capital investment required to place new power generation on line.

Public acceptance of a plant site is also desirable. Public pressure to preserve scenic natural features, or to prevent the placement of a power plant near residential areas of high population density, influences the ultimate selection of a power plant site. Suitable sites for large power plants are becoming increasingly scarce in the New York area. Limitations of the availability of the above-mentioned requirements has restricted the applicant in selecting suitable sites to build power plants to serve the applicant's service area.

A primary consideration for choosing the Indian Point site for Unit No. 2 was that the site was pledged to nuclear power generation as early as 1956, when the construction permit for Unit No. 1 was issued by the Commission. Unit No. 1 had been in commercial operation for over three years when the applicant filed its application for a construction license for Unit No. 2 on December 6, 1965. The applicant has had difficulty in finding sites within or near its service area upon which the Commission might approve construction of a nuclear plant and which could also win public acceptance.

Contributing to the siting decision were the following facts: the population density in the nearby area was low, cooling water was available, the geology of the site was adequate, and danger of flooding was extremely remote. Experience had been gained from operation of Unit No. 1 regarding the discharges of thermal, chemical, and radioactive effluents and their effects on the environment,[1] and studies had been made of the impact of incremental amounts of these discharges.

B. APPLICATIONS AND APPROVALS

Table I-1 lists the applications filed by the applicant and the approvals received from various governing bodies or agencies.[1] For those applications which have been granted, the date of issuance is included. The letters granting the permits are presented in Appendix I of the applicant's Supplement No. 1 to the Environmental Report.

Future Environmental Approvals

Future environmental approvals required by the applicant for the operation of Indian Point Unit No. 2 will include obtaining operating permits from the New York State Department of Environmental Conservation (Article 12, Public Health Law), the Department of the Army, Corps of Engineers (The Navigation and Navigable Waters Act, S407 - Refuse Act of 1899), and an operating license from the Atomic Energy Commission.

Application has been filed with the Department of Environmental Conservation for a permit for discharge of chemical solutions and an operating permit for the service boilers, and with the Department of the Army, Corps of Engineers for a permit to discharge effluents through the channel and diffuser into the Hudson River.

Table I-1

FEDERAL, STATE AND LOCAL AUTHORIZATIONS
REQUIRED FOR CONSTRUCTION AND OPERATION OF
INDIAN POINT UNIT NO. 2 AND UNIT NO. 1

AGENCY	DATE OF ISSUANCE	PERMIT, LICENSE, ETC.
Federal		
Atomic Energy Commission		
Indian Point Unit No. 1 (Docket No. 50-3)	5-4-56	Construction Permit CPPR-1
	3-26-62	Unit No. 1 Provisional Operating License DPR-5
Indian Point Unit No. 2 (Docket No. 50-247)	10-14-66	Construction Permit CPPR-21
	10-19-71	Facility Operating License No. DPR-26 to Load Fuel and Conduct Subcritical Testing
	Initial Decision by ASLB 7-14-72	Facility Operating License to Conduct Tests Up to 50% of Rated Power
Indian Point Unit No. 3 (Docket No. 50-286)	8-13-69	Construction Permit CPPR-62

REFERENCES FOR CHAPTER IX

1. Bureau of Mines, U. S. Department of the Interior, "Mineral Facts and Problems," 1970 Edition, p. 230.

2. Bureau of Mines, U. S. Department of the Interior, "Mineral Facts and Problems," 1970 Edition, p. 14.

3. Consolidated Edison Company of New York, Supplement No. 1 to Environmental Report for Indian Point Unit No. 2., September 9, 1971, Section 2.7.

4. Consolidated Edison Company of New York, Inc., Indian Point Generating Unit No. 2, Final Facility Description and Safety Analysis Report, Table 1.4.1.

5. Consolidated Edison Company of New York, Supplement No. 2 to Environmental Report for Indian Point Unit No. 2, October 15, 1971, Section 2.3.2.3.

6. Consolidated Edison Company of New York, Supplement No. 3 to Environmental Report for Indian Point Unit No. 2, February 15, 1972.

X. THE NEED FOR POWER

A. POWER DEMAND IN THE APPLICANT's SYSTEM

The area serviced by the applicant consists of the five boroughs of New York City and most of Westchester County, New York, and encompasses a population of 8,760,000 (1970).[1] The power needs of this region have been well known, particularly since the applicant actively recommends, through its "Save a Watt" program, increased efficiency of public use of electricity. The heaviest concentration of electric load occurs in Manhattan.

Figure X-1 shows the consumption of electricity by four major classes of users for the 1960-70 period in the applicant's service area. It can be seen that, during this decade, residential use of electricity increased about 95%, commercial and industrial use increased by 70%, and governmental use increased 96%. In general, the load requirements of the applicant's system differ from the national average in that most of the energy is distributed to residential and commercial customers and relatively little goes to large industrial users. For example, in 1968, about 22% was for residential use, about 44% for commercial use, and only 7.2% for industrial use, as compared with national averages of 27.7, 18.0 and 41.1%, respectively. The applicant in its Supplement No. 3 to the Environmental Report predicts a long-range forecast of sales of electrical output from Unit No. 2 to include 30.0% for residential use, 53.6% for commercial and industrial use, and 16.4% for railroad and governmental uses. Thus, the loading of the system tends to be closely related to the activities of individual residents and commercial establishments; loads are low during late night hours and on weekends and holidays and high during 8:00 a.m. - 5:00 p.m. working hours. The ratio of the maximum to the minimum system load during a 24-hr period may be as high as three to one, so that much of the capacity needed to meet the daytime peak sits idle or not loaded a good part of the time. The applicant has responded on May 30, 1972 in Appendix XII-23 that gas turbine units and some fossil-fueled plants will be used to meet the power needs during peak hours. However, the nuclear power plants will be used only as baseload facilities and will be operated continuously except during scheduled maintenance periods or forced outages.

Another special characteristic of the area serviced by the applicant is the slow growth of the population. The population remained essentially constant between 1950 and 1960; from 1960 through 1968 it increased only about 0.5% per year. The demand increase shown in Fig. X-1 is attributable to the development of new commercial and residential facilities and to the modernization of older facilities.

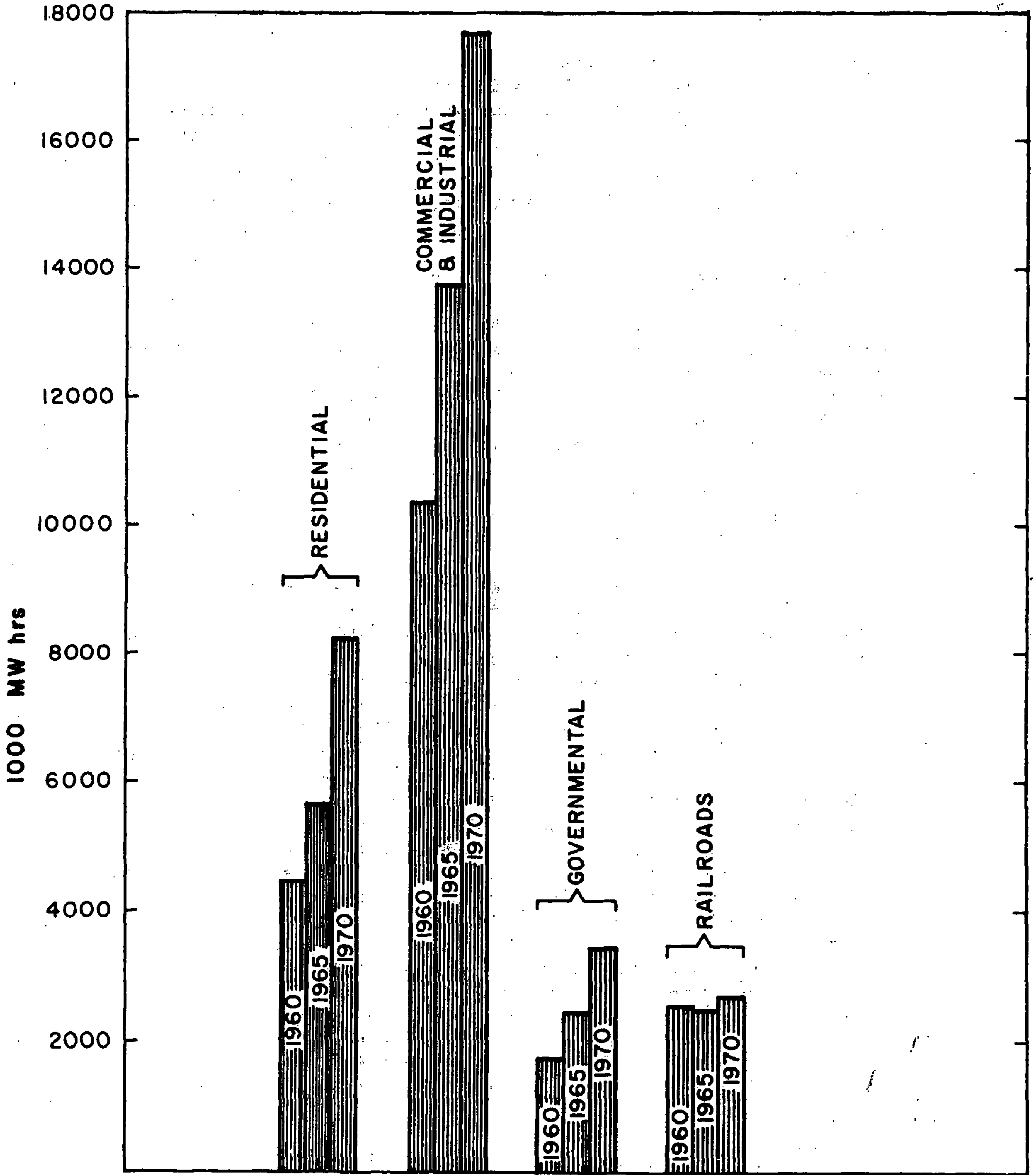


Fig. X-1
Consumption of Electricity by Classes of Customers in the Area Serviced by Consolidated Edison Company.

The peak demand in the applicant's system occurs in summer, largely for air-conditioning. Actual and projected peak demands for summer and winter shown in Table X-1, indicate an average estimated increase in demand for electric power of 5.0% per year (summer peak) and 4.5% per year (winter peak) during the period 1971 to 1980.[2] This is to be compared with 5.7% per year, the approximate growth rate in the New York area (Federal Power Commission [FPC] Coordinated Study Area B) during the period 1960 to 1970 inclusive.

B. PLANNED CAPACITY ADDITIONS

To meet the increasing demand, the applicant plans to increase the system capacity as shown in Table X-1. If the planned additions of capacity are on schedule, the gross reserve margin will be in the general range of 17 to 28% for the summer peaks and 36 to 62% for the winter peaks. The New York State Department of Public Service considers these reserves, particularly for summers, to be "so low as to be critical in the whole 1971-1975 period and the situation appears to be deteriorating instead of improving."[2] These reserves are to be compared with the generally used reserve criterion of 20% of peak load.

According to the FPC the criterion for reserve margin of 20% of peak load, which includes allowances for scheduled maintenance, forced outages, errors in load forecasting, and spinning reserve requirements, should be viewed as an approximate rule which may be modified upwards or downwards, depending on the actual conditions prevailing in individual systems. Due to the high percentage of older and less reliable generating units on its system, the applicant has found that the 20% margin is generally not adequate for system reliability. The largest unit now in service in the applicant's system is the 1,000 MW(e) Ravenswood Unit No. 3.* To maintain system reliability when large increments of generating capacity may be lost by forced outages of large units, correspondingly large system reserves are required. Recent experience indicates that frequent forced outages of new large generating units may be expected during the initial months of their operation.

Although the projected reserves on the applicant's system under normal circumstances would appear to be adequate, the applicant has experienced so many prolonged outages of major equipment and delays in new facilities during recent years that major maintenance has had to be deferred. This has created an extensive backlog of maintenance required to return the existing equipment to a normal state

*The Wall Street Journal reports (August 17, 1972) this unit operating at 60% of capacity due to continuing generator problems.

TABLE X-1

APPLICANT'S LOAD, CAPACITY AND RESERVES
FOR SUMMER AND WINTER PEAKS, 1971-1980

Year	Total Available[1] Capacity MW(e)		Peak Load MW(e)		Reserve MW(e)		Reserve % Peak Load	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
1971	9,509[2]	8,500	7,800[2]	6,225	1,709	2,275	21.9	36.6
1972	10,031[3]	9,823[4]	8,550	6,500	1,481	3.323	17.3	51.1
1973	10,585	9,247	8,950	6,800	1,635	2.447	18.3	36.0
1974	12,050	11,505	9,400	7,125	2,650	4,380	28.2	61.5
1975	12,050	11,460	9,850	7,475	2,200	3.985	22.3	53.3
1976	12,459	11,969	10,300	7,825	2,159	4,144	21.0	53.0
1977	13,544	12,701	10,750	8,175	2,794	4,526	26.0	55.4
1978	14,180	13,507	11,200	8,550	2,980	4,957	26.6	58.0
1979	14,095	13,412	11,650	8,950	2,445	4,462	21.0	49.9
1980	15,105	14,442	12,100	9,350	3,005	5,092	24.8	54.5

[1] Represents the applicant's forecast as of 1971 if all plans are implemented on schedule. Data from reference 2.
[2] Actual summer 1971 data.
[3] Actual data for summer 1972 show about 10,495 MW(e) available.
[4] These figures have been changed by delays in new capacity and by deferring retirement of older facilities. See discussion in text.

of dependability. An intensive maintenance program is planned by the applicant during the winter 1972-73 in an effort to provide greater equipment reliability for the peak load expected in summer of 1973.

The generating capacity of the applicant's system at the present time is provided by 66 baseload generating units, supplemented by gas turbines for peaking capability. This baseload totals 8,258 MW(e). Of the baseload units, 36 units, representing about 2,104 MW(e) or 25% of the baseload capability, are over 30 years old. Many of these are considered obsolete from the standpoint of efficient use of fuel and operating reliability. Also, in recent years all of the coal-fired units have been converted to oil or gas in order to meet air pollution criteria for New York City. Continued dependence upon over-aged generating equipment, with no new baseload capacity additions, can only lead to the increased possibility of system catastrophe with attendant loss of supply to large portions of the service area and the consequent hazards which accompany such a condition. Lost capacity due to average deratings and forced outages may total almost 3,000 megawatts during the winter 1972-1973.[3,4]

Toward the end of 1969, a 10-year plan[1] prepared by the applicant for the FPC called for the construction of new hydroelectric pumped storage, fossil fuel, and nuclear capacity; construction of new transmission lines and upgrading of existing lines; the purchase of power from other systems [total of 1,975 MW(e), 1969 through 1972]; and the retirement of selected units totaling about 2,300 MW(e). The schedule included addition of Indian Point Unit No. 2 in 1971 (delayed due to fire on November 4, 1971 and other construction difficulties) and Unit No. 3 in 1974, together with 2,100 MW(e) of gas turbine capacity in 1970-1972. No new baseload capacity has been added since 1969, while the load has continued to grow. In terms of the present situation, the power picture has changed since these plans were made but the overall conclusion for the critical need for Unit No. 2 remains the same.

C. EXPERIENCE IN MEETING DEMAND

1. Past Experience

The experiences and problems encountered by the applicant since 1969 are illustrative of the difficulties that operation of Indian Point Unit No. 2 is intended to help alleviate. For example, the applicant[5] experienced two severe power shortages during the 1969 summer season, one due to extreme weather conditions and the other to an abnormal amount of forced outages coupled with difficulties in purchasing power owing to schedule slippage elsewhere. As a result, the applicant requested customers using large blocks of power to reduce their load voluntarily and the general public to conserve power. Even then the applicant was forced to institute voltage reductions on 8 different days, and on 2 occasions to the maximum allowable reduction of 8%.

Voltage reductions were instituted on 15 days during the summer of 1970. On one occasion it was necessary to interrupt service to about 67,000 customers. During this occurrence, 425 MW(e) was gained by the voltage reduction, and an additional 390 MW(e) was gained by an appeal to the public to reduce power, but a disconnection of 57 MW(e) was still necessary - 13 MW(e) in Westchester, affecting 6,980 customers, and 44 MW(e) in Staten Island, affecting 59,953 customers.[6] As of September 9, 1971, the voltage on the system had been reduced 13 times during 1971.

2. The Summer 1972 Situation

To meet the anticipated demand during the summer of 1972, the applicant had to arrange for additional purchases beyond those already firmly made because Unit No. 2 was delayed due to construction difficulties and was not available for the summer of 1972 as the applicant had originally planned early in the winter. The applicant's capacity included the output of Bowline Unit No. 1, (600 MW(e), in which a total of 200 MW(e) has been purchased), 348 MW(e) of new barge-mounted gas turbines, 270 MW(e) of power purchased from Rochester Gas and Electric Company (from the Ginna Nuclear Power Plant), and 150 MW(e) of power purchased during daily peak loads from the Power Authority of the State of New York (up to September 29, 1972). Purchase of another 300 MW(e) from Ontario Hydro from May 1 - September 3, with possible extension through October 28, 1972 - the end of the summer capability period - was also negotiated by the applicant.[3] The applicant had been purchasing, on a week-to-week basis, approximately 95 MW(e) under a temporary export license granted by the National Energy Board to Long Sault, Inc., but this license expired on June 30, 1972. Consequently, a total of about 920 MW(e) had to be purchased to meet the anticipated summer peak load demand and to compensate for the unavailability of Indian Point Unit No. 2.

In addition, the applicant had to provide partial replacement of capacity through deferral of planned retirements.[3] A total of 452 MW(e) of retirements was deferred. (These deferred units are inefficient with much less reliability and desirability because of their excessive pollutant emission.)

The summer 1972 situation in the applicant's system is summarized in Table X-2. The tabulation also shows the situation in the New York Power Pool (see later discussion). The difference in the

TABLE X-2 1972 SUMMER PEAK SITUATION

	Consolidated Edison Company		New York Power Pool	
	June 1	August 1	June 1	August 1
Conditions without Indian Point Unit No. 1				
Net Dependable Capability--MW(e)	9,293[1]	10,495[2]	22,474[1]	23,901[2]
Net Peak Load--MW(e)	8,400	8,400	19,510	19,510[4]
Reserve Margin--MW(e)	893	2,095	2,964	3,891[4]
Reserve Margin--Percent of Peak Load	10.6	24.9	15.2	19.9
Needed Reserve Margin Based on Criteria of 20 Percent of Peak Load--MW(e)[5]	1,680	1,680	3,902	3,902
Reserve Excess/Deficiency at 20 Percent Margin--MW(e)[5]	- 787	+ 495	- 938	- 11
Conditions with Indian Point Unit No. 2 [436MW(e)]				
Net Dependable Capability--MW(e)	9,729	10,931	22,910	24,337
Net Peak Load--MW(e)	8,400	8,400	19,510	19,510[4]
Reserve Margin--MW(e)	1,329	2,531	3,400	4,327[4]
Reserve Margin--Percent of Peak Load	15.8	30.0	17.4	22.2
Indian Point Unit No. 2 [873MW(e)]				
Net Dependable Capability--MW(e)	10,166	11,368	23,347	24,774
Net Peak Load--MW(e)	8,400	8,400	19,510	19,510[4]
Reserve Margin--MW(e)	1,766	2,968	3,937	4,764[4]
Reserve Margin--Percent of Peak Load	21.0	35.4[3]	20.2	24.4[3]

[1] According to FPC analysis of May 10, 1972, this is the expected dependable resources as of June 1, 1972; applicant's resources include 8,823 MW(e) dependable generating capacity plus 470 MW(e) firm power purchases.

[2] According to the New York State Department of Public Service Analysis of June, 1972, the applicant's dependable resources include 748 MW(e) additional new capacity and purchase of 920 MW(e).

[3] Reserve margin must consider the amount of generating capacity that will be unavailable because much of the generating capacity is beyond normal retirement age. Much of the reserve capacity cannot be expected to be available. Based on last summer's experience it is estimated that an average of 2,350 MW(e) will be unavailable because of unscheduled outages. This represents 255 MW(e) more than the estimated reserve of 2,095 MW(e).

[4] Includes deduction of 500 MW(e) down for scheduled maintenance.

[5] Although a 20% minimum as a reserve margin capacity is an appropriate general rule in many situations, it is not appropriate for the applicant because of reasons already outlined in footnote 3.

applicant's capability and percent of reserve margin between the two months as shown in Table X-2 is reflected in the changing power picture because of the purchases and reduction in retirements and the unavailability of Unit No. 2. The reserve margin of 2,095 MW(e) without Unit No. 2 on line could be in jeopardy in view of the fact that, during the period June through September 30, 1971, unscheduled forced outages and plant deratings averaged 2,350 MW(e),[7] or 255 MW(e) more than the estimated reserve. According to the New York State Department of Environmental Conservation's comments in Appendix XII-11, the amount of daily unavailable power this past summer could range between 1,450 MW(e) and 3,250 MW(e) on any given day. As shown in Table X-2 the availability of Unit No. 2 at 50% and 100% of rated power would have alleviated this situation. Thus, the FPC[8] from its analysis of the power needs "concludes that all reasonable efforts should continue to bring this unit (Unit No. 2) into service at the earliest possible date. The need for added capacity against the contingencies of forced outages, as well as the desirability of implementing scheduled preventive maintenance programs, is self-evident."

In spite of the efforts to increase the reserves, the applicant had to institute voltage reductions of three to five percent in its system during the week of July 17 to 21, 1972.[9] If Indian Point Unit No. 2 had been on line during the period, it is likely that no voltage reductions would have been necessary.

3. The Winter 1972-73 Situation

The applicant now estimates that the winter 1972 peak will be 6,425 MW(e),[3] slightly lower than the earlier estimate given in Table X-1. During the period between now and the winter peak (usually occuring in December), the applicant expects to have 240 MW(e) available from the 600 MW(e) Roseton No. 1 (oil-fired, applicant's ownership is 40%). An estimated 663 MW(e) will be added because of increased thermal efficiency during the winter. Additional capability through firm purchases will bring the total up to 10,718 MW(e).[3] The gross reserves during the winter peak will thus be 4,293 MW(e) or 66.8% of the estimated peak demand. Without Indian Point No. 2, this will be reduced to 53.3%.

In commenting on the applicant's power needs, the FPC[9] indicated that the applicant's reserve margin during winter 1972-73 would be roughly 10 percentage points higher than we have noted in the preceding paragraph. The difference is attributable to differences in assumptions concerning what facilities will be available next winter. The FPC assumed the applicant's capability to be 7,384

MW(e) fossil, 2,842 MW(e) gas turbine and diesel, 1,138 MW(e) nuclear, and a purchase of 40 MW(e) making a total of 11,404 MW(e). In the figures given in Table X-3,[4] the retirement of 259 MW(e) and the exclusion of the 40 MW(e) purchase, reduces the capability to 11,105 MW(e). The applicant's testimony[3] apparently assumes 349 MW(e) more retirements than the 259 MW(e) just noted and also assures a firm purchase of 40 MW(e) from Maine Yankee. This reduces the capability at the time of the winter 1972 peak to 10,718 MW(e).

It must be emphasized that, because of the lower winter peak demand, the applicant's gross reserve in the winter is always much larger than in the summer.* Moreover, the applicant needs this larger reserve in order to replace or repair equipment during the lower demand period (roughly, October to May).

In recent years, the applicant's use during the summer of all of its capacity, including units that should have been retired from service, has increased the maintenance work to be performed during the winter months. The applicant states that the monthly maintenance schedule during winter 1972-73 will be between 800 and 1,800 MW(e).[3] This amounts to 11 to 28% of the estimated winter peak load.

During winter 1971-72 the applicant experienced an average daily unavailable capability from all combined causes of 2,608 MW(e), with actual occurrences as high as 3,743 MW(e). From this experience, the applicant estimates for winter 1972-73 an average daily unavailability of 2,600 to 3,100 MW(e).[3] This is 40 to 48% of the estimated winter 1972-73 peak load. If the applicant's experience during this next winter is similar to that of last winter, the unavailability of capacity will, at times, exceed the reserve margin without Indian Point Unit No. 2 in operation.

At the request of the New York State Atomic Energy Council, a representative of the New York State Department of Public Service has outlined the projected load, capacity and reserves for the applicant's system during the months of November 1972 through April

---

*This is true throughout the Northeast. The actual gross reserve margin for the Northeast (FPC Power Supply Region I, in December 1971 (winter peak) was 39.4% according to the 51st Semi-Annual Electric Power Survey published by the Edison Electric Institute (EEI Pub. No. 72-28, April, 1972). This is to be compared to 22.8%, the gross reserves during the summer peak of 1971 in the Northeast.

Table X-3. Consolidated Edison capacity, load, and margins – November, 1972–April, 1973

	Nov. 72	Dec. 72	Jan. 73	Feb. 73	Mar. 73	Apr. 73
			Capacity			
Thermal (conventional)	7,125[a]	7,125[a]	6,909	6,909	6,909	6,909
Thermal (gas turbine & diesel)	2,842	2,842	2,842	2,842	2,842	2,842
Thermal (nuclear)	1,138	1,138	1,138	1,138	1,138	1,138
Hydro (conventional)						
Hydro (pumped storage)						
Total controlled	11,105	11,105	10,889	10,889	10,889	10,889
Purchases		40	40	40	40	40
Sales						
Total capacity	11,105	11,145	10,929	10,929	10,929	10,929
			Peak load			
Estimated load	6,225	6,425	6,350	6,250	6,125	6,225
			Margins			
Gross margin (MW)	4,880	4,720	4,579	4,679	4,804	4,704
Scheduled maintenance	730	900	1,150	800	1,450	780
Margin after maintenance	4,150	3,820	3,429	3,879	3,354	3,924
Indian Point delay	(873)	(873)	(873)	(873)	(873)	(873)
Increased maintenance schedule	770					
Delay retirement[b]	259	259				
Additional purchase[c]	240	200	200	200	200	200
Margin after deducting Indian Point, etc.	3,006	3,406	2,756	3,206	2,681	3,251
			Unavailable capacity, past 12 months experience			
Average deratings	1,100	1,200	1,500	1,400	1,300	1,000
Average forced outage	1,300	1,100	1,400	1,300	1,500	1,500
Margin with average unavailability	606	1,106	−144	506	−119	751
High deratings	1,400	1,500	1,800	1,600	1,900	1,300
High forced outage	1,800	1,600	2,400	1,500	1,700	2,000
Margin with high unavailability	−194	306	−1,444	106	−919	−49
Required operating reserve	600	600	600	600	600	600

[a]Includes new units: Bowline No. 1, 400 MW (Consolidated Edison's share); Narrows Gas Turbines, 348 MW; Roseton No. 1, 240 MW (Consolidated Edison's share).

[b]Delay retirement: Hell Gate Nos. 2 and 3, 115 MW; Waterside No. 1, 35 MW; Hudson Ave Nos. 2 and 3, 94 MW; 59th Street No. 7, 15 MW.

[c]Recent purchase agreements: Maine Yankee, 40 MW (Nov. 72 only); Bowline No. 1, 200 MW (throughout the period).

1973.[4] The estimated monthly values of capacity and reserves, given in Table X-3, lead to the same conclusion as the average values noted above, namely, if Indian Point No. 2 is not available, there will be times during next winter when scheduled outages (maintenance), averaged forced outages and deratings may reduce the reserve margin to zero or less. In those periods when the reserve margin is above zero, it may still be less than the 600 MW(e) operating reserve required of the applicant as a member of the New York Power Pool.

Analysis of the information in Table X-3 indicates that, with Unit No. 2 on line and taking into account scheduled maintenance, the reserve margin ranges from 54.6% of peak load in March 1973 up to 66.3% in November 1972. With Unit No. 2 not available and with the increased maintenance schedule, power purchases, deferred retirements and additional capacity of Roseton No. 1, which is from the applicant's share of ownership of this plant, the applicant's reserve margin is reduced to 43.8% in March 1973 and 49% in November 1972. The New York State Department of Public Service, however, has indicated that, after deducting average unavailable capacity because of average deratings and forced outages, the applicant "will be unable to meet its load in January and March 1973."[4] This is because the applicant will be having a deficiency of reserve margins of 144 MW(e) in January and 119 MW(e) in March 1973. Also, in February 1973, the applicant will not be able to maintain the operating reserve of 600 MW(e) required as a partner in the New York Power Pool. If high deratings and high forced outages should occur, the applicant will not be able to meet its load in every month except two (December 1972 and February 1973); moreover, in all these months, the applicant will not have the required operating reserve of 600 MW(e). As a result the Department of Public Service concludes "on the basis of the above analysis, additional capacity is needed for the winter of 1972-1973 to help meet the applicant's load requirements."[4]

The above discussion demonstrates that a careful analysis of gross margins, margins after scheduled maintenance, margins after specified additions and deductions because of delay in retirement, increased scheduled maintenance, margins with average unavailability and with high unavailability is needed before conclusions can be drawn as to the significance of the percent of peak load. Therefore, although the applicant appears to have a high percent of gross reserve margins to meet the winter 1972 power needs, the applicant, however, will be in serious difficulty particularly during January and March 1973 without the availability of Unit No. 2 at any power levels to alleviate the situation as shown on Table X-3. Thus, the statement by the FPC[9] that the capacity of Indian Point Unit No. 2 is not critical to the applicant's reserve capacity for the 1972-73 winter peak period is based on gross reserve margins. FPC has not taken into account the maintenance, delays, forced outages, deratings and other requirements as outlined in Table X-3. FPC did state that the availability of Unit No. 2 can allow for maintenance of other operating units not now possible. Also reliability through testing of Unit No. 2 through the winter will be improved in anticipation of meeting the summer 1973 peak.

4. The Summer 1973 Situation

The load supply situation shown in Table X-4 during next summer has been estimated by the FPC Bureau of Power.[9] To meet the projected peak demand of 8,850 MW(e) (slightly less than the applicant's earlier projection shown in Table X-1), the FPC expects the applicant to have resources of 10,135 MW(e) without Unit No. 2 or 11,008 MW(e) with Unit No. 2. (These latter figures assume net firm purchases of 40 MW(e) from Maine Yankee.) These projections indicate a gross reserve margin during summer 1973 of 14.5% without Unit No. 2 or 24.4% with Unit No. 2. Comparison of these figures with those given for June 1, 1972 in Table X-2 shows that the projected situation for the applicant will be only slightly better than the situation early in the summer of 1972. Since, as noted earlier, the applicant's situation early in 1972 summer was poor, it follows that the need for capacity will remain during summer 1973. Without Indian Point Unit No. 2 in operation next summer, the gross reserve margin will not be sufficient to insure reliable power for the applicant's customers.

Although the applicant had to purchase additional power to make up for the unavailability of Unit No. 2 in the summer of 1972, the FPC[9] points out that in the summer of 1973, the applicant will have to reduce its import power from 1,200 MW(e) to 720 MW(e) from members of the New York Pool, Ontario and New England because of litigation regarding the Rock Tavern-Ramapo 345-kV transmission line. This also means that 480 MW(e) from the Roseton Station will not be available to the applicant.

D. APPLICANT'S PARTICIPATION IN POOLING AND COORDINATION AGREEMENTS

The applicant has been an early participant in intercompany agreements aimed at achieving maximum reliability and economy of service and is one of eight member utilities of the New York Power Pool. Table X-5 lists the members of the Pool.[5] Under the pooling agreement, each member continues to have full responsibility for

TABLE X-4 ESTIMATED 1973 SUMMER PEAK LOAD-SUPPLY SITUATION

	Consolidated Edison Co.	New York Power Pool
Conditions for 100 Percent Power Rating - 873 MW(e)		
Total Resources - MW(e)	11,018[1]	27,490
Net Peak Load - MW(e)	8,850	20,840[2]
Reserve Margin - MW(e)	2,158	6,650
Reserve Margin - Percent of Peak Load	24.4	31.9
Conditons for 50 Percent Power Rating - 436 MW(e)		
Total Resources - MW(e)	10,531[1]	27,053
Net Peak Load - MW(e)	8,850	20,840[2]
Reserve Margin - MW(e)	1,681	6,213
Reserve Margin - Percent of Peak Load	19.0	29.8
Conditions for 20 Percent Power Rating 175 MW(e)		
Total Resources - MW(e)	10,270[1]	26,792
Net Peak Load - MW(e)	8,850	20,840[2]
Reserve Margin - MW(e)	1,420	5,952
Reserve Margin - Percent of Peak Load	16.0	28.6
Conditions for 0 Percent Power Rating - 0 MW(e)		
Total Resources - MW(e)	10,135[1]	26,617
Net Peak Load - MW(e)	8,850	20,840[2]
Reserve Margin - MW(e)	1,285	5,777
Reserve Margin - Percent of Peak Load	14.5	27.7

[1]Includes net firm purchases of 40 MW(e).
[2]Includes net firm sales of 22 MW(e).

TABLE X-5

NEW YORK POWER POOL MEMBERS

Consolidated Edison Company of New York, Inc.

Long Island Lighting Company

New York State Electric and Gas Corporation

Orange and Rockland Public Utilities, Inc.

Rochester Gas and Electric Company

Niagara Mohawk Power Corporation

Central Hudson Electric and Gas Corporation

Power Authority of the State of New York

*Jamestown Municipal Electric System

*Long Sault, Inc.

*Village of Freeport

*New York State Companies which are not members of the New York Power Pool but which report their load and capability as part of the New York State Interconnected Systems.

maintaining adequate electric generating capacity and transmission facilities within its own service area. In particular, the applicant is required to maintain a reserve margin of at least 18% peak load. Each member must maintain an operating reserve consisting of a spinning reserve, which is capacity that can be available within 5 minutes' time, and a ready reserve, which is the capacity that can be available within 30 minutes' time. The applicant's share of the Pool's operating reserves amounts to about 600 MW(e). The FPC has recommended that, as a general rule, a minimum of 20% reserve margin capacity be maintained for large power pools whose capacity is predominantly from thermal stations.[10] This includes allowance for scheduled maintenance, forced outages, errors in load forecasting, and spinning reserve requirements. In return, under the pooling arrangement, each member of the Pool and the customers it serves receive the benefits associated with fully coordinated planning and cooperation of the systems.

An analysis by the New York State Department of Public Service of the New York Power Pool situation during the period November 1972 to April 1973 (similar to that shown in Table X-3), shows the picture to be brighter.[4] Without Indian Point Unit No. 2, and considering average deratings and average forced outages, the reserve margin ranges from 2,051 MW(e) or 11.8% of peak load for March 1973, to about 3,327 MW(e) or 18% of peak load for January 1973. In both January and March 1973 the reserve margins of 1,297 MW(e) and 851 MW(e), respectively, with, high unavailability will be lower than the required operating reserve of 1,400 MW(e) for the Pool. Then the Pool would be forced to go outside the system in order to purchase capacity and avoid possible load curtailment. The availability of Indian Point No. 2 at any power level would improve the situation in the New York Power Pool.

In addition to being a member in the New York Power Pool, the applicant is also a member of a larger area agreement, the Northeast Power Coordinating Council (NPCC)[11] The latter was formed out of an agreement in 1966 between the large electric utilities in New York, New England, and Ontario, aimed at further strengthening the service reliability of the interconnected company systems in this area. The New York State Department of Environmental Conservation[7] has presented information in Table X-6 updating the original FPC projections of the near-term gross generating capability and reserve conditions in the NPCC area and in the New York Power Pool for the winter of 1972-1973[11] It should be noted, however, that the NPCC is primarily a council for planning, coordination, and protection for the region and not a capacity resource pool for its member companies. The projections shown in Table X-6 include the full generating capability of Indian

TABLE X-6

PROJECTED ELECTRIC LOADS AND SUPPLY CONDITIONS WITHIN THE NORTHEAST AREA AND THE NEW YORK POWER POOL (WITH AND WITHOUT INDIAN POINT UNIT NO. 2)

		Winter 1972-1973
Northeast Power Coordinating Council*		
Planned Capability, MW(e)		59,857 2/
Peak Load		35,652
Anticipated Reserves, MW(e)		13,305 3/
Percent of Projected Peak Load		29.4
Planned Nuclear		2,835
Percent of Anticipated Reserve		21.4
New York Power Pool**		
Planned Capability, MW(e) (Including net of transactions and 873 MW(e) from Unit No. 2)		26,681 4/
Peak Load, MW(e)		18,540
Anticipated Reserves, MW(e)		7,241 3/
Percent of Projected Peak Load		39.1
Necessary Reserve at 20% 1 MW(e)		3,708
Surplus (Deficiency) MW(e)		3,533
<u>Without Indian Point Unit No. 2 (Nuclear, April 1972)</u>		-873
(Consolidated Edison Co. - Buchanan, New York)		
New Capability	MW(e)	25,808
Peak Load	MW(e)	18,540
Reserve	MW(e)	6,368 3/
Peak Load	%	34.4
Necessary Reserve at 20% 1/	MW(e)	3,708
Surplus (Deficiency)	MW(e)	2,660

*Includes New York, New England, and Canadian members.
**Includes net of sale transactions.

1/ FPC Staff estimate.

2/ With Indian Point No. 2 at 873 MW(e)

3/ Includes deduction of 900 MW(e) for scheduled maintenance.

4/ Winter capacity higher because of improved cooling efficiency.
Source: Evaluation of New York State Department of Public Service made on May 1, 1972, based on Consolidated Edison load and capacity estimates dated March 28, 1972 and report of NPCC dated April 1, 1972.[7]

Point Unit No. 2, 873 MW(e), which represents about 12% of the anticipated reserves of the New York Power Pool for the winter 1972-1973 period. Without Indian Point Unit No. 2, the available gross reserve of the New York Power Pool was projected to drop from 39.1% to 34.1% of peak load during this period. The estimate was also contingent on addition of 1,100 MW(e) of Roseton No. 1 and Gilboa 1 and 2 capability scheduled for winter 1972.

Analysis of the New York Power Pool reserves for the summers of 1969, 1970, and 1971 indicates that actual operating reserves experienced were only 6.0, 4.4 and 10.9%, respectively, after accounting for maintenance, unscheduled outages, and forced unit capacity deratings. Such a low reserve margin is not adequate and threatens system reliability. Further analysis indicates that the contributing factors are concentrated in the applicant's system. No new baseload capacity has been added to this system since 1969, while load has continued to grow. Some 1,833 MW(e) of gas-turbine peaking capacity has been added; however, extended operation of these units has resulted in extensive maintenance problems and reduced availability of the gas-turbine capacity.[12] In this connection, the applicant has stated[3] that its gas-turbine units, "intended for limited hours of operation, perhaps 500-1000 each year,.... have already been required to operate on the average, for the equivalent of 2000 hours per year since the summer of 1971, and will be required to continue operation at this level in the summer of 1972." Until the applicant increases its baseload capacity, the reliability of the New York Power Pool will be less than desirable.

Table X-2 also shows the 1972 summer peak situation for the New York Power Pool. It will be noted that during June and July gross reserves of the Pool (expressed as percent of peak load) are greater than those of the applicant; after August 1, the applicant's reserve margin is higher than that of the Pool.

The estimated 1973 summer peak load situation for the Pool is also shown in Table X-4.[9] As can be seen, the projected gross reserves of 31.9% of peak load of the Pool are greater than the applicant's gross reserve margins provided Indian Point Unit No. 2 is included. Without Unit No. 2 the gross reserves of the Pool drop to 27.7% of peak load. Based on gross reserves, the Pool should have sufficient reserves for winter 1972-73 and the summer of 1973. This does not include forced outages or deratings of plants in the Pool.

E. AVAILABLE ALTERNATE SOURCES

The applicant purchased 920 MW(e) and added 624 MW(e) gas-turbine capacity to its systems in 1971 to meet the shortages expected, particularly during the summer of 1971. In 1972 the applicant contracted for 920 MW(e) of purchased capacity, which included 200 MW(e) from Orange and Rockland's share of the Bowline Point Unit No. 1, scheduled to go on line in July 1972, and an additional 720 MW(e) from other utilities. These purchases are short-term and in some cases for limited hours of the day to meet the peak demand. They are not to be considered a solution to provide reliable power over the long term.

Thus the applicant needs to have Indian Point Unit No. 2 as a baseload facility on line as soon as possible in order to meet the baseload requirements for its own service area and to maintain needed reserve margins with respect to meeting the requirements of the New York Power Pool. The situation would be further complicated if any units scheduled to come on line are delayed.* Without these new plants available, a serious power shortage to the New York Metropolitan area can occur. Furthermore, the environmental impact of the air pollutants from the older fossil-fuel plants, which would have to operate to make up for the lack of availability of Indian Point Unit No. 2, should be added into the picture with the unavailability of Indian Point Unit No. 2. Details of the applicant's available alternate sources, particularly for the long-term, are discussed in Chapter XI.A.

The applicant in its testimony of October 19, 1971,[13] January 24-25, and May 18, 1972,[3] before the presiding Atomic Safety and Licensing Board, details the problems of power purchases to meet these shortages.

F. COST OF DELAY

The cost of delay to the applicant and its customers in placing this Plant on line in time has been reported by the applicant to consist of about $5,500,000 per month, the estimated cost of incremental operation and maintenance and out-of-pocket cost of replacing energy which would otherwise have been produced by Indian Point Unit No. 2 plus about $1,000,000 per month, the amount of interest during construction which would occur during the period of delay.[3] Operation would not only eliminate these costs but would generate electricity for the applicant's customers so as to begin financial return on capital investment. Taxes then paid by the applicant on the income obtained would support beneficial activities in the local communities.[3]

*The units involved here include those in other systems from which the applicant plans to purchase capacity.

G. CONCLUSION

Since the applicant's original decision to schedule the addition of Indian Point No. 2 to its system to meet the demand for electricity in the 1970's, voltage reductions and service interruptions have occurred; these events, taken together with new and more stringent air pollution restrictions and environmental protection concerns, have tended to increase the pressures on the existing capacity. Moreover, the availability of alternate sources of baseload capacity is limited to short-term purchase commitments. In view of this, the staff believes that the need for the additional baseload capacity represented by Indian Point Unit No. 2 has been clearly demonstrated.

S-27

94th Congress } COMMITTEE PRINT
2d Session }

LEGISLATIVE HISTORY OF THE COASTAL ZONE MANAGEMENT ACT OF 1972, AS AMENDED IN 1974 AND 1976 WITH A SECTION-BY-SECTION INDEX

PREPARED AT THE REQUEST OF

HON. WARREN G. MAGNUSON, *Chairman*

COMMITTEE ON COMMERCE

AND

HON. ERNEST F. HOLLINGS, *Chairman*

NATIONAL OCEAN POLICY STUDY

FOR THE USE OF THE

COMMITTEE ON COMMERCE

AND

NATIONAL OCEAN POLICY STUDY

PURSUANT TO

S. Res. 222

DECEMBER 1976

U.S. GOVERNMENT PRINTING OFFICE
65-319 WASHINGTON : 1976

COMMITTEE ON COMMERCE

WARREN G. MAGNUSON, Washington, *Chairman*

JOHN O. PASTORE, Rhode Island
VANCE HARTKE, Indiana
PHILIP A. HART, Michigan
HOWARD W. CANNON, Nevada
RUSSELL B. LONG, Louisiana
FRANK E. MOSS, Utah
ERNEST F. HOLLINGS, South Carolina
DANIEL K. INOUYE, Hawaii
JOHN V. TUNNEY, California
ADLAI E. STEVENSON, Illinois
WENDELL H. FORD, Kentucky
JOHN A. DURKIN, New Hampshire
JAMES B. PEARSON, Kansas
ROBERT P. GRIFFIN, Michigan
HOWARD H. BAKER, JR., Tennessee
TED STEVENS, Alaska
J. GLENN BEALL, JR., Maryland
LOWELL P. WEICKER, JR., Connecticut
JAMES L. BUCKLEY, New York

MICHAEL PERTSCHUK, *Chief Counsel*
S. LYNN SUTCLIFFE, *General Counsel*
MALCOLM M. B. STERRETT, *Minority Counsel*

NATIONAL OCEAN POLICY STUDY

FROM THE COMMITTEE ON COMMERCE
ERNEST F. HOLLINGS, South Carolina, *Chairman*

WARREN G. MAGNUSON, Washington
JOHN O. PASTORE, Rhode Island
VANCE HARTKE, Indiana
PHILIP A. HART, Michigan
HOWARD W. CANNON, Nevada
RUSSELL B. LONG, Louisiana
FRANK E. MOSS, Utah
DANIEL K. INOUYE, Hawaii
JOHN V. TUNNEY, California
ADLAI E. STEVENSON, Illinois
WENDELL H. FORD, Kentucky
JOHN A. DURKIN, New Hampshire
JAMES B. PEARSON, Kansas
ROBERT P. GRIFFIN, Michigan
HOWARD H. BAKER, JR., Tennessee
TED STEVENS, Alaska
J. GLENN BEALL, JR., Maryland
LOWELL P. WEICKER, JR., Connecticut
JAMES L. BUCKLEY, New York

FROM THE COMMITTEE ON PUBLIC WORKS
EDMUND S. MUSKIE, Maine
JAMES L. BUCKLEY, New York

FROM THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS
LEE METCALF, Montana
MARK O. HATFIELD, Oregon

FROM THE COMMITTEE ON FOREIGN RELATIONS
CLAIBORNE PELL, Rhode Island
CLIFFORD P. CASE, New Jersey

FROM THE COMMITTEE ON APPROPRIATIONS
LAWTON CHILES, Florida
CHARLES McC. MATHIAS, JR., Maryland

FROM THE COMMITTEE ON GOVERNMENT OPERATIONS
ABRAHAM RIBICOFF, Connecticut
CHARLES PERCY, Illinois

FROM THE COMMITTEE ON LABOR AND PUBLIC WELFARE
HARRISON A. WILLIAMS, JR., New Jersey
EDWARD M. KENNEDY, Massachusetts (Alternate)
RICHARD S. SCHWEIKER, Pennsylvania

FROM THE COMMITTEE ON ARMED SERVICES
STUART SYMINGTON, Missouri
WILLIAM L. SCOTT, Virginia

MEMBERS AT LARGE
HUBERT H. HUMPHREY, Minnesota
LLOYD BENTSEN, Texas
J. BENNETT JOHNSTON, JR., Louisiana
JOHN TOWER, Texas
BOB PACKWOOD, Oregon
WILLIAM V. ROTH, JR., Delaware

DEBORAH STIRLING, *Staff Director, NOPS*
JAMES P. WALSH, *Staff Counsel*
STEVEN FLAJSER, *Professional Staff Member*
GERALD J. KOVACH, *Minority Staff Counsel*

LETTER OF TRANSMITTAL

U.S. SENATE,
COMMITTEE ON COMMERCE,
September 29, 1976.

DEAR COLLEAGUE: It has been 4 years since the enactment of the Coastal Zone Management Act. Currently, all 30 coastal States and three of four eligible territories are in the process of developing coastal zone management programs under this legislation.

Since its enactment, the Coastal Zone Managment Act has been amended twice, in 1974 and again in 1976. The 1976 amendments are significant in both scope and concept.

Since the legislative intent of this Act, as amended, is frequently re-examined by the Congress and the Executive, the Committee requested the Library of Congress' Congressional Research Service to compile this history containing the legislative documents and debate.

It is hoped that this legislative history will prove useful to you and others involved in coastal zone management.

We wish to emphasize that the content of this legislative history have neither been approved, disapproved, nor considered by the Senate Committee on Commerce or the National Ocean Policy Study.

WARREN G. MAGNUSON,
Chairman, Committee on Commerce.
ERNEST F. HOLLINGS,
Chairman, National Ocean Policy Study.

LETTER OF SUBMITTAL

THE LIBRARY OF CONGRESS,
CONGRESSIONAL RESEARCH SERVICE,
Washington, D.C., July 26, 1976.

Hon. ERNEST F. HOLLINGS,
Chairman, National Ocean Policy Study, Committee on Commerce, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: In response to your request, we are submitting a legislative history of the Coastal Zone Management Act of 1972, and the 1974 and 1976 amendments.

This history contains an introductory section explaining the effect of the Stratton Commission's report on the movement for coastal zone management, and covers the efforts of the 91st and 92d Congresses toward this legislation. In addition, all reports and debates are included.

This work was compiled by Martin R. Lee, analyst in the Oceans and Coastal Resources Project.

We hope that this history will serve the needs of the Senate National Ocean Policy Study as well as those of Committees and Members of Congress interested in coastal zone management.

Sincerely,

NORMAN BECKMAN,
Acting Director.

CONTENTS

PART 1

Part 2

LEGISLATIVE HISTORY OF THE COASTAL ZONE MANAGEMENT ACT AMENDMENTS OF 1974

Part 3

LEGISLATIVE HISTORY OF THE COASTAL ZONE MANAGEMENT ACT AMENDMENTS OF 1976

PART 1

LEGISLATIVE HISTORY OF THE COASTAL ZONE MANAGEMENT ACT OF 1972

> in northern California, just north of Eureka. In Oregon the most likely candidate seems to be Alesea Bay, but Netarts is also a good candidate. In Texas the Baffin Bay region of the Laguna Madre, and perhaps Copano Bay should be considered * * *. (Committee on Commerce hearings, "Federal Oceanic and Atmospheric Organization." Pt. 2, serial No. 91–59, at p. 1258.)

Dr. B. J. Copeland of North Carolina State University recommended that "sanctuaries should be established to enable studying estuaries of various ecological types and under various ambient conditions", and gave these examples:

A. Oligohaline estuary—Pamlico River, N.C.
B. Medium salinity plankton system—Chesapeake Bay, Md.
C. Tropical Estuary—Kaneohe Bay, Hawaii.
D. Oyster Reef, grass flat—Barataria Bay, La.
E. Lagoon—Laguna Madre (Baffin Bay), Tex.
F. West coast—plankton system—Yaquina Bay, Oreg. (Committee on Commerce hearings, "Federal Oceanic and Atmospheric Organization," Pt. 2 serial No. 91–59 at p. 1259.)

Dr. Copeland stated that these types represent most of the estuaries in the United States with the exception of minor ones on rocky coasts and those in the Arctic.

The Committee is convinced that sound coastal zone management must be based upon basic ecological considerations, and to this end are persuaded by the statement of Mr. Sydney Howe, president of the Conservation Foundation:

> Traditionally, land-use planning is based largely on economic engineering, design and transportation concepts that consider natural processes only partially and indirectly. The science of ecology—"the systems analysis of nature" is concerned with the impact of man upon natural processes and the total consequences, including the effects on man and his works.
>
> * * * [N]ational policy for coastal management [should be] to give a priority to those uses which are compatible with the productive functioning of coastal natural systems and which cannot be provided elsewhere, and that where development is permitted it should be designed to minimize damage to these natural systems. Such decisions cannot be made without some understanding of these systems. Ecological knowledge, in short, should be a fundamental and initial basis of coastal zone planning and management.
>
> Our own experience with ecologically based development planning already has shown that in many situations it is posble to minimize adverse impacts of development and maximize developmental benefits if one can understand the natural systems affected. This kind of understanding is particularly important in coastal situations where filling, dredging, discharging of wastes, mining, obstruction of tidal or current flows, or removing of vegetation may generate unforeseen destructive effects on highly desirable and useful functions and forms of life elsewhere in the system. (Committee on Commerce hearings, "Federal Oceanic and Atmospheric Organization." Pt. 2, serial No. 91 59 at p. 972.)

Establishment of estuarine sanctuaries will provide information valuable in itself, as well as information on which sound coastal zone management decisions can be based.

Section 314. Interagency coordination and cooperation

Subsection (a) provides that unless the views of Federal agencies principally affected by a State's coastal zone management program are adequately considered, the Secretary is not authorized to approve that program. Where serious disagreement exists between a State and a Federal agency in the development of the management program, the Secretary is to seek to mediate the differences. Should such mediation on the part of the Secretary not result in success, then the parties are authorized to turn to the National Coastal Resources Board for further solution of the problems. Once again final authority for decisions on these matters rest in the purview of the Secretary and there is no intent here to diminish that authority.

Section 314(b)(1). This subsection requires all Federal agencies conducting or supporting activities in the coastal zone to administer their programs consistent with approved State management programs except in cases of overriding national interest as determined by the President. In order to determine whether Federal projects and activities are consistent with approved management programs, the subsection requires that program coverage procedures provided for and regulations issued under the Demonstration Cities and Metropolitan Development Act of 1966 (Public Law 89–754, 80 Stat. 1255) and Title IV of the Intergovernmental Cooperation Act of 1968 (Public Law 90–577, 82 Stat. 1098) shall be applied.

Paragraph (2) of subsection (b) provides that Federal agencies shall not undertake any development project in the coastal zone which in the opinion of the State is inconsistent with the management program of that State unless the Secretary receives comments from the Federal agencies, the coastal State, and the affected local governments, and then finds that the project is consistent with the objectives of this act.

The committee does not intend to exempt Federal agencies automatically from the provisions of this act. Inasmuch as Federal agencies are given a full opportunity to participate in the planning process, the committee deems it essential that Federal agencies administer their programs, including developmental projects, consistent with the State's coastal zone management program. If not, the ordinary course for a State would be to file a complaint with the Secretary or, failing that, with the National Coastal Resources Board. Again, however, once the Secretary has received comments from the Federal agencies, the State, and the affected local governments, he shall make his own findings as to the consistency of the Federal developmental project with the State's management program.

Also, where the Secretary of Defense informs the Secretary that a developmental project is necessary in the interest of national security, the committee intends that the Secretary will make an independent inquiry and finding as to the need for the project and its relationship to the State management program. It is not sufficient, for the purposes of this act, that the Secretary of Defense merely inform the Secretary that the developmental project is needed in the interest of national security. All reasonable efforts should be made by the Secretary to reconcile national security needs and the State management program in the case of such conflicts.

Paragraph (3) of subsection (b) provides that after final approval by the Secretary of a State's management program, any applicant for a Federal license or permit to conduct any new activity in the coastal zone shall provide in the license or permit application a certification that the proposed activities comply with the State's approved management program. Additionally, the applicant must give reasonable assurance that the activity will be conducted in a manner consistent with that program. The State is to establish procedures for public notice of such applications for certification. The State also must provide public hearings when appropriate. If a State agency fails to grant or deny a request for certification within 6 months from the time that request is received, the certification requirements shall be waived. No license or permit shall be granted until either the certification has been obtained or waived, or the activity has been found by the Secretary to be consistent with the objectives of the legislation or necessary in the interest of national security. Such a finding cannot be made, however, unless the Secretary has received detailed comments from Federal and State agencies and the State has provided an opportunity for a public hearing. Thus, paragraph (3) of section (b) assures that before a Federal license or permit is issued to conduct any new activity in the coastal zone, directly, significantly and adversely affecting the coastal waters, it will be reviewed by an appropriate State agency and a certification of compliance supplied. This is done as both an aid to Federal licensing and permitting agencies and to insure the development projects are consistent with the coastal State's management program. Emphasis is placed upon "new" activity. This activity is after the date of enactment of the legislation. It will thus be appropriate to distinguish between new activities, such as the building of a new marina, or the dredging of a new channel, as opposed to the maintenance of existing facilities or activities begun prior to the enactment of the bill.

Section 314(c) provides that State and local governments submitting applications for Federal assistance under other Federal programs affecting the coastal zone are required under this subsection to indicate the views of the appropriate coastal State or local agency as to the relationship of such activities to the State's approved management program. Federal agencies shall not approve proposed projects that are inconsistent with the management program, unless the Secretary finds that the project is consistent with the purposes of the title or necessary in the interest of national security. Those who seek Federal licenses or permits must receive certification that the proposed project is consistent with the State's approved management program. The same conditions exist for State and local governments seeking Federal assistance from other sources. They must indicate also the consistency of their proposed project with the approved State program.

Section 314(d) is a standard clause disclaiming intent to diminish Federal or State authority in the fields affected by the act; to change interstate agreements; to affect the authority of Federal officials; to affect existing laws applicable to Federal agencies; or to affect certain named international organizations.

Section 315. Annual report

The Secretary is required to submit an annnual report to the President for transmittal to the Congress not later than November 1 of each year, covering the administration of the title for the preceding fiscal year. Among other things the report is to include the Secretary's recommendations for additional legislation to achieve the objectives of the title to enhance its effective operation. The report shall include, but not be limited to, the following subject areas:

(1) There shall be an identification of the coastal State programs approved pursuant to this title during the preceding Federal fiscal year and a description of those programs;

(2) The Secretary shall list the coastal States which are participating in the provisions of this title and describe the status of each program and what has been accomplished during the past fiscal year;

(3) The Secretary shall itemize the allotment of funds to the various coastal States and give a breakdown of the major projects and areas where these funds have been spent;

(4) The report also shall identify any coastal State programs which have been viewed and disapproved or with respect to which grants have been terminated under this title and an explanation of why the action was taken;

(5) A listing of the Federal development projects which the Secretary has reviewed under section 314 of this title and a summary of final action taken by the Secretary on each such project;

(6) A summary of the regulations issued by the Secretary or in effect during the preceding Federal fiscal year; and

(7) A summary of outstanding problems arising in the administration of this title in order of priority.

Additionally, the Secretary may put in any other information as he deems appropriate. Throughout this act, the State has been the major focal point for planning and managing the coastal zone of the United States. It is felt that States do have the authority with the approval of the Secretary to delegate to local, areawide or interstate agencies some of the planning and management functions under this act.

In theory this legislation could result in 35 substantially different management programs lacking the coordination of a national strategy for managing this invaluable resource in the coastal zone. The Committee believes that one of the important functions of the Secretary will be to develop and to coordinate this strategy working closely with the Coastal Zone Management Advisory Committee. Therefore, it is hoped that the Secretary will work closely with a wide range of diverse interest and interested groups both on the local and state level. The result of such work are to be incorporated in the annual report and will serve to assess current status and to guide future decisions.

Section 315. Appropriations authorization

There are authorized to be appropriated (1) $12 million for the fiscal year ending June 30, 1973, and such sums as may be necessary for the fiscal years thereafter prior to June 30, 1977, for management program development grants under section 305 of the Act, to remain available until expended; (2) not to exceed $50,000,000 as may be necessary for the fiscal year ending June 30, 1973, and such sums as

93d Congress
1st Session

JOINT COMMITTEE PRINT

UNDERSTANDING THE "NATIONAL ENERGY DILEMMA"

PREPARED AT THE REQUEST OF

MELVIN PRICE, Chairman

JOINT COMMITTEE ON ATOMIC ENERGY

by Staff of JCAE

Printed for the use of the Joint Committee on Atomic Energy

U.S. GOVERNMENT PRINTING OFFICE
99-730 O WASHINGTON : 1973

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C., 20402 - Price $1.55
Stock Number 5270-01947

JOINT COMMITTEE ON ATOMIC ENERGY

MELVIN PRICE, Illinois, *Chairman*

JOHN O. PASTORE, Rhode Island, *Vice Chairman*

CHET HOLIFIELD, California
JOHN YOUNG, Texas
TENO RONCALIO, Wyoming
MIKE McCORMACK, Washington
CRAIG HOSMER, California
JOHN B. ANDERSON, Illinois
ORVAL HANSEN, Idaho
MANUEL LUJAN, Jr., New Mexico

HENRY M. JACKSON, Washington
STUART SYMINGTON, Missouri
ALAN BIBLE, Nevada
JOSEPH M. MONTOYA, New Mexico
GEORGE D. AIKEN, Vermont
WALLACE F. BENNETT, Utah
PETER H. DOMINICK, Colorado
HOWARD H. BAKER, Jr., Tennessee

EDWARD J. BAUSER, *Executive Director*
GEORGE F. MURPHY, Jr., *Deputy Director*
JAMES B. GRAHAM, *Assistant Director*
Col. SEYMOUR SHWILLER, *Technical Consultant*
JACK BRIDGES, *Technical Director—Energy Resources*
PETER A. BERNARD, *Special Counsel*
JOE B. LA GRONE, *Congressional Fellow*
CHRISTOPHER C. O'MALLEY, *Printing Editor*

CONTENTS

AUGUST 17, 1973.

MEMORANDUM OF THE CHAIRMAN

TO MEMBERS OF THE JOINT COMMITTEE ON ATOMIC ENERGY:

The Joint Committee on Atomic Energy has long considered it essential to have a capability to assess continually the overall national and world energy picture. The Atomic Energy Act provides the AEC with the statutory authority, and the Joint Committee with the Congressional "watchdog" responsibility, for the conduct of research and development in both civilian nuclear power and non-nuclear energy. The Joint Committee, therefore, must have general information on all energy matters in order to evaluate properly research priorities and other aspects of the Commission's civilian nuclear and non-nuclear energy programs.

Several months ago I requested that the JCAE staff consolidate current energy related data and develop an "energy display" system which, in less than an hour, could give an extremely busy person an understanding of the size and complexity of our national energy dilemma. An additional objective was to develop a display system that would permit the Members to see the potential results of various research and development programs. Utilizing this system, a Member could also evaluate with appropriate perspective the merits of proposed "solutions" to our energy dilemma that are continually being submitted to the Congress.

This Joint Committee print is a revision of an earlier one issued in May, 1973, entitled "Certain Background Information for Consideration When Evaluating the 'National Energy Dilemma.'" Both prints describe the energy display system developed and give complete instructions for its use.

As in the earlier print, one of the "options" or "exercises" is developed to illustrate how the display system can be used. It does not represent a specific prediction or proposal of the Committee or of the staff, and the described "option-exercise" in *no* way constitutes recommendations. It is described to enable the reader to understand completely the utilization of the suggested systems.

Several comments that we have received concerning the initial print of May 4, 1973, suggested that it would be helpful if we would provide a general display of our overall national energy "supply/demand" over a longer period of time. This enables a reader to gain a better understanding of where the United States stands with reference to the "era" of relatively cheap and available domestic fossil fuels and the next "era"—one requiring an ever increasing supply of non-fossil energy sources and imported energy sources. I, therefore, requested that our staff prepare the last chart in this booklet. In addition, certain technical changes were made to the charts and text. Otherwise, a reader with access to both the original print and this revised version will find the material quite similar.

You will notice that I have requested that the material be presented in a "narrative" form. It is designed to serve as a general reference document for those interested in energy matters. While this print has been prepared primarily for the use of the Joint Committee on Atomic Energy, I welcome its broad discussion and use by the Congress, Administration, and the public as a whole.

MELVIN PRICE, *Chairman,*
Joint Committee on Atomic Energy.

UNDERSTANDING THE "NATIONAL ENERGY DILEMMA"

I. INTRODUCTION

The United States with about 6% of the world's population is now consuming over 35% of the planet's total energy and mineral production. The average American uses as much energy in just a few days as half of the world's people on an individual basis consume in one year. This Nation has literally been developed without any significant restrictions due to lack of energy or mineral resources. However, we now see ever increasing indications of the fact that the United States cannot long maintain the growth rate of recent years in our energy consumption without major changes in our energy supply patterns.

The complexity of the energy problem has made it imperative that concise communication systems be developed so key people in the government can rapidly grasp the various aspects of this energy dilemma. One excellent communication technique is a visual display to enable decisionmakers to see the complexity of our present energy dilemma and the impact of various options that the United States has for dealing with its energy problems. This Joint Committee print describes such a device and system and shows how it can be used to display graphically the subject material.

II. SUMMARY

The staff of the Joint Committee on Atomic Energy has developed a graphic presentation which enables a person (who is not necessarily an energy specialist) to obtain a reasonable understanding of the broad problems, scale and complexity of our energy dilemma in about an hour. In addition, a method has been devised for visually displaying projected future effects of various energy policies on our domestic energy situation.

III. DESCRIPTION OF "ENERGY DISPLAY"

The staff has developed an "energy display" system that is made up primarily of transparent plexiglass sheets, one series of which has the total energy flow pattern for certain years displayed to scale and another series of sheets, installed at right angles, showing "cross plots" of certain information as each item evolves through the years. This particular device contains no information that has not been available to the public but is unique in its method of presentation. The data displayed are based on past history for the years of 1950, 1960, and 1970, and projections for 1980 and 1990, most of which has been published by the Lawrence Livermore Laboratory based primarily on information released by the Department of the Interior and the National Petroleum Council.[1]

[1] See Appendix: Ref. 1 and Ref. 2.

The best way to understand the device described in this committee print is for the reader to open the designated "*Fold Out*" (when suggested) and then follow its description in the text. The various fold-outs are located in the rear of this publication.

The energy "unit" used in the display system is that of a million barrels per day of oil equivalent. The reader must fully understand the conversion of all energy values to *b*arrels *p*er *d*ay of *o*il *e*quivalent (B/DOE). We chose to use the scale of barrels of oil *equivalent*[2] to try to make the situation more understandable to the layman, and also because imported oil, usually measured in barrels, is rapidly becoming a major factor in our national energy dilemma. We make these conversions by calculating the energy that would be produced from the various energy forms and then converting those numbers into the number of barrels of crude oil that would have to be used in order to obtain the same amount of energy. For instance, we have taken the tons of coal burned for a particular use and calculated the barrels of oil that would have to be burned in order to obtain the same amount of heat.

In order to give the reader a better concept of the magnitude of the "units" the following table lists several well known items and converts their productive or hauling capacity to oil equivalents.

TYPICAL "OIL EQUIVALENTS"

Location	Energy form	(Million) B/DOE
Total, State of Texas	Oil production	3.5 and declining (end 1972).
Total, State of Louisiana	Gas production	4.2 (end 1972).
Total, State of California	Oil production	0.9 and declining (end 1972).
Total, State of Pennsylvania	Coal production	0.9 (end 1972).
Total, State of West Virginia	do	1.4 (end 1972).
Hoover Dam	Electric capacity	0.02.
Total U.S. nuclear power	Generate electricity	0.3 (end 1972).
Large supertanker	Oil per load	1.5 (per voyage).
Alaska pipeline (Valdez)	Oil transportation	1.5 (projected).
Total U.S. demand	All	36.0 (early 1973).

It is also important for the reader to become familiar with an energy flow pattern for the United States during a period when the system was relatively simple. Though the pattern for 1950 would be good for this purpose, the proportional factors involved are too small to render to scale with complete legibility in this study. Therefore, the total energy flow pattern for the year 1960 will be used instead as the basic example.

Total Energy Flow Pattern (1960)

Open *Fold Out* "B." This is a chart of our national energy flow pattern as it actually existed in the year 1960. All the information shown has been reduced to the same scale and converted to the same "unit" described above. The "unit" (Million B/DOE) is shown in parenthesis after each particular item being described to assist the reader in identifying the exact portion of the chart the reader should be following.

[2] See Appendix: Conversion Tables.

OIL (1960)

Start by observing the lower left-hand of the chart. Observe that the total U.S. oil supply (9.7) in 1960 consisted of oil from domestic sources (7.8) and oil from imports (1.9). Then ignoring, for convenience' sake, the various flow patterns through such as petroleum refineries, notice the small amount of oil (0.3) shown to have been used in the generation of electrical energy. Next, note how the U.S. exported some oil (0.2) in the form of petroleum products; utilized a considerable amount (2.0) in the "residential & commercial" end use (about 75% single dwelling and the remainder apartment houses, offices, shopping centers, etc.); considerably less (1.3) in "industry" (iron and steel auto manufacturing, etc.); even less in "non-energy" (0.8) uses (manufacture of fertilizers, plastics, paints, etc.), and used the largest share of our oil (5.0) in the "transportation" sector (autos, planes, trains, etc.).

COAL (1960)

Now—looking back to the left of the flow pattern, the reader will see that in 1960 total domestic coal production was less (in heat equivalent) than oil or gas. This coal production was equivalent to about 5.3 million barrels of oil per day. A large amount of coal (2.0) was used to generate electricity—in fact, more than half of the Nation's electric energy in 1960 was generated by burning coal. A relatively small amount (0.5) was exported—primarily for metallurgical purposes to Europe and Japan. About the same amount of coal (0.5) was used, primarily for heating purposes, in the "residential & commercial" end use, and only a trace (0.1) was used in "transportation" (we still had some coal-fired railroads operating in 1960—mostly in the West and in freight service). The largest single use of coal (2.3) was in the "industrial" sector—iron and steel production, etc. Also notice we used some coal (0.1) in the "non-energy" sector.

GAS (1960)

Now back to the left of the chart, the reader will notice that the country's total gas supply (5.9) was composed of domestic sources (5.8) and only a trace (0.1) of imports. Some gas (0.8) was already being burned under boilers to produce electric energy. A great deal of gas (2.0) was utilized in "residential & commercial" end use, and the largest single use (2.8) went to the "industrial" sector—note that in 1960 industry already received more energy from gas (2.8) than from coal (2.3). Some gas (0.2) was used in the "non-energy" sector. A small amount of gas (0.2) was used in the "transportation" sector—primarily as energy to operate pipe lines.

HYDROELECTRIC (1960)

Back to the left of the chart, the reader can see that the Nation's final "supply" contribution in 1960 came from hydroelectric power (0.3). The United States had no significant production of energy for nuclear, geothermal, or other energy sources in the year 1960.

ELECTRICAL ENERGY (1960)

Next, the reader should look about a third of the way over in the top of the chart in the region indicating the "form of use" of energy and notice that the total "unit" input (3.4) into "electrical energy generation" for the year 1960 consisted of oil (0.3), coal (2.0), gas (0.8), and hydroelectric (0.3). The Nation lost, in our conversion process from heat to electricity, almost two-thirds (2.3) of our total input into our electric generation system. This loss is shown as "conversion losses." Such losses are not unusual. For example, the maximum conversion efficiencies in conventional steam electric plants is about 40 percent.

About half of the actual electricity generated was transmitted to the "residential & commercial" (0.5) end use, and slightly more (0.7) was utilized by the "industrial" sector.

Notice that in the year 1960, we could not even draw a "flow" line indicating electricity use by the "transportation" sector—our East Coast electrified railroad grid and the various electrically driven mass transportation systems did not utilize enough electricity during 1960 to be represented on this flow pattern.

END USE "EFFICIENCIES" (1960)

If the reader will examine the efficiency with which each "end use" sector converts the total energy supplied it to useful work, he can complete the flow pattern for 1960. Notice that the least efficient user was the "transportation" end use sector. This sector, with an input from oil (5.0), coal (0.1), and natural gas (0.2) for a total of (5.3), lost or rejected over 75% (4.0) of the total heat energy supplied to it. Accordingly, only about 25% (1.2) was actually converted to useful work moving our autos, trucks, trains, aircraft, and ships. This alarmingly low "efficiency" is primarily the penalty that we pay for the methods we use to obtain our mobility.

The "industrial" sector in utilizing its total input (7.1), lost about 30% (2.1), while effectively utilizing almost 70% (4.9) of the total energy supplied to this sector in the form of oil, coal, gas and electricity.

The "residential & commercial" sector took its total input (5.0) and lost about 30% (1.5) while utilizing nearly 70% (3.5).

Finally, if the reader will examine the overall efficiency of the system in 1960, he will notice that the total losses, or "lost energy," were made up of the "conversion losses" (2.3) from electrical generation and the losses from the "residential & commercial" (1.5), "industrial" (2.1), and "transportation" (4.0) sectors, for a total of 9.9 "units" rejected during the year. Our useful energy was made up of that actually utilized in "residential and commercial" (3.5), "industrial" (4.9) and "transportation" (1.2), for a total of 9.6 "units" of energy in the year 1960. We actually lost about 51% and utilized slightly over 49% of the total fuel energy consumed in this country.

(NOTE: On occasion the numbers on the displays will appear not to total correctly. This is due to the large numbers of mathematical conversions made and to "rounding off".)

ENERGY FLOW PATTERN (1950)

Keep *Fold Out* "B" extended so it can be referred to, and pull out *Fold Out* "A". This is a chart of the energy flow pattern of the United States in the year 1950. Notice that the physical size of the chart, along the vertical scales, indicates that the total energy consumption patterns in the United States in 1950 were already about 75 percent of what they became by 1960.

The main purpose for displaying the energy flow pattern for 1950 is so that the reader can see the relatively small amount of energy consumption in the decade of 1950 to 1960 as compared to the consumption patterns that the United States has sustained since that time.

ENERGY FLOW PATTERN (1970)

Fold in "A" and "B" and then open *Fold Out* "C". This is a chart of the energy flow pattern of the United States as it actually took place in the year 1970. The display for this year is again to the same scale as that used for 1950 and 1960. Notice the overall growth of the energy factors. The reader need not go through as much detail for the year 1970 as he did for 1960, but there are certain major points of interest that should be noticed.

The decade between 1960 and 1970 will probably be noted for two things—first, it was the decade of a massive expansion in the use of natural gas, and, second, it was the early stages of the "take-off" in the United States move toward greater use of electricity. While oil use increased just under 50% (from 9.7 to 13.9) and coal increased slightly over 40% (from 5.3 to 7.4), the use of natural gas almost doubled (from 5.9 to 10.7).

Notice to the top and left of the diagram where under the "supply/demand" portion for the first time one can draw lines representing nuclear (0.1) and geothermal (0.003) energy.

Electric energy more than doubled in that decade (from 3.4 to 7.1). For the first time one could show an electric use (0.007) flowing from the "electrical energy generation" section to that of "transportation."

Other things to note are the disappearance of coal in the transportation sector, the major decrease of coal in "residential & commercial" end use (down to 0.2 in 1970 from 0.5 in 1960), and that significant natural gas (0.3) and coal (0.1) was being used in the manufacture of "non-energy" products (mostly for fertilizer and plastics).

To the extreme right of *Fold Out* "C", the reader will notice that "lost energy" (14.7) for 1970 was actually slightly less than the "used energy" (15.0). The efficiency of our National overall energy conversion for the year, 1970 and 1971 may well turn out to be the best for many decades. The United States used about 50.5% and lost about 49.5%. These were the last years of the relatively efficient high compression automotive engines which required tetraethyl lead in gasoline. Also, the Nation had not embarked upon efforts to "clean up" the internal combustion engine or electric power production facilities with the resulting penalty to fuel consumption efficiency.

Energy Flow Pattern (1980)

Fold in "C" and then open *Fold Out* "D". This is a chart of the national energy flow pattern as projected for the year 1980. These particular projections are based upon the National Petroleum Council's and the Department of the Interior's work,[3] as interpreted by the Lawrence Livermore Laboratory. The reader should bear in mind that while the Nation is less than a third of the way from 1970 to 1980 calendarwise, it is already basically committed to what its energy use patterns will be in 1980 (barring major changes in the national or international area). There are many reasons for the high degree of confidence in the predictability of 1980. For instance, the Nation has already ordered a large part of the electrical capacity that can be functioning commercially by the year 1980; it has already ordered every major rail-based mass transit system that can be functioning by 1980; and the public still continues to commit the United States to an ever increasing number of automobiles with their known poor energy consumption patterns.

Notice how projections shown on this "fold-out" anticipate that almost 50% (10.0) of our oil requirements will be imported, and slightly over 50% (11.5) will be from domestic sources. This, of course, is a massive increase in imported oil from 1970 (3.5). Also notice that by 1980 the impact of nuclear energy should become a very significant factor in the overall U.S. energy picture.

The reader should notice the projection for the first coal gasification plant—it is represented about one-third of the way through the portion of the diagram depicting the flow of energy from coal and is shown as a "coal–gas" project with an input of 0.2 units, a useful conversion of approximately 0.13 units into gas, and a conversion loss of 0.07 units that is lost as rejected energy.

Finally, of note is the deterioration in the Nation's efficiency of converting and utilizing energy. Anyone who has a full-size 1973 automobile is aware of the effects of attempting to clean up the internal combustion engine—many similar moves are being made in an effort to improve the environment, or accomplish other desirable goals, with a resultant increase in energy consumption due to decreased efficiency of energy conversion. For example, our continuing move to generate electric power in less polluting ways adds to these energy losses.

Energy Flow Pattern (1990)

Fold in "D" and open *Fold Out* "E". This is a projected energy flow pattern for the calendar year 1990. The projections necessary for developing this energy flow pattern are a very crude "average" of those made by several sources. Again, the Lawrence Livermore Laboratory compiled the majority of the basic information. The reader must understand the great uncertainty of projections a decade or so in advance and also should consider that a majority of the information used is supplied directly by the industries involved. The United States Government does not have the facilities for a completely independent evaluation of certain of our various resources.

[3] See Appendix: Ref. 1, Ref. 2, and Ref. 3.

As a country, we might be able to make some significant changes in our supply and use pattern by the year 1990, but again, as is the case through the year 1980, these changes cannot be made as quickly and as easily as many people think. Indications are that unless drastic and immediate action is taken on several fronts, our reliance on imports of energy will actually be greater than indicated on the *Fold Out* for the year 1990 even assuming the supplies and demands of the other nations of the world will continue to be compatible with out national energy requirements.

There are several items that the reader should note on this particular energy flow pattern. In the area of "supply/demand" one can see that imported oil has been projected to far exceed that anticipated from domestic sources. Also note the first real impact of oil from shale and a larger growth of gasification of coal is projected. We should be operating liquid-from-coal plants by that time and have several oil-to-gas projects in being. Our Nation's use of coal should continue expanding quite rapidly assuming we are able to solve mining and sulfur-related environmental problems. For the first time the reader will notice the anticipated significant dependence on imported natural gas (4.0 units out of a total of 12.0 units) mostly in the form of LNG* and SNG. In 1990, the continuing growth in the electrification of the United States is noted, with about a 6% annual increase in fuel requirements for the generation of electricity. The increase in electrical generation plus our anticipated continuing increase in transportation uses (as much as 3½% per year) will result in an increase in the overall conversion losses to almost 55% (35.0 units out of a total of 62.8 units). The efficiency in our overall use of energy is expected to drop from a peak of slightly over 50% in 1970 to about 45% by the mid 1980's or 1990.

[*Fold in* "E".]

Recent Growth Patterns

A comparison of *Fold Outs* "A", "B", "C", "D", and "E", reveals important trends in certain energy factors. Keep in mind that all charts are drawn to the same scale so the actual dimensional changes represent the growth patterns in this country in a period of forty years. Using the same display technique, one would indicate a total energy flow pattern immediately after World War I about 45% the size of the one for 1960. A chart representing the flow patterns for 1940 would be about 53% the size of the one for 1960, and the one for 1950, shown on "A", would be about 75% the size of the one for 1960. Somewhere in the mid-1950's the United States "took off" on its energy consuming growth which laid the foundation for much of our energy dilemma. The graphical data projects a six-fold increase in electric generating capacity from the year 1960 to 1990 (3.4 "units" of supplied energy in 1960 up to at least 22.5 units in 1990). Trends indicate that from the year 1970 through about 1982 or 1983, the United States will use as much oil and gas as it had used from the beginning of its history until the year 1970. To compound the problem, much of the rest of the world itself now has energy consumption patterns that are growing at a faster rate than our own. It now appears that the world as a whole will use as much energy from all forms

*Liquid Natural Gas (LNG) and Synthetic Natural Gas (SNG).

between the period 1970 until the year 2000 as it did from the start of mankind until 1970. It is this massive growth in the use of fossil energy fuels that has mainly created the "energy dilemma" which exists in the United States and throughout the world.

[*Fold in all material.*]

Other Uses For "Energy Display"

A device for displaying the various energy factors as has been described can be useful in planning our national energy research and development programs and our tax and production incentive policies, etc., by showing the overall impact of specific recommendations for improving our utilization and conservation of energy. As an example of the usefulness of the device, we will examine the effect of fully insulating all of the homes and buildings in the United States by 1990 on the amount of imported oil the Nation would require.

In order to evaluate this proposal, the reader should open *Fold Out* "E" and start with the "residential & commercial" end use (14.5 units) item. Assume that 60% of this total applies to space heating and cooling of homes and buildings. The heating and cooling requirements would therefore impact a maximum of 8.7 units. If we were to insulate fully and successfully every structure in the United States by then, we would probably reduce the heating and cooling load by a maximum of 20% (new structures may be improved as much as 40%, but many old units could only be improved 10%). Our total savings would therefore amount to approximately 1.7 units during the year 1990. If one were to assume that all of this saving would result in a reduction of oil use into residences and commercial structures (3.1), then we would apply the 1.7 savings to our anticipated imports of 18.0 units and would therefore have an overall savings in our oil imports of just under 10%. In light of the interchangeability of energy for heating and cooling, particularly when one considers energy converted to the electrical form, it may be appropriate to evaluate the impact of the savings of 1.7 units due to insulation relative to our total estimated needs of all energy forms in 1990, which is indicated to possibly be about 68.5 units. The 1.7 units would therefore result in a savings of about 3%.

Bear in mind that the energy display device is not designed to evaluate the capital cost of the proposed "solutions" to our energy dilemma—that must be done independently. The example of the impact of insulating homes and other buildings may appear to be discouraging in its evaluation if capital costs are considered. This is *not* to suggest that we do not increase the insulation in structures—such obviously is desirable to the extent that we can afford it. This example should serve to point out, however, that no single approach of this nature is going to solve our energy dilemma all by itself.

[*Fold in* "E".]

Construction of "Cross Plots"

Now if the reader would visualize "intersecting" the energy flow patterns for each year with "cross plots" at right angles in the four areas indicated on *Fold Out* "A", one could construct "cross plots" or graphs showing the changes in "supply/demand," "form of use," "end use," and "efficiency" over the years from 1950 through 1990.

Now pull out *Fold Out* "F." It is a sketch of how this is done mechanically. Visualize standing up each of the four "energy flow patterns" that have already been examined, and space them with a proportionate distance between each for the years represented. The sketch on *Fold Out* "F" shows how the "efficiency" plot would be prepared.

[*Fold in all material.*]

Cross Plot—"Efficiency"

Pull out *Fold Out* "G." This is the "efficiency" cross plot resulting from the construction process just described. The reader can relate this efficiency curve, for example, to that part of *Fold Out* "D", where in 1980 the rejected energy (or loss) was 23.3 units and the useful energy was 19.9 units and the total consumption was thus 43.2 units. The reader may see how one can then take the information presented on these various cross plots and convert it to whatever form is wanted. For example, one could convert the "units" shown on the "efficiency" cross plot to approximate percentages and present the information as in the following table.

	Total energy to consumer (units)	Percent used	Percent wasted
Year:			
1955	16.2	48.7	51.3
1960	19.5	49.2	50.8
1965	24.0	50.4	49.6
1970	29.7	50.5	49.5
1975	36.3	46.8	53.2
1980	43.2	46.1	53.9
1985	52.0	45.1	54.9

Cross Plot—"End Uses"

Now fold in all charts in use and pull out *Fold Out* "H." It is a cross plot intersecting all of the annual energy flow patterns where indicated as "end uses" on fold out "A" (Energy Flow Pattern—1950). This one shows the growth over the years of the energy uses in the various sectors of the national economy. For example, notice how "transportation" has grown from 5.3 units in 1960 to 12.0 units in 1980. Notice how "residential & commercial" has grown from 5.0 in 1960 to 9.9 in 1980. Transportation almost triples in that period, while the residential and commercial sector will not quite double.

Cross Plot—"Form of Use"

Put away "H" and open *Fold Out* "I." This cross plot is constructed so that the reader can see changes in the "Form of Use" of energy as it is made available for consumption by the consumer. Our liquid use (primarily oil) will have grown from just under 10 units in 1960 to over 19 units in 1980. Generated electricity will go from 1.2 units in 1960 to about 4.9 in 1980. This chart should give the reader an idea of the massive requirements we have facing us for the handling of these various forms of energy. For example, handling fuels in liquid form will require pipelines, tankers, import terminals, refineries, etc. Handling fuels in solid form normally requires railroads. Our massive electrification efforts will require large investments in generating plants, copper and aluminum wires for transmission, distribution, etc.

[*Fold in* "I."]

Cross Plot—"Supply/Demand"

Open *Fold Out* "J." This is a "supply/demand", or S/D, curve that is drawn by intersecting all of the annual energy flow patterns at the left hand side of each diagram. In the resulting chart we have changed to cross-hatch patterns on the imported oil and gas so that the reader can more readily distinguish imports from our domestic sources. The reader can review how this cross plot was constructed by comparing certain of the numbers shown vertically on the "S/D" cross plot with those on the left hand side of the appropriate years on Fold Outs "A" through "E."

[*Fold in* "J."]

It was found desirable to include a series of energy supply/demand charts in which oil and gas fuel imports are combined to indicate the total deficiency in our domestic supplies of energy. The following sections describe these charts.

"Supply/Demand" Chart (From "Energy Display")

Open *Fold Out* "K". This chart is constructed by taking the information shown on the "supply/demand" cross plot and eliminating the blank spaces between the different sources. The rise shown in the domestic oil in the lower right hand part of the graph would be from Alaska oil if such were to be brought into production by 1977.

"Supply/Demand" Chart (1960–1985)

Now fold back "K" and pull out *Fold Out* "L". This particular chart is basically the same as the one the reader has just examined. However, in this chart the "imports" of both oil and gas and their products are now moved to the top and labeled as "imports and/or shortages." We have added the word "shortages" because the inflexibility of the supply system could result in shortages if we are unable to obtain the necessary imports for any reason.

The area marked "surplus oil," is a display of the spare productive capacity that Texas, Louisiana, and Oklahoma had once been thought to possess. Estimates of this item vary a great deal depending upon when they were made. Recent evaluations [4] of such "surplus" capacity are lower than ones made years ago. It is shown so that one can see how the combination of all of our "fossil fuels" (oil, gas, coal and "surplus oil") has actually resulted in a fairly predictable total over the years. Our present problems have not simply shown up overnight—we had some indication several years ago that they would develop.*

---

[4] See Appendix: Ref. 4.

* See Joint Committee on Atomic Energy hearings, "Development, Growth, and State of the Atomic Energy Industry", February and April 1963.

The reader should recognize that the projections shown for imported fuels required are considerably larger than those made as recently as two years ago. The total energy demand is projected at over a million barrels a day greater by the year 1980 than was earlier estimated for that period in data compiled in early 1971. Nuclear plants are also falling 15% or so behind what was anticipated as recently as 1971. Our slippage in nuclear in the year 1980 alone will require well over one-half a million barrels per day of oil *equivalent*. If such is replaced by imports (and even if we could buy it for its present price of about $4.00 a barrel) it will result in a foreign exchange loss of almost one billion dollars during that one year alone. (See page 18 for information on how nuclear power growth estimates have increased with time.)

This estimate is based on a shortfall of 18,000 megawatts of nuclear capacity in the AEC's goal of 150,000 megawatts by 1980. The delays are being incurred primarily by matters relating to the licensing of nuclear powerplants and problems in meeting the exacting quality requirements of this new industry.

This particular chart underscores the massive nature of the problem facing the United States with reference to importing crude oil, petroleum products, and gas. For instance, it now appears that our actual cost for imported fuel in 1972 resulted in an outflow of at least $7.5 billion, offset with a return of somewhat over $3.5 billion from dividends, etc., of the multi-national companies involved in overseas energy operations. Projections based on this chart indicate that in 1973 our energy purchases from overseas will probably exceed an outflow of $9 billion. In 1975 it will probably exceed $13 or $14 billion. By 1980 the purchases will approach a minimum of $20 billion, and by 1985 at least $30 billion. These numbers are based on the precarious assumptions that oil, gas, and petroleum products will still be sold to us at today's prices and that it will be readily available to the world in such massive quantities.

A recent article in the *New York Times* [5] quotes recent projections of Ford, Bacon and Davis, Inc., in which they expect over $14 billion will be the deficit costs for oil imports during 1975, $30 billion by 1980, and $54 billion by 1985. This particular article goes on to comment:

> "The projections are fantasies. Long before 1985, such import needs will bankrupt America, eliminating us as a customer."

A publication just released by one of the major international oil companies [6] projects that the range of costs of U.S. oil imports in the year 1985 will range from at least $30 billion per year to as much as $70 billion per year

[*Fold in* "L".]

This concludes the description of the "energy display" system and its associated charts. We would like to emphasize again that the material thus far presented has not been new. We have simply altered the method of displaying information hoping that it will be easier to understand.

[5] See Appendix: Ref. 5.
[6] See Appendix: Ref. 6.

IV. DESCRIPTION OF DISPLAY TECHNIQUES FOR LONG-RANGE "OPTION-EXERCISE" PROJECTIONS

The need for a technique of presenting long-range projections and for providing a device that will assist in evaluating possible options in meeting United States energy needs is obvious.

Despite all of the recognized dangers in making long-range projections, we consider it essential to extend energy estimates to at least the year 2000.

The first reason for this is the very nature of many research and development projects that are constantly before Congress. Many of these projects have lead times of decades before they will really impact the American energy picture.

The second reason for such projections is not as immediately apparent. It has to do with the very thrust of what may be the only real direction for America to go with its future energy strategy. The Nation is actually finding itself in the "twilight" of the fossil fuel age. We have used the cream of our oil, gas, and coal resources as one of the basic building blocks of a technical and industrial society the likes of which the world has never seen. We will now have to use our technical capacity to carry ourselves into the next "age," or "era." We can make this transition primarily by buying time through the next few decades through accelerated uses of our remaining domestic fossil resources (particularly coal, oil, gas, and oil shale) and by conserving and using our energy more wisely. The degree of determination of the Nation to do these things—our obvious moves toward development of new sources, our energy conservation programs, the price we're willing to pay (both in dollars and environmentally) for accelerating uses of domestic fossil sources, etc., can help produce the strongest posture for our Nation as it faces the energy dilemma.

"Guidance" Required

Open *Fold Out* "M", entitled "Guidance" Required. The approach we are utilizing involves estimating "demand" lines through the year 2000 and then subtracting from each the maximum amounts of "imports &/or shortages" that the Nation's economy can tolerate. These are the two general but basic guidlines that must be delineated by our Government in order for technicians and engineers to "exercise" the various options concerning domestic energy sources that are available for filling the domestic energy requirement.

[*Fold in* "M".]

FORECAST OF ENERGY DEMAND TO YEAR 2000

Open *Fold Out* "N". This chart displays several of the more recent appraisals of the Nation's energy demand through the year 2000.[7] There are several other recent projections that call for even larger energy consumption than those shown on this chart but in order for such to take place, it would require a massive commitment to the all but total electrification of the Nation.

[7] See Appendix: Refs. 3, 6, 7, and 8.

The reader will notice that the Nation is now using the oil equivalent of about 36 million barrels per day. This is very close to the "high forecast" as shown on *Fold Out* "N". If the Nation continues on its present growth rate decreased by one-tenth of 1% every decade, we would reach an energy "demand" of almost 120 million barrels per day oil equivalent by the year 2000. The predominance of recent projections appear to estimate that the United States will require at least 95 million barrels per day oil equivalent by the year 2000. Historically, particularly over the past two decades, forecasters have consistently underestimated the growth of energy requirements in the U.S. The chart shows a population curve to give the reader an indication of the continuing relationship between population and energy use in the United States.

In an effort to be on the conservative side of these estimates, the committee staff has carried out several "option-exercise" projections starting with low "demand" curves. Six of the exercises are based on 87.5 million Barrels Per Day Oil Equivalent (B/DOE) by the year 2000, and two on the low number of 82.0 million B/DOE for the year 2000. One such "option-exercise" will be described later in this print. The reader should understand that the committee is in no way recommending that the "demand" for energy in the U.S. be curtailed to such a degree—it is fully aware of the requirements for energy to support our way of life, our jobs, and our national security. The low numbers were used for energy "demand" in order to reduce the apparent requirements for "total domestic sources" to a minimum.

[*Fold in* "N".]

The second "guidance" required before the "options" can be "exercised" intelligently is that of estimating the maximum imports of oil, petroleum products, and gas that can be tolerated. Attempting to eliminate imports altogether is probably unrealistic and would also compound the energy problems of the Northeastern section of the Nation. It may also complicate our national efforts to encourage orderly energy developments on a worldwide basis.

The "exercises" of the display system have been made assuming an "imports &/or shortages" area of approximately $20 billion per year—again assuming the cost will remain constant and that imported fuel will be available to the Nation. This approach calls for the leveling out of the rate of imports at about 12 million barrels per day of oil equivalent.

The reader can now see how the "guidance" requirements shown on *Fold Out* "M" have been tentatively defined so that various estimates and options may be exercised concerning our domestic energy sources. If the selection of total demand and of the maximum amount of fuel imports that it is judged the Nation can tolerate is of a magnitude similar to that discussed above, a major effort in almost all of the various domestic energy sources will be required

Option Exercise 7-A

Open *Fold Out* "O". This is a chart of one of eight different displays prepared of our national energy situation through the year 2000. We have selected Option Exercise 7-A to explain the method of presenting such data. This particular exercise is one that appears to have a relative balance in the degree of determination used in trying to assemble the required domestic energy supplies. It should be emphasized again that these displays in no way constitute actual proposals from the Joint Committee or its staff—the chart is shown primarily to illustrate the method of presentation developed and to give the reader an indication of the complexity and magnitude of the energy dilemma in the United States. The reader should recall that this particular display starts with the assumption of a depressed "demand" requirement which is over 25% below what would result by the year 2000 if the Nation were to continue its current growth rates in energy use. This particular display also includes an acceptance of a magnitude of "imports &/or shortages" which appears to exceed what is considered desirable by many concerning themselves with the financial security and stability of the United States.

If the reader will then start at the bottom of the chart, general information will be presented on each of the various domestic sources which was considered to meet our energy needs.

"*Lower 48 oil.*" This option considers domestic oil production in all the States, except what may be available from the Alaska North Slope. This is being done in an attempt to help decrease some of the misunderstanding that usually follows when an evaluation impacts the North Slope Alaska production at an early stage of an analysis. The United States is probably capable of predicting domestic oil production with about an 80% or 85% accuracy for a decade or so. The oil industry has a broad based experience in anticipating rate of "finding," numbers of "dry-holes," cost of production, etc. The industry is a mature one technically capable of immediately carrying out a program for the maximum production of oil from our domestic resources. "Option Exercise 7–A" is targeted for a major, but not necessarily a maximum effort to strengthen domestic oil production. This option assumes at least a 50% price increase in domestic crude, immediate development of known off-shore deposits (Santa Barbara channel, for example), a major increase in off-shore operations in the Gulf of Mexico, outer continental shelf operations off the East Coast of the United States, and an increased effort in the Federal lands in the Western part of the country. Few petroleum production experts would consider it appropriate to show a much more optimistic curve than the one represented on *Fold Out* "O."

"*Coal.*" This particular option shows an almost tripling of coal production in the next three decades. This could be accomplished by a tripling of strip-mining of coal and at least a 50% increase in underground mining of coal above current rates, or other combinations of mining technology. Coal has a resource base which could apparently support even a greater increase than shown, but the availability of water, reclamation problems, fabrication limitations of the massive equipment which will be required, steel, transportation facilities, and other such items could make the coal impact shown on *Fold Out* "O" optimistic. Bear in mind that it will be impossible to evaluate the coal input into our domestic energy system until the Congress has settled on strip-mining legislation, clarified leasing procedures, etc. It will be possible, once the rules are drawn, to project coal production with a predictability of 90% or better for a few years in advance. The resource is already fairly well defined and the industry is mature.

"Domestic gas." This one is probably the hardest to estimate. Most engineers will agree that the Nation will be fortunate if long range projections of gas availability are 50% either way of actual production. The strategy in this option would require the deregulating of both new and flowing natural gas prices to try to sustain or slightly increase our current production of gas for the next decade or so. The numbers shown here are very close to those of the Federal Power Commission, with the exception that, in Option 7–A the option tapers off much faster from the year 1985 toward the year 2000 than most estimates. It is hoped that the United States will discover a massive new gas supply but our history this past winter of problems, even in the State of Texas, could well be indicative that even this display is optimistic. Fortunately any new natural gas supplies would impact quite rapidly if the reserves do exist. The United States has a fully matured gas industry that can expand rapidly.

"Geothermal." Geothermal power is probably fairly predictable, despite present technical unknowns, once the Nation has established a level of environmental problems that it is willing to tolerate and estimated the amount of capital that can be committed to the development of such power. In Option 7–A, an approach is illustrated that would have at least 100,000 megawatts capacity operating by the year 2000. The reader should recall that the display of such an "option" does not constitute an endorsement of its probability or feasibility. A geothermal input of this magnitude would require a massive effort in California, and several other States, and would generate the electric equivalent of over 100 Hoover dams.

"Hydroelectric." Hydroelectric capacity can be projected with nearly 100% reliability—once the rules are drawn. The hydroelectric equivalent shown in Option Exercise 7–A represents at least a 50% increase in today's capacity. The great majority of attractive sites are in National Parks, scenic areas, and the like. It would be necessary to build dams in such places as the Grand Canyon if the Nation were to undertake a massive effort to increase its hydroelectric systems.

"Alaska Oil." This particular estimate assumes that the Alaska (Valdez) line will be in operation in late 1977 and would reach about 1,500,000 barrels per day of oil by early 1980. It then assumes construction of an oil line through Canada in the early 1980's, with that line going on stream and at full capacity by 1984. It also assumes that considerable oil will be found in the federally owned Navy Petroleum Reserve #4 (on the North Slope) and that such production will be developed. The development of the preceding combination could increase domestic oil production by over 4,000,000 barrels a day. The Alaska North Slope impact is probably 80 or 85% predictable, again because the Nation is in a position to proceed and has done a great deal of work in the area already. The necessary technology exists and a mature industry is available.

"Oil Shale." Oil shale, like coal, consists of a massive resource in place. Unfortunately, however, oil recovery from oil shale may well be even more severely limited by water restrictions than production of coal will be. While the technology is basically available for above ground production, several demonstration plants may be required

before financing information can be obtained for the commercial effort that will be required. Limiting factors appear to be uncertainties in the investment climate and questions with reference to leasing and using Federal lands. In order to produce even 1,000,000 barrels per day of shale oil, using surface technology, it will be necessary to have massive mines with the total daily tonnage of material handled well in excess of that of our present daily coal production. As 3,000,000 barrels per day operation in the Western part of Colorado, including all of its support population and facilities, will come very close to requiring the equivalent of the total minimum water flow of several of the larger rivers of that area. No efforts are made to project impacts of various "in situ" proposals because their technology is still in its infancy. Predictability of shale operations is very close to 80 or 90% or better. A combination of basically mature industries is available for these operations. Despite such problems. oil shale may represent one of the cheapest and cleanest additions to the Nation's energy mix.

"*Solar.*" Solar technology should permit us to soon take over some of the heating and cooling load requirements in the Southwestern part of the United States. The estimate on *Fold Out* "O" shows a 1,000,000 barrels per day equivalent from solar. This would satisfy the heating and cooling load of more than all of the houses that will exist in New Mexico, Arizona, and Nevada at the turn of the century. Predictability of solar is still fairly weak because of the requirements of developing several phases of the necessary technology and the nonexistence of a mature industry at this time.

"*Nuclear.*" A nuclear capacity build-up to over 1,000,000 megawatts by 2000 is shown on Option Exercise 7–A. This display is slightly under the latest estimate of the nuclear industry of the maximum amount of nuclear capacity which could be added over the next two decades. A table of the various pertinent estimates of nuclear capacity follows to facilitate comparisons:

	Capacity in megawatts [1]			
	AEC, 1962	AEC, 1968	AEC, 1972	AIF, 1973
Year:				
1980	40,000	150,000	132,000	146,000
1985	100,000	300,000	280,000	365,000
1990	200,000	500,000	508,000	700,000
2000	700,000	1,000,000	1,200,000	

[1] See Appendix: Refs. 3, 10, 11, and 12.

The 1962 estimates are presented above since they reflected the best estimates of the future need for nuclear generating capacity at the time a comprehensive nuclear power development program was delineated. A comparison of subsequent estimates indicates a twofold increase, over the period 1962 to present, in the energy goals for installed nuclear power capacity by the year 2000.

The Atomic Industrial Forum estimate was developed as the maximum which would be feasible providing the limitations presently imposed by specific factors such as licensing, development of additional uranium supplies, technical and construction man-power limitations, financing, and so forth, are significantly diminished and a massive national effort is made to develop the nuclear systems.

Although the nuclear capacity additions have been developed on the basis of considerable study, past experience with new and complex technologies indicates problems may be expected in the attainment of such a maximum goal. To attain or approach to a major degree the maximum estimates utilized for nuclear power in *Fold Out* "O" will require a massive industrial effort and major upgrading in a number of areas such as quality control performance by industry, licensing procedures, etc.

The various problems relating to the licensing, construction and operation of nuclear powerplants have already resulted in a situation where identical plants built in Japan and the United States by the same suppliers take five years in Japan, and over eight years in the United States. This option assumes a national effort to develop the required uranium supply and the various support systems for nuclear powerplants.

The one exercise described to illustrate the use of the graphic presentation to evaluate a possible solution to the energy situation clearly indicates the magnitude of effort required to maintain reasonable control of the problem. It should be recognized that many potential supply items were not displayed because of lack of available projections or information. Wind power, tar sands, and tidal sources are some such items. "Option Exercise" 7–A appears to be one of the more balanced of the several exercises examined by the JCAE staff to date. Initial reaction of the reader may lead to the assumption that an almost unlimited number of combinations of domestic energy options exists. Unfortunately, the deterioration of the Nation's domestic supply of cheap fossil fuel energy has actually severely limited the national options that are available.

[*Fold in* "O".]

"S/D CHART"—(1900–2050)

Open *Fold Out* "P". This chart should enable the reader to grasp better the meaning to the United States of the difference between the "era", now ending, of relatively cheap and available domestic fossil fuels and the emerging "era" of a requirement for an ever increasing supply of non-fossil energy sources and for imported energy fuels. The reader should notice that even a significant decrease in our energy "demand" and a major increase in our domestic fossil supplies will only provide a few years respite in our Nation's energy dilemma.

Both maximum and minimum estimated "demand" curves are shown. The maximum curve reflects a demand for approximately 175 million barrels per day oil equivalent, with the United States reaching a per capita energy saturation point near the year 2075. The minimum demand curve assumes both per capita energy saturation plus zero population growth in the decade of 2030. It is necessary to again emphasize the great uncertainty of such different distant projections irrespective of their sources. The trends, not the details, are the important factors. (The staff utilized at least three sources for this *Fold Out* "P".)[8]

[*Fold in* "P".]

[8] See Appendix: Refs. 13, 14, and 15.

V. CONCLUSION

The method described in this print has been found to be of great value to members of the Joint Committee and others who have viewed the data in studying energy matters. The graphic method facilitates the evaluation of specific energy factors in context with other energy supply matters. The interchangeability of energy forms is readily evaluated from a comprehensive presentation of information on all energy forms. The method also facilitates the evaluation of specific suggestions for the solution of our energy problems. Presentation of the information on such suggested solutions in graphic form requires inclusion of information on both the schedule of availability of the energy and magnitude factors both of which are at times not given the consideration they should be given.

The information on presentation of energy supply matters is being printed in the hope that it will be of assistance to Government officials, the industry and public in the study of energy supply problems. The need for prompt action in a number of areas is clearly evident from the data compiled in this print. It is hoped that this information will contribute to the evaluation of various solutions and expedite decisions and actions which are required to minimize problems in these areas.

APPENDIX

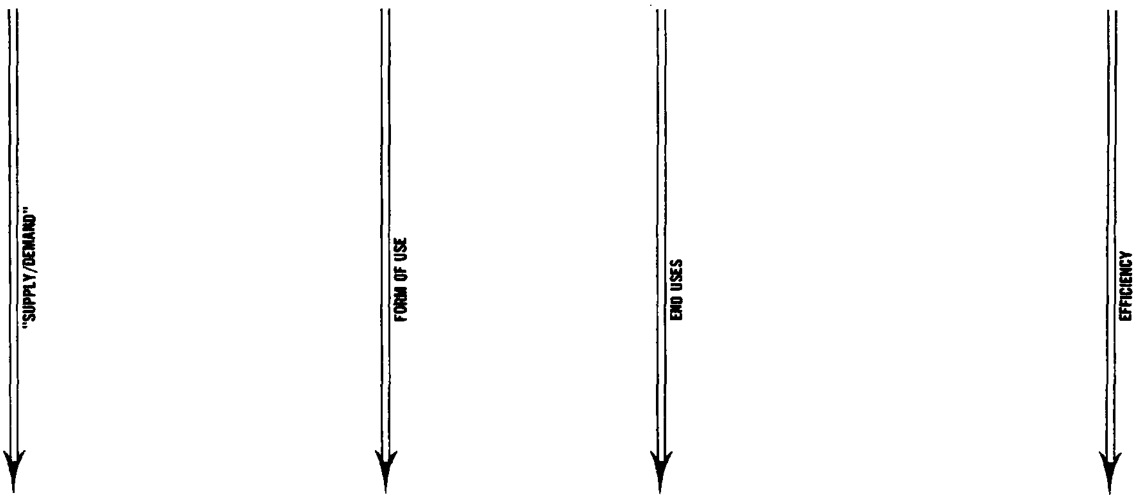
A. References

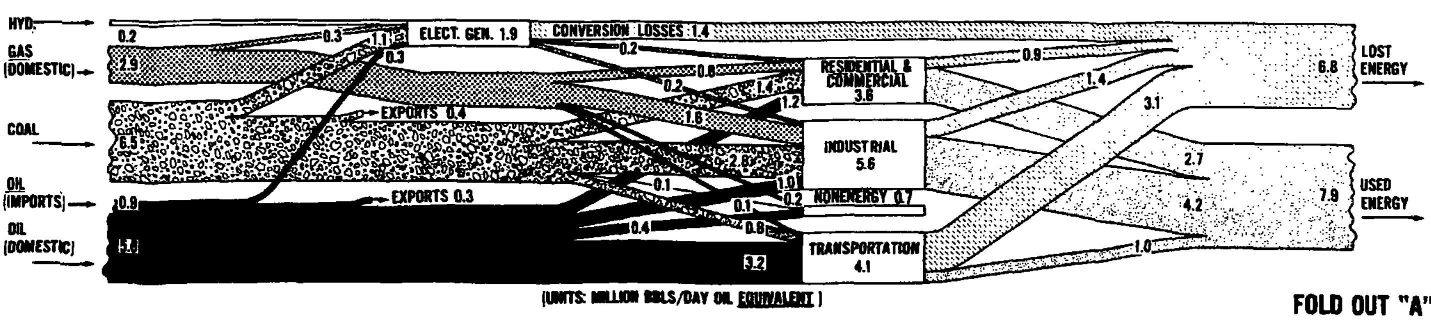
1. Lawrence Livermore Laboratory; study, "Energy: Uses, Sources, and Issues," UCRL–51221 of May 30, 1972.
2. National Petroleum Council; "Initial Appraisal—July 1971," of The United States Energy Outlook.
3. National Petroleum Council; "Report on United States Energy Outlook," of December 1972.
4. "America's Energy Needs and Resources," Department of the Interior News Release, Remarks by the Hon. Hollis M. Doyle, Assistant Secretary for Mineral Resources, Department of the Interior; Stanford University, Palo Alto, California, Jan. 12, 1971.
5. *New York Times* article by J. T. Claiborne, Jr., "A Crisis Not of Energy But of Money-Changers," March 22, 1973.
6. Shell Oil Company; "The National Energy Outlook," March 1973.
7. U.S. Department of the Interior, "United States Energy Through the Year 2000," of December 1972.
8. Associated Universities, Inc., Report "Reference Energy Systems and Resource Data for Use in the Assessment of Energy Technologies," of April 1972. Report to U.S. Office of Science and Technology, under Contract OST–30; Document AET–8.
9. U.S. Atomic Energy Commission "Civilian Nuclear Power—A Report to the President—1962," of 1962.
10. U.S. Atomic Energy Commission; WASH 1082 of March, 1968.
11. U.S. Atomic Energy Commission, "Nuclear Power 1973–2000," of December 1, 1972.
12. Testimony of W. Kenneth Davis, chairman, Ad Hoc Committee on Resource Needs for Nuclear Power Growth, Atomic Industrial Forum, and vice-president, Bechtel Power Corporation, presented before Subcommittee on Energy of Joint Committee on Atomic Energy hearing on "Proposed Changes in AEC Contract Arrangements for Uranium Enriching Services", March 7, 1973. To be published in October 1973.
13. Gaucher, L. P., "The Solar Era," *Mechanical Engineering*, August 1972.
14. Roberts, Ralph, "Energy Sources and Conversion Techniques," *American Scientist*, January 1973.
15. Lapp, Ralph, "*The Logarithmic Century*" Prentice-Hall, 1973.

B. Conversion Tables

1 Barrel (Bbl. or B) = 42 gallons (gl.).
1 Bbl. crude oil = 5,800,000 Btu.
1 kWh = 3,412 Btu.
1 cu ft natural gas (CH_4) = 1,000 Btu.
1 ton coal = 26,000,000 Btu.

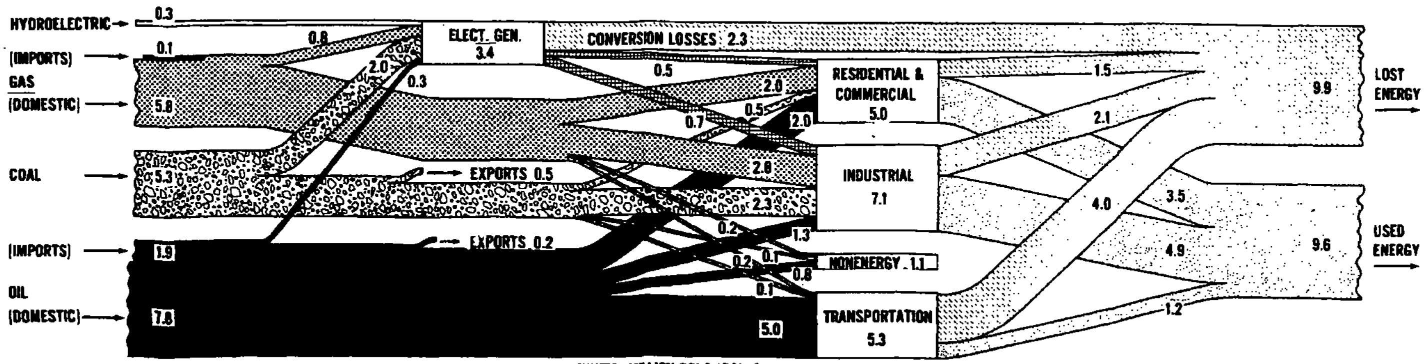
1950





FOLD OUT "A"

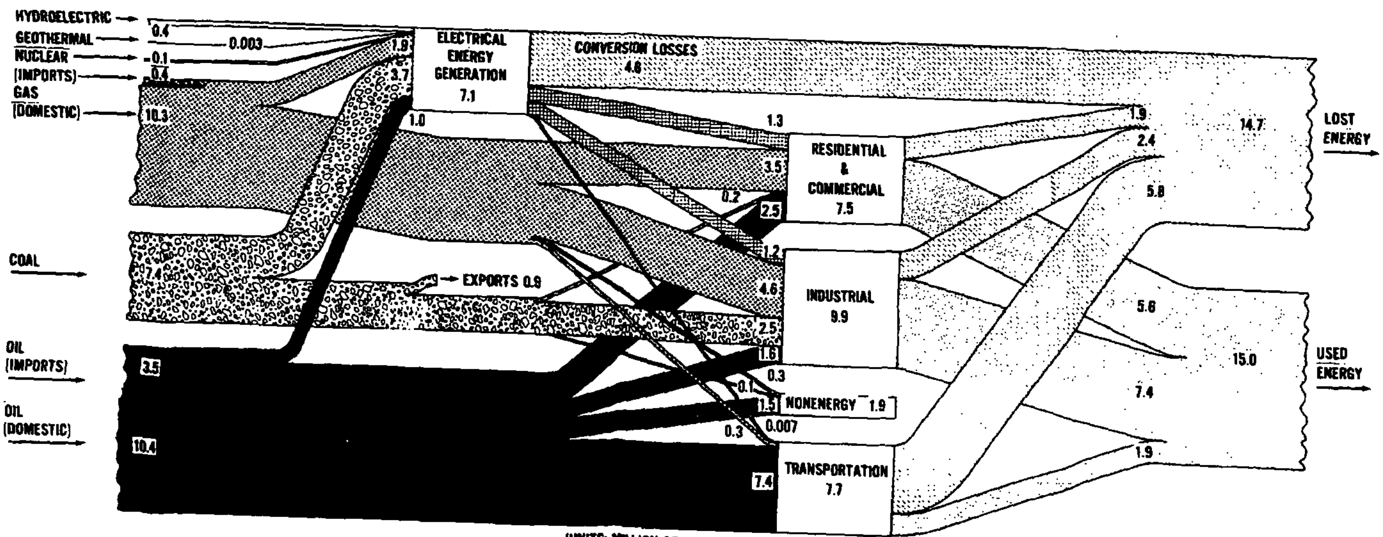
1960



(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

FOLD OUT "B"

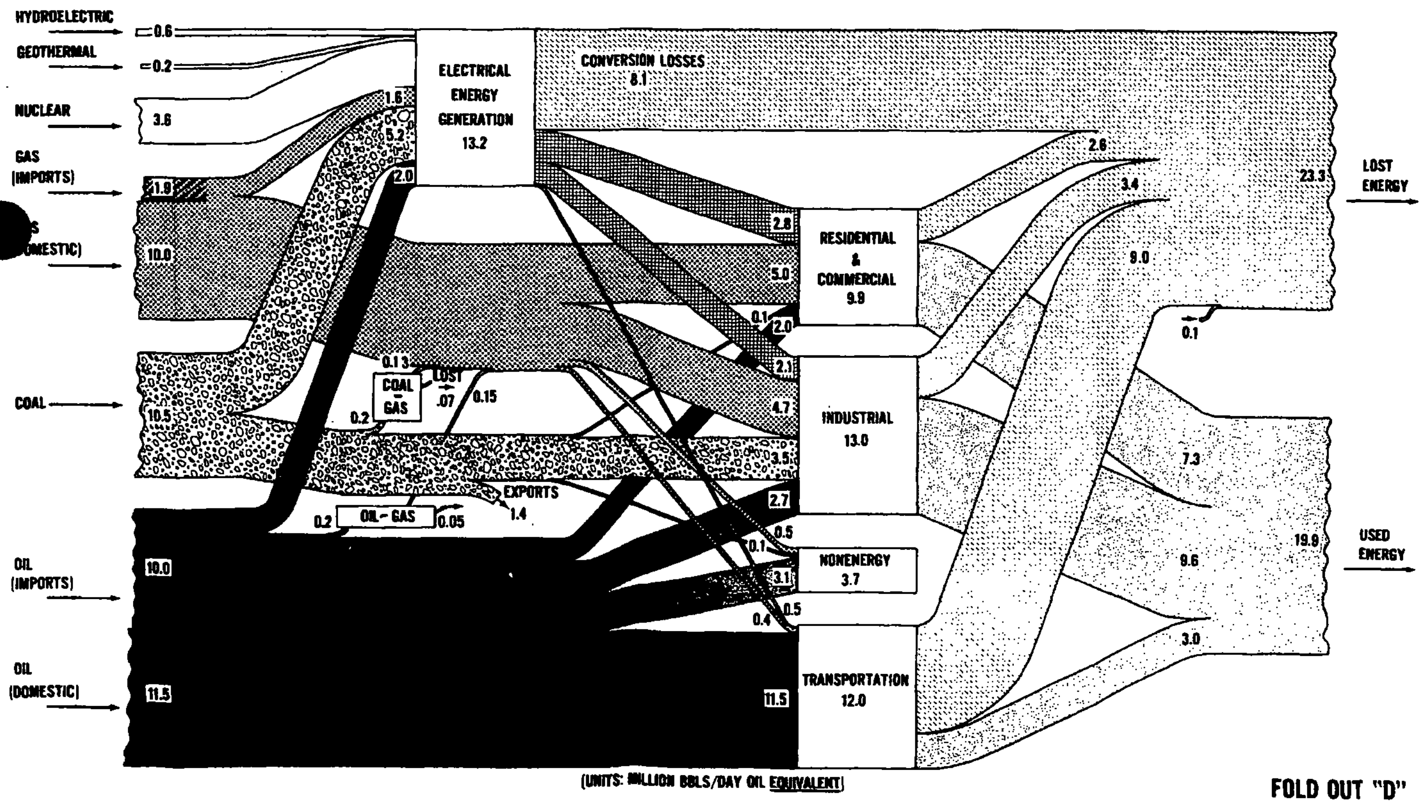
1970



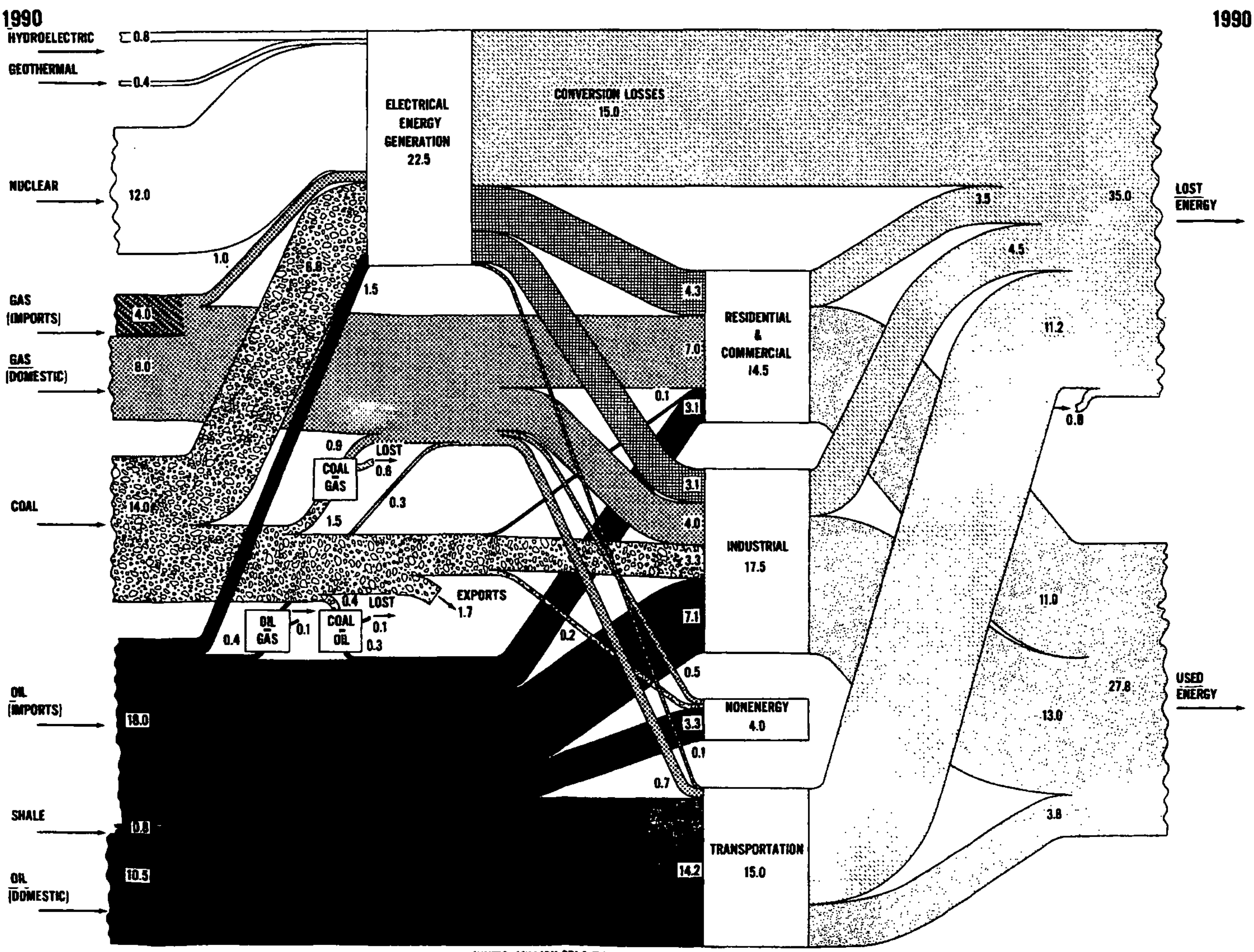
(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

FOLD OUT "C"

1980

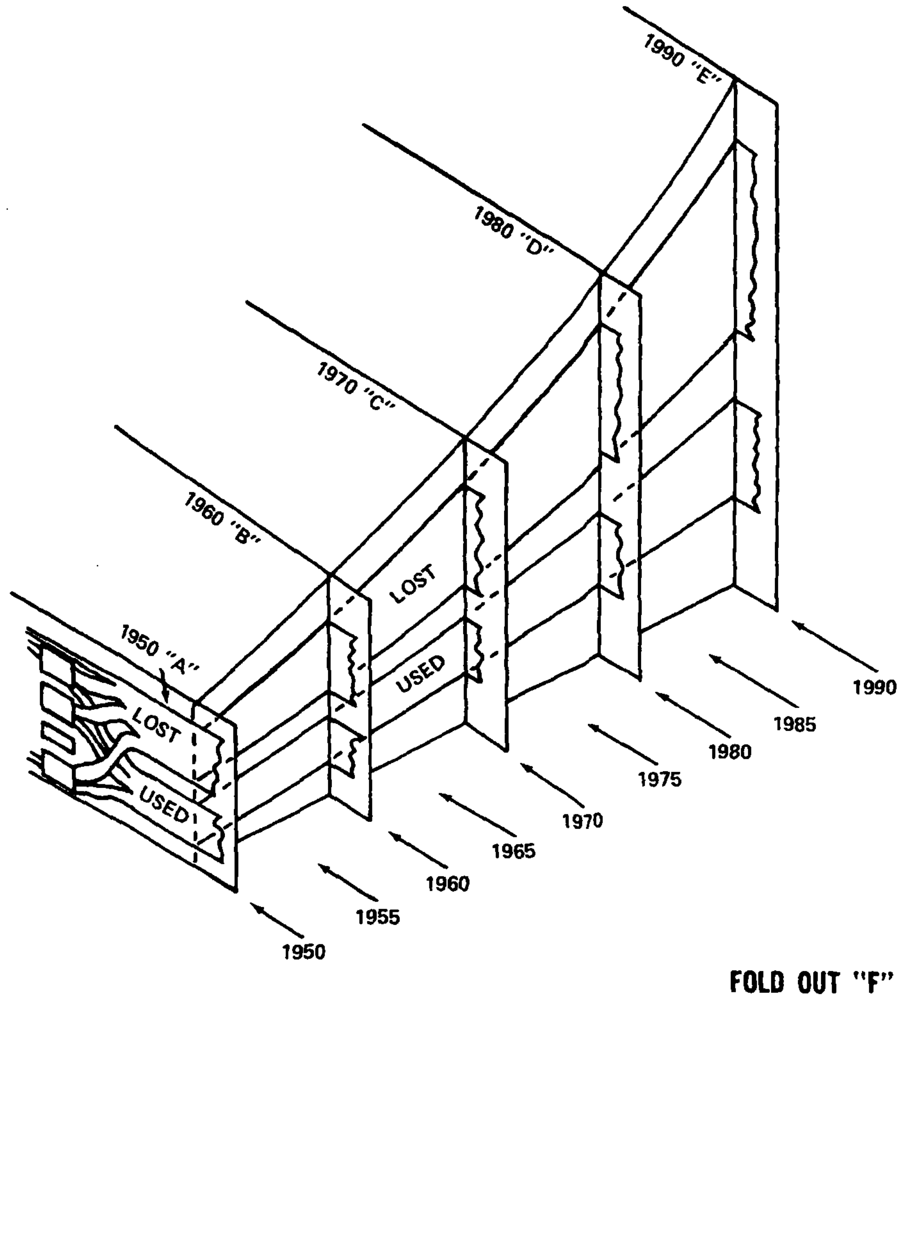


FOLD OUT "D"

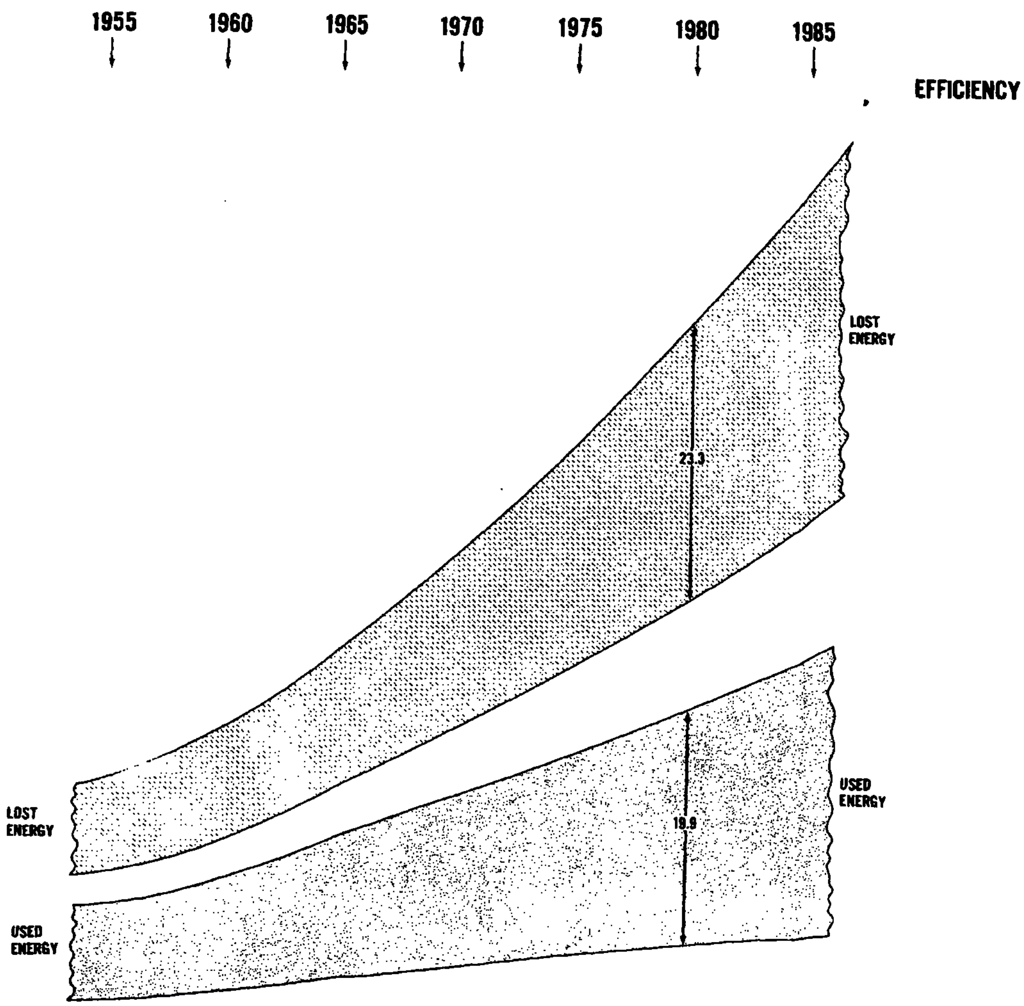

1990
HYDROELECTRIC
0.8
GEOTHERMAL
0.4
NUCLEAR
12.0
1.0
GAS (IMPORTS)
4.0
GAS (DOMESTIC)
8.0
COAL
14.0
6.6
1.5
0.9
COAL GAS
LOST
0.6
1.5
0.3
OIL GAS
COAL OIL
0.4
0.1
LOST
0.1
0.3
0.4
EXPORTS
1.7
OIL (IMPORTS)
18.0
SHALE
0.8
OIL (DOMESTIC)
10.5
ELECTRICAL ENERGY GENERATION
22.5
CONVERSION LOSSES
15.0
4.3
7.0
0.1
3.1
3.1
4.0
3.3
7.1
0.2
0.5
3.3
0.1
0.7
14.2
RESIDENTIAL & COMMERCIAL
14.5
INDUSTRIAL
17.5
NONENERGY
4.0
TRANSPORTATION
15.0
3.5
4.5
11.2
0.8
11.0
13.0
3.8
35.0
27.8
1990
LOST ENERGY
USED ENERGY
(UNITS: MILLION BBLS/DAY OIL EQUIVALENT)

FOLD OUT "E"

CONSTRUCTION OF "CROSS PLOTS"
("EFFICIENCY" PLOT SHOWN)

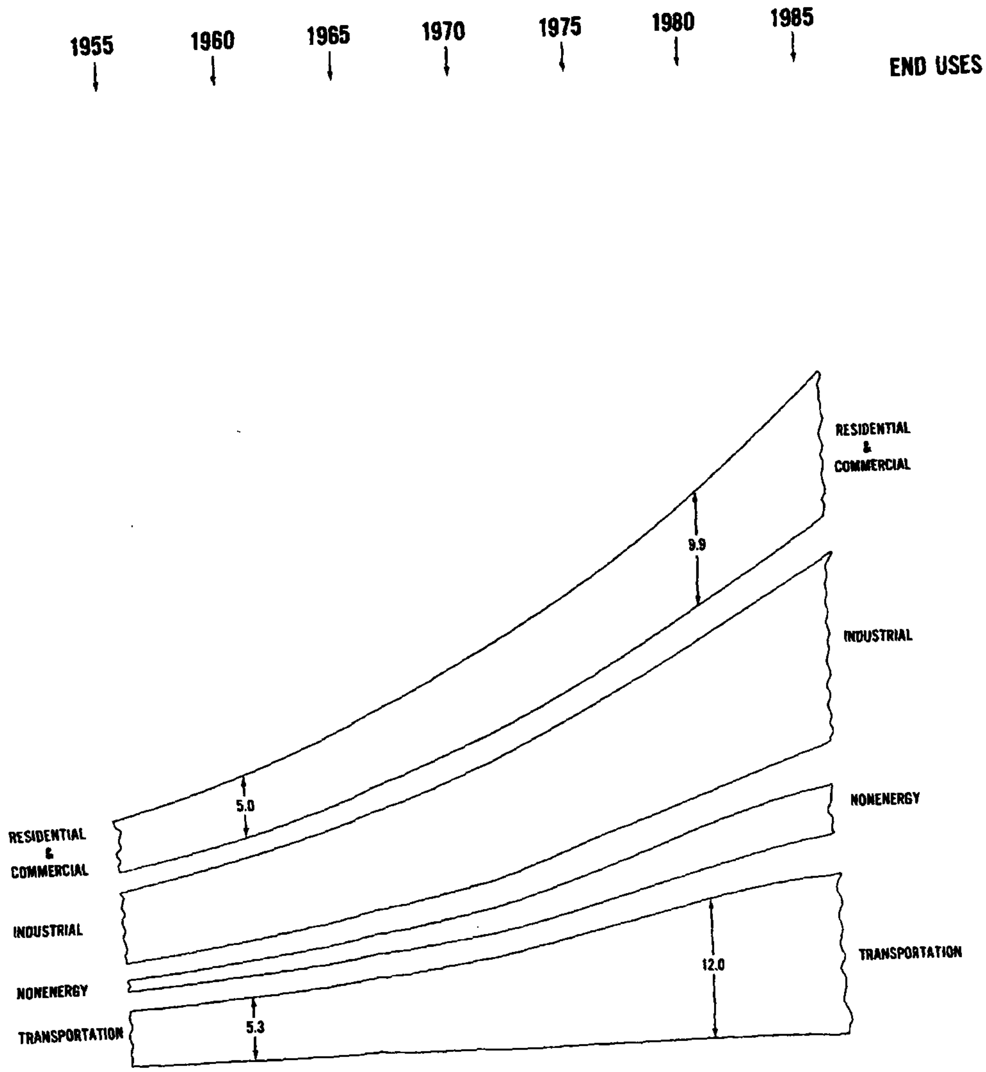


FOLD OUT "F"

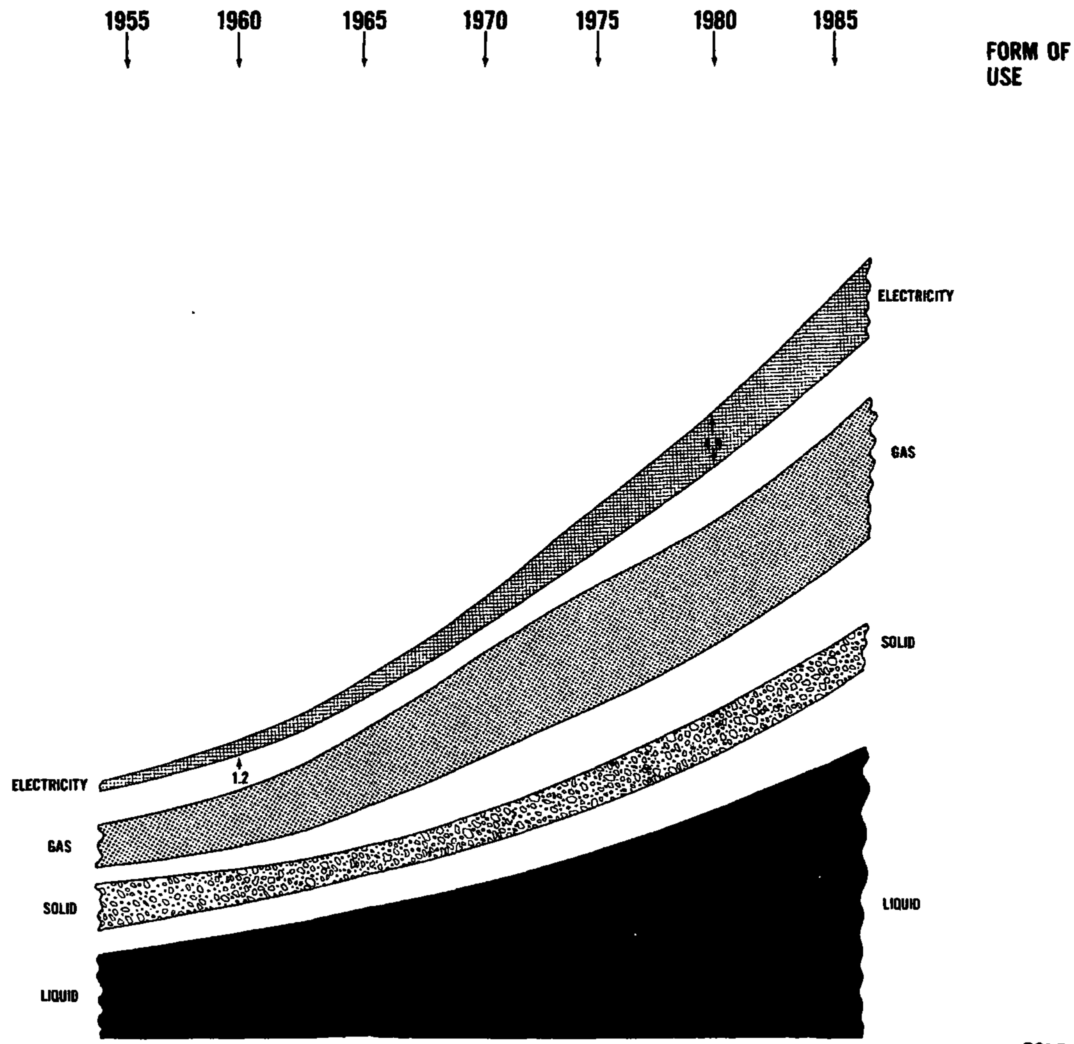


1955
1960
1965
1970
1975
1980
1985
EFFICIENCY
LOST ENERGY
23.3
LOST ENERGY
USED ENERGY
19.9
USED ENERGY

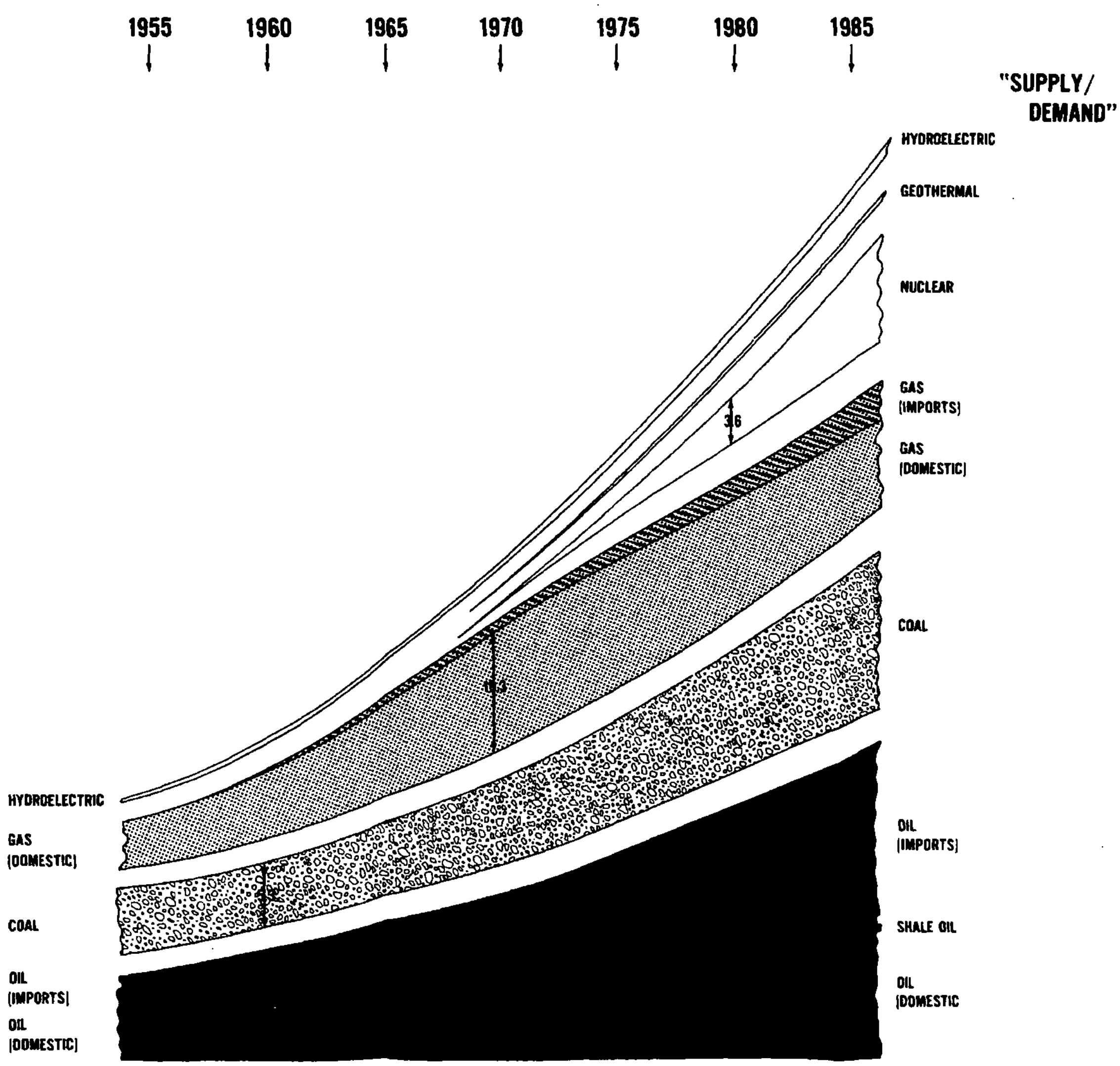
FOLD OUT "G"


1955
1960
1965
1970
1975
1980
1985
END USES
RESIDENTIAL & COMMERCIAL
INDUSTRIAL
NONENERGY
TRANSPORTATION
5.0
9.9
5.3
12.0
RESIDENTIAL & COMMERCIAL
INDUSTRIAL
NONENERGY
TRANSPORTATION

FOLD OUT "H"


1955
1960
1965
1970
1975
1980
1985
FORM OF USE
ELECTRICITY
GAS
SOLID
LIQUID
1.2
ELECTRICITY
GAS
SOLID
LIQUID

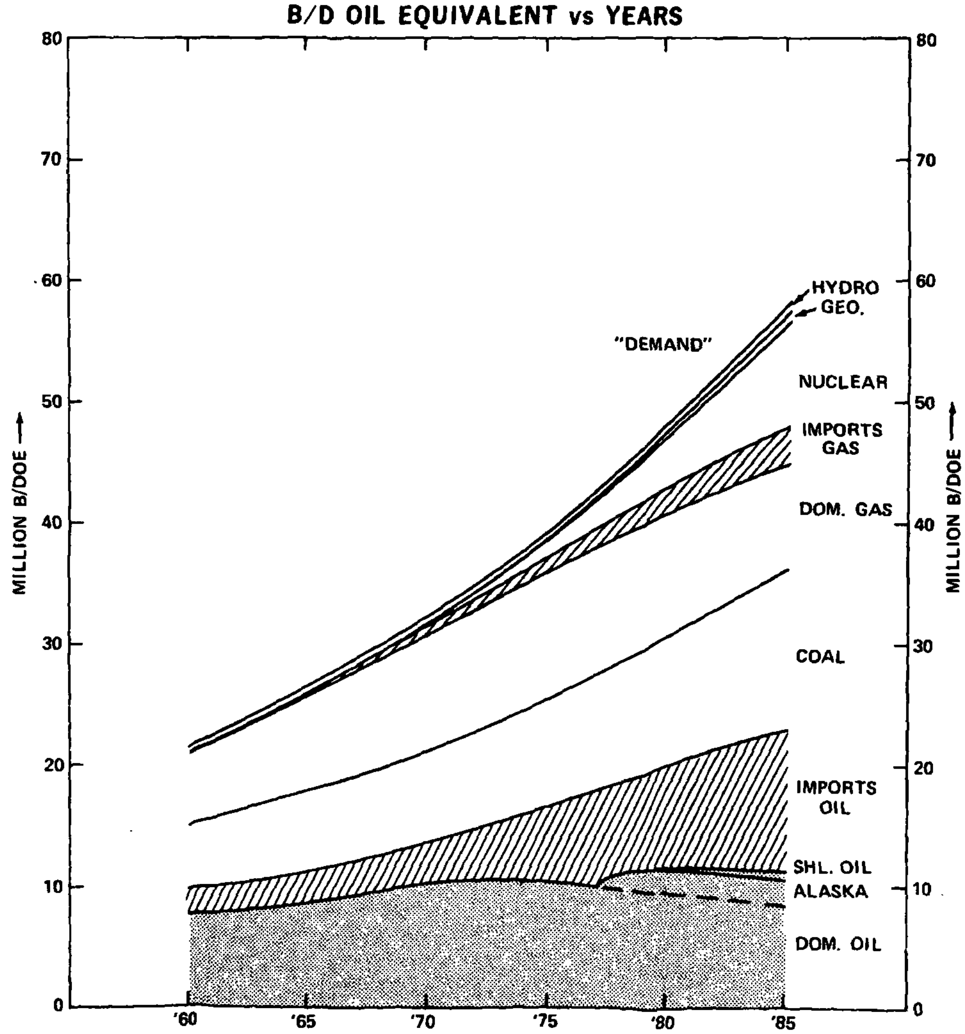
FOLD OUT "I"



1955
1960
1965
1970
1975
1980
1985
"SUPPLY/ DEMAND"
HYDROELECTRIC
GEOTHERMAL
NUCLEAR
GAS (IMPORTS)
GAS (DOMESTIC)
3.6
COAL
OIL (IMPORTS)
SHALE OIL
OIL (DOMESTIC
HYDROELECTRIC
GAS (DOMESTIC)
COAL
OIL (IMPORTS)
OIL (DOMESTIC)

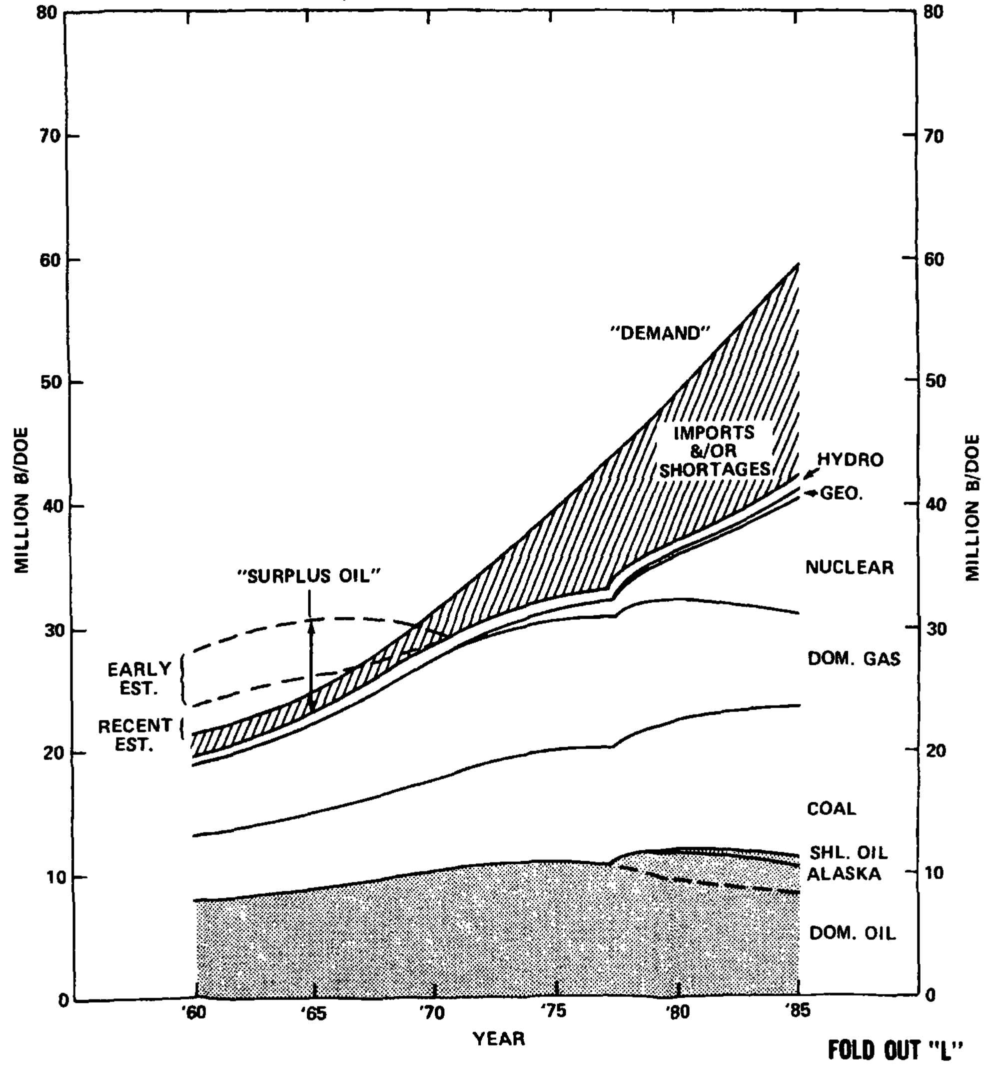
FOLD OUT "J"

"SUPPLY/DEMAND"
(FROM "ENERGY DISPLAY")
B/D OIL EQUIVALENT vs YEARS



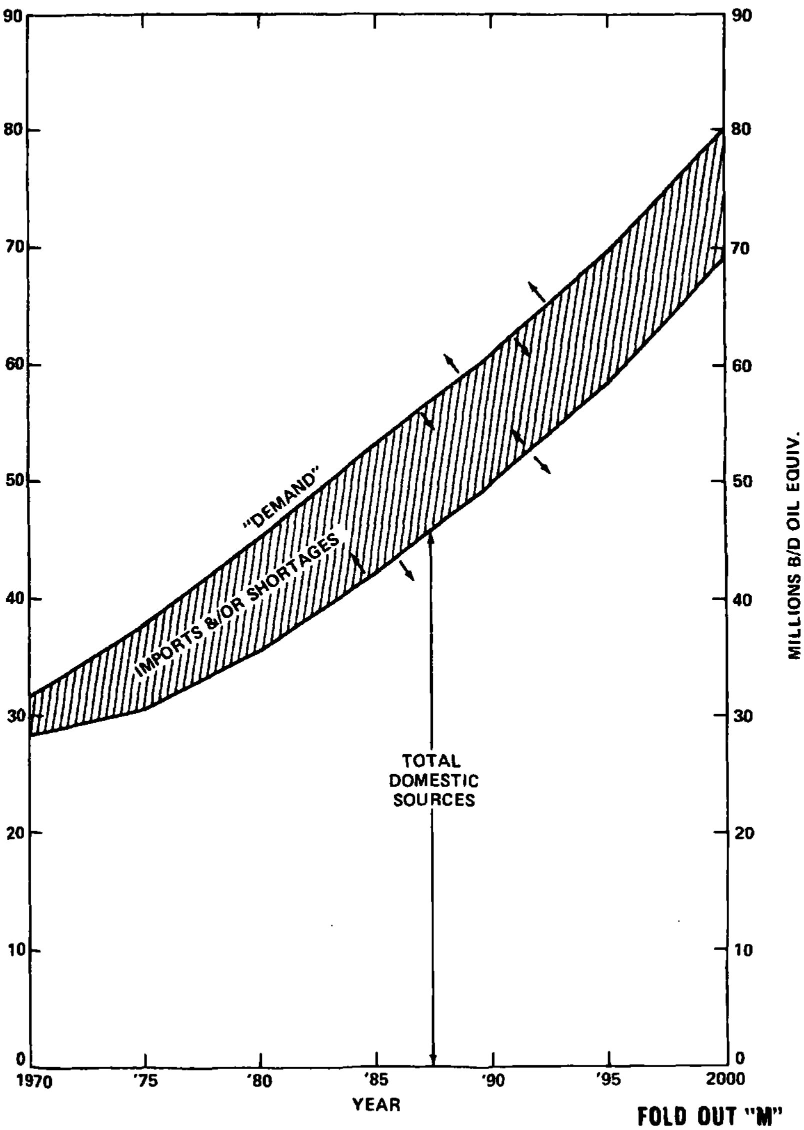
FOLD OUT "K"

"SUPPLY/DEMAND"
(1960-1985)
B/D OIL EQUIVALENT vs YEARS



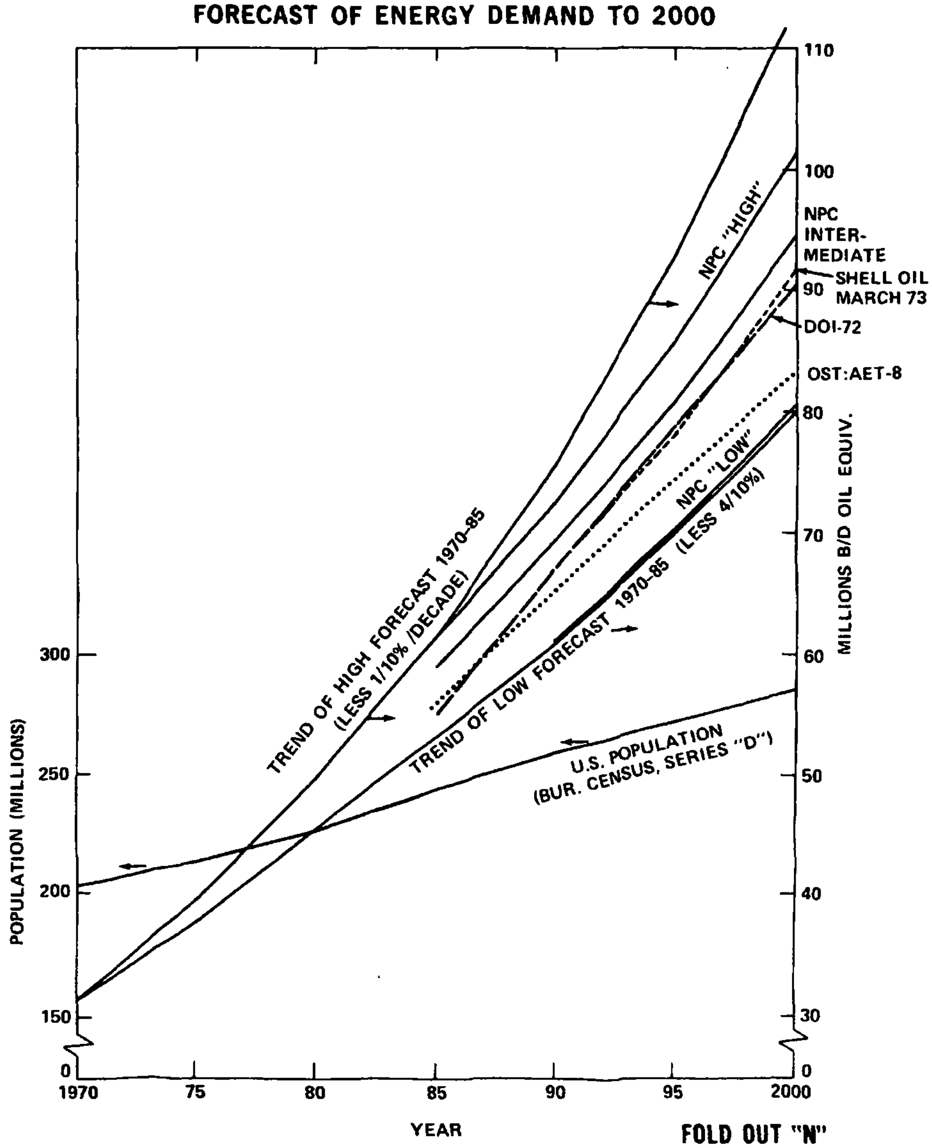
FOLD OUT "L"

"GUIDANCE" REQUIRED



FOLD OUT "M"

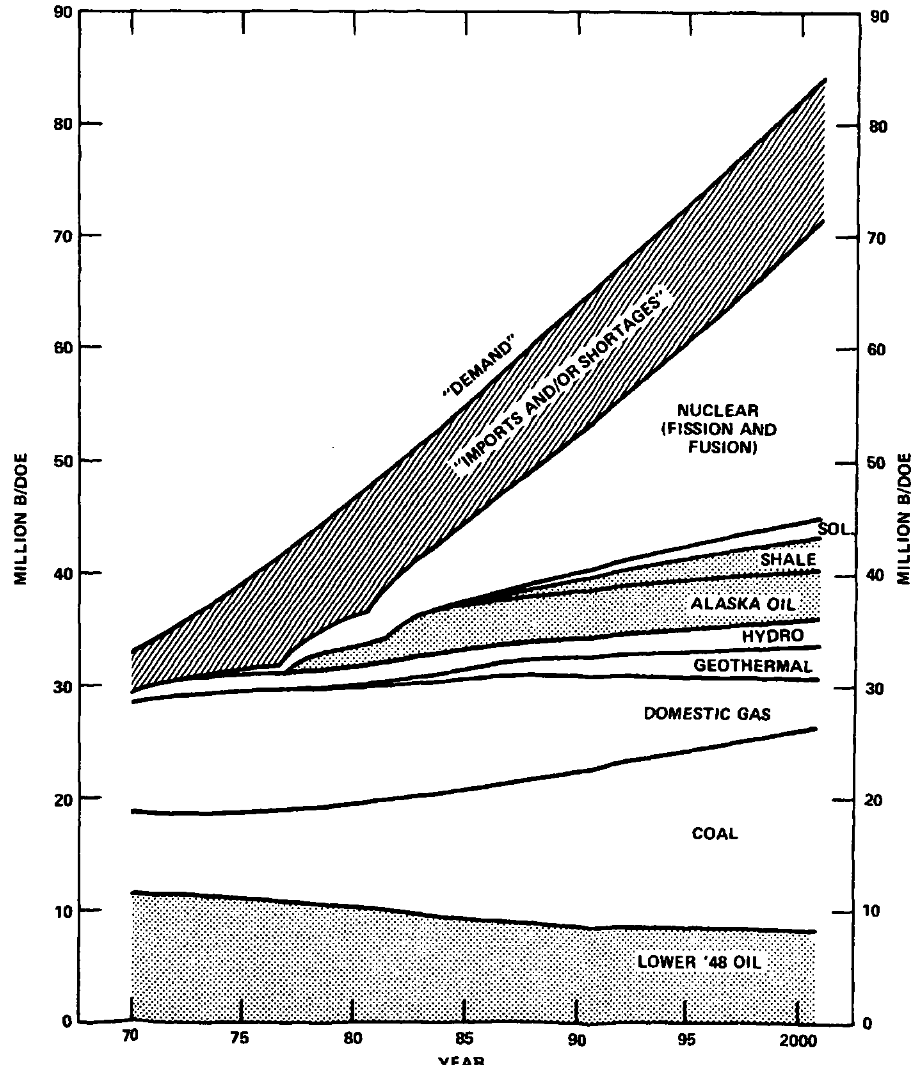
FORECAST OF ENERGY DEMAND TO 2000



FOLD OUT "N"

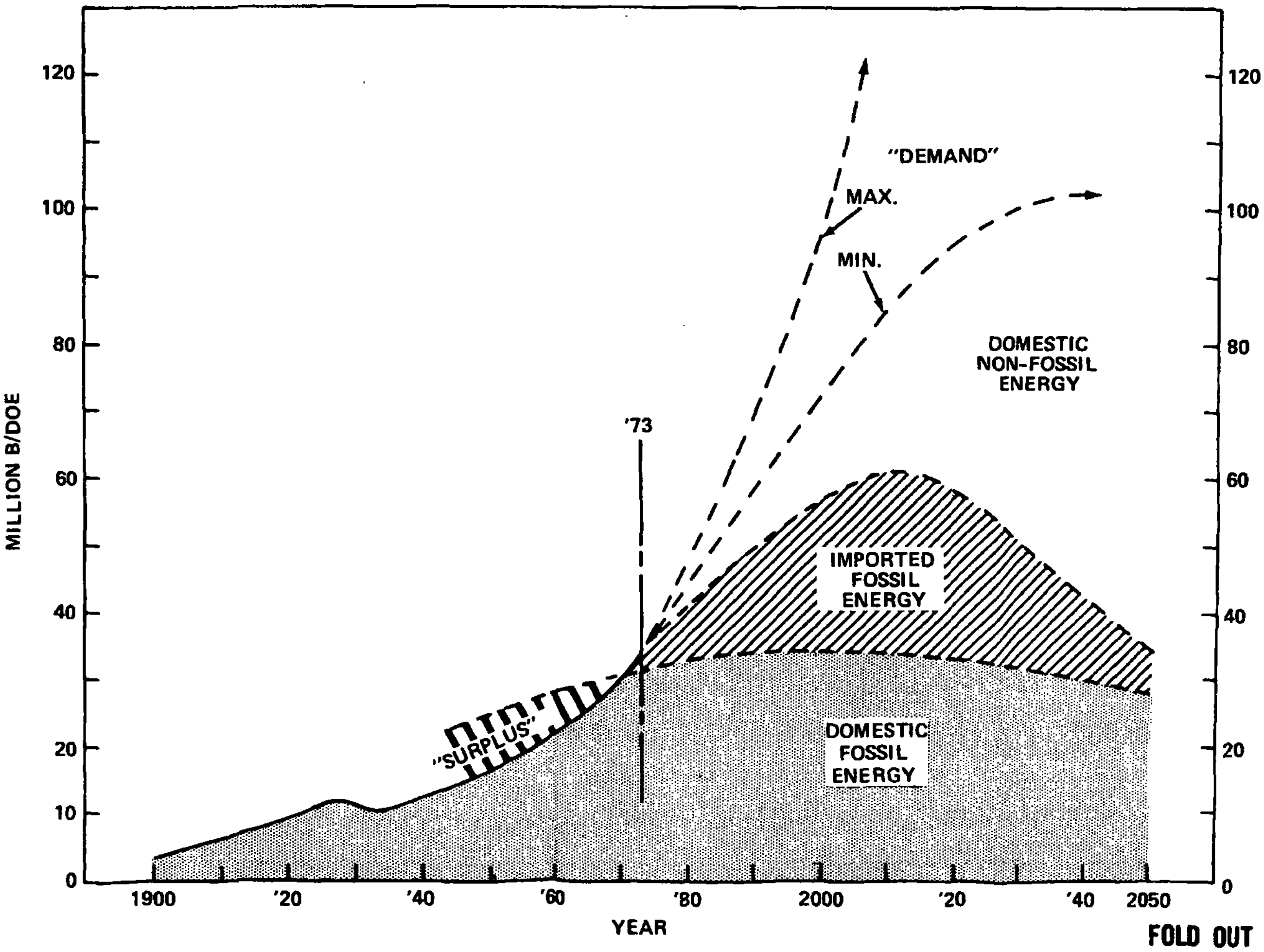
N

"SUPPLY/DEMAND"
[JCAE "OPTION EXERCISE 7-A" 3-73]
B/D OIL EQUIVALENT vs YEARS



FOLD OUT "0"

"SUPPLY/DEMAND"
(1900 - 2050)
B/D OIL EQUIVALENT vs YEARS



FOLD OUT "P"

P

~~[illegible]~~ WASH-1281

202
12.17.73

24,495

THE NATION'S ENERGY FUTURE

A REPORT TO RICHARD M. NIXON PRESIDENT OF THE UNITED STATES

1 DECEMBER 1973

MASTER

Submitted by Dr. Dixy Lee Ray
Chairman, United States Atomic Energy Commission

DISCLAIMER

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

OFFICE OF THE CHAIRMAN

December 1, 1973

The President
The White House

Dear Mr. President:

In response to your directive of 29 June of this year, viz:

> " . . . I am directing the Chairman of the Atomic Energy Commission to undertake an immediate review of Federal and private energy research and development activities, under the general direction of the Energy Policy Office, and to recommend an integrated energy research and development program for the Nation. . . . By December 1 of this year, I am asking for her recommendations for energy research and development programs which should be included in my fiscal year 1975 budget."

I am pleased to present this Report.

As requested, the Report was developed under the general guidance of the Energy Policy Office. It has also benefited from the active participation of those Federal Agencies most concerned with energy research. Additionally, there has been widespread consultation with representatives of the private sector, including a broad range of energy industries. A more detailed description of the procedures that were followed and a listing of those persons most directly involved are attached hereto.

Any merit the Report may have deserves to be widely shared with those who devoted their time, energy, and talent to its development. Any shortcomings are my responsibility alone. Formal concurrence in the recommendations was not requested from either individuals or agencies; the final recommendations are based on all

For sale by the Superintendent of Documents
U.S. Government Printing Office, Washington, D.C. 20402
Price $1.95 Stock Number 5210-00363

the information gathered and result from my considered judgment of the kind of thoughtful, well-considered energy research and development program that this Nation urgently needs to pursue.

Considerations for using today's technology to meet and overcome the present energy crisis, and to be responsive to "Project Independence", are being submitted separately.

I earnestly hope that this Report will be helpful in your efforts to mobilize the Nation's resources toward the attainment of a capacity for energy self-sufficiency by 1980. I believe that, in surmounting this challenge, the Nation can emerge stronger and more free than ever before to pursue with renewed vigor its high aims of domestic and international peace and well being.

Respectfully yours,

Chairman

Attachment

ATTACHMENT

UNITED STATES ENERGY RESEARCH AND DEVELOPMENT PROGRAM

This report is based upon the results of several major and somewhat independent efforts:

- A group of Energy Workshops, organized under the sponsorship of Cornell University, considered the major directions and overall framework required for a national program. Specific workshop topics and the membership of each are shown in Appendix C of the Report. The deliberations will be separately published.

- Sixteen Technical Review Panels were established. These were made up of 121 Federal employees from thirty-six Departments and Agencies assisted by 282 consultants from the private sector. More than 1100 specific proposals for the energy research and development program were reviewed and evaluated. Membership of the panels and the consultants employed are listed in Appendix C.

- Review of the results from the Workshops and the Technical Panels was conducted by an Overview Panel chaired by Mr. Stephen A. Wakefield, Assistant Secretary for Energy and Minerals, Department of the Interior. The membership included:

  Mr. William E. Simon, Deputy Secretary of the Treasury

  Dr. Beatrice E. Willard, Member, Council of Environmental Quality

  Dr. Betsy Ancker-Johnson, Assistant Secretary for Science and Technology, Department of Commerce

  Dr. Stanley M. Greenfield, Assistant Administrator for Research and Development, Environmental Protection Agency

Mr. William A. Anders, Commissioner, Atomic Energy Commission

Mr. Bruce T. Lundin, Director, Lewis Research Center, National Aeronautics and Space Administration

Mr. John P. Abbadessa, Controller, Atomic Energy Commission

The Overview Panel made specific recommendations on the composition of the ten billion dollar, five year program and on the fiscal year 1975 budget.

- A draft of the report was sent to more than 100 individuals for comment. It also went to all concerned government Departments and Agencies.
- I consulted personally with numerous leaders in government, industry, and the scientific community throughout the period of the Report's preparation.

WASH-1281
UC-2

THE NATION'S ENERGY FUTURE

A REPORT TO

RICHARD M. NIXON

PRESIDENT
OF
THE UNITED STATES

1 DECEMBER 1973

Submitted by Dr. Dixy Lee Ray
Chairman, United States Atomic Energy Commission

Table of Contents

List of Tables and Figures

EXECUTIVE SUMMARY

Purpose:

The Report, directed by the President in his June 29, 1973, Statement on Energy, recommends:

- A national energy research and development (ER&D) program.
- A five-year, $10 billion Federal ER&D program.
- The FY 1975 Federal budget for ER&D.

Findings:

- Present energy problems stem, in large part, from the lack of a coordinated national ER&D program over the last 20 years. Only nuclear power has received sustained support at adequate levels.

- The requirement to regain and maintain energy self-sufficiency stems from conditions more fundamental than the current crisis. Worldwide energy shortages impend as energy-intensive industrial growth spreads and accelerates.

- The United States has the resources and technology for self-sufficiency. A properly directed, sustained national commitment can attain that goal.

- Five tasks are required to regain and sustain self-sufficiency, and simultaneous effort is urgently required on all five. Their contributions to self-sufficiency will begin to materialize in the order listed:

  Task 1. Conserve energy by reducing consumption and conserve energy resources by increasing the technical efficiency of conversion processes.
  Task 2. Increase domestic production of oil and natural gas as rapidly as possible.
  Task 3. Increase the use of coal, first to supplement and later to replace oil and natural gas.
  Task 4. Expand the production of nuclear energy as rapidly as possible, first to supplement and later to replace fossil energy.
  Task 5. Promote, to the maximum extent feasible, the use of renewable energy sources (hydro, geothermal, solar) and pursue the promise of fusion and central station solar power.

- The recommended program, based on what is now known, is both necessary and sufficient to maximize ER&D's contribution to the Nation's energy goals. Even so, 1985 is the earliest date by which self-sufficiency can reasonably be expected with this program.

- By 1980, the recommended ER&D program is expected to reduce oil imports to half (6 million barrels/day) of those currently projected. Other extraordinary measures will be required to restrict consumption, increase domestic production, or both by enough to displace the other half.

Recommendations:

- The national and Federal ER&D programs, FY 1975-1979, and the FY 1975 Federal ER&D budget are shown in the table below. (The FY 1974 Federal ER&D budget is shown for comparison.)

ER&D PROGRAM AND BUDGET RECOMMENDATIONS
($ Millions)

	ER&D Programs, FY 1975-1979			Federal ER&D Budget	
Self-Sufficiency Tasks	Total Required	Private Expected	Federal Recommended	FY 1974 Planned	FY 1975 Recommended
1. Conserve Energy and Energy Resources	4,940	3,500	1,440	62.3	166.2
2. Produce Oil and Natural Gas	4,960	4,500	460	19.5	51.7
3. Produce and Use Coal	5,175	3,000	2,175	167.2	405.0
4. Produce Nuclear Energy	5,340	1,250	4,090	517.3	731.7
5. Use Other Sources, Pursue Future Prospects	2,085	250	1,835	123.0	217.5
TOTAL	22,500	12,500	10,000	889.3	1,572.1

- Establish an operational Energy Research and Development Administration not later than July 1, 1974, to plan and coordinate the total program and to direct the major share of the Federal program.

- Conduct a comprehensive program review at least annually, reallocating funds among programs as required. Increase the total program only if reallocations are insufficient to fund all highly promising prospects.

- Ensure full consideration of the energy consequences of all Federal actions taken to achieve nonenergy goals.

- Maximize private-sector involvement in the conduct, review, and evaluation of the Federal ER&D program, both to conserve Federal dollars and to speed up the application of technological advances.

- Initiate in FY 1975 a Synthetic Fuels Pioneer Program: privately funded construction, induced by loans or price guarantees, of several full-scale commercial plants for producing synthetic fuels from coal using existing technologies. Federal ER&D funds would be used to collect and disseminate engineering, economic, and environmental data that would serve as benchmarks for evaluating new developments. The program would lay the groundwork for a rapid expansion of domestic energy production capacity and focus ER&D effort, Federal and private, on highest priority problems.

- Accelerate ongoing work in three supporting programs that contribute to the goals of the recommended ER&D program:

1.	Environmental Effects Research	$650 Million
2.	Basic Research	300 Million
3.	Manpower Development	50 Million
		$1000 Million

1

Purpose and Scope

This report is prepared in response to the President's directive in his June 29, 1973, energy message. Its purpose is to recommend:

- The national energy research and development program needed to regain and maintain energy self-sufficiency.
- The five-year, $10 billion Federal energy research and development program to supplement research and development expenditures expected from the private sector.
- The Fiscal Year 1975 Federal energy research and development budget.

Since the President's directive was announced, the Nation has become acutely aware that shortages of energy—especially oil—threaten its social, economic, and environmental priorities. The energy shortages of today and those projected for future decades stem, in part, from the lack of a coordinated national program for energy research and development over the past 10 to 20 years. Today's impending shortages impart a long overdue sense of urgency to the effort being launched to meet not only immediate requirements but also the growing needs of the years ahead.

The challenge posed by the immediate energy future carries with it an unparalleled opportunity to emerge better equipped than ever before to pursue the Nation's higher goals of domestic and international peace and prosperity. The Nation has long had the human and material resources to surmount the present challenge and seize its corresponding opportunity; the widespread awareness of the necessity to do so can now provide the essential will to convert its potential into practice.

This report is based on a series of studies carried out under the guidance of the Energy Policy Office in conjunction with Government departments and agencies having energy responsibilities. People from industry, foundations, and the academic community were also consulted, together with other private citizens having responsibilities and acknowledged expertise in the energy field.

A number of issues had to be dealt with to limit the scope of the report to energy research and development. The most important were:

- The role of energy in our society.
- The relationship of energy research and development to energy policy.
- The distinction between energy research and development and energy production.
- The impact of research and development and other energy policy actions on the future of the Nation's energy system.
- The necessity to support energy development with an expansion of environmental effects research, basic research, and manpower development.
- The consequences of energy policies aimed at attaining other goals, such as economic growth, consumer protection, and land use

THE ROLE OF ENERGY IN OUR SOCIETY

Energy is the *sine qua non* of a modern society's ability to do the things it wants to do. Such goals as maintaining the standard of living for a growing population, national security, improved quality of life, increased affluence, and increased assistance to less developed societies can only be attained with increasingly large amounts of energy. While lower energy costs allow a society more freedom of action in seeking its goals, the availability of energy is the first requirement of having any freedom of action at all.

RESEARCH AND DEVELOPMENT: ONE PART OF POLICY

Federal energy policy comprises those actions that aim to have a direct impact on the Nation's energy system by increasing supply, reducing demand, or changing production and use patterns. For example, one possible policy is to let the market determine what goes on in the energy system. Another policy is to intervene by rationing, price controls, mandatory allocations, price guarantees, and other nonmarket measures to change certain operations of the market and presumably the results for the economy.

The aim of Federal energy policy is to ensure that the Nation's ability to pursue its higher order goals is not unduly impaired by energy shortages.

To respond to current problems, policy-makers must select from among a set of actions limited by existing physical and institutional constraints. However, energy research and development actions can be taken now that will expand the range of actions that will be possible in the future.

By its nature energy research and development is an investment in the Nation's future. Numerous opportunities for research that would yield early results exist and should be pursued vigorously; a major part of the recommended program is designed to remove obstacles to the attainment of energy self-sufficiency by 1980. Still, a program aimed only at the immediate future would be less than fully responsive to the Nation's needs. Major improvements in the energy situation can come only from sustained effort over an extended time because long lead times are required to improve the technologies for producing and using energy. Accordingly the recommended program was designed to meet the Nation's energy needs in the years beyond 1980, as well as to make the maximum possible contribution to the Nation's immediate energy goals.

RESEARCH AND DEVELOPMENT VS. PRODUCTION

Research and development activities extend from fundamental research on the properties of matter to successful demonstration on a commercial scale of the technical and economic feasibility of new processes. The application of new processes on a scale big enough to make a significant impact on the energy system is production, not research and development. A vigorous program for increasing energy production in the immediate future is urgently needed to move toward self-sufficiency. Such a program must rely primarily on existing technologies—not on research and development. Although some "quick fixes" of particular engineering problems in producing energy might be considered research and development, the bulk of the research and development program cannot be expected to make big differences in energy **production** rates in any short time.

The dividing line between research and development and production is not absolute; the two can be mutually supportive. Nothing identifies specific needs for immediate research and development attention more quickly than a major production program, and few actions can have as much short-term impact on a major production program as top priority research and development to remove production bottlenecks. The Manhattan Project of World War II is a classic example of how these two kinds of effort can be integrated and applied toward rapid attainment of a specific goal. Still, a balanced research and development program must not be limited only to efforts aimed at supporting immediate production programs; it must also include those efforts aimed at making possible the production programs that will be needed in the future.

RESEARCH AND DEVELOPMENT, POLICY, AND THE NATION'S ENERGY FUTURE

The national energy research and development program begun now and carried out over the next few years is a principal vehicle for shaping the evolution of the Nation's energy system. What is done and not done in that program will define the technological boundaries of future energy policy choices. Accordingly, obtaining agreement on how the energy system should evolve is the first step in designing an energy research and development program.

Energy policies other than research and development will also be required if the energy future is to evolve in the desired direction. Some energy policy decisions will be necessary to support research and development. Other decisions will be needed to foster the application of new technologies after commercial feasibility has been demonstrated. Still other policies aimed at goals outside the energy system will influence both the execution of the research and development program and the implementation of new technologies derived from it.

SUPPORTING PROGRAMS

The evolution of the energy system will be heavily influenced by policies not directly aimed at energy questions, e.g., environmental effects, basic research, and manpower development policies. Because of their close relationship to energy, specific programs in these areas are recommended for levels of **incremental** funding in addition to the $10 billion energy research and development program. The recommended increments to these supporting programs are considered the **minimums** required to guarantee both the successful conduct of the proposed energy research and development and the rapid implementation of its results throughout the energy system.

OTHER POLICY ACTIONS

Because energy plays such a central role in our society, a number of policy actions on nonenergy goals will affect the energy system. Some areas where policy actions affect the energy system are rate regulation, price controls, antitrust and patent laws, land-use laws, and leasing of public lands.

Because decisions on these policies involve a wide range of considerations outside energy matters, this report refers only to their implications and merely suggests directions that will facilitate energy research and development and help realize its benefits.

SYNOPSIS

Chapter 2 summarizes the recommended five-year $10 billion Federal program, details of which are in Appendix A, and presents the recommended Fiscal Year 1975 budget, the first increment of the recommended program.

Chapter 3 summarizes the energy supply and demand situation and indicates how much change is needed to regain self-sufficiency.

Chapter 4 sets out the five major tasks required to regain and maintain energy self-sufficiency and from these tasks derives the goal of the Nation's energy research and development program.

Chapter 5 discusses the role of the Federal Government in energy research and development, including its relations with industry, its own research and development strategy, criteria for funding of Federal programs, and guidelines for managing the Federal effort.

Chapter 6 explains the technological obstacles to accomplishing the five tasks and discusses the major constraints under which the research and development program must be carried out.

Chapter 7 classifies the research and development objectives under each of the five tasks into short-, mid-, and long-term categories.

2

The Recommended Five-Year National Energy Research and Development Program

Table 2-1 summarizes the recommended five-year research and development program. This program, properly executed, can reasonably be expected to attain the objectives set out in Chapter 7. The salient features of the program are:

- A reasonable balance among the tasks required to regain and maintain energy self-sufficiency:

Task 1.	Conserve energy and energy resources	22%
Task 2.	Increase domestic production of oil and gas	22%
Task 3.	Substitute coal for oil and gas	23%
Task 4.	Validate the nuclear option	24%
Task 5.	Exploit renewable resources (solar, geothermal, fusion, hydroelectric)	9%
		100%

- Massive concentration of effort on short-term objectives: 70% of the total program and 45% of the Federal program go to short-term goals.

- A prudent level of effort directed toward mid-term goals: 23% of the total program and 39% of the Federal program.

- A small but significant share of the program aimed at long-term goals: 7% of the total program, all Federal.

- A conservative estimate of the private research and development contribution that could be forthcoming in response to vigorous and imaginative Federal leadership. (Estimates are based on the 1971 data from the Ford Foundation Energy Policy Project for research and development in the oil, gas, coal-mining, electrical, and electrical supplier industries [$1400 million/year] plus data on

Table 2-1.—RECOMMENDED NATIONAL ENERGY RESEARCH AND DEVELOPMENT PROGRAM, FY 1975-1979

Self-Sufficiency Task	($ Millions) Short-Term Objectives	Mid-Term Objectives	Long-Term Objectives	Total
1. Conserve Energy and Energy Resources				
Federal	1,160	280		1,440
Private	3,200	300		3,500
Subtotal	4,360	580		4,940
2. Increase Domestic Production of Oil and Gas				
Federal	430	30		460
Private	4,300	200		4,500
Subtotal	4,730	230		4,960
3. Substitue Coal for Oil and Gas on a Massive Scale				
Federal	1,690	485		2,175
Private	2,500	500		3,000
Subtotal	4,190	985		5,175
4. Validate the Nuclear Option				
Federal	1,100	2,990		4,090
Private	1,000	250		1,250
Subtotal	2,100	3,240		5,340
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible				
Federal	135	150	1,550	1,835
Private	220	30		250
Subtotal	355	180	1,550	2,085
TOTAL				
Federal	4,515	3,935	1,550	10,000
Private	11,220	1,280		12,500
GRAND TOTAL	15,735	5,215	1,550	22,500
Supporting Programs (incremental Federal funding to present programs)				
Environmental Effects	650			
Basic Research	300			
Manpower Development	50			
	1,000			

research expenditures of the automobile industry provided in Congressional hearings [$200 million/year] adjusted for inflationary increases since 1971 and increased expenditures in response to already recognized shortages, making a total of some $2000 million/year in FY 1974. Industry can reasonably be expected to increase research and development spending by at least 25% above current estimates in response to the more than doubled Federal contribution, properly structured Federal policies, and the incentives of higher prices.)

- Allocation of Federal funds among tasks based on the total requirements of each task and on the contributions expected from industry; the Federal share of the total effort varies from slightly under 10% for Task 2 to 88% for Task 5.
- Recommendation of $1000 million for increases in research and development funding of ongoing Federal programs that support energy research and development and energy production.

CONTRIBUTION TO SELF-SUFFICIENCY

Table 2-2 shows the estimated contribution of the recommended program to the goal of regaining self-sufficiency. Entries for 1972 display the composition of energy inputs for that year, including imports of 5.1 million barrels/day of oil equivalent (mostly oil and some natural gas). The Total Energy entries for 1980 and 1985 are based on a projected annual rate of growth in energy consumption of 4.1% from 1972 to 1980 and 3.9% from 1980 to 1985. The conservation entries show the energy savings expected to result from the recommended research and development program. Fuel-source entries for 1980 and 1985 show:

- Contributions expected with programs underway before the President's June 29, 1973, energy initiatives (first column).
- The extra contribution expected from the accelerated research and development efforts included in these initiatives (second column).
- The total contributions expected with the $10 billion program recommended in this report (third column).

The data support the following conclusions:

- Self-sufficiency may be attained by 1985 with the expected payoff of the proposed research and development program. By then, the proposed program should yield the equivalent of:
  (1) 7.0 million barrels/day of energy savings from conservation efforts, and
  (2) 9.0 million barrels/day of increased domestic production.

Table 2-2.—ESTIMATED CONTRIBUTION TO ENERGY INPUTS
(Million Barrels/Day Oil Equivalent)

Energy Source	1972 Actual Inputs	1980 Total with Former Program[1]	1980 Increment from Recommended Program[2]	1980 Total with Recommended Program	1985 Total with Former Program[1]	1985 Increment from Recommended Program[2]	1985 Total with Recommended Programs
Total Energy	34.1	47.0		47.0	57.0		57.0
1. Conservation	—	—	4.7	(4.7)	—	7.0	(7.0)
Production Requirements	34.1	47.0		42.3	57.0		50.0
2. Domestic Production of Oil and Gas	21.4	21.5	0.5	22.0	21.5	5.1	26.6
3. Domestic Coal Production and Conversion	5.9	9.1	0.5	9.6	11.4	2.5	13.9
4. Nuclear	0.3	3.6	0.2	3.8	7.1	0.6	7.7
5. Renewable Resources (Solar, Geothermal, Hydroelectric)	1.4	0.8	0.2	1.0	1.0	0.8	1.8
Imports	5.1	12.0	(6.1)	5.9	16.0	(16.0)	0.0

[1] Contributions expected from policies in effect prior to the President's June 29,1973, energy initiatives, including the energy research and development program contemplated before that initiative. See Appendix B for a comparison of the formerly contemplated program and the program recommended in this report.

[2] See Appendix B for explanation of the methodology used to derive these values.

- By 1980 the recommended program will have decreased the demand for imports by half, to 5.9 million barrels/day of oil equivalent.

- To replace by 1980 the other half of the demand for imports, the Nation must, in addition to conducting the accelerated research and development program:
  (1) reduce energy use by imposing administrative restrictions on consumption, and/or
  (2) take extraordinary measures to stimulate a sharp increase in domestic production.

STRATEGY FOR PROGRAM EXECUTION

The major elements of the strategic approach embodied in the proposed program are:

- Proceed immediately and simultaneously with work on all promising conservation and supply technologies.

- Within each technology, concentrate major effort on the most promising technical approach and keep back-up options advancing at a reasonable pace.

- Pursue most individual research efforts in an accelerated but orderly manner, avoiding the risks of "great leaps forward" that do not materialize; seek, instead, sustained progress toward established objectives.

- Take high risks in a few technologies having very high potential payoffs (e.g., in situ coal gasification and shale retorting and massive fracturing of tight formations containing gas).

- Employ the principle of redundancy: conduct enough parallel efforts to be able to afford failure in some and still attain overall objectives.

- Move toward the capability for self-sufficiency by laying the essential groundwork for a production program based on improved technologies.

A MODEL FOR INTEGRATING RESEARCH AND DEVELOPMENT AND PRODUCTION EFFORTS

One major departure from the conventional approach to research and development is proposed: a Synthetic Fuels Pioneer Program. This effort would begin construction in FY 1975 of a number of commercial-scale plants using existing technologies to produce commercial quantities of synthetic fuels from coal. Program objectives are to:

- Demonstrate the Nation's determination to regain and maintain energy self-sufficiency through an action program that produces commercial quantities of synthetic fuels.

- Lay the technical, engineering, and production groundwork required to support rapid acceleration of synthetic-fuel domestic production if required.

- Adapt proven technologies for synthetic-fuel production to United States conditions.

- Identify by experience the nature and magnitude of the technical, environmental, and economic problems that require priority research and development attention.

- Assign hand-picked teams of scientists, engineers, and technicians to break major bottlenecks to increased productivity and to learn to control and treat adverse environmental effects.

- Establish, based on sustained full-scale operation, technical, engineering, and economic benchmarks for evaluating improvements that result from research and development programs.

- Provide a bridge between the research and development community and the production sector that will facilitate the exchange of information, ideas, and experience gained under full-scale operational conditions.

Major features of the program would be that:

- Federal guarantees of prices or loans under the Defense Production Act or such other authority as may be appropriate would ensure the commercial viability of the plants.
- Exceptions to normal permit requirements would be granted under the authority of emergency energy legislation.
- Defense Production Act or other authority would be used to allocate materials and components on a priority basis to begin construction of these plants in FY 1975 with the objective of having them in full production by the end of FY 1976.
- Plants would be built, owned, and operated by private commercial concerns or consortia; no major Federal construction monies would be required.
- Federal research and development funds in the amount of $355 million would be earmarked for extra construction costs incurred for modifications required to support experimental testing of advanced design components ($100 million) and for research and testing operations ($255 million).
- There would be wide dissemination of the engineering, production, economic, safety, environmental, and other data acquired from operating the plants.
- Plants would be available to the Government for experimentation and evaluation of new techniques, materials, and components on the basis of cost reimbursement to the operator.
- Necessary measures would be taken to contain any adverse environmental impacts within the immediate locale of the plants; this action would provide an ideal experimental base for research into methods of environmental protection and restoration. Industry would bear the costs of containment, and Government would share research costs with industry.

Compared to the total national requirement, the actual production impact of the Synthetic Fuels Pioneer Program would be modest. Its chief benefits would be the knowledge and experience gained that would provide a credible capability for rapid expansion of production if required. This would provide for better integration of the research and development and production programs.

Examples of the kinds of plants that could be included in the program are:

- Pipeline-quality (high-BTU) gas plants using the Lurgi process
- Low-BTU gas plants using the Koppers-Totzek process

- Solvent-refined-coal plants
- Oil from shale plants
- Methanol plant
- Plants to produce hydrogen, ammonia, olefins, diolefins, aromatics, and other petrochemicals.

Details of program implementation remain to be worked out, but discussions with industry representatives indicate that the proposed program could expect an enthusiastic reception from industry. It is strongly recommended as an action program that promises increased production, increased knowledge, and an increasingly realistic and productive interaction between Government and industry based on hard facts derived from commercial-scale operations.

RECOMMENDED FY 1975 BUDGET

Table 2-3 summarizes the FY 1975 Federal budget recommendations by task and displays for comparison purposes corresponding Federal obligations made in FY 1973 and planned for FY 1974. Several features of the program are evident in Table 2-3.

Table 2-3.—FEDERAL ENERGY RESEARCH AND DEVELOPMENT OBLIGATIONS BY MAJOR PROGRAM ELEMENT, FY 1973-1975

Self-Sufficiency Task	($ Millions) Actual FY 73	Planned FY 74	Recommended FY 75	Percent Increase FY 73-75
1. Conserve Energy and Energy Resources	52.8	62.3	166.2	215%
2. Increase Domestic Production of Oil and Gas	20.0	19.5	51.7	159%
3. Substitue Coal for Oil and Gas on a Massive Scale	88.8	167.2	405.0	356%
4. Validate the Nuclear Option	395.8	517.3	731.7	85%
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible	82.8	123.0	217.5	162%
TOTAL	640.2	889.3	1,572.1	146%

- A very substantial acceleration of the upward trend (begun in FY 1974) of Federal energy research and development obligations is proposed. Annual Federal research and development funding would more than double over FY 1973 and would increase by more than three quarters (77%) over FY 1974.

- The largest percentage increase (356%) would be devoted to the use of coal, the Nation's most plentiful energy resource.

- Energy conservation and efforts to use renewable resources would receive major increases.

- The funding increase recommended for oil and gas production reflects the vigorous private research and development programs in that industry and the advanced state of technology that has resulted. Recommended Federal efforts are intended as supplements to selected key areas, including resource assessment, needed to round out an ongoing private program.

- The fission power program would receive a modest increase, much of it aimed at speeding up the availability of electricity from nuclear power plants. This reflects in part the generous level of funding for the nuclear program over past years compared to other programs.

NEED FOR CONTINUING PROGRAM REVIEW

One crucial point deserves emphasis. The FY 1975 budget recommendations are presented with high confidence that they are the right first step in the five-year program. The five-year funding levels are presented with confidence that they represent a sound plan based on what is now known for the five-year period. The actual five-year obligations will be different from those recommended here because the rate at which progress will occur in each program element is unforeseeable.

The entire program should be evaluated at least annually and funds reallocated among surviving programs. If circumstances justify, the $10 billion, *which now appears sufficient*, should be expended earlier than planned, and the total cost of the five-year program should be increased to fund essential research and development. In no case should the planning figures for the later years of the proposed program, or even the total program figures, be either a floor or a ceiling on program funding. Rather, each program should be funded on its merits, accelerated when it succeeds, and terminated or cut back severely when it fails after a reasonable amount of effort. These determinations should be made as part of a total program review, not on a project-by-project basis.

SUMMARY OF FEDERAL PROGRAM ELEMENTS

The following sections contain summaries of the work planned in the principal program elements of each self-sufficiency task. A more detailed budget display for the Federal Energy Research and Development Program is presented in Table 2-4, and subprograms are explained in Appendix A. The major subprograms and funding levels are summarized below in accord with the five major tasks and their short-term, mid-term, and long-term objectives. Tables 2-5 through 2-10, found at the end of the descriptive material, provide summaries for each Fiscal year, FY 1975 through FY 1979, and for the total program of total obligations, operating expenses, equipment obligations, and construction obligations.

Table 2-4.—FEDERAL ENERGY RESEARCH AND DEVELOPMENT OBLIGATIONS BY INDIVIDUAL PROGRAM ELEMENT, FY 1973-1979

	($ Millions)			
Self-Sufficiency Task	Actual FY 73	Planned FY 74	Recommended FY 75	Recommended FY 75-79 Program
1. Conserve Energy and Energy Resources	52.8	62.3	166.2	1,440
Reduced Consumption	12.1	22.3	29.9	210
Increased Efficiency	40.7	40.0	136.3	1,230
2. Increase Domestic Production of Oil and Gas	20.0	19.5	51.7	460
Production	12.8	11.2	31.7	310
Resource Assessment	7.2	8.3	20.0	150
3. Substitute Coal for Oil and Gas on a Massive Scale	88.8	167.2	405	2,175
Mining			45	325
Direct Combustion			30	200
Synthetic Fuels			240	1,270
Common Technology			90	380
4. Validate the Nuclear Option	395.8	517.3	731.7	4,090
Safety, Enrichment, HTGR, and Other	129.7	151.7	216.2	1,245.7
Breeder	266.1	365.6	515.5	2,844.3
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible	82.8	123	217.5	1,835
Fusion	74.8	98.7	145.0	1,450
Solar	4.2	13.2	32.5	200
Geothermal	3.8	11.1	40.0	185
TOTAL	640.2	889.3	1,572.1	10,000
Supporting Programs (incremental Federal funding to present programs)				
Environmental Effect			105.9	650
Basic Research			43.0	300
Manpower Development			5.0	50
			$153.9	$1,000

	($ Millions) FY 75	FY 75-79
Task 1. Conserve Energy and Energy Sources	**$166.2**	**1440.0**
A. Reduced Consumption	**29.9**	**210.0**
1. End-Use Consumption	**19.9**	**150.0**

Major studies will be conducted to determine energy use patterns in building conditioning, industrial processes, transportation systems, integrated utility systems, and patterns across energy sectors. Information gained should provide opportunities for initiating or developing energy-conserving designs, construction, and operating practices.

2. Improved Management	**10.0**	**60.0**

A vigorous effort will be launched to coordinate the activities of the many government departments and agencies that have been compiling data pertaining to the U.S. energy system. Existing systems models will be improved or new models developed, and the data base will be greatly enlarged and kept current. The systems approach and models will be used to assess new technologies and to provide quantitative analysis of alternative energy policies, energy research and development strategies, and energy system configurations.

B. Improved Efficiency	**136.3**	**1230.0**
1. High-Temperature Gas Turbine	**18.3**	**315.0**

In conjunction with conventional steam turbines, combined cycles can be formed that produce greater thermal efficiencies than the steam turbine cycle alone. An open-cycle high-temperature gas turbine will be built to operate in a 100-MW(e) combined-cycle demonstration power plant by 1979. A 2- to 3- MW(e) power plant demonstration unit will be used to assess space heating from power plant waste heat; if successful, the Department of Housing and Urban Development will use such units in model energy-conserving housing developments. A special helium direct-cycle gas turbine facility will be built to develop turbines for use with the high-temperature gas-cooled nuclear reactor.

2. Advanced Cycles, Fuel Cells, and Other Concepts .	**18.0**	**210.0**

Potassium vapor and magnetohydrodynamic "topping" cycles can also form combined cycles for steam turbines. A 30-MW(e) potassium vapor topping unit will be built and operated by 1979 as a pilot plant. Fuel cells of considerable variety will be assessed in pilot plants. The use of wastes as fuels and basic generator research for magnetohydrodynamics are included in this program.

		($ Millions) FY 75	FY 75-79
3.	**Advanced Auto Propulsion**	53.0	300.0

Advances in fuel economy and reductions in pollutant emissions using feasible state-of-the-art technologies will be sought and demonstrated for automotive engines. Results will serve to define regulatory standards. Several propulsion and vehicle systems will be evaluated, two of which will be brought to the engineering development phase. Prototype batteries, motors, controls, and power conditioning equipment will be demonstrated by FY 79. Nonpetroleum energy sources will be investigated.

4. **Rail, Bus, Ship, and Air** 20.0 205.0

Two major demonstrations are planned to evaluate integrated bus transit systems in large cities. Intermodal transfer of freight from truck to rail will be investigated. New aircraft and ship designs with low drag characteristics will be evaluated and the feasibility of nuclear-powered commercial ships will be examined.

5. **Energy and Fuel Transportation and Storage** 27.0 200.0

A joint government-industry development program is expected to produce prototype demonstration projects for 1100-kV a-c overhead transmission systems and a 100-MW d-c terminal system by 1979. Four improved types of underground cables will be developed for commercial use in that period. Battery development will continue, with emphasis on the sodium-sulfur and lithium-sulfur designs. A 10-MW pilot model of the more promising design will be built for testing at practical storage levels. The concepts of storing energy in a superconducting magnet or a flywheel will be examined to the point of engineering development. Advanced marine transportation systems will be explored to increase availability and distribution of domestic fuel sources.

The savings in oil equivalent that can be expected from attainment of the objectives of the program in Task 1 are 4.7 million barrels/day of oil by 1980 and 7.0 by 1985.

Task 2. Increase Production of Oil and Gas **$51.7** **$460.0**
(including resource assessment)

A. **Resource Assessment** 20.0 150.0

New and improved techniques and equipment will be developed and tested to aid the assessment of potentially discoverable resources of fossil and nuclear fuels and supporting elements; to promote their discovery and conversion to reserves; and to determine the quality and usable quantity of coal, oil shale, and tar sands. Data will guide Federal leasing policy and stimulate accelerated exploration by industry.

	($ Millions) FY 75	FY 75-79
B. Secondary and Tertiary Recovery	10.7	70.4

In a joint program with industry, 15 types of reservoirs will be tested with combinations of four methods for secondary and tertiary recovery of residual reserves. Twenty separate experiments will be conducted. Analysis of results is expected to determine economic feasibility for a variety of particular reservoir types.

C. Stimulation of Low Permeability Formations	9.1	96.3

Fluid or hydrofracturing and chemical-explosive fracturing techniques will be tested on a scale not previously tried in an attempt to stimulate low-permeability gas reservoirs that cannot be economically tapped using conventional completion techniques. Seven experiments are planned in three different reservoirs. One further nuclear stimulation demonstration is planned. The program is designed to determine which stimulation technique or combination is most suitable for particular reservoir characteristics.

D. Advanced Drilling	2.6	15.5

Development will be continued on jet drilling techniques and equipment and spark cavitation drilling concepts to increase deep drilling rates. Development of reliable downhole power supplies of up to 100 hp will be pursued. Blowout control and oil-spill cleaning methods will be assessed and improved.

E. Oil-Shale Processing	9.3	127.8

In situ retorting of oil shale will be tested in the Rocky Mountains, using a combination of several different fracturing techniques and retorting conditions. The recovery rates for each combination and the control problems encountered will be analyzed to determine optimal technical design.

The attainment of the objectives of the programs under Task 2 will guarantee the previously projected supply, equivalent to 21.5 million barrels/day of oil, and contribute an **additional** supply, equivalent to 0.5 million barrels/day by 1980 and 5.1 million barrels/day by 1985.

Task 3. Substitute Coal for Oil and Gas	$405.0	$2175.0
A. Mining	45.0	325.0

New and improved techniques for surface and underground coal and oil-shale mining that would increase productivity and recovery rates and at the same time meet environmental and health standards will be developed and tested in demonstration mines. Integrated mining reclamation methods will be applied to acid Eastern and arid Western surface-mined areas to find optimum techniques for each region.

	($ Millions) FY 75	FY 75-79
B. **Direct Combustion**	30.0	200.0

Pilot, demonstration-scale, and module plants having a pressurized fluid-bed combustion system will be constructed. A companion effort through the demonstration scale will be conducted in atmospheric fluid-bed systems. Combustion modifications will be made in conventional coal- and oil-burning boilers and furnaces to improve the efficiency of combustion under environmentally acceptable conditions.

C. **Synthetic Fuels**	240.0	1270.0
1. **High-BTU Gasification**	35.0	340.0

Four pilot plants for testing advanced technologies will be built. The best features will be incorporated into a demonstration plant by 1979. Knowledge gained from building and operating plants with existing technologies, under the Synthetic Fuels Pioneer Program, should stimulate progress in this area.

2. **Coal Liquefaction**	75.0	375.0

Three pilot plants to test advanced processes for coal liquefaction will be constructed, and a design for a major demonstration plant is expected by 1979.

3. **Low-BTU Gasification**	30.0	200.0

Entrained-bed and fluidized-bed methods for gasifying coal will be tested through demonstration-plant operation in a joint government-industry program of research and development. Three to five other promising approaches to gasification will be tested on a pilot scale.

4. **Synthetic Fuels Pioneer Program**	100.0	355.0

This aggressive new program will immediately begin construction of full-scale commercial plants using existing technologies for producing synthetic fuels from coal. The Lurgi gasification technique and the Fischer-Tropsch liquefaction method will be employed, and a combined process for methanol production will be included. Funding will be derived almost exclusively from private industry, with guaranteed prices or loans as incentives. These will be provided under the Defense Production Act or other authority. Federal research and development funds will be added for investigating processes, testing modifications that appear promising, and disseminating findings. Benchmarks will be established for engineering performance, economic parameters, and environmental aspects of commercial operations. This ambitious production program is expected to accelerate specific research and development efforts related directly to commercial-scale operations and to speed up the implementation of new advances.

	($ Millions) FY 75	FY 75-79
D. Common Technology	90.0	380.0
1. Environmental Control Technology	70.0	260.0

Program emphasis is on the development of advanced flue-gas desulfurization processes that reduce requirements for sludge handling and control and recover elemental sulfur. A major effort will be made to complete and operate several lime/limestone pilot units attached to coal-fired electric generating plants.

The relatively new program directed toward identifying and controlling fine-particulate emissions will be accelerated. Approximately half the funding will be directed to the construction of pilot and demonstration units and instrumentation required to assess the dimensions of this problem and the success of tested processes.

Chemical and mechanical cleaning processes applied to raw coal are expected to remove up to half the organic sulfur. The TRW Meyers process seems promising for such cleaning and will be tested.

Fuel-conversion process-control research and development efforts will identify trace-element emissions that are expected to be present in significant quantities when large volumes of coal are processed. Little is known about their characteristics and control. The program will determine the pollutant effluents and their rates of release and develop processes for control so that the technology can be applied in early commercial-scale plants.

Residues from coal processing will create massive disposal problems that could impact heavily on the environment. Methods for treating, revegetating, or otherwise mitigating harmful or undesirable effects will be sought. In situ coal gasification will be examined as a means of reducing environmental problems.

	FY 75	FY 75-79
2. Supporting Research and Development	20.0	120.0

Essential and urgent efforts in developing fittings, pipes, and other hardware; enhancing supplies of hydrogen; and characterizing materials are required to support the main programs in coal research. Coal conversion processes will operate at high temperatures, contain corrosive and abrasive materials, and may include high pressures. To be economic, the processes must run for long periods without overhaul or replacement of major parts. Materials and components that can survive under such conditions must be engineered and tested. In many cases, basic metallurgy problems must be solved. Undoubtedly, new problems will be identified through operation of pilot and demonstration plants and the commercial-scale plants in the Synthetic Fuels Pioneer Program. Hydrogen used in coal conversion processes to enrich the BTU content of the products is produced from the coal or from process water. Current methods are costly or use large quantities of feed stock. Theoretical and empirical efforts will be needed to develop better catalytic methods to produce hydrogen from water.

The attainment of the objectives of the programs under Task 3 will guarantee the previously projected supply, equivalent to 9.1 million barrels/day of oil, and contribute an **additional** supply equivalent to 0.5 million barrels/day by 1980. By 1985 the projected supply of 11.4 million barrels/day will be increased by 2.5 million barrels/day.

	($ Millions) FY 75	FY 75-79
Task 4. Validate the Nuclear Option	**$731.7**	**$4090.0**
A. Safety, Enrichment, HTGR, Other	**216.2**	**1245.7**
1. Safety—Reactors and Fuel Handling	**90.6**	**719.2**

Theoretical and experimental investigations will be conducted to determine component failure and accident probabilities for nuclear reactors. Practical results derived from the Loss of Fluid Test Facility (LOFT) will yield data necessary for the design and engineering of safety features and the establishment of regulatory standards.

An engineered waste-storage facility will be constructed, and a pilot facility in bedded salt will be developed to assess the disposal of long-lived radioactive wastes in geologic formations. Ancillary solidification processes will be tested. Methods for elimination of krypton, tritium, and transuranic components of reactor and reprocessing effluents will be tested.

A dry cooling tower to replace liquid cooling will be investigated in Wyoming in a joint government-industry venture. Standardized criteria for nuclear reactor siting will result from an in-depth assessment of the relationship between site characteristics and construction and operating experience, hopefully expediting future installations.

2. Uranium Enrichment	**64.2**	**294.2**

The search for more-efficient uranium enrichment processes will include development aimed at improving the gaseous diffusion process, demonstrating the commercial feasibility of the gas centrifuge method, and exploring the technical feasibility of isotope separation using lasers. The centrifuge test facility and ancillary facilities will be completed.

		($ Millions) FY 75	FY 75-79
3.	**High-Temperature Gas Reactor (HTGR)**	40.0	163.8

The base program for the HTGR will continue the development of components and will review safety features. Reprocessing and refabrication pilot plants will be built to complete needed research and development on the ^{233}U-thorium cycle. This work will enlarge the potential fuel supply by adding the abundant element thorium to uranium as a reactor fuel.

4.	**Light Water Self-Sustaining Reactor**	21.4	68.5

An experimental core for this reactor will be tested in the Shippingport facility. Success of this concept will offer a way to make the light-water reactor fuel cycle self-sustaining through conversion to the ^{233}U-thorium cycle.

B.	**Breeders**	515.5	2844.3
1.	**Liquid Metal Fast Breeder Reactor (LMFBR)** ...	477.0	2556.6

A comprehensive LMFBR technology effort includes support of the Fast Flux Test Facility and support of a 300-MW(e) LMFBR demonstration power plant scheduled for operation in 1980 as a joint government-industry venture. The LMFBR base program includes continued development of fuels and studies of their behavior under different conditions. Engineering and safety aspects will be analyzed at a variety of specialized facilities. These include an advanced fuels laboratory, a steam-generator test facility, a safety test facility, and a transient safety test facility. The suitability of various methods for handling and transporting plutonium will be assessed to generate appropriate standards.

2.	**Gas Cooled Fast Reactor (GCFR)**	17.0	140.0

The program for the GCFR will provide required technology on fuel and reactor-core development, physics, and safety. A low level of effort will also be expended on the molten-salt breeder program.

3.	**Advanced Technology**	21.5	147.7

This work is planned to develop new breeder fuel and materials that can increase breeding ratios and power ratings and decrease the conservatism presently required in breeder designs. Neutron cross-section information needed for the design of fast reactors will be developed.

The attainment of the objectives of the programs under Task 4 will guarantee the previously projected supply equivalent to 3.6 million barrels/day of oil, and contribute an **additional** supply equivalent to 0.2 million barrels/day by 1980. By 1985 these programs will guarantee the previously projected supply of 7.1 million barrels/day of oil equivalent and add 0.6 million barrels/day of oil equivalent.

	($ Millions) FY75	FY75-79
Task 5. Exploit Renewable Energy Sources	$217.5	$1835.0
A. Fusion	145.0	1450.0
1. Magnetic Confinement	135.0	1340.0

Recent successes in fusion-related experiments confirm that the program should move to the next level of orderly experimental development. Computer-analyzed theoretical studies of fusion-relevant plasmas in various confinement configurations will be performed to understand the equilibrium, stability, and transport properties of the plasmas. Facilities will be constructed to test plasma shapes, neutral-beam heating, scaling, and improved confinement. Fusion plasmas create neutron, neutral, charged-particle, and photon environments that have adverse effects on most materials. Basic and applied research will be directed at finding compatible materials that can be fabricated for use in fusion reactors.

2. Laser Fusion 10.0 110.0

This subprogram will extend the theoretical base established in the military-oriented laser fusion program. An experimental demonstration of significant thermonuclear burn and of scientific break even for the method is scheduled.

B. Solar 32.5 200.0

1. Heating and Cooling of Buildings 12.8 50.0

Solar heating and cooling of buildings is entering the pilot-plant stage. Applicability studies, design-criteria development, and component testing will be conducted on a much enlarged scale. Operating pilot systems will be installed in single-family and multifamily dwellings, in agricultural buildings, and in commercial and industrial buildings. This effort could provide the basis for an industry prepared to manufacture solar-energy heating and cooling systems in large quantities. Component development is expected to increase reliability and decrease costs.

2. Solar Thermal Conversion 5.0 35.5

Major emphasis in this subprogram will be placed on the research and development of key subsystems for the optical-transmission central-receiver tower approach. Three system-design efforts will be conducted in parallel. Design, hardware procurement and integration, and testing of a 10-MW(e) pilot plant will be achieved.

		($ Millions) FY 75	FY 75-79
3.	**Wind Energy Conversion**	6.2	31.7

A series of experimental wind generator systems in increasing size and performance capability will be constructed and tested. Multi-unit wind generator systems making up a wind "farm" up to 10 MW(e) will be built late in the program period.

4. **Ocean Thermal Conversion** 1.9 26.6

Emphasis will be placed on design, production, and testing of system components. Key elements that will require significant adaptation of existing technology include the heat exchanger, deep-water pipe, and overall plant structural design.

5. **Photovoltaic Conversion** 4.2 35.8

The photovoltaic program will concentrate on the single-crystal silicon approach, with a modest effort on alternative materials and concepts. Major improvements in materials and processes are needed to permit automated production of cells and to accomplish significant cost reductions.

6. **Bioconversion** 2.4 20.4

The construction and operation of one small-scale pilot plants involves the conversion of wastes into methane and clean fuels. Later in the program period a 10-ton/day urban waste pilot plant will be constructed. Laboratory-scale studies of methods for converting various organic materials, particularly including biomass production, will also be studied.

C. **Geothermal** 40.0 185.0

1. **Resource Assessment and Exploration** 9.7 49.2

Activities include the development and field use of new and improved geophysical, geochemical, geologic, and hydrologic instrumentation and techniques to locate and evaluate geothermal resources. Improved prospecting and evaluation methods should allow more confident prediction of the energy potential of individual wells and entire fields. Assurance that a significant (20 to 30 year) supply of geothermal energy is available for plant operation is essential in inducing potential users to invest in power plant development.

2. **Environmental, Legal, and Institutional Research** .. 3.4 10.9

The effects of potential earth-tremor effects that might result if geothermal resources are extracted will be analyzed. Recirculation methods may maintain in situ conditions and obviate such problems. Minerals, salts, and noxious gases may be prominent by-products of the extraction procedures and must be monitored and eliminated. Technology transfer will be encouraged by cooperative arrangements with industry, and special attention will be given to the institutional, legal, social, and environmental issues bearing on utilization of these novel sources of energy.

	($ Millions) FY 75	FY 75-79
3. **Resource Utilization**	16.9	78.6

Several different types of geothermal resources will be examined: high-temperature low-salinity and high-salinity convective wells, geopressured sedimentary systems, low-temperature convective wells, hot dry rock, and normal geothermal gradients. Four different demonstration plants will be completed and a fifth plant will be started. Each type of resource poses special problems in location and distribution, reservoir analysis, environmental hazards, energy conversion and utilization, and severity and solution time of technical questions involved in bringing the resource to on-line production. Each experimental facility, therefore, will serve as a flexible test bed for research and engineering development, as well as for demonstrations of electrical generation and other uses of geothermal heat. Technology transfer will be encouraged by cooperative arrangements with industry.

4. **Advanced Research and Technology**	10.0	46.3

Major technical problems to be solved are concerned with drilling in hostile geothermal environments, methods of well completion, materials and equipment for extracting corrosive fluids, monitoring and controlling emissions and wastes, and developing practical binary cycles that use low-temperature working fluids.

The attainment of the objectives of the programs under Task 5 will guarantee the previously projected supply, equivalent to 0.8 million barrels/day of oil, and contribute an additional supply equivalent to 0.2 million barrels/day by 1980. By 1985 it will guarantee the previously projected supply of 1.0 million barrels/day and add 0.8 million barrels/day of oil equivalent.

SUPPORTING PROGRAMS (Incremental Funding)	**$153.8**	**$1000.0**
A. **Environment**	105.9	650.0

These programs aim to provide a sound scientific and technical basis for ensuring that potential environmental and health insults will be recognized and effectively controlled as policies to regain and maintain self-sufficiency are implemented.

1. **Pollutant Characterization, Measurement, and Monitoring**	13.3	96.3

The chemical and physical characteristics of by-products associated with each phase of existing and new energy systems from extraction through utilization of the energy will be identified. Methods will be improved or developed for measuring and monitoring ambient and source levels of airborne sulfur oxides, fine particulates, sulfates, krypton, strontium, tritium, waterborne nitrates, and cyanides released by energy systems.

	($ Millions) FY 75	FY 75-79
2. **Environmental Transport Processes**	20.5	110.0

Field studies will be conducted to determine the relationships between emissions of thermal, chemical, and radioactive pollutants and the resulting environmental concentrations by accounting for the pathways of these substances from the energy-system emitter to ultimate fate in the atmosphere or in fresh or marine waters.

3. **Effects: Health, Ecological, Welfare, and Social** ..	69.1	413.7

These studies are intended to strengthen the scientific basis for existing and new air and water quality standards, to define the effects of simultaneous exposure to number of pollutants, and to determine long-term low-level effects of fossil-fuel and radioactive pollutants. Ecological research will assess the impact of coal, oil shale, uranium, and geothermal extraction techniques; of emissions released from energy conversion and reprocessing plants; of waste-heat release and antifouling additives; and of entrainment and impingement in cooling systems. The effects of environmental pollution on the general social welfare will be investigated in studies of public attitudes and values and in physical analyses of artistic works and building materials.

4. **Environmental Assessment and Policy Formulation**	3.0	30.0

Mechanisms will be developed to evaluate the institutional, economic, sociological, and technical implications of environmental impacts and controls and to calculate cost-benefit relationships. Such analyses of alternative energy systems and research and development proposals should permit rational integration of environmental considerations into the energy-policy decision-making process.

B. **Basic Research**	43.0	300.0

These programs are designed to explore phenomena, processes, and techniques in physical, chemical, biological, environmental, and social sciences affecting energy to ensure the development of new basic knowledge. Discoveries of new concepts may revolutionize energy production and utilization.

		($ Millions) FY 75	FY 75-79
1.	**Materials**	8.0	55.0

This work is directed toward understanding the reactions of materials subjected to high temperature, thermal shock, radiation in various forms, and corrosives. Super-conducting materials for very long distance electrical transmission, ion conductance phenomena, and properties of ceramic materials will be investigated.

2.	**Chemical, Physical Engineering**	16.0	110.0

The production of hydrogen and hydrocarbons by thermochemical, photochemical, and biochemical processes from nonfossil sources including water will be stressed. Efforts will be supported to gain understanding of hydrogen storage systems, principally hydrides; of catalysis and the roles of surfaces; of kinetic and heat-transfer processes that affect combustion efficiences; of thermodynamic properties of reactants and carriers important in the energy system; of atmospheric and oceanic mixing; of separation processes; and of methods for detecting the distribution of trace elements and pollutants.

3.	**Biological**	12.0	80.0

Basic knowledge will be acquired to convert organic wastes to usable fuels and to detoxify energy-related wastes. Hydrology and climatology, ecosystem interactions, and environmental geology will receive attention.

4.	**Plasmas**	3.0	20.0

Fundamental research into plasmas and their response to electromagnetic fields and radiation will aid in the development of direct energy conversion systems, orbital solar stations, colliding-beam fusion reactions, and the potential use of kinetic and rotational energies of ocean and planetary movements. Plasma physics is essential, of course, to the entire fusion program.

5.	**Mathematical and Social**	4.0	35.0

Modeling of the entire energy system will require mathematical and computer techniques to handle large and complex technical and socioeconomic data bases in order to understand the effect of technological developments and policy decisions on the energy system. To better understand future energy requirements, social and psychological responses of people, including motivational studies, and national attitude analyses may be helpful. Finally, analysis of the effects of national regulatory policies and international relations on the dynamics of both energy research and development and production will require novel methodologies.

	($ Millions) FY 75	FY 75-79
C. Manpower Development	5.0	50.0

While the potential for redistribution of technical manpower is high, reorientation or retraining will be necessary, and major growth in the longer term must be ensured. The proposed funding level will support a program that would reach over 2000 persons annually, many of them faculty and managers responsible for the education and training of the future manpower pool.

1. **Faculty Orientation**	1.5	7.5

Institutes, special courses, workshops, conferences, and off-campus appointments for university faculty currently teaching courses in science or technology or conducting research in these fields will be organized and supported.

2. **Managerial Training and Orientation**	0.5	2.5

Courses and workshops for managers will orient them to particular problems in augmenting the technical manpower forces under their control.

3. **Student and Postgraduate Support**	1.5	20.0

Support will be directed toward undergraduate and postgraduate students pursuing science and engineering. Traineeships, scholarships, research stipends, and postdoctoral fellowships will be required in energy and energy-related areas.

4. **Industry/Labor Manpower Development Program**	1.5	20.0

A cooperative program with national laboratories and contractors will lead to retraining and reorientation of technical workers whose skills are presently inappropriate to specific needs in energy-related industries. Government funding will support external educational assistance, manpower increases needed to conduct training, and training period stipends.

The incremental funding provided in these areas of environmental research, multidirectional research, and manpower development represents vital support for the near and longer term energy research and development and implementation efforts. Additional program detail is in Appendix A.

Table 2-5.—SUMMARY SCHEDULE OF FEDERAL ENERGY RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979, BY TASK
($ Millions)

Self-Sufficiency Task	FY 73	FY 74	FY 75-79 Energy Research and Development Programs						FY 75-79 Agency Projections
			FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79	
1. Conserve Energy and Energy Resources									
Reduced Consumption	12.1	22.3	29.9	43.7	51.5	44.4	40.5	210.0	15.0
Increased Efficiency	40.7	40.0	136.3	223.4	267.0	287.8	315.5	1230.0	80.0
Subtotal	52.8	62.3	166.2	267.1	318.5	332.2	356.0	1440.0	95.0
2. Increase Domestic Production of Oil and Gas									
Production	12.8	11.2	31.7	89.1	79.5	59.5	50.2	310.0	50.0
Resource Assessment	7.2	8.3	20.0	23.0	29.5	37.5	40.0	150.0	40.0
Subtotal	20.0	19.5	51.7	112.1	109.0	97.0	90.2	460.0	90.0
3. Substitute Coal for Oil and Gas on a Massive Scale									
Mining			45.0	57.0	64.0	77.0	82.0	325.0	
Direct Combustion			30.0	35.0	40.0	44.0	51.0	200.0	
High-BTU Gasification			35.0	75.0	92.0	81.0	57.0	340.0	
Coal Liquefaction			75.0	75.0	75.0	75.0	75.0	375.0	
Low-BTU Gasification			30.0	37.0	42.0	48.0	43.0	200.0	
Synthetic Fuels—Industry Pioneering			100.0	100.0	55.0	50.0	50.0	355.0	
Environmental Control Technology			70.0	50.0	42.0	45.0	53.0	260.0	
Supporting Research and Development			20.0	22.0	24.0	27.0	27.0	120.0	
Subtotal	88.8	167.2	405.0	451.0	434.0	447.0	438.0	2,175.0	842.0
4. Validate the Nuclear Option									
Safety and Other	42.7	51.7	90.6	125.6	143.0	170.5	189.5	719.2	609.9
Uranium Enrichment	50.3	56.8	64.2	54.8	57.4	58.4	59.4	294.2	284.5
High Temperature Gas Reactor	7.2	14.2	40.0	44.7	24.2	26.9	28.0	163.8	128.6
Light Water Self-Sustaining Reactor	29.5	29.0	21.4	17.7	9.8	9.8	9.8	68.5	68.5
Liquid Metal Fast Breeder Reactor	253.8	356.8	477.0	538.6	510.8	524.2	506.0	2,556.6	2,470.6
Gas Cooled Fast Breeder	1.0	1.0	17.0	23.0	29.0	33.0	38.0	140.0	27.0
Advanced Technology	11.3	7.8	21.5	24.5	30.5	34.0	37.2	147.7	83.2
Subtotal	395.8	517.3	731.7	828.9	804.7	856.8	867.9	4,090.0	3,672.3
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible									
Fusion—Confinement	39.7	55.8	135.0	230.0	261.0	338.0	376.0	1,340.0	1,132.0
Fusion—Laser	35.1	42.9	10.0	20.0	25.0	25.0	30.0	110.0	
Solar	4.2	13.2	32.5	39.9	41.4	42.2	44.0	200.0	80.0
Geothermal	3.8	11.1	40.0	41.0	40.8	35.7	27.5	185.0	20.0
Subtotal	82.8	123.0	217.5	330.9	368.2	440.9	477.5	1,835.0	1,232.0
TOTAL	640.2	889.3	1,572.1	1,990.0	2,034.4	2,173.9	2,229.6	10,000.0	5,931.3

Table 2-6.—SUMMARY SCHEDULE OF FEDERAL ENERGY RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

	FY 75-79 Energy Research and Development Programs					
	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
Operating Expenses	1,062.1	1,311.0	1,451.4	1,519.3	1,618.8	6,962.6
Equipment	160.7	233.4	211.3	242.4	250.3	1,098.1
Construction	349.3	445.6	371.7	412.2	360.5	1,939.3
TOTAL	1,572.1	1,990.0	2,034.4	2,173.9	2,229.6	10,000.0

Table 2-7.—OPERATING EXPENSES FOR FEDERAL ENERGY RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

	FY 75-79 Energy Research and Development Programs					
Self-Sufficiency Task	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
1. Conserve Energy and Energy Resources						
Reduced Consumption	26.6	34.3	38.2	36.6	35.2	170.9
Increased Efficiency	112.2	155.5	178.8	190.2	216.0	852.7
Subtotal	138.8	189.8	217.0	226.8	251.2	1,023.6
2. Increase Domestic Production of Oil and Gas						
Production	26.0	70.2	67.6	51.6	45.9	261.3
Resource Assessment	14.8	19.8	24.7	31.5	33.7	124.5
Subtotal	40.8	90.0	92.3	83.1	79.6	385.8
3. Substitute Coal for Oil and Gas on a Massive Scale						
Mining	28.5	34.5	36.0	41.5	45.5	186.0
Direct Combustion	12.8	18.4	10.9	12.4	13.3	67.8
High-BTU Gasification	12.5	24.0	47.0	49.0	53.0	185.5
Coal Liquefaction	52.0	38.0	38.0	40.0	45.0	213.0
Low-BTU Gasification	3.8	5.0	7.[illegible]	10.0	14.0	39.8
Synthetic Fuels—Industry Pioneering	46.0	45.5	50.0	44.5	44.0	230.0
Environmental Control Technology	42.0	25.0	22.0	30.0	47.0	166.0
Supporting Research and Development	18.0	20.0	21.5	24.0	24.0	107.5
Subtotal	215.6	210.4	232.4	251.4	285.8	1,195.6
4. Validate the Nuclear Option						
Safety and Other	74.8	88.5	104.6	117.6	130.6	516.1
Uranium Enrichment	44.1	47.0	48.0	49.0	50.0	238.1
High-Temperature Gas Reactor	20.8	21.3	22.8	25.3	26.3	116.5
Light Water Self-Sustaining Reactor	21.1	17.4	9.3	9.3	9.3	66.4
Liquid Metal Fast Breeder Reactor	303.6	361.3	380.4	390.6	382.3	1,818.2
Gas Cooled Fast Breeder	13.0	21.4	26.8	30.2	34.6	126.0
Advanced Technology	21.1	23.8	29.2	32.4	35.6	142.1
Subtotal	498.5	580.7	621.1	654.4	668.7	3,023.4
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible						
Fusion—Confinement	112.0	170.0	215.0	235.0	265.0	997.0
Fusion—Laser	8.0	17.0	22.0	22.0	27.0	96.0
Solar	21.2	22.4	21.5	19.3	19.9	104.3
Geothermal	27.2	30.7	30.1	27.3	21.6	136.9
Subtotal	168.4	240.1	288.6	303.6	333.5	1,334.2
TOTAL	1,062.1	1,311.0	1,451.4	1,519.3	1,618.8	6,962.6

Table 2-8.—EQUIPMENT OBLIGATIONS FOR FEDERAL ENERGY RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

Self-Sufficiency Task	FY 75-79 Energy Research and Development Programs					
	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
1. Conserve Energy and Energy Resources						
Reduced Consumption	2.7	6.2	8.7	4.2	3.5	25.3
Increased Efficiency	20.5	41.2	49.0	46.2	47.2	204.1
Subtotal	23.2	47.4	57.7	50.4	50.7	229.4
2. Increase Domestic Production of Oil and Gas						
Production	5.7	18.9	11.9	7.9	4.3	48.7
Resource Assessment	2.7	3.2	4.3	6.0	6.3	22.5
Subtotal	8.4	22.1	16.2	13.9	10.6	71.2
3. Substitute Coal for Oil and Gas on a Massive Scale						
Mining	13.0	16.0	18.5	22.5	30.0	100.0
Direct Combustion	5.1	6.6	9.4	10.2	15.1	46.4
High-BTU Gasification	1.5	1.0				2.5
Coal Liquefaction	5.0	7.0	5.0	6.0	10.0	33.0
Low-BTU Gasification	1.0	1.7	2.0		1.0	5.7
Synthetic Fuels—Industry Pioneering	4.0	4.5	5.0	5.5	6.0	25.0
Environmental Control Technology	10.0	5.0	4.0	4.0	5.0	28.0
Supporting Research and Development	2.0	2.0	2.5	3.0	3.0	12.5
Subtotal	41.6	43.8	46.4	51.2	70.1	253.1
4. Validate the Nuclear Option	13.8	7.1	8.4	8.9	8.9	47.1
Safety and Other	5.1	4.8	6.4	6.4	6.4	29.1
Uranium Enrichment						
High-Temperature Gas Reactor	1.2	1.4	1.4	1.6	1.7	7.3
Light Water Self-Sustaining Reactor	0.3	0.3	0.5	0.5	0.5	2.1
Liquid Metal Fast Breeder Reactor	23.4	33.3	27.4	29.6	40.7	154.4
Gas Cooled Fast Breeder	1.0	1.6	2.2	2.8	3.4	11.0
Advanced Technology	0.4	0.7	1.3	1.6	1.6	5.6
Subtotal	45.2	49.2	47.6	51.4	63.2	256.6
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible						
Fusion—Confinement	23.0	49.0	24.0	58.0	35.0	189.0
Fusion—Laser	2.0	3.0	3.0	3.0	3.0	14.0
Solar	8.3	11.6	11.0	10.1	14.6	55.6
Geothermal	9.0	7.3	5.4	4.4	3.1	29.2
Subtotal	42.3	70.9	43.4	75.5	55.7	287.8
TOTAL	160.7	233.4	211.3	242.4	250.3	1,098.1

Table 2-9.–CONSTRUCTION OBLIGATIONS FOR FEDERAL ENERGY RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

Self-Sufficiency Task	FY 75-79 Energy Research and Development Programs					
	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
1. Conserve Energy and Energy Resources						
Reduced Consumption	0.6	3.2	4.6	3.6	1.8	13.8
Increased Efficiency	3.6	26.7	39.2	51.4	52.3	173.2
Subtotal	4.2	29.9	43.8	55.0	54.1	187.0
2. Increase Domestic Production of Oil and Gas						
Production						
Resource Assessment	2.5		0.5			3.0
Subtotal	2.5		0.5			3.0
3. Substitute Coal for Oil and Gas on a Massive Scale						
Mining	3.5	6.5	9.5	13.0	6.5	39.0
Direct Combustion	12.1	10.0	19.7	21.4	22.6	85.8
High-BTU Gasification	21.0	50.0	45.0	32.0	4.0	152.0
Coal Liquefaction	18.0	30.0	32.0	29.0	20.0	129.0
Low-BTU Gasification	25.2	30.3	33.0	38.0	28.0	154.5
Synthetic Fuels–Industry Pioneering	50.0	50.0				100.0
Environmental Control Technology	18.0	20.0	16.0	11.0	1.0	66.0
Supporting Research and Development						
Subtotal	147.8	196.8	155.2	144.4	82.1	726.3
4. Validate the Nuclear Option						
Safety and Other	2.0	30.0	30.0	44.0	50.0	156.0
Uranium Enrichment	15.0	3.0	3.0	3.0	3.0	27.0
High-Temperature Gas Reactor	18.0	22.0				40.0
Light Water Self-Sustaining Reactor						
Liquid Metal Fast Breeder Reactor	150.0	144.0	103.0	104.0	83.0	584.0
Gas Cooled Fast Breeder	3.0					3.0
Advanced Technology						
Subtotal	188.0	199.0	136.0	151.0	136.0	810.0
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible						
Fusion–Confinement		11.0	22.0	45.0	76.0	154.0
Fusion–Laser						
Solar	3.0	5.9	8.9	12.8	9.5	40.1
Geothermal	3.8	3.0	5.3	4.0	2.8	18.9
Subtotal	6.8	19.9	36.2	61.8	88.3	213.0
TOTAL	349.3	445.6	371.7	412.2	360.5	1,939.3

Table 2-10.—OPERATING EXPENSES AND EQUIPMENT AND CONSTRUCTION OBLIGATIONS FOR FEDERAL SUPPORTING RESEARCH AND DEVELOPMENT PROGRAMS, FY 1975-1979
($ Millions)

	FY 75-79 Energy Research and Development Programs					
	FY 75	FY 76	FY 77	FY 78	FY 79	FY 75-79
Operating Expenses						
Environmental Research	88.5	98.5	111.0	125.7	137.1	560.8
Basic Research	39.0	52.1	59.6	60.7	59.2	270.6
Manpower Development	5.0	9.0	12.5	12.3	11.2	50.0
Subtotal	132.5	159.6	183.1	198.7	207.5	881.4
Equipment Obligations						
Environmental Research	5.9	9.9	10.5	18.7	6.2	51.2
Basic Research	4.0	5.9	6.4	6.3	6.8	29.4
Manpower Development						
Subtotal	9.9	15.8	16.9	25.0	13.0	80.6
Construction Obligations						
Environmental Research	11.5	13.5	7.0	3.0	3.0	38.0
Basic Research						
Manpower Development						
Subtotal	11.5	13.5	7.0	3.0	3.0	38.0
TOTAL	153.9	188.9	207.0	226.7	223.5	1,000.0

3

Energy Supply and Demand

The goals of the energy research and development program can be deduced from a brief analysis of the energy situation which sets out:

- Recent developments.
- The present situation.
- Desired future conditions.
- Measures required to attain those conditions.
- Research and development needs to make those measures possible.

RECENT DEVELOPMENTS

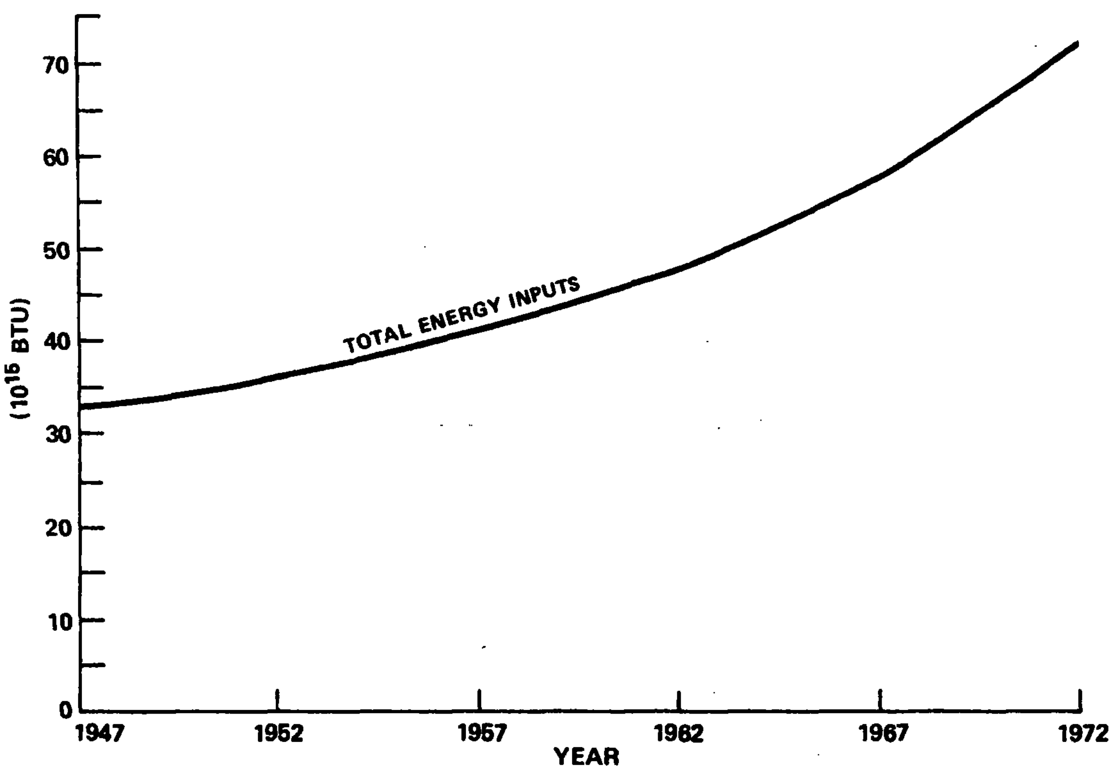
This Nation has until recently been blessed with abundant domestic supplies of readily accessible fuels. As a result, energy has been cheap relative to other commodities. Even today, United States energy costs relative to those of other commodities are less than in any other industrialized country, and these costs have declined over the last several years. In 1972 energy costs amounted to some 4% of the United States gross national product compared to 8 to 12% for most nations in Western Europe.

Until quite recently, energy has been produced from domestic resources in ways that seemed environmentally acceptable. Under these conditions United States consumption of energy has expanded enormously and at increasingly rapid rates, as shown in Figure 3-1. In 1972, with one-sixteenth of the world's population, the United States consumed more than one-third of the world's total energy production. The trend in absolute level of energy consumption is upward, although the United States share of total world consumption can be expected to fall as development proceeds in other countries.

About 25 years ago, major trends caused by market forces began to influence the energy system. The cleanest and most convenient fuels, natural gas and petroleum, were also the cheapest; so they began to displace coal. As

Figure 3-1

GROWTH IN UNITED STATES TOTAL ENERGY CONSUMPTION, 1947-1972



	Year 1947	1952	1957	1962	1967	1972
Total Energy Inputs (10^{12} BTU)	33,035	36,458	41,706	47,422	58,265	72,091
Five-Year Average Annual Rate of Growth (%)[1]		1.99	2.73	2.60	4.20	4.35

[1] These are average annual growth rates for each successive five-year period (e.g., 1947-1952, 1952-1957).

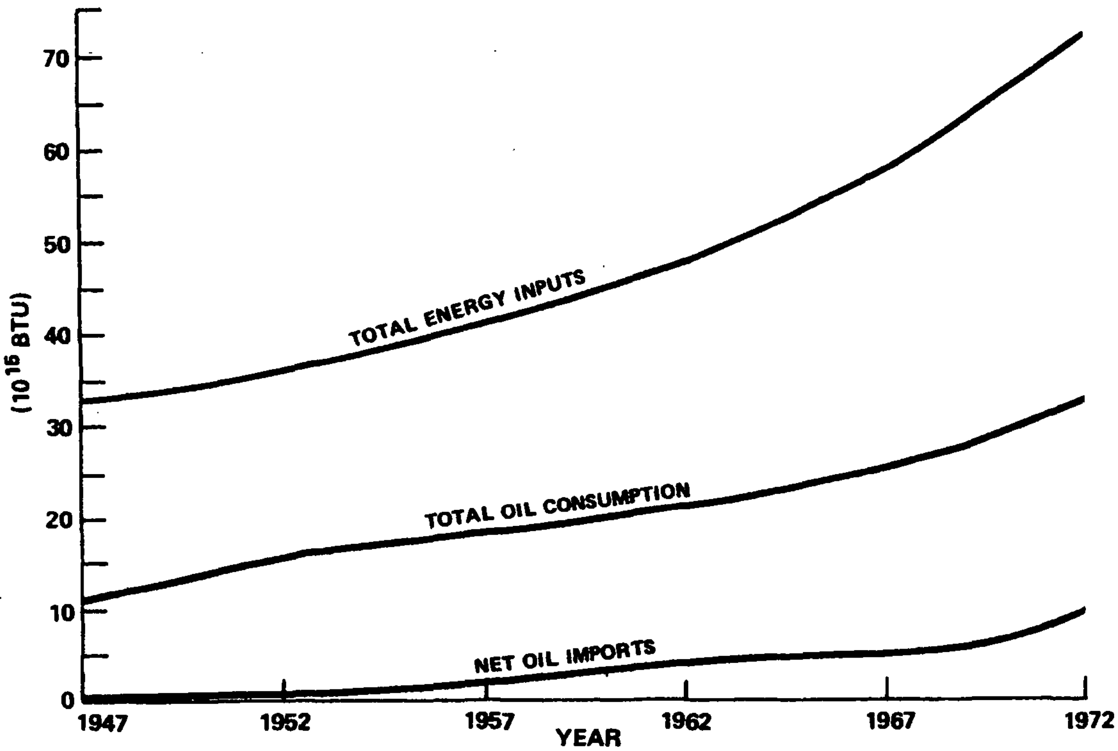
SOURCE: "UNITED STATES ENERGY THROUGH THE YEAR 2000," DEPARTMENT OF INTERIOR, 1972

consumption of petroleum began to outstrip domestic production rates, the United States began to import foreign oil because it was cheaper than domestic oil.

Although the Nation has been importing crude oil and refined products since the late 1940s, it was a net exporter of energy until 1958. Until then the energy value of coal exports exceeded that of oil imports. Figure 3-2 traces the growing contribution of oil and oil imports to our energy supplies. In 1957 the net imports of petroleum and petroleum products were 1

Figure 3-2

UNITED STATES OIL CONSUMPTION AND OIL IMPORTS, 1947-1972



	Year					
	1947	1952	1957	1962	1967	1972
Energy Inputs (10^{12} BTU)						
Total Energy Inputs	33,035	36,458	41,706	47,422	58,265	72,091
Total Oil Consumption	11,367	15,334	18,570	21,267	25,335	32,812
Net Oil Imports	10	1,186	2,253	4,222	4,841	9,588
Oil Imports as a Percentage of:						
Total Oil Consumption (%)		7.7	12.1	19.9	19.1	29.2
Total Energy (%)		3.3	5.4	8.9	8.3	13.3
Oil Consumption as a Percentage of Total Energy (%)	34.4	42.1	44.5	44.8	43.5	45.5

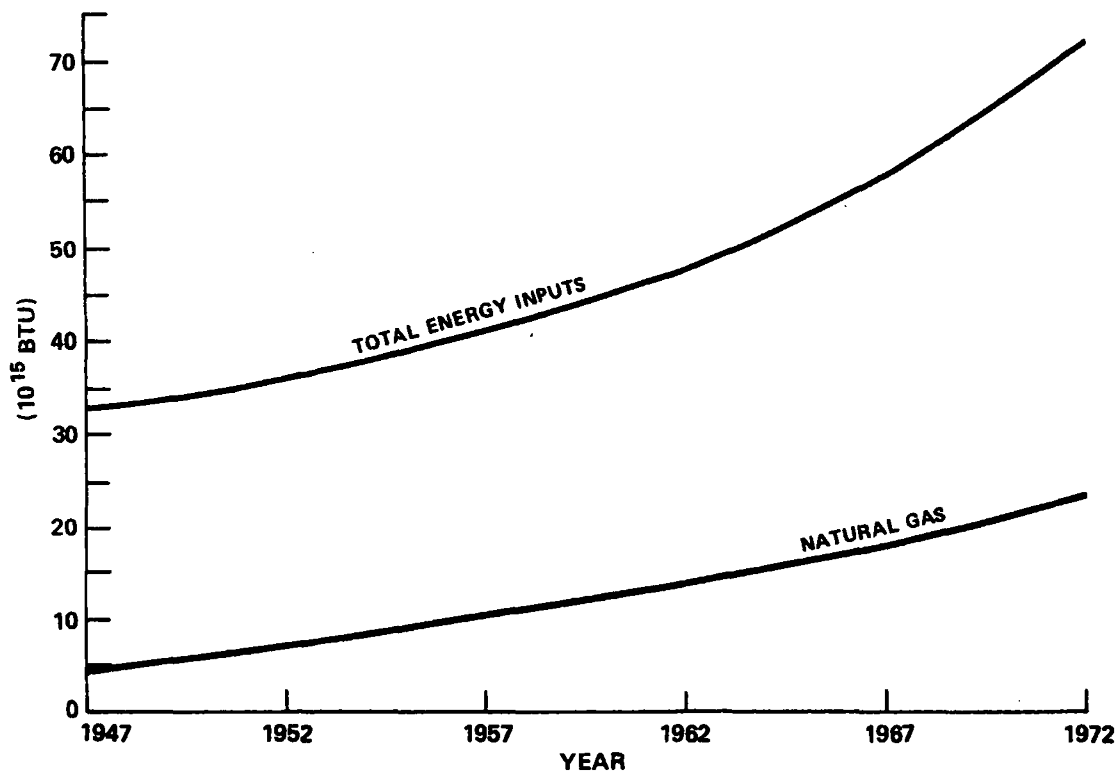
SOURCE: "UNITED STATES ENERGY THROUGH THE YEAR 2000," DEPARTMENT OF INTERIOR, 1972

million barrels/day. This represented some 12% of United States oil consumption, but only 5% of United States energy consumption at the time. The import levels grew slowly at first then rapidly in recent years. During the first half of 1973, the United States imported over 6 million barrels/day of oil, which represented about 33% of its oil consumption and about 17% of its energy consumption in that period.

Late in this same period, the rate of exploration for natural gas declined for two reasons. First, natural gas is often found in conjunction with or while seeking oil; however, with the discovery of cheap foreign oil sources, most oil exploration activity moved abroad. Second, a ceiling was imposed on the wellhead price of gas. As drilling costs rose and finding rates declined, the ceiling price reduced the incentive to drill for gas in the United States. With the price of gas lower than it would have been on the free market, gas consumption grew at an even faster rate than total energy consumption, increasing from 13% of total energy consumed in 1947 to 32% in 1972, as shown in Figure 3-3. Natural gas had all the advantages; it was cheaper,

Figure 3-3

UNITED STATES NATURAL GAS CONSUMPTION, 1947-1972



	Year					
	1947	1952	1957	1962	1967	1972
Energy Inputs (10^{12} BTU)						
Total Energy Inputs	33,035	36,458	41,706	47,422	58,265	72,091
Natural Gas	4,518	7,760	10,416	14,121	18,250	23,308
Natural Gas as a Percentage of Total Energy (%)	13.7	21.3	25.0	29.8	31.3	32.3

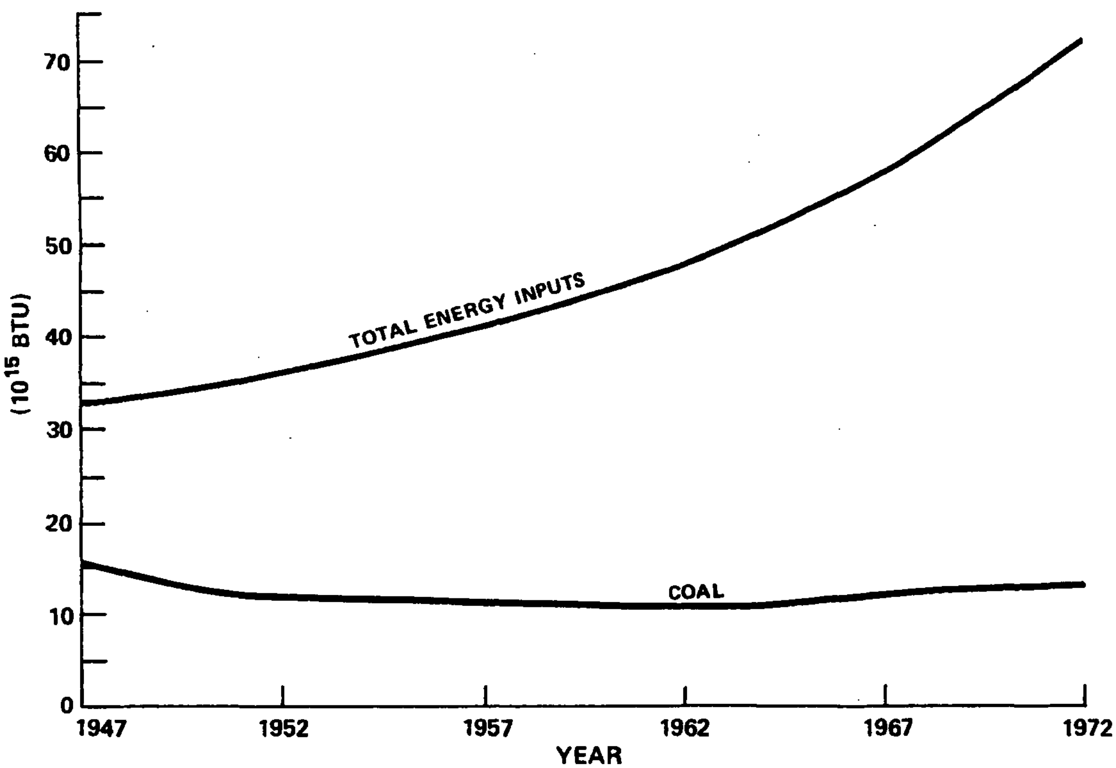
SOURCE: "UNITED STATES ENERGY THROUGH THE YEAR 2000," DEPARTMENT OF INTERIOR, 1972 cleaner, and more convenient than other fuels, and its supply appeared to be ensured.

The gains in oil and gas use were made at the expense of coal. The share of coal in supplying total United States energy needs fell from 48% in 1947 to 17% in 1972. Details are shown in Figure 3-4.

More recently, environmental concerns led to the passage of the Clean Air Amendments of 1970 (P.L. 91-604), which set ambient air quality standards to be attained and maintained. Meeting these standards required

Figure 3-4

UNITED STATES COAL CONSUMPTION, 1947-1972



	Year 1947	1952	1957	1962	1967	1972
Energy Inputs (10^{12} BTU)						
Total Energy Inputs	33,035	36,458	41,706	47,422	58,265	72,091
Coal	15, 824	11,868	11,168	10,189	12,256	12,428
Coal as a Percentage of Total Energy (%)	47.9	32.6	26.8	21.5	21.0	17.2

SOURCE: "UNITED STATES ENERGY THROUGH THE YEAR 2000," DEPARTMENT OF INTERIOR, 1972 significant reductions in emissions of sulfur oxides from the stacks of most coal-burning processes. At that time most coal used had a high sulfur content; so the new emission standards accelerated sharply the shift from coal to oil and gas.

So long as supplies of oil imports seemed to be ensured, there was little cause for concern about domestic self-sufficiency. United States companies owned controlling interests in the firms producing and delivering foreign oil, and there seemed to be no practical limits on foreign production capacity. That much of the refining was done abroad and products were imported was no cause for concern so long as a continuous flow of fuel was reasonably ensured. Failure to use cheap foreign oil would have caused an unnecessary rise in the cost of energy at home and slower progress toward meeting desired environmental standards. The result has been an increasing dependence on oil imports.

THE PRESENT SITUATION

Suddenly a new set of conditions exists. A major portion of foreign oil supplies has been interrupted, and there are no readily available alternate sources for the quantity required. Consequently the United States faces major economic dislocations and unwelcome changes in the way its people live, work, and play.

Energy policy makers must choose among some undesirable alternatives to adjust to these new conditions. To absorb the sudden reduction in oil imports, the United States will pay a high price in some combination of dollars, environmental impacts, and social dislocations. The exact amounts of each required to balance energy supply and demand are determined by the state of energy production and use technology and by the behavior patterns of the producers and consumers of energy. The nature of the present emergency is clear; its dimensions are less so.

HOW FAR TO SELF-SUFFICIENCY?

The specifics of the energy supply and demand situation as of 1970 are displayed in Figure 3-5. Forecasts of the demand for energy and the contribution of the various fuel sources to meet that demand are based largely on projections of trends dictated mostly by economic considerations. A consensus of estimates of the 1980 energy situation past trends continued is shown in Figure 3-6. That consensus projected oil imports of 10 million barrels/day and gas imports equivalent to almost 2 million more barrels/day of oil. Clearly the energy situation in 1980 will have to differ by the equivalent of some 12 million barrels/day of oil from previous estimates if the Nation is to be self-sufficient by then.

In the face of current and projected shortages, the price of energy relative to that of other commodities will rise sharply. This rise will generate economic incentives both to conserve energy and to increase domestic supplies. The extent of these changes depends on:

- How fast the price rises.
- How high it rises.
- How long it maintains given levels.
- What consumers and producers expect to happen to future prices.
- Their responses over time to the pattern of actual and expected price increases.

None of these quantities is known.

One thing is clear beyond question: the Nation must exert every effort toward reducing the rate of growth in energy demand and increasing domestic energy supplies. The projected shortage of approximately 12 million barrels/day of oil equivalent by 1980 (Figure 3-6) did not incorporate the effects of the sharp rise in the price of energy expected in the near future.

Because the rise in energy cost will, of itself, restrain the growth of energy demand to some extent, the self-sufficiency target for increased production by 1980 will be something less than 12 million barrels/day of oil equivalent. How much less is not known with any confidence; one high-priority energy research and development objective must be to develop better methods for predicting that quantity.

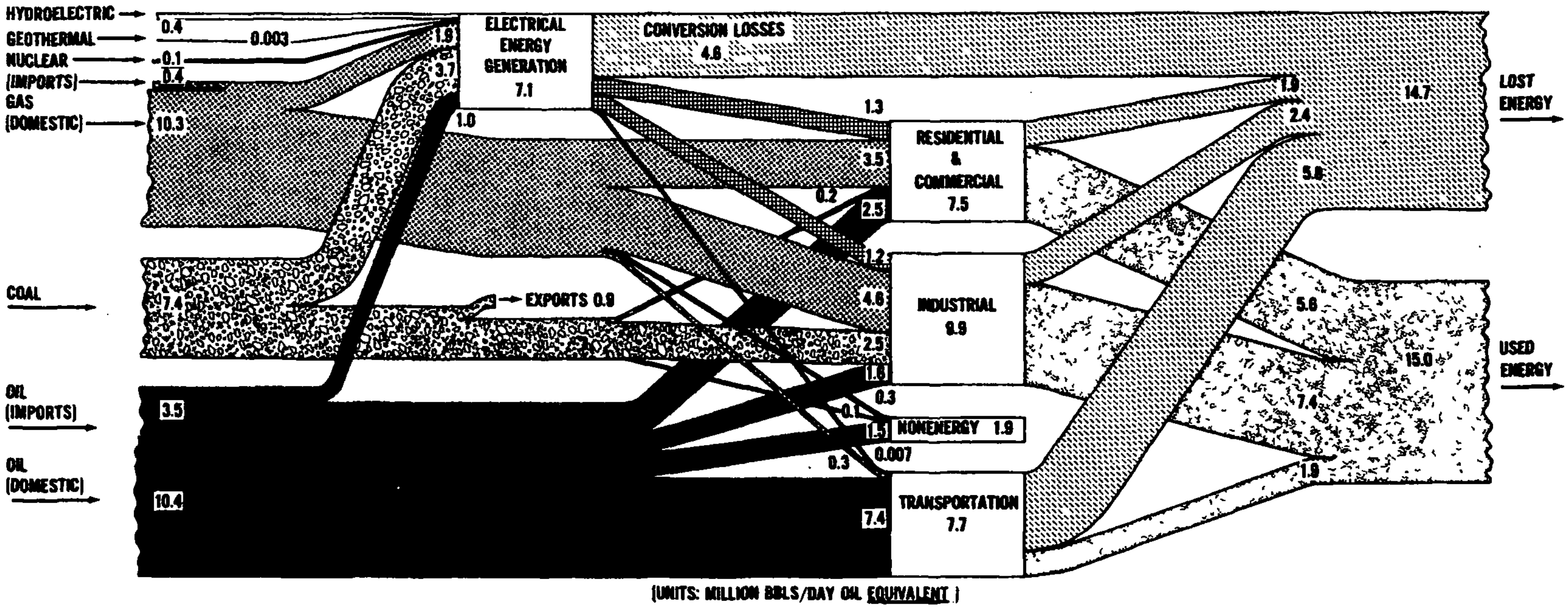
Projections of the effect of price increases on moderating energy demand were developed as follows. If the real cost of energy doubles throughout the economy by 1980, an optimistic prediction would be to expect a 10% reduction in total energy demand in response to a doubling of the relative price of energy. This means that domestic supplies would still have to increase by the equivalent of something like 7.3 million barrels/day of oil if administrative rationing measures are to be avoided. An even more optimistic prediction—that a doubling of the relative price of energy would reduce the demand by 15%—would still require an increase in domestic production of about 5 million barrels/day of oil equivalent.

Clearly a major part of the burden of attaining self-sufficiency without controls must fall on increased supplies. For the United States to attain energy self-sufficiency by 1980, even if present energy costs are doubled, domestic supplies will have to increase by the equivalent of 5 to 7 million barrels/day of oil.

But the requirement to regain self-sufficiency does not stem from the present oil embargo alone. Figure 3-7 shows the expected long-range development of the Nation's energy future before the requirement to regain and sustain domestic self-sufficiency. Although estimates this far in the future are imprecise, this figure does show the relative magnitudes of the major transformations that were projected for the energy system. The huge bulge in projected imports is the most striking characteristic. The balance-of-payment implications of this level of imports in the face of competing claims from other users and restricted production rates by producing countries are reason enough in themselves to begin now to move

Figure 3-5
UNITED STATES ENERGY FLOW PATTERN
ACTUAL – 1970

1970



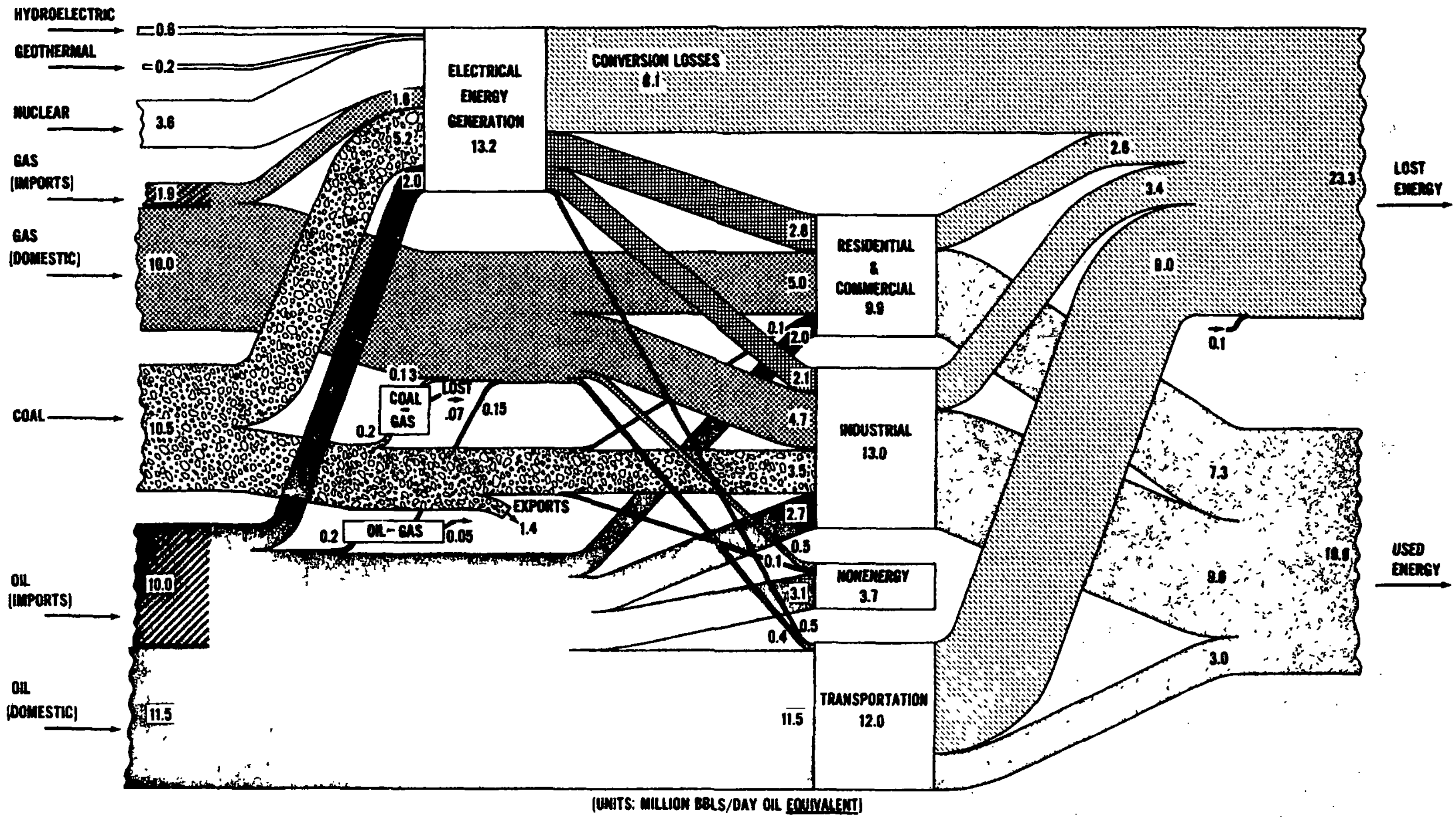
SOURCE: "UNDERSTANDING THE 'NATIONAL ENERGY DILEMMA'." JCAE, 1973

Figure 3-6

UNITED STATES ENERGY FLOW PATTERN

PROJECTED – 1980

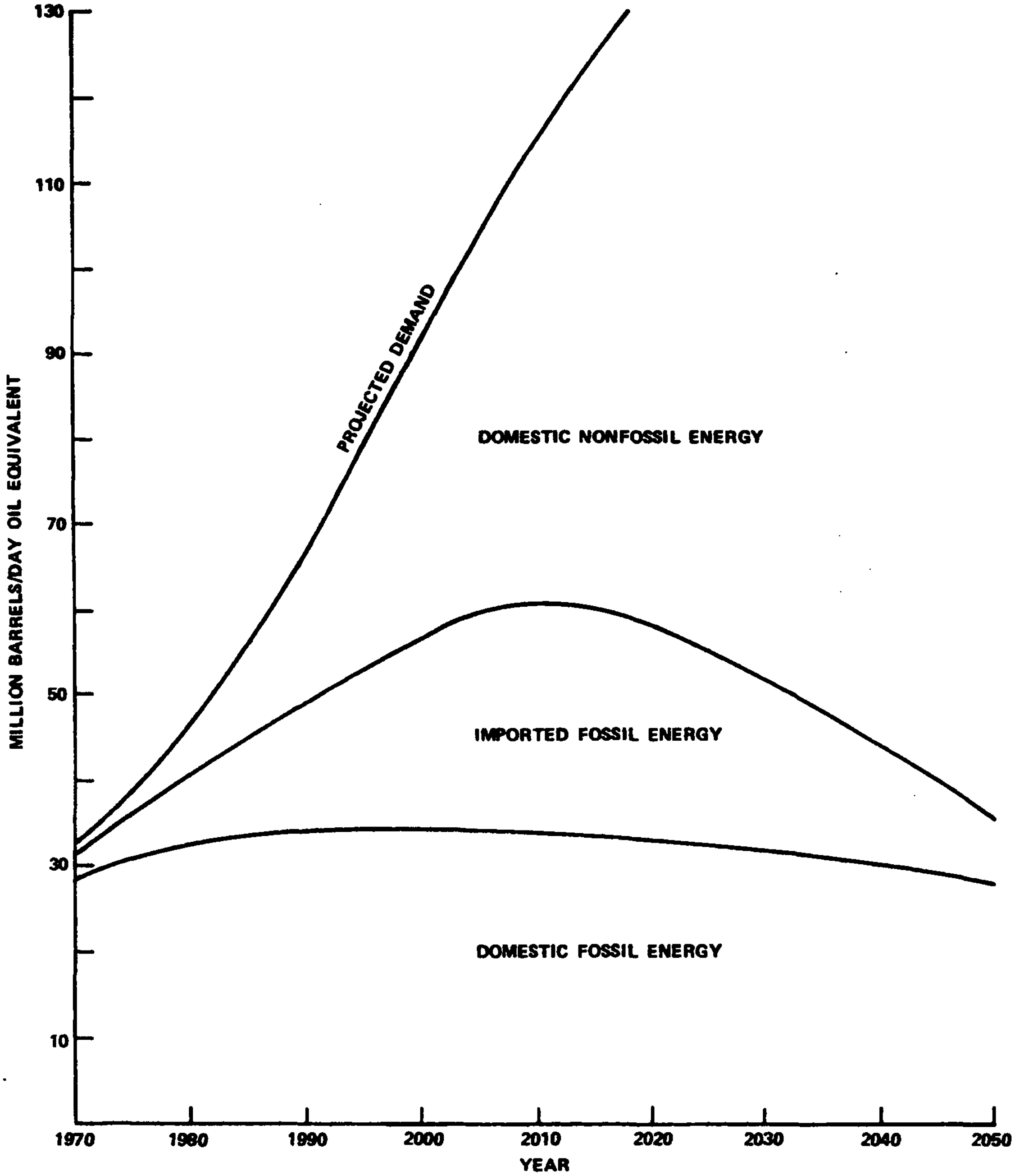
1980



SOURCE: "UNDERSTANDING THE 'NATIONAL ENERGY DILEMMA'," JCAE, 1973 toward self-sufficiency. The present crisis has simply accelerated the time of a general awareness of the problem; it may well turn out to have been a blessing in disguise. Figure 3-7 also helps convey the magnitude of the job to be done in sustaining domestic self-sufficiency for any period after it is attained by 1980.

Figure 3-8, a modification of Figure 3-7, displays an estimate of the changes that will have to be made by 1980 in domestic energy production and consumption to regain self-sufficiency by 1980. It shows the dramatic increase in domestic fossil-fuel production that will be required, even assuming a 10% decline in the previously projected levels of energy demand. Such a fundamental change over the next seven years will be possible only with a vigorous energy research and development program and an equally vigorous production program that supports the early and widespread application of technological advances throughout the economy. The clear message in Figures 3-7 and 3-8 is that major transformations of the energy system are going to be required and the Nation must get started on them now.

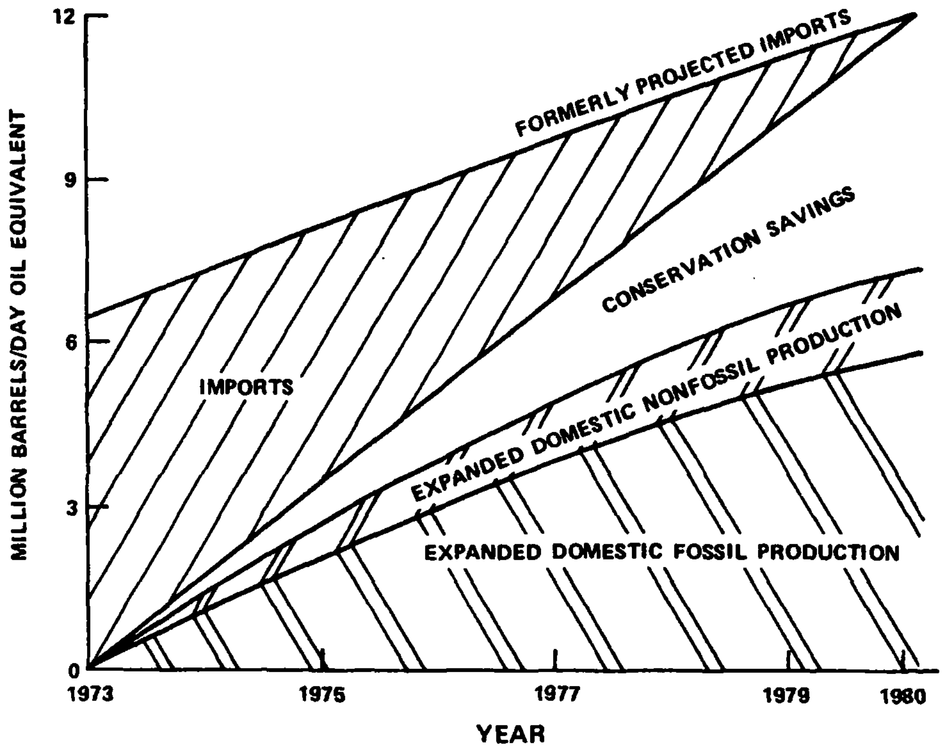
Figure 3-7
ENERGY FUTURE WITHOUT SELF-SUFFICIENCY



SOURCE: "UNDERSTANDING THE 'NATIONAL ENERGY DILEMMA'," JCAE, 1973

Figure 3-8

SELF-SUFFICIENCY BY 1980 THROUGH CONSERVATION AND EXPANDED PRODUCTION



IMPORT REPLACEMENT (Million Barrels/Day Oil Equivalent)	YEAR 1973	1980
Formerly Projected Imports	6.5	12.0
Conservation Savings*		4.7
Expanded Domestic Nonfossil Production		1.5
Expanded Domestic Fossil Production		5.8

*Includes both conservation techniques and energy real price increases.

4

Tasks Required to Regain and Maintain Energy Self-Sufficiency

The President has determined that the Nation should regain energy self-sufficiency by 1980. The Nation's longer term energy goal is to maintain that self-sufficiency at minimal dollar, environmental, and social costs.

Urgent research and development and supporting policy emphasis must be placed immediately and simultaneously on five major tasks to realize these goals. These five tasks are:

- Conserve energy and energy resources.
- Increase domestic production of oil and gas.
- Substitute coal for oil and gas on a massive scale.
- Validate the nuclear option.
- Exploit renewable energy sources to the maximum extent feasible.

The major features of these tasks are set out below.

TASK 1. CONSERVE ENERGY AND ENERGY RESOURCES

Every effort short of administrative controls, if possible, must be made to reduce energy consumption and to increase the technical efficiency of the energy system. There is an overriding need for knowledge about the effects of potential policy options and of price rises on energy consumption and for an extensive data base and a usable model of the energy system. Global policy analyses of the interactions among the components of the energy system are urgently needed to identify potential conservation opportunities and the measures required to exploit them. Information from such efforts can serve to guide immediate choices among policy options. For example, such analyses would identify as candidates for energy savings those activities most destructive of the environment which are deemed least essential to society's other goals.

At the same time, urgent attention must be directed to achieving the desired end-use energy consumption with fewer energy resources. This category of goals focuses on improving the efficiency of both stationary and mobile conversion processes and of transmission, distribution, and storage systems. Large savings might come from new ways of combining existing technologies to capture what is now waste heat from certain processes to do useful work. In general, gains in efficiency may be expected to reduce undesirable environmental effects and energy costs as well as extend the useful lifetime of our domestic energy sources. The immediate gain from conservation measures will be to minimize the extra production needed from domestic resources to regain self-sufficiency.

TASK 2. INCREASE THE DOMESTIC PRODUCTION OF OIL AND GAS

The role of oil and gas is so pervasive in the Nation's energy economy that the highest priority must be given to locating and recovering more oil and gas from domestic fields and to recovering more oil from shale. Secondary and tertiary recovery methods in existing fields, improved drilling methods for offshore sites, release of gas from tight formations, and extraction of oil from shale, offer much promise for immediate and short-term payoff. Scrupulous attention to environmental risks must be ensured, but such attention cannot be allowed to interfere with production increases. Rather, work must proceed at once on methods to prevent environmental damage, e.g., oil spills and well blowouts, and to clean up after accidents that do occur. Techniques must be advanced to contain the leachings from shale residue in confined areas. In situ retorting of shale, while problematical, could have very large benefits if successful.

TASK 3. SUBSTITUTE COAL FOR OIL AND GAS ON A MASSIVE SCALE

This task can be divided into two parts. The first is to switch wherever possible to the direct use of coal where oil and gas are now used, as in boilers in industry and in central power stations. This action can be taken almost immediately. The switch would be limited primarily by the amount of coal available, the transportation capability, and the availability of equipment to modify certain plants. Coal is an enormous domestic resource, and immediate and intensive efforts must be mounted to mine more of it and burn it at acceptable emission levels. "Front-end" processes that remove excess sulfur during combustion and "back-end" processes, such as stack-gas cleanup, must receive urgent and continued attention. Special attention is needed to determine quickly the appropriate balance between the removal of micron particles and the removal of sulfur oxides. Ambient air quality standards should be considered in conjunction with extensive instrumentation and monitoring to detect adverse effects at an early stage. Processes for solvent refining of coal should be explored on a priority basis. As with shale, in situ processes, though a high-risk area, offer the prospect of very high payoff if they can be developed.

The second part of the coal-substitution task is the conversion of coal to synthetic fuels: low-BTU gas; high-BTU, or pipeline quality, gas; liquid boiler fuel; and a synthetic crude suitable as refinery stock. Some existing methods are technically feasible; however, much work is needed to achieve improved yields. This is especially true for liquid fuels, where the technologies are less advanced and the estimated product costs are relatively high. A major effort must begin now to ensure these options.

The coal effort is a good example of how short-term and mid-term programs will support each other: many of the efforts directed at improving the yield, safety, and acceptability of mining and desulfurizing coal will readily apply to the more-advanced programs.

TASK 4. VALIDATE THE NUCLEAR OPTION

A self-sufficiency based on fossil fuels can only be temporary. Though large, these resources are finite. Statements about reserves adequate to last for hundreds of years seldom speak to the feasibility, let alone the desirability, of extracting them. Their extraction and conversion create major environmental problems, and the cost of energy will continue to rise as long as major dependence is placed on them.

Moreover, oil, gas, and coal are important sources of raw materials for fertilizer and other petrochemical industries. The world's growing demands for food alone preclude continued long-term reliance on fossil fuels as the Nation's principal source of energy.

As other nations develop economically, their fuel requirements will increase rapidly, much as did those of the United States. These requirements will place growing demands on the world's supply of fossil fuels. Many argue that the Nation has a responsibility to support its high standard of living from its own resources and a responsibility to leave some of its readily available fossil resources to future generations.

Finally, concern has been expressed about the possible eventual "greenhouse" effects of increasing the atmospheric concentrations of carbon dioxide resulting from the use of fossil fuels. Future limitations on worldwide carbon dioxide emissions may be necessary. All these reasons make clear the need to move as quickly as possible to replace fossil with nonfossil fuels for energy uses.

The Nation has already begun to exploit its nonfossil energy resources. Nuclear power now generates some 5% of all electricity, and this fraction is scheduled to increase to 23% by 1980. The projected increase must be ensured and accelerated. Nonfossil sources must increase sharply their already large planned contribution to the energy supply in the next decades.

The United States has a unique opportunity to exert world leadership by advancing the development of nonfossil energy technology. As reliance on domestic fossil fuels begins to decline, the United States might export fossil fuels to other nations for a period. In the longer range future the export of nonfossil energy technology could be a major source of foreign exchange earnings and could help other nations free themselves from dependency on fossil fuels.

In the shorter term, research and development on reactor safety, waste management, fuel processing, and standardization of design is urgently needed to speed up the installation of nuclear reactors.

Accelerated research on converter and breeder reactors, to include use of the thorium cycle, offers promise of more-efficient power production and a great reduction in fuel requirements, with corresponding reductions of the problems created by mining, waste disposal, and radioactivity. Breeder reactors offer the promise of truly permanent self-sufficiency with minimal and eventually perhaps no extraction of ores. Additional effort must be directed to the elements of the nuclear fuel cycle from mining to reprocessing methods.

TASK 5. EXPLOIT RENEWABLE ENERGY SOURCES

For the long-term there is hope that environmentally clean, naturally renewed domestic sources of energy can be tapped at reasonable costs. Nuclear fusion and central-station solar power now appear to be the most promising prospects.

In the short-term and mid-term, however, much can be done and much yield can be expected from a sound program vigorously executed. For example, with available technology the economic feasibility and reliability of solar space heating and cooling should be demonstrated soon. Considerably more research and development must be done if significant amounts of the indirect sources of solar energy, such as wind currents, ocean thermal gradients, and bioconversion, are to be used. Geothermal resources are already providing significant amounts of power in certain regions. Their contribution should be increased wherever possible to reduce the need for fossil fuels.

5

The Federal Role in the National Program

The Federal Government's responsibilities in the national energy research and development program are to:

- Establish the goals of national energy policy, including those for energy research and development.
- Identify, in conjunction with private industry, the research and development needed to reach those goals.
- Ensure, through appropriate exchange of information with industry, that essential research and development is done by private sources, joint private and Government undertakings, or Government efforts.
- Accelerate technological advances throughout the energy system.
- Discharge these responsibilities in a manner consistent with the Government's nonenergy responsibilities.

Whenever national goals coincide with those of private industry, then private industry should be encouraged to attain the national goals. The free enterprise system has repeatedly demonstrated its ability to get results fast when given the proper incentives.

A competitive, free enterprise market is not well-suited to accomplish all the Nation's goals. Considerations, such as environmental concerns, basic research needs, and national security, that may not be readily integrated into the profit motive will not receive the necessary priority in the market. The Government should intervene to ensure adequate priority to considerations that are deemed necessary in the national interest, but are not funded by the private sector.

GENERAL GUIDELINES FOR FEDERAL/INDUSTRY PARTICIPATION

The major guidelines used in the development of the recommended program were to:

- Maximize industry participation, both to conserve Federal dollars and to speed the application of new processes.
- Tailor participation methods to individual industries.
- Ensure that no industry or firm realizes windfall profits at the taxpayers' expense, while preserving appropriate incentives that reward successful innovation.
- Use the best existing capabilities and expand Government facilities only when no capability exists nor can be created in the private sector.
- Press vigorously for the establishment of a single Government organization (Energy Research and Development Administration) to coordinate the national program and to plan, coordinate, and execute the predominant part of the Federal program.
- Develop Federal measures to reduce the commercial uncertainties of early application of new technologies.
- Ensure that efforts to attain energy goals do not unintentionally compromise efforts to attain other national goals (e.g., price stability, full employment, and consumer protection).
- Ensure that Federal actions taken in pursuit of other national goals also give full consideration to their impact on energy.
- Attain energy goals with minimal interference in the competitive market and in close coordination with Federal, state, and local regulatory agencies in regulated sectors.

The application of these guidelines and consultation with industry representatives show that the bulk of the private effort will be concentrated primarily on short-term objectives. Thus, the recommended Federal program does not include funds for all the short-term research and development contemplated in the national program. The best estimates possible suggest that with appropriate policies the Government might reasonably expect industry to allocate about $2.5 billion per year for direct energy-related research and development, most of it aimed at short-term payoff. The Federal program is designed to encourage private expenditures and to conduct needed short-term work over and above that expected to be funded by the private sector.

Based as it is on the profit and growth motives, the incentive for the private sector to undertake research and development expenditures diminishes as the expected time of payoff increases. Accordingly, the Federal share of the national program must be larger in meeting mid-term energy needs than in meeting short-term objectives.

Those efforts expected to yield major payoff only in the long term must depend almost entirely on Federal funding. Most of these efforts are in early stages of development and can be funded adequately without consuming a major share of the Federal budget for energy research and development.

The range of methods for Government participation extend from monitoring private actions to conducting research in Government facilities. Among the available methods are Government contracts for research and development work, cost-sharing arrangements with private concerns, use of Government facilities by private investigators, guarantees of product price, guaranteed loans, guarantees of rates of return (as in utility regulation, for example), and tariff or quota protection of the domestic market to maintain a price structure that will stimulate private activity.

One of the hardest dilemmas that will confront energy policy makers is the need on the one hand for high prices and profits to stimulate private activity and the desire on the other hand to protect consumers against undue exploitation. The objective here should be to reward to the extent possible only private activity that involves new work or increased production while avoiding windfall or "unearned" profit increases to energy-producing firms.

Another series of dilemmas will arise as measures aimed at energy goals conflict with measures aimed at other national goals. Examples will be in areas of antitrust enforcement, taxation, leasing of public lands, patent rights, and attainment of ambient air quality standards as opposed to emission standards. In these areas trade offs among the goals will be required.

Finally, a series of incentives over and above research and development expenditures will be required to move the research and development results into production quickly to regain self-sufficiency by 1980.

In some cases the Government may have to offer contingent guarantees to industry to reduce risks to a level that will ensure both direct participation in research and development and early implementation of results. In such cases (guaranteed loans, guaranteed product prices, etc.), the Government incurs a contingent obligation similar to FHA or VA mortgage guarantees. These possible obligations are not included in the Federal energy research and development budget; they are treated as possible costs of realizing the most rapid impact on energy production.

Specific measures should be tailored to fit the particular industrial conditions. The requirement for a comprehensive and consistent set of Federal policies tailored to individual industrial conditions is only one very important reason why the early creation of a Federal Energy Research and Development Administration is essential to the successful execution of the national research and development program.

RESEARCH AND DEVELOPMENT STRATEGY OPTIONS

Energy policy makers will need to make choices among a number of competing considerations. Self-sufficiency, environmental improvement, and low energy cost are the three that are central to energy issues.

Energy research and development policy makers also must decide on the relative emphasis to be given in the Federal program to these considerations. The different priorities that can be placed on each constitute the available range of research and development strategy options.

With three considerations, there are ten possible strategies: a balanced strategy that gives equal emphasis to all three, and three in which each consideration is given first priority. For example, if self-sufficiency is accorded first priority, the three strategies under that condition are: second priority to environment and third priority to low cost, or second priority to low cost and third priority to environment, or equal priority to environment and low cost.

Two major reasons dictate the selection of the self-sufficiency/environment/low-cost strategy for the Federal program. First, the three possible self-sufficiency strategies are the only ones consistent with the urgent nature of the energy problems confronting the Nation and the support of the five tasks that have to be accomplished for the Nation to regain and sustain self-sufficiency.

Second, the competitive private sector already contains within it one of the most powerful incentives ever known to reduce costs: the profit motive. There is in the private sector no corresponding motive to move toward self-sufficiency. Also, the private incentive to clean up the environment is less compelling than the profit motive. Accordingly, the Federal Government should emphasize research and development programs aimed at regaining energy self-sufficiency achieved under acceptable environmental conditions and rely on the market forces to reduce energy costs.

The implications of this recommendation must be made clear. A significant and sustained rise in the price of energy relative to other commodities can be anticipated. As the price of energy rises, there will have to be some important changes in the way energy is used. Not all of them will be welcome, but the benefits of self-sufficiency can more than offset the costs.

CRITERIA FOR FUNDING FEDERAL PROGRAMS

Federal research and development criteria for assessing priorities among competing research and development programs and proposals include: the current state of scientific knowledge; the probability of future technological success; capital, resource, labor and environmental limitations on production feasibility and cost; and geographical, political, and other constraints on the application of new technologies. When allocating money, each program must be assessed for its probability of success, the investment of research and development funds required, the timing and extent of potential payoff, and noneconomic aspects.

The following questions should be considered when allocating funds for research and development projects:

- What will the project cost in each year to completion?
- What is the probability that the project will be successfully completed and when?

- If the project is successful, how long will it take to implement the new technology?
- What is the expected amount and timing of the gain from the scheduled implementation?
- What are the projected amounts and timing of the costs of realizing that gain?
- What is the "rate of return on investment" expected from each project (the present value of expected costs subtracted from the present value of expected benefits and the result divided by the present value of projected costs)?

Projects should be ranked in order of the size of the answer to the last question, then funded in sequence down that list to the limit of the money available for energy research and development if there are no overriding noneconomic considerations. If such considerations do exist, they and their implications for the program should be stated explicitly.

Precise and accurate estimates of the quantities involved are not required to get useful guidance from this approach. While absolute levels of the quantities involved are impossible to specify with precision because of future uncertainities, the direction and extent of **differences** in the magnitude among the various projects are much easier to estimate. More can be said about how projects might differ in the future than can be said about the absolute values of the crucial parameters. One way to do this is to set out the sequence of events that has to transpire for each project to be economically viable, then evaluate those sequences which are more likely and those which are less likely, and determine whether the differences are large or small. These kinds of estimates are sufficient to provide useful funding priority guidance.

A number of specific criteria can be identified, and estimates of "high," "medium," and "low" assigned to each program area. With these, semi-quantitative indicators (not measures) can be generated. These indicators can help specify the relative priorities among programs. Indicators so derived should not be used as inflexible decision rules. Rather, they can serve as useful inputs to informed judgments about the relative amounts of money that ought to go to the various programs.

A high indicator value does not necessarily mean a large number of dollars should go to that program; it means that the program should receive all the reseach and development dollars that can be spent prudently in the area. How many dollars can be spent prudently is a determination that must come from an informed judgment of the program's history, its present position, and the prospects for its future development.

Because of the claims of higher priority programs, a low-value program may have to be held to a funding level well below that which could be spent prudently. The absolute number of dollars going into a low priority program may still exceed that going into a high priority program because of differences in the scope of the programs concerned. For example, conservation studies may be the highest priority program, but may be able to absorb prudently only a few tens of millions of dollars, while the nuclear fusion effort, having lower priority, calls for more money, yet still less than it could absorb prudently.

To be successful in augmenting energy supplies or reducing demand, a research and development proposal must show promise of success in three successive stages and must not be inconsistent with overriding noneconomic considerations. The four areas of inquiry and the major considerations in each are:

Research and Development Stage

- Adequacy of scientific base
- Probability of future technological success

Implementation and Production Stage

- Production capability
- Availability of ancillary resources
- Environmental cost consequences

Payoff Stage

- Timing of payoff
- Economics of payoff

Noneconomic Considerations

- Environmental effects not considered in costs
- National security
- Political
- Regional

A detailed explanation of the application of these criteria is contained in Appendix B. The results can provide useful guidance in the assignment of relative priorities for funding. Program rankings derived from the analysis are listed in Table 5-1 for the major elements of the recommended program.

The program rankings are not, and are not intended to be, definitive; they are indicative of the appropriate relative funding priorities derived from the recommended energy research and development strategy. They are a means by which program priorities may be estimated in the presence of large uncertainties about specific future results.

Concern is often expressed as to the availability of ancillary resources (water, transportation, land areas, manpower, capital) to support the application of a prospective new technology. While these deserve some consideration, they should not exert a major influence on research and development funding for two reasons.

Table 5-1

ILLUSTRATIVE PROGRAM PRIORITIES BASED ON CRITERIA

Weighted Criteria	Total Rank	Unweighted Criteria	Total Rank
Conservation	(70)	Conservation	(43)
Resource Assessment	(68)	Coal and Shale Processing	(42)
Oil and Gas	(67)	Resource Assessment	(41)
Coal and Shale Processing	(67)	Oil and Gas	(40)
Mining Coal and Shale	(64)	Fission	(39)
Fission	(63)	Mining Coal and Shale	(38)
Conversion Techniques	(57)	Conversion Techniques	(36)
Advanced Transportation Systems	(54)	Advanced Transportation Systems	(35)
Energy and Fuel Transportation Distribution and Storage	(54)	Energy and Fuel Transportation Distribution and Storage	(33)
Geothermal	(45)	Fusion	(29)
Fusion	(43)	Geothermal	(28)
Solar	(40)	Solar	(27)

First, one of the aims of the research and development itself is to reduce the major technical obstacles to implementation. Thus, a presently perceived obstacle that can be reduced is a call for more research and development, not less.

More importantly, only as application begins can realistic evaluations of these supporting resource requirements be made and the amount of the limited resources that will go to a particular energy technology be determined. All the resources needed to implement all the technologies in the research and development program exceed the available supply, but this does not mean that any research and development work should be curtailed. It means only that not all technologies are going to be implemented at their maximum possible rate. Those which are implemented, and the speed with which this is accomplished, will be decided largely by the success of the research and development program and by the market, where the users of each process must bid away from other users enough resources to support its application. The results will be reflected in the energy price from that technology, as well as in the prices of other commodities that use the same resources.

Management of the Federal Program

Two key elements are urgently required in the management of Federal energy research and development if it is to be successful: unity of effort and and flexibility.

Unity of Effort. The preceding section described one method for considering all the Nation's energy research and development needs in a common framework. The importance of such unified consideration in planning the program is self-evident. The necessity for unified direction and coordination of the program's execution is equally if not more urgent.

A first requirement for making the most rapid possible progress toward self-sufficiency is a comprehensive and detailed inventory of the opportunities for increasing production from each of the energy sources, increasing the efficiency of energy transformation and distribution, and decreasing energy and energy resource consumption. These must be defined according to common standards and evaluated by the same criteria used to determine the potential impact on the self-sufficiency goal. Centralized direction of this effort will be essential to charting the alternate paths to self-sufficiency, selecting the most sensible path for major emphasis, and providing backup options in case of delays. A single Government agency will be required to accomplish these tasks effectively.

For example, some of the early questions that will have to be resolved in the program's execution can only be answered sensibly by a single group with overall responsibility for the program. The balance between total systems approaches and the role of major systems components is one such question. Work must begin at once on all the component areas by making the best estimates possible of values for the parameters of major components (e.g., how much will oil and gas production increase; how much must coal production increase; how much coal will go to each use?). At the same time, the total system must continue to be better defined so these parameters can be adjusted as work proceeds and initial results are obtained.

Other crucial questions will relate to what kind of work and how much of it is performed in Government laboratories and in industrial facilities; technical vs. institutional or policy measures to increase production; speed of application vs. environmental constraints; speed of research work vs. cost of the final process; when to freeze a design and go for application rather than seek continued improvements; how much effort to divert to immediate concerns vs. the effort going to more distant concerns; and a host of others. The way these issues are resolved at the outset of the effort will have a major impact on the shape of the entire effort. Failure to provide unified, coordinated guidance and direction in their resolution will invite if not guarantee the program's failure. A plan for a national research and development program and the money to carry it out are only two of the four essentials of success. The other two are an effective management structure and vigorous execution responsible to changing conditions.

Flexibility. The remaining essential requirement for conducting an effective program of the dimensions recommended with the urgency demanded by our energy situation is the ability to adjust to changes as they occur. By its nature research and development is an expedition into the unknown. New knowledge, new discoveries of resources with existing techniques, and a host of other facts will generate rapid shifts in the needs of individual programs.

The specific five-year program recommended herein appears **now** to be that best suited to the Nation's needs, but it will have to be modified in light of new circumstances as it is executed. The fiscal year 1975 budget recommendations are firm; they are the way to **start** the program. But estimates for future years and even program totals should be subject to continuing review and evaluation in light of changes in the Nation's energy situation.

Flexibility in the application of funds and their transfer among programs will be essential to the capability to exploit success. Changes in priorities and reallocation of effort among programs and between the Federal and private sectors will be required. Again, only a single agency with the authority to make such shifts can capitalize on opportunities as they are discovered and shut off failures as they are identified.

Finally, flexibility in the approaches to dealing with industry will be required. The coal mining industry, the coal using industries, the oil and gas industries, the transportation industries, and others all differ in fundamental respects. What works best in one industry may be totally wrong in another where conditions differ. Accordingly, the ability to set specific goals and constraints and to select, from among the possible Federal measurements, that combination best suited for each sector will be crucial to the most effective Government/industry cooperation.

Because the majority of the energy production system is privately owned, effective Government/industry cooperation will be essential in translating the program results into increased supplies. Wherever possible, some form of cost-sharing and participatory decision making should be used.

When only Government management and funds are involved, there may be a tendency to extend a project beyond the reasonable point of cutoff, even when it is apparent to the potential industrial users that the undertaking no longer holds reasonable promise for producing useful results. Industrial management and partial industrial funding provide a method for subjecting programs to the discipline of the market place and redirecting resources in a timely manner.

International Cooperation

A final need for a centralized management capability derives from opportunities for cooperative international efforts in energy research and development. A recent interagency task force has identified the criteria that should apply in such efforts and the most promising prospects for international cooperation. The task force considered international research and development against a backdrop of four basic issues:

- Which technologies offer promise for cooperative research and development, and which countries are doing significant work worthy of cooperation?
- Should the programs be bilateral or multilateral?

- What role should U.S. industry play, and can and should the Government stimulate industrial participation?
- What will be the technology transfer and balance of trade implications of increased cooperation?

The following criteria were used to establish priorities for cooperative research:

- Useful foreign technology.
- Impact on U.S. energy deficit.
- Time to commercial utility.
- Lack of barriers to information exchange.
- Opportunities to expand cooperation.

The five criteria refer to the potential benefit to be derived from cooperative research and development, and not whether the technology in question is necessarily high on the list of current U.S. domestic priorities. The task force reached the following judgement:

- High overall priority: coal technology, geothermal, energy conservation, environmental studies, resource assessment, and transportation systems.
- Medium overall priority: conversion technology, fuel transport, fusion, hydrogen economy, reactor safety, and solar.
- Low priority: electrical transmission, energy storage, hydro, miscellaneous sources such as wind and tidal power, all other nuclear, and oil and gas technology.

Clearly a single Government agency working in conjunction with the Department of State could better realize the potential benefits from such a program and integrate them into the planning and execution of the national and Federal programs than can the existing organization, or lack thereof, for Federal energy research and development.

6

Obstacles to Realizing National Energy Goals

This chapter describes basic technological obstacles that stand in the way of decreasing energy demand and increasing energy supply and institutional factors that may act as further constraints on the choice of programs to overcome energy shortages.

TECHNOLOGICAL OBSTACLES

Task 1. Conserve Energy and Energy Resources

Reduce End-Use Consumption. Significant results in energy conservation in the absence of administrative controls cannot be attained until research has been conducted to overcome:

- Insufficient knowledge of the effects of alternative policy options.
- Inadequate data for predicting the extent to which energy consumption is responsive to increases in the relative cost of energy.
- Inadequate identification of opportunities for substituting energy-conserving practices and processes for energy-intensive ones throughout the economy.
- Lack of an adequate data base and of models for systematic analyses of the energy system and the interactions of its major components.

Improve Efficiency of Energy Use. Ways must rapidly be found to meet a given end-use energy demand with fewer energy resources.

Industrial processes use approximately 40% of all energy consumed in the United States today. Industrial processes, equipment, and methods, whether dependent on heat or on electric power are inefficient. Major increases in efficiency are possible, as demonstrated by a few pioneering industry studies. A chloride electrochemical reduction process for aluminum production is substantially more efficient than the next best alternative and also cleaner. The payoff of increased efficiency in all types of energy uses will be prompt and continuing, reducing resource use and the environmental impact of energy production and use. Major gaps in current technology are:

- Insufficient development of catalysts to substitute for heat or electric energy.
- Inadequate methods for using the waste heat of power plants and industrial processes for process heat and for space heating.
- Inadequate methods for using waste process heat to generate electricity.

Space heating and air conditioning account for almost 25% of all energy consumed in the United States today. Heating and cooling efficiency is largely dependent on building design and on the design of the conditioning unit and its control mechanisms. Future construction and modifications of present buildings should incorporate concepts leading to greater energy efficiencies. The building industry is so fragmented, however, that there is no prospect of significant impact without Government incentives, and the diverse building codes enacted by the multiplicity of independent jurisdictions complicate the problem of adopting standard designs. Principal limitations to greater efficiency are:

- Lack of a total-systems approach to the energy needs of individual buildings and clusters of adjacent buildings.
- Lack of coordination of the solar heating and cooling approach with building design.

The transportation sector accounts directly for about 25% of total fuel use and more than 50% of oil consumption. Shifts of travel practices from truck and auto to more-energy-efficient modes could reduce significantly the total energy demand and local pollution levels. Major obstacles to the shift are:

- The lack of general public acceptance of mass-transportation vehicles and systems in their current form.
- Inadequate data about the response of citizens to incentives to make more efficient use of cars.

Conversion Techniques. The conversion of fossil fuels and nuclear fuel to electricity is a relatively inefficient process. The newest central-station power plants typically have efficiencies of about 38 to 40%; the overall industry average is nearer 30%. The remainder is lost in the form of waste heat, which contributes to pollution. Demand for electricity has grown more rapidly than that for other forms of energy; its doubling rate is now 10 years.

To supplement the regular steam cycle, generating plants could, with so-called "topping cycles," use the high-temperature spectrum of the combustion gases. These include magnetohydrodynamic (MHD) cycles, liquid-metal cycles, or direct turbine drive by the hot gases before they are used to form steam. An increase in overall system efficiency of 15% is theoretically possible; the savings in fuel would be enormous (in the range of 25% or more), and waste-heat rejection would be reduced by as much as 40 to 45%, which would decrease environmental problems as well. The need is urgent for work on:

- High-temperature gas turbine, potassium topping cycle, and magnetohydrodynamics.
- Materials for use with high-temperature working fluids.
- Cost and life of fuel cells.
- Scale factors for commercial-sized equipment.
- Heat rejection and utilization technology for base-load plants.
- Methods for combining different technologies and processes to achieve greater efficiencies and reduce total heat rejection.

Energy Transmission, Distribution, and Storage. Once electric energy is generated at a power plant, it may travel many miles to the consumer. In the process, voltages are stepped up and down. In general, the higher the voltage, the smaller the losses in transmission, but the higher the capital requirement for the line. Transmission lines are designed to optimize the trade offs between these economic factors. The ever-increasing demand for electric energy will require more power lines in the future and power lines of increased capacity. Major difficulties are:

- Resolution of land-use and visual-impact problems to permit use of more efficient, higher capacity overhead transmission systems.
- Costly, inefficient underground cables with inadequate capacity.
- Instantaneous matching of generation to load within and between electric power systems.
- Lack of adequate, efficient energy storage systems.

Advanced Transportation Systems. Transportation uses 25% of all energy consumed in the United States at an efficiency that rarely exceeds 20%. Furthermore, automotive and aircraft engines today are designed to run only on refinery products of crude oil, a pattern that cannot be changed significantly in the near future. Because of their intolerance for fuel substitutes, automotive and aircraft engines may set the lower limit on needs for liquid petroleum products. The supply of natural gas, which is a suitable alternate fuel, is even more constrained than that of liquid petroleum. When an automotive engine converts fuel to mechanical energy, there are other losses in the automotive power train that further reduce system efficiency. Moreover, vehicles are designed to optimize features other than fuel economy. Primary technological blockages to change are:

- Lack of vehicles designed to provide efficient transportation service with minimum fuel consumption.
- Lack of automotive engines that are both highly efficient and environmentally acceptable.
- Inability to use substitute fuels and fuel supplements (e.g., methanol) on a large scale.
- Inefficient automotive power trains.

Task 2. Increase Production of Oil and Gas.

Oil and Gas. The ratio of proven domestic reserves to production for both oil and gas continues to fall. The recovery of oil from operating fields averages only some 30% of the oil in place and is only some 40% in the newest fields. Every 1% increase in recovery rates presents an addition of 4 billion barrels to U.S. proven reserves, an amount equal to about two-thirds of present annual consumption.

Much gas exists in impermeable rock formations and cannot presently be recovered economically. Moreover, theories that explain the formation of hydrocarbon resources predict the existence of large undiscovered reserves. Large areas contiguous to the continental United States may contain undiscovered reserves, although some of them may exist at depths that cannot be explored and tapped economically with today's exploration and drilling techniques. Major technical obstacles to a rapid increase in domestic production of oil and gas are:

- Lack of economical recovery methods for oil and gas remaining in producing fields.
- Lack of recovery methods for gas trapped in impermeable formations.
- Lack of economic discovery and recovery methods for oil and gas at great depths.
- Inadequate methods for preventing large oil spills and for containing and cleaning up spills with minimum damage.

Shale Deposits. Oil can be produced by retorting shale to generate a crude-oil product from the hydrocarbon-rich kerogens of the shale deposits. Both nonnuclear and nuclear methods of fracturing rock offer promise of releasing the shale in forms suitable for in situ retorting. Shale as a source of oil has the advantage that its BTU content per barrel of produced oil is slightly higher than that of the natural petroleum product. In addition, shale has a higher hydrogen content than does coal; so less hydrogen is needed to produce the liquid fuel. Some 75% of the richer shale deposits are located on federally owned property. Major recovery problems are:

- Lack of economically viable and technically reliable methods for retorting shale deposits, especially in situ.
- Lack of adequate technology for fracturing shale deposits in situ.
- Lack of environmentally acceptable methods of handling the shale debris generated by above ground retorting.

Task 3. Substitute Coal for Oil and Gas

Mining and Direct Use of Coal. The energy content of known domestic coal reserves is significantly larger than that of any other energy resource available with today's technology. However, the use of coal has dropped sharply in the past two decades (Chapter 3). Approximately 60% of coal reserves have a sulfur content that is so high that combustion emissions will not meet air quality standards without the use of new emission-control techniques. The decline in the use of coal has resulted in a contraction of the industrial base. Major obstacles to the use of coal are:

- Lack of proven techniques for reclaiming surface-mined areas, especially in semiarid and arid regions.
- Low productivity of underground mining methods.
- Limited ability to burn high-sulfur coal in ways that meet established pollutant (sulfur oxides) emission standards.
- Production of undesirable waste products by current stack-gas scrubbing methods.
- Lack of effective methods for removing micron particulates from stack gases.

Production of Gas and Oil from Coal. *Low-BTU Gas from Coal.* Oil and gas have been produced from coal for many years. The technology was used in Germany during World War II, but it has not been economically competitive with other sources of oil and gas. Before natural gas was widely used as an energy source, synthetic gas was manufactured from coal. It is acceptable by modern standards. A gasifier using air should be able to produce a clean low-BTU fuel that could be burned in most fossil-fired electric utility boilers as well as in smaller industrial boilers. Only 35 to 40% of the original heat content of the coal would be lost in the conversion process. Rapid installation of improved gasifiers could be expected in the utility industry. The principal impediments are:

- Inadequate development of gasifiers for low-BTU product.
- Lack of a high-temperature desulfurization process to clean up the gas.
- Lack of advanced techniques to salvage the excess heat loss.
- High cost of transporting low-BTU gas.

High-BTU Gas and Liquids from Coal. Processes for producing high-BTU gas and liquids from coal rely on increasing the ratio of hydrogen to carbon over that found in coal. Given sufficient price incentives, industry should be able to produce high-BTU gas from coal at costs competitive with naphtha conversion, imported liquified natural gas, or natural gas transported from Alaska. The product from liquefaction processes contains less than half the hydrogen necessary to make pipeline-quality gas from coal but less of the original heat value is lost in the process. The liquid product is also easier to transport and store. Principal obstacles to production are:

- Need for a breakthrough in production of hydrogen by catalysis or other methods.
- High cost of producing methanol from coal.
- Lack of methods to remove organically bound sulfur in coal.
- Insufficient knowledge about engineering needs to accommodate various grades and types of coal.
- Environmental constraints, particularly the availability of water supplies.

Task 4. Validate the Nuclear Option

Current Nuclear Reactors. The present generation of converter nuclear reactors is being installed at a rate well below original expectations. In addition to construction delays, licensing delays, and environmental and safety concerns, the evolutionary nature of the industry has resulted in continual design changes in successive reactors. Each new design modification has required a full-scale review for licensing by the Atomic Energy Commission. The current plans for high-level waste disposal call for storage of fission-product waste above ground for up to 100 years while a permanent disposal method can be developed. There is an urgent need to improve the following conditions:

- Inefficient fuel utilization of present light-water reactor designs.
- Shortage of experimentally confirmed test data on environmental and safety problems associated with converter reactors.
- Plutonium and fission-product waste handling and disposal problems.
- Lack of standardization in reactor design and site selection procedures.

Fuels. The current family of nuclear converter reactors uses a relatively inexpensive fuel derived from high-grade uranium and thorium ores. Known reserves of these high-grade ores are limited, and medium-grade ores have not been well explored. To support the expected growth in nuclear power plant capacity, the uranium mining industry must expand its output fivefold in the next 12 years. Obstacles to expanded use are:

- Lack of techniques for mining rich uranium ores without making lower grades of ore less accessible for future mining.
- Need for more-efficient enrichment techniques.
- Need for more-efficient fabrication and reprocessing techniques.

Breeder Reactors. Breeder reactors (liquid metal fast breeder, gas cooled fast breeder, molten salt breeder, etc.) are necessary to provide longer term sources of energy from nuclear fission because supplies of low-cost fissionable material are limited. The development of fuels and materials in turn will dictate reactor-design concepts. Work must be done on:

- Technical fuel and materials problems associated with breeder reactors.
- Excessive doubling time and specific fuel inventory of current designs.

Task 5. Exploit Renewable Energy Sources

Geothermal. At several locations geothermal energy has already been harnessed in the form of dry steam (Geysers, California) or hot water (Wairaiki, New Zealand), but such locations are rare and do not contribute significantly to the energy supply. Larger reservoirs of geothermal energy exist in the form of hot rock, hot brine, geopressured zones, and magma.

Many such sources contain heat energy at temperatures that are too low for use in conventional power-generation systems. Other sources contain contaminating salts or other minerals. Technical impediments to early increased use are:

- Lack of economical ways to find and assess geothermal reservoirs and determine their nature.
- Absence of recovery and use techniques for low-temperature or contaminated geothermal resources.
- Minimal understanding or control of potential environmental insults (earthquakes, tremors, and disposal of vast amounts of noxious gases, minerals, and salts) that might result from substantial geothermal exploitation.

Solar. For many years solar energy has been used directly on a small scale to heat water for homes or provide heat to grow plants. Unless solar energy is concentrated, however, the temperature rise associated with solar heating is too low to produce power with conventional generating techniques. Weather and day-night variations make the supply of solar energy intermittent and require that storage systems be provided for times when sunlight is inadequate.

Decentralized solar systems for space heating, water heating, and air conditioning in buildings are technically feasible today. Operating costs are appealing, but initial capital costs are high. Thus, there is no significant market force to create the necessary industry. Demonstrations with Government buildings might help stimulate a significant market for commercial buildings in the near future. Principal constraints are:

- Inefficient solar-energy collection technques.
- Inefficient energy storage techniques.
- High capital costs for decentralized heating and cooling systems.

Fusion. If fusion reactors become technically feasible, the world's oceans will provide an inexhaustible supply of fuel. Several approaches to the concept are being explored. Although recent successes are encouraging, demonstrating technical feasibility and completing the necessary reactor concepts will take considerable time. Principal difficulties are:

- Lack of adequate testing facilities to conduct critical scientific experiments.
- Lack of knowledge as to which, if any, of the suggested approaches will lead to success.
- Insufficient development of materials for planned reactors.

General Requirements

Environment. Energy production and use have been major contributors to detrimental changes in air, water, and land quality. Increasing per capita consumption of energy has been directly related to increasing insult to the environment. The relationship must be altered if desired environmental standards are to be attained.

It has only recently been realized that efforts to increase the standard of living through increased energy use may have undesirable environmental impacts. As a result, research has been initiated into the nature of these impacts, which arise from all phases of the energy cycle from fuel exploration and extraction to energy conversion and waste management. Major gaps include:

- Inadequate knowledge of the physical and chemical transport processes by which pollutants become distributed in the environment and find their way to man.
- Lack of knowledge about the health, ecological, welfare, and social impacts of various energy systems and the pollutants they generate. Such knowledge is vitally needed to set standards, to establish guidelines for the siting of energy systems, and to direct research to control and ameliorate these impacts.

Basic Research. Fundamental knowledge of the physical, biological, economic, and social laws that govern living patterns and the properties of matter has been the cornerstone of man's increasing control over the forces of nature. The energy system of the Nation is so complex that there is not a single discipline that does not play some part in its functioning. Increases in fundamental knowledge should lead to greater understanding, and such understanding should contribute to more efficient operation of the system.

Much technological development has been characterized by empirical process development. More often than not it has become difficult to move beyond certain barriers because of a lack of fundamental knowledge. In such cases, basic disciplines have been called upon to determine what relationships existed and to find approaches to overcoming the problem. With recognition of the energy shortage and with forecasts of increasing shortages for many years, maintaining the competence to react quickly to such calls for assistance is essential. Broad areas for basic research reflect:

- Insufficient knowledge of the physical and chemical nature of matter.
- Insufficient knowledge of biology and biological processes.
- Insufficient knowledge of the economic and social interactions of man.

Systems Analysis. The complexities and dynamics of the United States energy system are such that it is virtually impossible to discern even the major interactions that occur throughout the system or to predict the effects of changes to the system. Systems analysis is presently limited by:

- Lack of a valid energy model.
- Lack of a valid up-to-date data base for the model.

INSTITUTIONAL CONSTRAINTS ON TECHNOLOGICAL DEVELOPMENT

Federal and State Environmental Laws and Regulations

The National Environmental Policy Act (NEPA) of 1969 was a significant recognition by the Congress and the Administration that our national growth could no longer continue uninhibited by concern for the environment. The Act requires that an Environmental Impact Statement be published in draft form no later than 90 days before a "significant Federal action" is taken that could have an effect on the environment. A final report must be published no later than 30 days before that action. Recent court interpretations of the Act and guidelines dictate that the impact statements must be developed to support Congressional authorization and appropriation for the "activity." Thus all new or significantly altered programs will require the preparation of Environmental Impact Statements before authorization or appropriations.

Environmental standards issued by either the Federal Government or state governments should not be considered constraints to technological development. Rather, they set requirements for research and development that must be met if the technology is to be implemented within the respective jurisdictions. There is considerable concern about the validity of many such standards that have been based upon incomplete data and analysis or a complete lack of knowledge regarding the impact of certain pollutants on the environment. For instance, a major technological objective is to determine the effects of pollutants on the ecosystem and its inhabitants. That determination could establish a firmer basis for environmental standards, and the standards, in turn, would determine technological objectives for research and development efforts.

The pace of development of particular types of energy may ultimately be related to public acceptance. Delays in the environmental research program could result in significant delays in the preparation of environmental impact statements, licensing of power-generation facilities, and the implementation of various energy technologies.

Land Use and Water Mangement

The use of land for energy-related activities, such as fuel extraction, siting of fuel-conversion and power-generating facilities, transmission-line rights-of-way, and waste-management requirements, is becoming a significant factor. Regional and national management policies must be developed to accommodate competing needs for land and water for development of energy resources, wildlife conservation, recreation, irrigation and agricultural programs, and lumber and paper-pulp industries. Mining and reclamation and especially conversion processes for coal require large amounts of water, and water is not plentiful in those areas of the West where vast reserves of coal are located. An equitable distribution of land and water resources to competing claims must be devised. Such an integrated policy will be required to maintain the Nation's scenic beauty and ecological integrity as it meets its energy needs.

Federal and State Laws and Regulations Governing Health and Safety of Miners and Industrial Workers

The enactment of such laws as the Operational Safety and Health Act (OSHA) has had a widespread impact on industry, generally in terms of increased requirements for capital expenditures to provide much-needed additional safeguards for workers' health and safety and has also resulted in decreased productivity.

New technological developments should produce equipment and methods that are consistent with the laws and regulations. As such, the laws and regulations are not constraints to technological development but are an objective of such development.

Manpower Availability for Research and Development

In the late 1960s, employment opportunities for scientists and engineers declined owing largely to the termination of large programs in the aerospace industries. More recently, conditions have stabilized, and employment among scientists and engineers is high. A major increase in research and development funding could require a major increase in scientific and technical personnel.

If major increases in research and development funding are directed into new fields, the pace may be limited by the rate at which investigators can be educated, trained, or retrained to work in those areas. More importantly, most of the program categories comprising energy research and development are multidisciplinary. They rely on many of the same disciplines for both research and development. A shortage of trained manpower can create a competitive atmosphere that could result in spiraling wages and relatively inefficient use of research and development dollars. Currently the number of proposals for energy and energy-related research and development projects by firms and individuals in academic positions indicates that manpower is available for additional work.

The universities and industry have the greatest potential for producing new scientific and technical manpower. Research and development funds channeled to them would produce, in addition to increased knowledge, a large working force for future research and development. This force would comprise both undergraduate and graduate students and older workers retrained for new fields. Trained personnel can be retrained within a year or two and well-trained graduate students can be produced within two to three years.

These limitations on the growth of an available manpower pool and the hazards of attempting to radically increase funding for programs that would compete for scientific manpower dictate that extreme care be exercised in designing the energy research and development program for the next five years. If major acceleration is necessary in certain program areas, such acceleration may entail costs not only in dollars but also in the loss of capability to enhance or continue research and development in some competing programs.

Government Policies Concerning the Exchange of Information Between Large Corporations (Antitrust Laws) and Patent Rights

The public and privately owned electric utilities are regulated and have formed the Electric Power Research Institute (EPRI) to use funds charged to the rate base to conduct research and development of benefit to the entire industry.

By contrast, companies in the oil industry are specifically precluded from joining together in such a venture. As a result, each oil company must work on its own research and development goals; much duplication results. Since different oil fields have different physical characteristics, a wide variety of techniques has been developed for drilling, control, production, and stimulation of oil and gas. If each company could benefit from the experience of others, the net result should be more efficient operations and greater production. What does not exist and is precluded from existing is a central clearinghouse for research and development data and information that is in the hands of individual oil and gas companies. If solutions are developed by individual companies, proprietary rights could preclude widespread application or even application in regions where most appropriate. The oil industry is spending more than $600 million annually for research and development. With existing constraints, however, coordinated programs in the industry leading to the necessary solutions are not possible.

The oil industry has been reluctant to undertake cooperative efforts with the Government because rights to proprietary data could be compromised. Both patentable and unpatentable data are involved.

The same is true for other industries. Individual companies fear that funds invested in research and development would not be returned if the benefits are afforded to the industry as a whole.

The concept embodied in EPRI partially solves the problem by permitting the industry to share the risk as well as the benefit. When only one company or a part of the industry has an interest, however, it should be accorded some right to the advantages of research and development when it shares risk with the Government. It appears inconsistent to assume that, because taxpayers' dollars are spent to enhance the public good, an industry that risks capital along with the taxpayer should not be allowed to derive specific benefit. This area needs much consideration.

Government Policies Concerning Leasing of Federal Lands

Much of the oil, gas, oil shale, and geothermal resources and reserves in the United States are on public lands or beneath U.S. waters. The exploration and exploitation of those lands requires Government consent through leasing. Many such areas have not been opened to leasing, and vast reserves and resources have yet to be tapped. Although the outer continental shelf in the Atlantic Ocean may contain as much or more oil and associated gas than the Alaskan North Slope, there is as yet no leasing program for that area, and exploitation cannot be undertaken.

A similar situation exists for the oil-shale reserves located in the Piceance Creek Basin of western Colorado. About 75% of the rich shale deposits are located on federally owned property. Although the development of these areas is not primarily a research and development function, the lack of an adequate assessment of the potential resource base is a significant obstacle to energy policy formulation and research and development planning.

Market Uncertainties

Industry cannot predict with any degree of certainty future market conditions, e.g., the effects of the rising prices of imported oil and the regulated price of natural gas. The significance of these conditions lies in the fact that projected shortages in the supply of these commodities probably will not be overcome by private incentives as long as major market uncertainties exist.

Short-run self-sufficiency can be attained only by imposing measures that reduce the demand for energy to the maximum amounts that can be supplied from domestic resources. Other policy decisions that permit the maximum increase in domestic production will be required to realize short-term increases in the production of energy from domestic resources. Measures to increase domestic supply must continue with a view to relaxing the nonmarket measures imposed to reduce consumption. The first step in this direction is to accelerate the implementation of existing technologies for producing energy from domestic resources.

The overwhelming majority of the domestic production capability resides in the private sector. Private-sector investment decisions are made on the basis of expectations regarding future prices of energy rather than current prices. Thus, in the absence of Government policies to reduce the commercial uncertainties of increasing domestic production, there will be a substantial time lag in the implementation of existing technology until domestic producers are convinced that the high prices are going to prevail for long enough to make their investment profitable.

Moreover, other obstacles to rapid construction of additional domestic production capacity must be removed. Leasing policies that make available potential sources of domestic fuels must be devised. Guarantees of prices, guarantees of rates of return on investment, tax write-off policies, depletion allowances, and other risk-sharing measures to reduce the uncertainty of commercial ventures to acceptable levels must be considered. The dilemma confronting the Federal Government is that risk-reducing measures may diminish the incentive for private-sector research and development efforts aimed at reducing the costs of domestic production.

Capital investments for supporting functions may become limiting. For example, transportation of coal to market or to distant conversion plants will require revitalization of the rail industry or construction of special slurry pipelines.

There are two fundamental difficulties with a market approach to achieving domestic energy self-sufficiency. The effectiveness of the approach depends on the expectations of private producers about the continued high level of energy prices for substantial periods in the future. Given the potential availability of cheap foreign sources of energy materials, private producers must weigh carefully the risks of a major investment in a high-cost technology, using domestic resources. Supplies that can be cut off quickly can be turned on again as quickly. A private producer who makes a major investment in an oil-shale plant that can produce and sell oil for $5 a barrel can find himself in an untenable position if, soon after production begins, oil at $3 a barrel becomes available from foreign sources. Thus, relying primarily on market forces to generate increased domestic production implies an extended period of administrative controls to restrict consumption to available domestic supplies.

Research and development expenditures are justified for a commercial enterprise only with the expectation that they will lead to a sufficiently large increase in profits to provide an acceptable rate of return, compared to alternative uses of the limited capital available to the firm. In a situation without government-guaranteed product prices, there is no assurance that a private concern would find major research and development expenditures, with all the uncertainties involved, an attractive investment compared to additional productive capacity at guaranteed prices or rates of return.

7

Objectives of the National Energy Research and Development Program

The technical and scientific obstacles and the various political, environmental, manpower, and legal constraints to implementation of vitally needed energy technologies have been discussed in the previous chapter. The accelerated energy research and development program recommended in this report is designed to overcome these obstacles as expeditiously as possible.

It is essential in planning a balanced research and development program both to meet short-term needs and to ensure the means of meeting the needs of the decades beyond the short-term. The current scientific and technological limitations on various promising programs are reflected in the time required before commercial application of program results can be implemented. In this chapter the specific technological objectives sought for the time periods defined as short-, mid-, and long-term are summarized. This listing indicates the allocation of effort according to the different time periods within which the beginning of commercial payoff is expected.

NEAR- OR SHORT-TERM (PRESENT TO 1985)

This category includes research and development objectives that enhance the implementation of existing technologies, identify additional resources, and improve the efficiency of existing techniques, practices, and processes. Particular attention is given to removing barriers to public acceptance, satisfying existing standards, and developing an improved basis for standards in all energy production and use areas. In the list that follows, objectives with most immediate commercial payoff in energy production or conservation are marked with a •.

Task 1. Conserve Energy and Energy Resources

- • Identify and quantify energy-conserving practices and processes throughout the economy.

- Develop a model of the energy system and an appropriate data base; use the model to improve the quantitative understanding of the energy system and its interactions and to assist managers to better plan and manage energy research and development.
- Increase the efficiency and capacity of electrical transmission and distribution systems, both above and below ground.
- Increase the efficiency and capacity of energy storage systems.
- Develop combined-cycle technology.
- Develop materials and technologies for high-temperature "topping cycles," including potassium topping cycles and magneto-hydrodynamics.
- Demonstrate techniques and consumer incentives that shift demand to more efficient transportation modes for people and goods for both urban and inter-city travel.
- Evaluate and demonstrate vehicle designs that optimize fuel economy and develop more efficient engines that are environmentally acceptable.

These objectives will enhance the efficiency, acceptability, or resource base of existing energy technologies. Progress in achieving these objectives will help attain the goal of energy self-sufficiency and will clarify choices among mid-term and long-term energy research and development goals as time goes on.

Task 2. Increase the Domestic Production of Oil and Gas

- Demonstrate effectiveness of new and currently available methods for secondary and tertiary recovery from existing oil and gas fields and publicize results.
- Develop methodologies to recover gas from tight formations.
- Improve methods for assessing potential oil and gas recovery from offshore sites and oil shales.

Task 3. Substitute Coal for Oil and Gas on a Massive Scale

- Improve emission-control technology for coal, especially with second-generation stack-gas cleaners.
- Mine coal with improved techniques and more effective reclamation.
- Improve gasifiers for production of low-BTU gas.
- Enhance supplies of hydrogen for coal conversion technologies.
- Develop materials for the construction and operation of coal conversion plants and develop methods for handling solids, including grinding, transporting, and separating from liquids.
- Demonstrate economic viability and reliability of the conversion of coal to gas and oil.

Task 4. Validate the Nuclear Option

- Evaluate environmental and safety problems associated with converter reactors.

- Standardize nuclear reactor site selection procedures.
- Demonstrate safe procedures for handling and storing radioactive materials, including plutonium.
- Develop long-term disposal procedures for radioactive wastes, including plutonium.
- Improve enrichment techniques for uranium.
- Improve fuel fabrication and reprocessing methods.

Task 5. Exploit Renewable Energy Sources

- Reduce capital costs for solar heating and cooling units.
- Find and assess potential reservoirs of geothermal energy.
- Develop improved methods for extraction of heat from geothermal sources.
- Assess potential dangers of disturbing geological formations by extracting geothermal resources.

MID-TERM PERIOD (1986-2000)

Mid-term energy research and development program goals aim at providing alternative energy sources and increased ability to substitute more plentiful fuels for scarcer ones. Conservation and efficiency measures, conversion of coal to gas and oil, breeder reactors, and certain solar and geothermal sources are prime elements of the mid-term program. The long lead time for development and implementation of these promising technologies makes it urgent to accelerate funding now to meet expected energy demands more than a decade from now.

Task 1. Conserve Energy and Energy Resources

- Demonstrate gains in efficiency from combined-cycle technologies.
- Develop engines capable of using a greater variety of fuels.

Task 2. Increase the Domestic Production of Oil and Gas

- Demonstrate the economic viability of oil recovery from oil shale.

Task 3. Substitute Coal for Oil and Gas on a Massive Scale

- Improve the economic viability and reliability of conversion of coal to oil and gas.
- Develop improved catalysts for fuel conversion processes.
- Maintain efforts to assess and minimize environmental impacts of energy production.

Task 4. Validate the Nuclear Option

- Demonstrate economic viability and reliability of various breeder reactors.

- Evaluate environmental and safety aspects of breeder reactors.
- Develop fuels and materials for advanced reactors.

Task 5. Exploit Renewable Energy Sources

- Demonstrate methods to produce significant amounts of electricity from direct solar incidence, from ocean thermal gradients, from wind, etc.
- Develop photovoltaic, thermoelectric, and bioconversion techniques to a significant level of productivity.
- Demonstrate economic viability of advanced geothermal methodologies.
- Demonstrate technical viability of thermonuclear fusion technologies.

LONG-TERM PERIOD (BEYOND YEAR 2000)

Many presently unanticipated variables, of course, will become important in the long-term period. Changes in the organization of society, in the patterns of transportation and other energy uses, in the needs of industry, and in overall economic growth patterns may occur. The long-term goal of the energy research and development program for self-sufficiency is the production of adequate amounts of environmentally clean, low-cost fuels from relatively inexhaustible domestic sources. Energy should be available in forms best suited to the energy needs of the various sectors of the economy. Specific objectives include:

Task 1. Conserve Energy and Energy Resources

- Improve technologies for conversion of fuels to electricity.
- Improve methods for transmission, distribution, and storage of energy.

Task 5. Exploit Renewable Energy Sources

- Develop large-scale direct and indirect solar-energy conversion programs.
- Develop methods for producing hydrogen in large quantities at low cost.
- Develop fusion technologies to economically viable status.
- Provide advanced materials for fusion reactors.

Supporting Programs

Certain supporting objectives in closely allied areas must be pursued as complements to the specific energy objectives set out above. The most important of these are:

- Enhance basic research into energy systems and fuel sources.

- Continue basic research into chemistry, physics, geology, and biology to identify new potentials and provide the basis of knowledge for solution of problems that experience shows will arise.
- Establish the nature, emission patterns, distribution in the environment, and ecological and medical effects of pollutants.
- Provide improved bases of knowledge for setting environmental standards and minimizing environmental impacts from energy technologies.
- Develop detailed methods to enhance environmental and ecological integrity and overcome any necessary but undesirable impacts that have accumulated.
- Create and sustain an adequate supply of scientifically and technically competent manpower to support the operation of the energy system and the research and development program.

Analysis of these objectives and the time period when they are currently expected to be achieved is a useful input to the process of designing a balanced national energy research and development program.

Appendix A

FY 1975-1979 ENERGY R&D PROGRAMS AND SUPPORTING PROGRAMS

This appendix outlines the recommended national energy research and development program and supporting program. The appendix includes discussions of:

- Program Goals
- FY 1975-1979 Program Objectives
- Contributions to the Energy System If Success Is Achieved
- Program Plan
- Supporting Evidence
- Budget

TASK 1–CONSERVE ENERGY AND ENERGY RESOURCES

A. REDUCED CONSUMPTION **$210M**

Program Goals:

1. End-Use Conservation **$150M**

To conserve energy and energy fuels by reducing the rate of growth in consumption and to achieve this reduction while maintaining an acceptable standard of living and environment, under conditions of minimal social and economic dislocation.

2. Improved Management .... **$ 60M**

To conserve energy, energy sources, and energy research and development resources by providing analytic tools for comparative analyses of alternative energy strategies that will assist energy policy and energy research and development policy decision makers in establishing policies.

FY 75-79 **Program Objectives:**

1. End-Use Conservation

a. To maximize specific energy efficiency in buildings by developing and demonstrating improved design, construction techniques and practices, operational methods and maintenance practices, and use of materials that require less energy for production.
b. To reduce energy consumption in industrial processes by developing and demonstrating improved design, construction techniques and practices, operational methods, and maintenance practices and the use of materials that require less energy for production.
c. To increase the energy efficiency of transportation systems by developing and demonstrating more efficient utilization of alternate modes, patterns of traffic flow, coordination of systems to urban growth patterns, and use of local regulations.
d. To demonstrate the energy efficiencies to be derived from integrated utility systems that would provide a community with all utility services from a single plant.
e. To develop appropriate information and data, with cross-energy-sector applications, for analysis of the implications of demographic trends, land use alternatives, and new technologies in terms of their impact on energy demands.

2. Improved Management

a. Develop and maintain an adequate base of information and data on and improve existing and develop new quantitative models of the U.S. energy system in order to provide the analytical tools required for analyses of alternative energy policies or management concepts.

b. Conduct assessments, including evaluation of environmental, economic, and social factors, of emerging energy technologies and integrate the results of those assessments into evolving national energy policies and strategies.
c. Develop evaluation criteria for the selection of energy research and development strategy alternatives and identify the trade offs implicit to these alternatives.
d. Develop recommendations for systematic management of energy research and development including identification of total resource needs and the allocation of those resources among competing programs, taking into consideration the appropriate roles for Federal and private funding.

Contributions to the Energy System If Success Is Achieved:

1. End-Use Conservation

The potential savings available through the application of conservation measures are obviously very large and difficult to predict. A 20% savings by 2000 is a conservative estimate. If 30% of the existing buildings in the U.S. are modified so that their heating and cooling loads are reduced 40% and 30%, respectively, a savings of 3% of the present total annual energy used in the U.S. will be realized.

If 50% of the new buildings built each year incorporate energy conservation design features that result in a 40% savings in consumption, a total savings of 15% of the present U.S. consumption would be realized at the end of 10 years.

Ultimately a 30% reduction in primary fuel requirements for industrial thermal processes is a realistic goal, through improved thermal processes and waste energy utilization.

Improved transportation efficiency, especially improved auto occupancy and improved management of freight, could reduce projected transportation demand by about 5% by 1978 and 10% by the year 2000.

Market analysis shows that Modular Integrated Utility Systems (combinations of various utility services in a single facility) can be utilized to service 16% of all new construction. Based on this estimate, energy requirements for space heating, hot water, air conditioning, and electricity in new construction can be reduced 35% by 1986—a reduction of 8.5% of total energy requirements for residential utilities.

2. Improved Management

Improved management planning using modern analytic techniques and a current data base can provide a means for rapid objective assessment of energy system requirements, trends, capabilities, and limitations. The decision maker would have at his disposal a more rational basis for assessing trade-off options and the allocation of resources to meet either energy needs or research and development requirements. Viable options for program planning can be analyzed to optimize payoff with minimum expenditures of resources.

Program Plan:

1. End-Use Conservation

Since too little is known about the specific opportunities for research and development leading to more efficient equipment, building, and process design, early program emphasis must be on problem definition and program design and formulation. The FY 1975 objectives and expenditures must, if necessary, be applied to "software"–or studies leading to program formulation. That activity will be supplemented by an acceleration of those programs already underway where specific objectives are clear (e.g., Modular Integrated Utility Systems–MIUS).

The software results are expected to include numerous proposals for "hard" research and development activities that can be begun immediately, and a rapid rise in program funding levels is anticipated. Concepts for energy conservation abound, but their implicit effects are essentially unknown. Once those effects are better defined, it should be possible to move directly to demonstration projects in many fields. Other "software" results are expected to specify the need for more research and development on component or material design that would result in a rapid rise in laboratory experimentation.

2. Improved Management

Improved management must begin with the development of an open-ended data base and models that will provide for forecasting of impacts and estimated results of various research and development efforts. A second level of effort will be directed toward analyzing those alternative models on a quantitative basis and translating the results into management tools for evaluation of research to be undertaken and research and development underway.

Supporting Evidence:

1. End-Use Conservation

The general subject area of process and utilizing-device efficiency is so broad that a primary necessity exists to define those topics of highest potential "payoff" before detailed technical investigation is begun in earnest. The range of disparity between theoretical requirements for energy and actual use patterns shows that there is a wide range of opportunities for increasing efficiency. Land, building, and equipment designers and contractors, industrial users of energy, and the individual consumers comprise a widely disparate field of potential research and development partners. Clearly, only the Federal Government can lead in such a fragmented area of investigation, development, and demonstration. It should be noted that many governmental pricing research and development regulatory policies have been based on an effort to promote cheaper or more abundant energy. Effort will be needed to smooth a transition from some of these policies.

Research and development conducted under the aegis of the Government can produce new standards for performance and design that would support policy incentives by the Executive and the Congress, and demonstration of more efficient designs can lead to the adoption of new equipment, methods, and construction that will produce savings for the user as well as the Nation.

2. Improved Management

Systems and planning analysis functions exist in all Government agencies that are currently active in energy or energy-related research and development. Such functions are necessary for program management and analysis. However, there does not exist the technological base for management and analysis of energy policy and research and development. Decision makers are forced to rely on multiple data bases and systems for analysis purposes. Both central policy coordinators and individual program directors can benefit from centralized planning and analysis models in addition to the requisite agency support offices.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
End Use Conservation						
Buildings	6.2	10.0	11.0	11.6	11.2	50.0
Industry	5.4	9.0	14.0	12.8	13.8	55.0
Transportation	1.8	4.2	4.5	3.0	1.5	15.0
Integrated Utility Systems	4.5	5.0	4.0	1.0	0.5	15.0
Cross Energy Sector Studies	2.0	3.5	4.0	3.0	2.5	15.0
TOTAL	19.9	31.7	37.5	31.4	29.5	150.0

Budget (continued):

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Improved Management						
Energy Data Base and System Modeling	3	3	4	3	3	16
Technology Assessment of Emerging Energy Systems	2	2	4	4	2	14
Evaluation Criteria for Energy Systems	2	2	1	1	1	7
Systematic Management Analysis of Alternative Energy Futures	3	5	5	5	5	23
TOTAL	10	12	14	13	11	60

B. INCREASED EFFICIENCY $1440M

Program Goals:

1. **High-Temperature Gas Turbine** $315M

To conserve energy fuels by developing high-temperature turbine systems that will result in increased efficiency of energy conversion.

2. **Advanced Cycles, Fuel Cells, and Other** $210M

To conserve energy fuels by developing more efficient methods for converting fuels to useful energy (other than through high-temperature gas turbine systems).

3. **Advanced Automotive Propulsion** $300M

To conserve energy and energy fuels by developing more efficient propulsion systems for automotive units.

4. **Rail, Bus, Ship, and Air Systems** $205M

To conserve energy by developing more efficient propulsion systems and increasing the efficiency of use patterns of air, rail, bus, and ship systems.

5. **Energy and Fuel Transmission, Distribution and Storage** $200M

To conserve energy by developing more efficient and reliable means of transmitting, distributing, and storing energy and energy fuels to meet the demand sector of the future in a safe, environmentally acceptable way.

FY 75-79 Program Objectives:

1. **High-Temperature Gas Turbines**

   a. To increase the overall efficiency and reliability of power generation and space heating systems by developing efficient high-temperature gas-turbine systems.
   b. To develop a direct cycle gas turbine for use with the high temperature gas reactor (HTGR).

2. **Advanced Cycles, Fuel Cells, and Other**

   a. To increase the overall efficiency and reliability of power generation by developing potassium-vapor topping and magnetohydrodynamic (MHD) conversion systems.
   b. To develop efficient and economical fuel cells for centralized and decentralized power generation.
   c. To develop systems for the economical conversion of wastes to power.
   d. To investigate, evaluate, and develop new concepts for efficient energy conversion.
   e. To evolve the basic constituent technologies that enable the substantial improvement of various power systems or that make feasible entirely new concepts for power generation.

3. **Advanced Automotive Propulsion**

   a. To improve the energy consumption efficiency of existing propulsion systems for autos and trucks and demonstrate new energy conservative vehicle systems.
   b. To explore and develop systems to use alternative fuels as substitutes for fuels derived from crude oil.

4. **Rail, Bus, Ship, and Air Systems**

   a. To conserve energy by improving systems capability to integrate mass transit systems.
   b. To develop design and engineering improvements to increase energy efficiency of ships.
   c. To improve efficiency of energy use by air transportation systems.

5. **Energy and Fuel Transmission, Distribution and Storage**

   a. To develop new or improved technology for a-c and d-c bulk power transmission systems that will provide the capability to double the present capacity (with further eventual increase to 4 to 10 times present capacity) economically and without environmental degradation.

b. To develop underground transmission systems capable of matching future overhead systems in both power capacity and voltage with as low a cost differential between overhead and underground as possible.

c. To improve distribution system efficiency and reliability through advanced systems security/control methods and equipment.

d. To develop efficient and environmentally acceptable methods of storing energy for use during peak energy demand periods.

e. To develop advanced ship concepts for the transportation of fuels with improved throughput and efficiency and with improved environmental and safety controls.

Contributions to the Energy System If Success Is Achieved:

1. High-Temperature Gas Turbines

Energy savings in the year 2000 will amount to 2 x 10^{15} BTU, if high temperature gas turbines can be developed. Such turbines used in conjunction with ordinary steam cycle converters could raise the conversion efficiency of central station power plants to 50% or greater.

High-temperature gas turbines directly coupled to heating system burners could produce electric power and reject the waste heat for space heating purposes. The electric power generated would be a bonus not obtained in current heating systems. Some 2 x 10^{15} BTU per year could be saved this way by 2000. A direct-cycle gas turbine operating from the helium coolant from the HTGR will reduce efficiency losses that are expected if heat exchange to a second fluid is effected.

2. Advanced Cycles, Fuel Cells, and Other

Potassium topping cycles would conserve 1 x 10^{15} BTU per year by 2000. MHD used in a topping-cycle mode would effect similar savings.

Conversion systems using wastes as fuels have an unknown effect on the energy system but represent a major potential in solving municipal (and other) waste disposal problems.

Fuels cells could be used for decentralized conversion of fuels (e.g., natural gas) to electric power in homes or buildings or used to replace peak power generating systems at decentralized locations.

3. Advanced Automotive Propulsion

The proposed transportation energy research and development program will reduce transportation dependence on crude oil by 22% in the year 1985, by 55% in the year 2000, and up to 100% after the year 2000. The proposed program for auto/trucks will result in a projected savings of approximately 1 billion barrels of oil per year by 1985 and 3 billion barrels per year by 2000.

4. Rail, Bus, Ship, and Air Systems

Information will be developed which could result in operational economics of aircraft to accomplish a 15% reduction in fuel use by 1985. The propulsion segment of the program provides means for reducing aircraft fuel requirements in the mid-1980's and beyond by major improvements in engine technology. Savings on the order of 30% or more by 2000 appear to be feasible; the proposed program will initiate the research and development effort required. The successful completion of research and demonstration projects directed toward a near-term reduction in transportation petroleum consumption by means of shifts to the energy conservative bus and rail modes of transportation could result in reducing the total projected transportation energy consumption by 3% in 1985 (0.15 billion barrels per year) and 5.8% in the year 2000 (0.36 billion barrels per year). With successful research and development, potential power savings of 15% can be made in the operation of ships.

5. Energy and Fuel Transmission, Distribution and Storage

Current technology applied to the projected need for electrical power in 1985 and 2000 would result in a doubling and quadrupling, respectively, of power lines and auxiliary facilities. The research and development objectives, if attained, would allow the transmission and distribution of the power with fewer high-capacity lines and result in underground transmission of much of the increased supply. Storage systems using batteries, electromagnetic, or mechanical devices would reduce requirements for peak load generation equipment that are inherently less efficient and make no use of the excess base load capacity during off-peak hours.

Liquefied natural gas tankers operating today lose up to 10% of their capacity through evaporation and represent significant safety hazards both on the seas and in port. Research and development would increase efficiency and mitigate the dangers. New ship concepts such as submarine tankers and extremely large barge-tankers would allow the shipment of energy fuels from arctic regions, lower costs for bulk shipment, and obviate requirements for deep-water ports for deep-draught tankers.

Program Plan:

1. High-Temperature Gas Turbine

An open-cycle high-temperature gas turbine will be developed to the point of constructing and operating a combined cycle 100-MW demonstration power plant by 1979. A variety of fuel sources must be tested for compatibility. Catalytic combustion processes, water cooling techniques, and the application of ceramic materials for blades will be included in the development program.

A high-temperature gas turbine whose exhaust is used for space heating will be developed. A 2- to 3-MW power plant demonstration unit will be constructed and tested. Following tests, several such units will be used by the Department of Housing and Urban Development for demonstration in model energy conserving housing developments.

A 750-MW(e) helium direct-cycle gas turbine facility will be constructed to develop a turbine for use with the HTGR.

2. Advanced Cycles, Fuel Cells, and Other

A preliminary design and detailed economic assessment of a 1000-MW power plant using a potassium topping cycle will define program specifications. Based on these specifications, development will proceed to include design, construction, and operation of a pilot 30-MW potassium vapor topping cycle unit by 1979.

The MHD program will accelerate the development of the open cycle, liquid-metal closed cycle, and closed-cycle plasma concepts. All three program elements will address materials questions, systems analysis, and component design.

The program directed toward tne use of wastes as fuels includes systems studies and prototype equipment development and testing for combustion, biochemical conversion and pyrolysis, and combusting wastes for power generation and auxiliary emission control technology development. Six incinerator-boiler pilot plants would be constructed or modified and operated.

Fuel cell development would be extended substantially to produce pilot and demonstration plants for acid hydrogen, methyl alcohol molten carbonate, alkaline hydrogen and high-temperature (1000°C) solid electrolyte type cells. Both centralized and decentralized applications would be studied. Pilot plants 10 kW or larger are planned.

Higher conversion efficiencies may be realized by utilizing advanced concepts such as Feher (CO_2) cycles, thermionics, or thermogalvanic cells. Applied research to test these concepts is planned in the FY 1975-1979 period.

A vigorous program of supporting research and development is necessary to augment the above program. Emphasis will be on metals and ceramics research for high-temperature application, thermodynamics, and catalysis.

3. Advanced Automotive Propulsion

Significant short-term impact can be achieved by conducting a program of research, development, and demonstration to provide a factual data base for a regulatory program aimed at reducing automotive petroleum consumption.

Assessment studies will be conducted to define the fuel economy improvements achievable with state-of-the-art technology and with new improved technology. Results will be disseminated, and development of the new technology will be initiated. Demonstrations of fuel economy improvements achievable with this technology will begin.

Several propulsion and vehicle systems will be evaluated, two of which will be brought to the engineering development phase. Preliminary battery design for a moderate performance electric car will be completed in FY 1977, and prototype motors, controls and power conditioning will be demonstrated in FY 1979. Studies will continue on the technical and economic feasibility of using fuels derived from domestic nonpetroleum energy resources for automotive transportation.

4. Air, Rail, Bus, and Ship Systems

Significant short-term impact can be achieved also by conducting a program of research, development, and demonstration to provide a factual data base for a regulatory program aimed at reducing aircraft petroleum consumption. Studies will be conducted to provide the technical basis for operational measures which will reduce near-term fuel savings on current aircraft.

Work will be done to provide the technical information required by developers of synthetic hydrocarbon fuels for assurance that the fuels, when produced, will be suitable for current aircraft propulsion utilization and to devise and demonstrate the technology for alternate fuels handling at airports.

Work will be directed toward technology for improving fuel economy of existing engine types, for development of advanced fuel-conservation gas turbine engines, low-drag aircraft, and for adaptation of aircraft gas turbine engines to the use of alternate fuels.

Some effort will be expended to determine the technical and economic feasibility and to generate critical long-lead technology for air-cushion vehicles, lighter-than-air vehicles, and very large slow airplanes as energy-conservative alternatives to conventional aircraft for large cargo shipment.

New rail and bus technology developed by industry and the Federal Government is proposed to be brought to bear in new-initiative demonstrations. Major efforts for integrated bus transit systems are proposed for a city with a population under 1,000,000 to be followed by a larger city of about 2,000,000. Computer aided information dissemination systems will be demonstrated.

Work will be done to improve those aspects of ship design and operation that impact on fuel consumption (hull shape, propeller design, and anti-fouling techniques). Work will continue on nuclear propulsion for ships, at least through the exploratory development phase.

5. **Energy and Fuel Transmission, Distribution and Storage**

Development objectives during the FY 1975-1979 period include prototype 1100-kV a-c overhead transmission lines and a 100-MW d-c terminal demonstration project. Four improved types of underground cables will be developed and completed for commercial use, and model tests of superconducting cables will be conducted.

A 10-MWH pilot model of a sodium-sulfur or lithium-sulfur battery will be built and a superconducting energy storage magnet will be developed to the prototype design stage. Engineering development of a flywheel facility will be completed.

Concept designs of surface and underwater ocean tankers, especially adapted for arctic service, will be completed. Advanced designs for LNG tankers with greater efficiency and safety will be developed. Computer controlled sailing ships will be studied and scale models tested.

Supporting Evidence:

1. **High-Temperature Gas Turbines**

Although gas turbines are now used widely, the use of gas turbines in sizes required for central station base load power production is rare, and lifetimes are too short to justify economic operation. Conservative management policies within the utility industry retards acceptance of this innovation and market formation. Large scale demonstration is necessary to encourage adaption to commercial use. Research and development partnership with industry should be forthcoming.

2. **Advanced Cycles, Fuel Cells, and Other**

Potassium topping cycles are technically feasible, but several materials problems must be overcome before systems can be built that will operate for lifetimes required in central power stations. Progress on MHD systems is also materials dependent.

Wastes used as fuel is also a technically feasible concept, but the economics of such an industry will depend largely on total system design to include recovery of other valuable resources (e.g., metals). Cost analyses and total system demonstration are required for proof of the concepts.

Fuel cells work today, but capital costs are high. Their ultimate application may depend on plentiful supplies of natural or synthetic gas or hydrogen. Less expensive catalysts and mass production methods may hold the key to reducing high initial costs.

Advanced concepts such as Feher (CO_2) cycles, thermionics, and thermogalvanic conversion are still in the early stages of technical evaluation. Theoretical efficiencies are high (60% or greater) but much bench scale testing is required to prove concepts for eventual economic application.

3. Advanced Automotive Propulsion

There seems to be no insurmountable manpower or capital availability problems in developing greater efficiency in automotive engine design and operation. Certain engines including the Rankine and Stirling cycle engines are inherently more efficient than the present internal combustion engine, and it should be possible to adapt one of these for future use on automotive systems.

Widespread application of new designs or concepts must be preceded by industrial willingness to change long standing methods of operation or governmental sanctions.

4. Air, Rail, Bus, and Ship Systems

Aircraft turbines are relatively efficient at present, but large savings in fuel can be achieved through improvements in the national air use system. Similarly, it is imperative that much thought be given to shifting transport modes from relatively inefficient automotive and air systems to the more inherently efficient rail system. The use of nonpetroleum fuels for aircraft systems would effect a significant savings in crude-oil requirements.

While ocean transport is still the most economical form of cargo shipment, there remain significant impediments to greater efficiency, specifically in drag reduction.

Nuclear ships exist today, but the economics of wider commercial use must be studied further, demonstrated, and safety aspects proven.

5. Energy and Fuel Transmission, Distribution and Storage

Cost restrictions inherent in underground transmission systems and superconducting magnets may require Federal tax incentives initially. No other restrictions in development or operating skills, material, or equipment are preemptive. Transmission systems with larger capacity are technically feasible, but economic criteria demand further development for cost-reduction purposes.

Storage systems must show economic advantages over peak-load generating costs that are now incurred.

The potential for finding and exploiting significant quantities of fuels in the arctic regions demands that we investigate appropriate means for economic and safe transport of those fuels to U.S. markets.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
High-Temperature Gas Turbines	18.3	66.8	79.3	76.8	73.8	315.0
Other						
Potassium Topping Cycle	7.0	14.5	26.0	20.5	22.0	90.0
Wastes as Fuel	1.5	2.6	2.3	1.9	1.7	10.0
Fuel Cells	5.5	9.5	17.0	21.0	27.0	80.0
Advanced Concept	2.0	2.0	2.0	2.0	2.0	10.0
Enabling Technology	2.0	3.0	5.0	5.0	5.0	20.0
Subtotal	18.0	31.6	52.3	50.4	57.7	210.0
Advanced Automotive Propulsion	53.0	59.0	59.0	71.0	58.0	300.0
Air, Rail, Bus, and Ship Systems						
Air	10.0	19.0	26.0	30.0	54.0	139.0
Rail & Bus	4.0	5.3	6.3	9.0	10.4	35.0
Ship	6.0	8.2	4.2	5.8	6.8	31.0
Subtotal	20.0	32.5	36.5	44.8	71.2	205.0

Budget (continued):

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Energy & Fuel Transportation Distribution & Storage						
Overhead T&D	8.1	7.4	7.4	7.4	9.4	39.7
Underground T&D	5.3	7.5	7.8	10.0	12.0	42.6
Storage	4.2	7.0	11.7	12.5	15.5	50.9
Systems Research	2.4	3.6	4.0	2.9	3.9	16.8
Ship Delivery System	7.0	8.0	9.0	12.0	14.0	50.0
Subtotal	27.0	33.5	39.9	44.8	54.8	200.0

TASK 2—INCREASE PRODUCTION OF OIL AND GAS

A. PRODUCTION $310M

Program Goal:

To increase the production of oil and gas by developing and demonstrating new technologies and extending current technologies that will result in rapid and economic in situ recovery of domestic resources.

FY 75-79 Program Objectives:

1. To increase the production of oil in operating fields by developing and demonstrating methods for secondary and tertiary recovery of residual reserves.
2. To increase the production of oil and natural gas by developing and demonstrating methods for stimulating flow in low permeability reservoirs.
3. To increase the production of synthetic petroleum from oil shale by developing and demonstrating methods for processing oil shale in situ to recover liquid products.
4. To increase the production of oil and gas by developing and demonstrating equipment design and methods of operation that will result in more economical drilling operations, environmentally sound practices, and a concomitant rise in find rates and the exploitation of deeper reservoirs.

Contributions to the Energy System If Success Is Achieved:

It is estimated that secondary and tertiary recovery could increase the production in operating fields by 260 million barrels per year by 1985. This could also result in the production of an additional 700 billion cubic feet of associated natural gas per year by that time. Improved methods for stimulating the flow of oil and natural gas in low permeability reservoirs could result in recovery of an additional 70 million barrels of oil and 2.6 trillion cubic feet of natural gas per year by 1985. Sucessful development of the technology for processing oil shale in situ could result in the production of 200 million barrels of synthetic oil per year by 1985. The development of equipment and procedures for faster, deeper, and more economical drilling could result in the discovery and recovery of 500 million barrels of oil and 2.5 trillion cubic feet of natural gas per year by 1985. Better drilling and operating policies could reduce the incidence of oil spillage and make offshore operations more environmentally acceptable.

Program Plan:

Combinations of four methods for secondary and tertiary recovery of oil will be tested in approximately 20 experiments that will include some 15 reservoir types. These experiments will determine optimum methods applicable to particular reservoirs.

Seven experiments are planned in three different reservoirs to determine the potential of massive hydraulic fracturing and chemical explosive fracturing for stimulation of low permeability formations. One further nuclear stimulation demonstration is also planned. The program is designed to determine which stimulation technique or combination of techniques is most suitable for given reservoir characteristics.

In situ retorting of oil shale will be tested in the Rocky Mountain basins using a combination of several different fracturing techniques and retorting conditions. The recovery rates for each combination and the control problems encountered will be studied to determine optimum technical design.

Development will be continued on jet drilling techniques and equipment and spark cavitation drilling concepts. Field tests on prototype equipment are planned to determine what improvements are possible in rate of penetration and capabilities in differing rock formations. Better control devices and practices will be tested to show potentials for reducing oil spillage, and oil-spill cleanup methods will be assessed.

Supporting Evidence:

Oil company research on secondary and tertiary recovery has been significant (~$30M/year). The lack of data exchange has inhibited widespread application of techniques or development of techniques with more general application. A Federal effort should be capable of drawing the technology base together and effecting technology transfer.

Nuclear stimulation of tight gas reservoirs has been successfully demonstrated. Further testing is required to demonstrate economics and to enhance efficiency. Explosive and hydraulic fracturing is effective in certain reservoirs, but massive techniques are theoretically indicated for effectiveness in the tight reservoirs.

In situ oil-shale retorting has been successfully demonstrated on a pilot scale.

Faster experimental drilling techniques now exist. Improvements are required in control technology, downhole equipment developments, and in extending operating lifetimes. "Blowout" control and oil-spill cleanup development are continuing activities of the oil industry but require greater emphasis to support enlarged offshore drilling activities.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Secondary and Tertiary Recovery (fluid injection)	10.7	22.4	20.5	12.0	4.8	70.4
Stimulation (conventional and nuclear)	9.1	31.2	23.2	16.6	16.2	96.3
Oil Shale In Situ (conventional and nuclear)	9.3	30.0	30.7	29.6	28.2	127.8
Advanced Drilling	2.6	5.5	5.1	1.3	1.0	15.5
TOTAL	31.7	89.1	79.5	59.5	50.2	310.0

B. RESOURCE ASSESSMENT $150M

Program Goal:

To support the increased production of oil and gas, the substitution of coal for oil and gas, and the production of nuclear fuels by enlarging the qualitative and quantitative inventory of domestic resources through exploratory techniques and new equipment and methods research.

FY 75-79 Program Objectives:

1. To improve as rapidly as possible the knowledge level of domestic resources and economically available reserves of oil and gas, both onshore and offshore.
2. To improve as rapidly as possible the knowledge level of domestic resources and economically available reserves of uranium and thorium.
3. To assess the Nation's coal resources in terms of quality, regional distribution, and recoverability.
4. To improve the information base on the distribution and quality of oil shales and tar sands.
5. To maintain an overview of the quantities and availability of nonenergy mineral resources essential to the energy-producing system.
6. To improve general exploration theory and technology.

Contributions to the Energy System If Success Is Achieved:

This research and development will lead not only to knowledge of new resources but also to better ability to judge the quality of existing resources. In coal especially this will lead to the ability to do better other research on combustion (which is related to the by-product content of coal types). In the oil-shale area it will also better define sites for in situ plants.

Program Plan:

Program activities would comprise 70% research in preexploration assessment technology and 30% analysis and research in exploration technology for onshore resources; and 90% exploration and 10% analysis and research for offshore resources.

Preexploration assessment to include the use of novel techniques will enlarge the data base necessary to analyze regions where resources are expected. The analysis effort will consist of accumulating, collating, and assessing data to improve methods of determining resource availability, both quantitatively and qualitatively.

The research effort is largely directed at the development of new exploration and analytic tools needed to locate and assess new reserves, including analogic digital modeling of energy resource deposits and identification of sedimentary process indicators for exploratory work.

A viable technology transfer program is required to disseminate findings to industrial users who would conduct most actual exploration efforts.

Supporting Evidence:

Federal responsibility for the development of natural resources cannot be properly discharged without knowledge of the resource base. Determination of viable energy options, resource development priorities, public land lease programs, prices, and subsidies should be based on reliable evidence of resource availability.

The current Federal research and development resource assessment program is not considered adequate to support a vigorous expansion in the use of domestic resources. Rational development at an increased pace requires greater knowledge than now exists if the highest payoff at least cost and environmental risk is to be ensured.

Industry welcomes and relies on Federal data and analyses to design their exploration and exploitation programs. Further, such data and analyses will provide a more rational basis for the development of national energy policies and energy research and development programs.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Petroleum and Natural Gas	6.7	8.3	13.0	20.0	22.0	70.0
Uranium and Thorium	6.3	6.7	8.0	9.0	10.0	40.0
Coal	3.0	4.0	4.5	4.5	4.0	20.0
Oil Shale	1.0	1.0	1.0	1.0	1.0	5.0
Non-Fuel Resources	1.0	1.0	1.0	1.0	1.0	5.0
General Exploration Technology	2.0	2.0	2.0	2.0	2.0	10.0
TOTAL	20.0	23.0	29.5	37.5	40.0	150.0

TASK 3—SUBSTITUTE COAL FOR OIL AND GAS

Program Goal:

1. **Mining** **$325M**

To develop and demonstrate more productive, safe, low environmental impact coal mining technology to the point where the mining industry can rapidly incorporate this technology in greatly expanded future operations.

2. **Direct Combustion** **$200M**

To substitute coal for oil and gas by developing coal-fired boilers for electric power generation which have improved thermal conversion efficiency, reduced costs, and acceptable environmental impact.

3. **Synthetic Fuels** **$1270M**

To substitute coal for oil and gas by developing the technology for converting coal to clean liquid and gaseous fuels.

4. **Common Technology** **$380M**

To provide the necessary supporting research and development to achieve the other coal objectives and to develop the technology necessary for reducing, to acceptable levels, the environmental impact of commercial scale coal processing, transportation, conversion, and combustion operations.

FY 1975-79 Program Objectives:

1. **Mining**

   a. To develop and demonstrate surface coal mining systems featuring integrated extraction and reclamation processes that meet environmental, social, and economic constraints.
   b. To develop underground coal mining systems that increase average productivity to 30 tons/man shift with as complete extraction as possible in a manner that ensures safety and environmental protection.
   c. To develop systems for mining oil shale in an environmentally safe and productive manner.

2. **Direct Combustion**

To complete pilot-scale tests of four methods of clean combustion of coal and to build and operate one pressurized fluidized-bed boiler system.

3. **Synthetic Fuels**

   a. To investigate several processes for converting coal to pipeline-quality gas and to build and operate a demonstration coal gasification plant.

b. To build and operate three to five pilot plants and two combined-cycle demonstration plants to test four processes for converting coal to gas of a low BTU content.
c. To investigate several processes for converting coal to liquid boiler and distillate fuels, select three or more of these for further testing in pilot plants, and design one demonstration plant.
d. To support the construction of two commercial-scale plants incorporating state-of-the-art processes and techniques for producing oil and gas from coal and to measure, monitor, and evaluate the operation of these plants.

4. **Common Technology**

a. To obtain data through laboratory research on materials and component development for various coal conversion processes.
b. To provide exploratory data for development of new processes.
c. To develop an economical method of removing sulfur dioxide from flue gas.
d. To reduce impurity and pollutant discharges resulting from the combustion of coal.
e. To improve the technology for impurity removal from coal by physical and chemical treatment.
f. To ensure the environmental acceptability of commercial scale processes of converting coal to gas and to liquids.
g. To develop economical methods of disposing of wastes resulting from the use of coal.
h. To investigate the feasibility of converting coal to gas in situ.

Contributions to the Energy System If Success Is Achieved:

1. **Mining**

To attain energy self-sufficiency, U.S. coal mining capability will have to at least triple in this century. In the near-term over 600 million tons/year of additional coal production capacity will be required by 1985.

2. **Direct Combustion**

When fluidized-bed boilers are developed, they will capture at least 25% of the market for new coal boilers. This implementation rate would result in 300 MW (or 0.2 x 10^{15} BTU fuel input) installed capacity in 1985 and 40,000 MW (2.2 x 10^{15} BTU) in the year 2000.

3. **Synthetic Fuels**

As a result of the proposed program, full-scale (250 million cubic feet/day) high-BTU gasification plants could be operating by 1980. Present estimates point to 1.2 trillion cubic feet/year of high-BTU natural gas from coal by 1985 and 3 trillion cubic feet/year by 1990.

Commercial production of low-BTU gas is expected to proceed at a rapid pace after successful demonstration, and the estimated benefits of this program to the Nation are:

	1985	2000
No. plants	10 commercial plants	210 commercial plants
Electric power	32.9×10^6 MWH(e)	1150×10^6 MWH(e)
Q energy released for priority uses	0.28×10^{15} BTU	9.8×10^{15} BTU
Q saved by high efficiency	0.014×10^{15} BTU	$0.49\text{-}0.9 \times 10^{15}$ BTU

Coal liquefaction could produce 250,000 barrels/day of liquid fuels in 1985. By the year 2000 it could produce 3 to 4 million barrels/day of liquid fuels and 1.5 trillion cubic feet of by-product synthetic pipeline gas.

4. Common Technology

Flue-gas cleaning and fuel cleaning could ultimately impact upon the entire industrial, residential/commercial, and utility market. Flue-gas environmental control capabilities could be achieved on 10 to 16 x 10^{15} BTU of generating capacity by 1985 and 20 to 40 x 10^{15} BTU of generating capacity by 2000. By the year 2000, yields of 2 to 6 x 10^{15} BTU/year of clean usable energy could be obtained by fuel cleaning. Ultimate application of pollution control technologies will allow achievement of air quality criteria from fuel combustion and, thus, continued use of existing domestic coal as fuel.

In situ gasification of coal could produce large quantities of pipeline-quality gas without recourse to mining and the disposal of processing-plant wastes.

Program Plan:

1. Mining

The surface coal mining program will develop and demonstrate mining and reclamation systems and equipment that would permit surface mining in the western and Appalachian coal fields at minimum cost and environmental impact. Particular attention will be paid to demonstration projects to assess the efficacy of the best present technology and identify and resolve indicated deficiencies.

The underground coal mining program will develop and conduct demonstrations of equipment systems for high-speed horizontal mine development, improved longwall mining, continuous materials handling systems, improved roof control systems, commercial extraction of methane from virgin coal and gob areas, and novel mining concepts. Technology for environmental protection associated with underground mining, including control of subsidence phenomona, control of chemical mine drainage effluents, and acceptable methods of waste disposal will be demonstrated.

The shale mining program is directed toward heading off immediate critical problems in oil-shale mining in the Piceance River basin, Colorado, where mining may be greatly increased soon. Principal emphasis will be on: (1) systems analysis effort to adapt surface mining technology to the unique problems of large-scale oil-shale extraction; (2) the development of basic structural parameters for the design of underground mines; (3) investigation of occurrence and movement of groundwater in the oil-shale strata; and (4) investigation of environmentally acceptable means of restoring surface-mined terrain to as good or better than original condition. New facilities will include a multipurpose prototype mine shaft to provide access to the deeper oil-shale sections.

2. Direct Combustion

Several clean combustion processes will be developed and tested in pilot plants. These include: (1) the pressurized boiler concept, in which the fluidized bed contains the heat transfer surface and the hot pressurized off-gases are expanded through a gas turbine; (2) the atmospheric pressure concept; and (3) the direct turbine drive concept. A mathematical model describing the fluidized-bed combustion process will also be developed. Each of the three variations will be tested in a separate intermediate sized plant (30 to 50 MW). One full-scale demonstration plant will be built.

3. Synthetic Fuels

The proposed plant for high-BTU gasification involves the acceleration of the present program being conducted under the joint direction of the Office of Coal Research and the American Gas Association, and the present Bureau of Mines program, as well as a program of supporting research and development for equipment/materials research and development and for basic studies of gasification chemistry. This plan includes the operation of the Hygas process pilot plant and the CO_2-Acceptor process pilot plant, completion of the construction and operation of pilot plants for the Synthane and Bi-Gas processes, and the construction and operation of one 80 million cubic feet/day demonstration plant.

The low-BTU gasification program includes the construction of the entrained bed gasifier type pilot plant [30 MW(e) to 50 MW(e)] within an existing utility and consisting of a gasifier, a gas turbine, a waste heat boiler, and a steam turbine. Cycle efficiency is estimated to be over 40% with initial operation expected in 1977. A fluidized-bed gasifier (pressure type) pilot plant [30 MW(e) to 50 MW(e)] will also be constructed. Initial operation is planned for 1978. A slurry fired pilot scale plant is planned for initial operation in 1976 or 1977. This is a pumpable coal/water high-temperature slurry feed system with high-temperature clean up of sulfur and particulates in a single compact vessel. In addition, three to five of the numerous new concepts for low-BTU gasification will be tested at the pilot scale.

Supporting development, including hot gas cleanup projects, will be carried out. Approximately two-thirds of the funding will be for the two demonstration projects and one-third for the smaller scale projects.

The coal liquefaction program consists of a series of interrelated, mutually supporting projects that will investigate alternate methods to liquefy coal. The work includes appropriate pilot plant, process plant, and laboratory-scale experiments. The end result is expected to be a demonstration plant test center where synergistic processes can be tested singly and in combination to show both technical feasibility and economic viability. A solvent refined coal (SRC) pilot plant will be completed and put in operation.

In addition, it is planned to support industry initiatives in funding the construction of two commercial scale plants to produce synthetic fuels from coal using state-of-the-art processes and technology. The operation of these plants will be monitored and evaluated to determine engineering improvements needed to upgrade processes and to assess the potential for further research and development in coal conversion processes.

4. Common Technology

Although the basic feasibility of producing gas and oil from coal and shale has already been demonstrated, ultimate economic practicality of these energy sources may depend either on the development of new procedures for at least part of these processes or on the gradual improvement of existing processes, materials, and equipment. Specific areas where technology development and support research are needed include: equipment development, materials improvements, investigation of catalysts and chemical kinetics for conversion processes, process development, and hydrogen production.

Methods for ensuring the environmentally acceptable combustion and utilization of domestic fuels will be reduced to commercial practice. Processes will be developed and demonstrated for improved control of particulate, sulfur dioxide, and hazardous pollutant emissions from combustion flue gases. Methods for environmentally sound coal conversion will be reduced to commercial practice. Technology for the physical and chemical separation of pollutant-forming constituents from coal will be demonstrated. Methods for ensuring the environmental integrity of major conversion technologies will be developed, and conversion process by-product recovery/utilization will be developed.

Concepts for the in situ gasification of coal will be evaluated and tested on a small scale to determine the potential for producing synthetic gas without recourse to mining and surface processing, thus reducing the overall environmental impact.

Supporting Evidence:

1. Mining

A resource base of necessary research skills exists within the Government owing to existing programs in the Bureau of Mines and Geological Survey. Lead time exists in which to develop skilled manpower for implementation of research results. Union resistance to improved mining systems can be expected to be minimal because of historical union positions, benefits to the miners, and the importance of the energy crisis. The importance of the crisis will also affect potentially inhibiting legislative restrictions. As the economic incentive (a long-term requirement for coal) increases, the coal industry will be able to adapt its financial and management structure to the necessary capital expenditures for innovative mining techniques. The same should hold true for the mining equipment industry.

2. Direct Combustion

Much of the technology in this area is available on a laboratory-scale basis. Further engineering and development is required to demonstrate its use on a commercial scale.

3. Synthetic Fuels

Several methods are known for producing pipeline quality and low-BTU gas from coal on a laboratory scale. The program described will allow further larger scale testing of these processes and the completion of a demonstration plant. The coal liquefaction program is based on technology that has been carried through small scale equipment and is supported by ongoing pilot plant projects. The primary risk involves scale-up, which means that plant outputs cannot be guaranteed but product quality can. The primary barrier to commercial acceptance is industrial fear of the magnitude of the investment in commercial plants. By underwriting the major risk, the Government will ensure the maximum rate of commercial adoption of these processes.

4. Common Technology

The various processes for burning and converting coal could not be pursued economically or rationally without parallel technology development and supporting research. Government funding of the pollution control area is required in view of the requirement for a cohesive, well-directed research and development program to support environmental quality control. Private industry cannot be relied upon to develop the broad research and development program that is needed.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Mining	45	57	64	77	82	325
Direct Combustion	30	35	40	44	51	200
Synthetic Fuels	240	287	264	254	225	1,270
Common Technology	90	72	66	72	80	380
TOTAL	405	451	434	447	438	2,175

TASK 4—VALIDATE THE NUCLEAR OPTION

A. HTGR, SAFETY, WASTE MANAGEMENT, ETC. $1245.7M

Program Goal:

To guarantee the nuclear option by performing research and development that will enhance the safety, environmental acceptability, reliability, and economic viability of nuclear converter reactors.

FY 75-79 Program Objectives:

1. To develop an improved basis for assessing the performance of safety systems and to develop improved safety systems and surveillance instrumentation necessary to ensure the safe and reliable operation of nuclear power plants.
2. To develop the control technology necessary to reduce nuclear power industry effluents to the lowest practical levels and to develop to full scale use a safe and efficient means for disposing of wastes generated by the nuclear power industry.
3. To develop techniques to reduce the environmental impact of thermal discharges from power plants and to develop guidelines for more rapid and standardized procedures for selection and review of facility sites.
4. To develop more efficient methods for uranium isotope separation.
5. To conduct research and development needed to heighten assurance of safe, reliable operation of the HTGR.
6. To develop satisfactory fuel fabrication and reprocessing systems for thorium to be used in the HTGR.
7. To successfully demonstrate the Light Water Self-Sustaining Reactor.

Contributions to the Energy System If Success Is Achieved:

The program proposed will ensure that nuclear power plants are available to meet their planned share of the requirements imposed by the growth in demand over the next few decades. Nuclear reactors are now used to generate 5% of the Nation's electrical power. This fraction is expected to grow to about 23% by1980, 49% by 1990, and 60% by the year 2000.

The program is directed at ensuring that the technology and resources are provided at the appropriate times to meet these scheduled increases in the role of nuclear power. It is also directed at ensuring that current apprehensions about the safety of nuclear power are met by definitive research and development at an early time.

The HTGR and the light water self-sustaining reactor can more efficiently and economically utilize available uranium and thorium resources and reduce the uranium supply and separative work requirements per unit of power over plant life. This will make sizable contributions toward conserving resources.

Program Plan:

Theoretical and experimental investigations will be conducted to obtain more complete information as to component failure and accident probabilities for nuclear reactors. Practical experimental results will be derived from the Loss of Fluid Test Facility (LOFT). The investigations will yield additional data applicable to the design and engineering of safety features and the establishment of regulatory standards.

The design of an engineered waste storage facility will be completed and construction begun early in the five-year period. Studies will continue on disposal of long-lived radioactive wastes in geologic formations, and a pilot facility in bedded salt will be constructed. Ancillary solidification processes will be developed and tested. Development will continue, and pilot and demonstration plants will be constructed to reduce or eliminate krypton, tritium, and transuranic components from reactor and reprocessing effluents.

The concept of the dry cooling tower to replace wet cooling will be the subject of a joint government-industry technology demonstration in Wyoming. Results and other studies are expected to lead to the construction and operation of a larger scale test facility after 1980.

A significant effort will be directed towards enlarging the options for siting of nuclear facilities.

The search for more efficient processes for uranium enrichment will include development aimed at improving the gaseous diffusion process, the demonstration of commercial feasibility of the gas centrifuge process, and exploratory efforts to prove technical feasibility of isotope separation using lasers. The Centrifuge Test Facility and ancillary facilities will be completed.

The base program for the High Temperature Gas Reactor (HTGR) will continue development of components and the review of safety features. The completion of research and development for ^{233}U-thorium utilization in the HTGR will include the completion and operation of reprocessing and refabricating pilot plants. Process demonstrations will open the path to using large resources of thorium in addition to ^{238}U.

An experimental core for a self-sustaining light water reactor using the ^{233}U-thorium fuel cycle will be tested in the AEC's Shippingport facility.

Supporting Evidence:

The current problem is to ensure timely licensing for construction and operation of nuclear power plants. One of the most important near-term objectives in this regard is to provide further assurance of the safety of the water and gas-cooled reactors. A considerable expansion of the reactor safety program needs to be undertaken to resolve questions raised. A related question concerns the management of highly radioactive wastes. A final solution to this problem is probably not necessary in the near-term period, but study and evaluation of several potential waste-management methods can result in the selection of the most promising interim and permanent disposal techniques. There must be sufficient assurance given that the present and proposed handling of these wastes is not only satisfactory for the time being but also that the methods used will not place undue burdens on future generations.

One of the principal problems will be finding suitable locations for nuclear power plants. About 50 sites have now been approved, and it is becoming difficult in some cases to locate new sites that meet AEC site criteria for safety, are available, and can supply water coolant needs. A program on dry cooling towers is included that will increase site selection possibilities by reducing the need for access to large amounts of cooling water. The efficiency of the electrically generated power will be about 10% lower when dry cooling towers are used, but success of this technical innovation will overcome a difficult siting problem. Coupled with development of efficient cryogenic transmission methods, use of dry cooling towers will permit clustering of power reactors in parks in remote areas of the country, where population density is low and land costs are less significant.

A determined production program will be required to prevent shortages of nuclear fuel over the period before the breeder is heavily relied on. Additional uranium isotope separation capacity must be provided, with construction begun in the next two years if the enriched-uranium requirements of the 1980s are to be met. Planning now for improvements in isotope separation will ensure an adequate and low-cost capability.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Reactor Safety, Reliability, and Performance	90.6	125.6	143.0	170.5	189.5	719.2
Uranium Enrichment	64.2	54.8	57.4	58.4	59.4	294.2
High-Temperature Gas Reactor	40.0	44.7	24.2	26.9	28.0	163.8
Light-Water Self-Sustaining Reactor	21.4	17.7	9.8	9.8	9.8	68.5
TOTAL	216.2	242.8	234.4	265.6	286.7	1,245.7

B. BREEDER REACTORS $2844.3M

Program Goal:

To guarantee the nuclear option by developing a safe, environmentally acceptable, and economically successful breeder reactor that will draw upon domestic resources to provide an alternative long-term energy supply.

Program Objectives:

1. To develop the technology for and demonstrate the commercial feasibility of the liquid metal fast breeder reactor (LMFBR).
2. To resolve the principal design and engineering problems of breeder reactors.
3. To develop the technology and methodology necessary to resolve safety questions affecting breeder reactor design.
4. To develop the necessary technology, methods, and procedures for handling and transporting plutonium.
5. To develop the technology for alternative breeder concepts including the gas-cooled fast reactor (GCFR) and the molten-salt breeder reactor (MSBR).
6. To develop advanced technology that would result in improved utilization of fissile resources.

Contributions to the Energy System If Success Is Achieved:

Liquid metal fast breeder reactors will begin to assume an important role by the 1990s and will displace the light-water reactors as the principal nuclear plant by the early part of the next century. The breeder will be a more efficient electric generating plant thereby reducing thermal discharge to the environment and making more than 50 times greater utilization of uranium as a fuel source. By the year 2000, breeder reactors could be providing more than 250,000 MW(e) to our electrical system which would be the equivalent of about 13×10^{15} BTU thermal input. The gas-cooled fast reactor, although significantly behind the LMFBR in the developmental schedule, is a potential alternate to the LMFBR, and, if warranted, commercial operations could begin in the early 1990s.

Program Plan:

A comprehensive LMFBR technology effort is being conducted which includes support of: (1) the Fast Flux Test Facility required to conduct necessary fuels and materials testing programs and to demonstrate the performance of components selected for LMFBR use, and (2) an LMFBR demonstration plant program.

The LMFBR base program includes the continued development of fuels and investigation of their behavior properties under different conditions and with increased knowledge of the physics of breeder cores. Extensive work will be accomplished on the development of new components and the analysis of the total reactor system incorporating selected designs. The base program also includes support for the operation of the Experimental Breeder Reactor and the Liquid Metal Engineering Center.

The engineering and safety aspects of the LMFBR program will include the construction and operation of an LMFBR engineering facility and advanced fuels laboratory, a steam generator test facility, a safety test facility, and a transient safety test facility. Technology development for handling, transporting, and containing plutonium will continue toward establishing the most desirable methods and procedures for adoption as standards and to resolve public questions regarding safety.

The program for the GCFR would provide required technology on fuel and reactor core development, physics, critical assembly tests, and safety analyses. In the MSBR area a fairly low level of effort will be expended to reevaluate the economics of this concept in light of recent information on fuel costs.

Advanced technology research is planned to develop new breeder fuels and materials that can increase the breeding ratios and power ratings and decrease the conservatism presently required in breeder designs. Also, neutron cross-section information needed for the design of fast and safe test reactors will be developed.

Supporting Evidence:

Adequacy of the manpower resources to meet the research and development program will have to be planned and programmed. There is presently a surplus of technical personnel suited to the research and development program. Beyond the first two years, additional trained technical manpower will be needed in scientific and engineering disciplines. These will have to come from the universities. The requirements are within the peak supply capability of engineering schools. Availability of manpower should be no problem if measures are taken to ensure vigor of the educational programs during the intervening period.

The availability of fuel should not present any problems but will require careful monitoring and management during the expansion of the first-generation nonbreeding reactors and plutonium recycle employment. Operation of breeders in the early years will require additional uranium supplies, but, as newly bred fuel becomes available, the demands for uranium will decline relative to continuation of a light-water reactor economy.

Capital costs of breeder reactors must be kept within a range that does not greatly exceed current reactor capital costs so that the fuel cost savings realized by breeders will be sufficient to permit total power generation costs to be lower for breeders.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Liquid Metal Fast Breeder	477.0	538.6	510.8	524.2	506.0	2,556.6
Gas Cooled Fast Breeder	17.0	23.0	29.0	33.0	38.0	140.0
Advanced Technology	21.5	24.5	30.5	34.0	37.2	147.7
TOTAL	515.5	586.1	570.3	591.2	581.2	2,844.3

TASK 5—EXPLOIT RENEWABLE ENERGY SOURCES

A. FUSION $1450M

Program Goal:

To guarantee the nuclear option in the long range by developing the technology necessary for a fusion reactor to provide an inexhaustible, economically competitive, inherently safe, and environmentally acceptable supply of energy for domestic consumption.

Program Objectives:

1. To conduct theoretical, computational, and experimental studies in the body of knowledge that predicts the behavior of thermonuclear fusion experiments and the operating characteristics of fusion reactors.
2. To develop the technology necessary to perform fusion research.
3. To investigate, develop, and establish the feasibility of low-density closed (tokamak), high density closed (theta pinch), and open (mirror) magnetic confinement systems as a basis for practical fusion power generation.
4. To investigate, develop and establish the feasibility of laser fusion as a basis for practical fusion power generation.
5. To develop the engineering base, qualify materials, develop components, and conduct engineering studies necessary for the design, construction, and operation of prototype, demonstration, and commercial fusion power reactors.

Contributions to the Energy System If Success Is Achieved:

Fusion power systems are being developed primarily for electric power generation. Since the fuel supply for fusion is effectively infinite and its safety and enviromental features are very attractive, fusion power reactors could eventually become the primary source of electric power for the United States.

Because fusion power plants have the potential for high-temperature operation, they would be attractive for combining with industrial and municipal systems that could utilize the rejected heat. Examples of potential applications are numerous: basic manufacturing processes, water desalination, mineral and fossil fuel processing, space heating, and air conditioning, to name a few.

The commercialization of fusion power reactors would occur at the time of the successful operation of a fusion demonstration reactor. The goal of the projected program is to begin operation of this system by 1995.

Fusion reactors could be producing commercial electric power in the first decade of the next century and by 2020 could add 18×10^{15} BTU of energy input to our electrical system.

Program Plan:

The research subprogram will develop the knowledge to predict the performance of plasma-confinement experiments and the operating characteristics of fusion power reactors. In order to support the theoretical proving research, it will require extensive application of centralized dedicated computer facilities with an integrated network of remote job processing terminals. Theoretical studies of fusion-relevant plasmas in various confinement configurations are necessary to understand the equilibrium, stability, and transport properities of the plasmas. Experimental work on plasma production and heating, along with instrumentation development for plasma measurements, are among the earliest projects.

The development subprogram will provide the technology to plan or conduct plasma experiments. The magnetics subprogram requires very large, superconducting magnets to produce large volume, high magnetic fields to confine and stabilize fusion plasmas. The heating program will emphasize the development of neutral-beam injections for heating and/or fueling tokamak and mirror plasmas. The advanced design activity provides for the definition of conceptual designs and cost estimates for experiments prior to fabrication. Other development-activity objectives include energy storage devices, direct energy conversion, and components to support the various testing programs.

The present plan for plasma confinement systems development utilizes three principal magnetic confinement concepts. These are low-density closed systems (principally the tokamak), high-density closed systems (theta pinch), and open systems (magnetic mirror). The construction and operation of seven new facilities to test plasma shapes, neutral-beam heating, scaling, and improved confinement will be undertaken.

The technology subprogram deals with the problems that need to be solved for prototype, demonstration, and commercial fusion power reactors. Included are materials studies to determine the effect of 14-MeV neutrons and other high-energy particles on material performance, radiation environment simulation to create a simulated fusion reactor environment in which materials and components can be tested, and system studies to provide guidance. Other areas covered include major parts of the heat transfer system and the engineering base needed for the design and construction of such subsystems. Examples are neutronics, plasma engineering, coolants, blankets, shielding, tritium handling, and instrumentation.

The laser fusion subprogram will build on the theoretical base established in the military oriented laser fusion program. Projected achievement sequence is: (1) an experimental demonstration of significant thermonuclear burn; (2) the experimental demonstration of scientific breakeven for the laser fusion concept; and (3) the conduct of some reactor design studies throughout the program.

Supporting Evidence:

Although controlled thermonuclear fusion has yet to be technically demonstrated, recent program successes indicate high probabilities of success in being able to initiate and sustain fusion reactions. This factor warrants emphasis in fusion research and development.

Based on previous experience with nuclear reactors, it is clear that a savings of several years can be realized if reactor technology is developed now, assuming technical feasibility of the fusion reaction.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Research	43	52	47	70	44	256
Development	20	26	37	46	55	184
Confinement	59	113	122	153	194	641
Technology	13	39	55	69	83	259
Laser Fusion	10	20	25	25	30	110
TOTAL	145	250	286	363	406	1,450

B. SOLAR ENERGY $200M

Program Goal:

To exploit the sun and wind in order to provide a renewable, economically competitive, and environmentally acceptable energy supply for domestic consumption.

FY 75-79 Program Objectives:

1. To determine, through pilot applications, the effective use of solar thermal energy for heating and cooling of buildings.
2. To effectively use solar thermal energy for electric power generation through operation of a pilot plant [10 MW(e)].
3. To effectively use wind power for electric power generation by construction and operation of individual windmills [>100 kW(e)] and a windmill farm [10 MW(e)].
4. To determine the technical feasibility of producing electric power from ocean thermal gradients by laboratory-scale testing of prototypes and full-scale testing of necessary components.
5. To determine the capability to produce economically competitive photovoltaic cells by laboratory experimentation and development of mass production concepts.

6. To demonstrate, by pilot plant operation, the economic feasibility for conversion of wastes to fuels and the use of biota as fuel for power plant operation.

Contributions to the Energy System If Success Is Achieved:

Solar energy is virtually inexhaustible and is inherently clean. Successful research and development should ultimately lead to the capability to reduce the demand for fuels and power to heat and cool homes and commercial buildings by 30%.

Solar thermal, wind, ocean thermal gradients, and photovoltaic systems used to produce electric power could be used in decentralized or centralized applications depending on economies of scale. The potential exists for providing a large proportion of the electric power needs for the Nation from solar conversion stations without storage systems. However, the realization of the economical storage systems will substantially increase overall applications of solar energy.

Bioconversion is possible today, but it is not economically attractive. Converting wastes to fuels needs to be demonstrated on a large scale, and the use of biota as fuel is in the early study stages.

Program Plan:

The objective is to develop proof-of-concept experiments that will allow program management to concentrate at an early date on those technologies which show the most promise toward providing the Nation's energy requirements. It should be possible at the end of the five-year program to predict the complete range of the beneficial effects and the extent of application and utilization of solar energy.

Solar heating and cooling of buildings is entering the pilot plant stage. Applicability studies, design criteria development, and component testing will be conducted on a much enlarged scale. Operating pilot systems will be installed in single-family and multifamily dwellings, in agricultural buildings, and in commercial/industrial buildings. This development could provide the basis for an industry prepared to manufacture solar energy heating and cooling systems in large quantities.

Major emphasis in the solar thermal conversion area will be placed on the research and technology developments of key subsystems for the optical transmission/central receiver tower approach. Three system design efforts will be conducted in parallel. Design, hardware procurement and integration, and a testing program of a 10-MW(e) pilot plant will be achieved.

A series of experimental wind generator systems in increasing size and performance capability will be constructed and tested. The first unit of 100-kW(e) size will be built in the first year. Four additional advanced units will be developed and used in experimental operation in the following years. Multiunit wind generator systems making up a wind "farm" up to 10 MW(e) will be constructed late in the program period.

The ocean thermal energy conversion subprogram emphasis will be placed on the design, production, and testing of system components. Key elements that will require significant adaptation of existing technology include the heat exchanger, the deep-water pipe, and the overall plant structural design. A test facility is planned for construction.

The photovoltaic program will concentrate on the single-crystal silicon approach with only a modest research and development effort on alternative materials and concepts. Materials development and improved processes are necessary to permit automated production of cells to accomplish major cost reductions.

The construction and operation of a small-scale pilot plant involving the conversion of wastes into methane would lead to a 10 ton/day pilot plant later in the period. Laboratory-scale studies of methods for converting various organic materials to electric power, including research on biomass production, would be prominent in the program plant.

Supporting Evidence:

With the primary exception of photovoltaics, the development of practical systems will not require high technology. The research and development costs for solar energy should be very small in relation to the value of energy saved. Because solar energy systems are capital intensive and practical systems have not been fully developed, Federal involvement in the program is warranted.

Life-cycle costs for solar building heating and cooling look attractive, but capital investment is high and deters market formation. Component cost and reliability must be improved and has a high probability of success.

Solar thermal systems are currently projected to provide power at approximately double the cost of alternative nonsolar methods. New design concepts are being investigated for cost reduction purposes.

Wind energy systems can be built but must provide evidence of economic viability and aesthetic acceptance. Ocean thermal gradients can be exploited if appropriate thermodynamic cycle machinery can be engineered to operate in a hostile environment. Bioconversion systems are possible today, but many questions about degree of impact and economic viability must be answered by proof-of-concept experiments.

There is no potential impact from solar energy heating and cooling systems on the environment or safety. Problems associated with public and institutional acceptability will require resolution in the near-term.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Heating and Cooling of Buildings	12.8	13.6	10.7	6.5	6.4	50.0
Solar Thermal	5.0	7.0	7.5	8.5	7.5	35.5
Wind Energy	6.2	6.7	7.2	7.5	4.1	31.7
Ocean Thermal	1.9	3.5	4.5	7.2	9.5	26.6
Photovoltaic	4.2	5.6	7.0	8.0	11.0	35.8
Bioconversion	2.4	3.5	4.5	4.5	5.5	20.4
TOTAL	32.5	39.9	41.4	42.2	44.0	200.0

C. Geothermal $185M

Program Goal:

To exploit geothermal sources by developing and demonstrating the technology that would allow commercial production of electrical power and other energy uses in environmentally acceptable ways.

FY 75-79 Program Objectives:

1. To increase present knowledge of the location, nature, and extent of the Nation's geothermal energy resources.
2. To identify and resolve the environmental, legal, and institutional barriers to geothermal resource utilization.
3. To advance, through technology development, the operational efficacy and efficiency of relevant components, devices, and techniques as required to achieve practical geothermal resource utilization.
4. To accelerate, through demonstration plants, the commercial production of electricity from geothermal resources.

Contributions to the Energy System If Success Is Achieved:

The five-year effort will greatly enhance the industrial capability to locate and evaluate geothermal resources, to identify and solve the environmental problems associated with geothermal developments, to clarify institutional and legal issues involved in geothermal energy uilization, and to upgrade the existing technology available for geothermal development and utilization, including power generation and heat applications.

The present program is designed to stimulate the commercial production of at least 20,000 MW(e) by 1985 from various types of geothermal resources (equivalent to an oil consumption rate of approximately 0.7 million barrels of oil per day) plus important additional fuel savings through use of geothermal energy for such nonelectric purposes as space heating and air conditioning, extracting minerals, and desalinating brines. The corresponding goals for the years 2000 and 2020 are 80,000 MW(e) and 200,000 MW(e), which would save nearly 3 million and 6 million barrels of oil per day, respectively. The equivalent heat values for 1985, 2000, and 2020 are 1.5, 6.0, and 15×10^{15} BTU's.

Program Plan:

The five-year program is a coordinated effort toward meeting all objectives for four types of geothermal resources and preparing for prompt demonstration of energy production from two other types.

Each type of resource poses special problems in location and distribution, reservoir analysis, environmental hazards, energy conversion and utilization and in the severity of and solution time of technical questions involved in bringing the resource to on-line production. Each experimental facility will, therefore, be a flexible test bed for research and engineering development as well as for demonstrations of electrical generation and the other uses of geothermal heat. Throughout the program effective technology transfer will be encouraged by cooperative arrangements with industry, and special attention will be given to the institutional, legal, social, and environmental issues bearing on utilization of that particular type of resource.

Under this program plan, demonstration plants using four of the six advanced resource types will be completed and operated jointly with industry to obtain engineering and economic data. Two other resource types would be demonstrated soon after.

Resource Type	Demonstration
1. High-temperature (> 180°C) convective	
a. Low-salinity (20,000 ppm or less)	1978
b. High-salinity (over 100,000 ppm)	1979
2. Low-temperature (<180°C) convective	1979
3. Geopressured sedimentary basins	1979
4. Hot dry rock	1981
5. "Normal" geothermal gradients	1983

Supporting Evidence:

One geothermal resource type is presently being used to produce power in the U. S. – dry steam generating 400 MW(e) at The Geysers near Santa Rosa, California. Six other types – brines at high temperature and low salinity, high temperature and high salinity, low temperature and low salinity, and in geopressured reservoirs, plus dry hot rock at shallow depth and in deep, normal-gradient formations – are potentially available for economic energy recovery. The first of these is being utilized in several foreign installations.

Major technical problems to be solved are concerned with the handling of corrosion and toxic substances and the successful utilization of low-temperature fluids. Practical binary cycles that use low-temperature working fluids must also be developed.

Theory and engineering design are available to support further development in the use of several resource types, and experimentation and demonstration have begun for a few. What is required now is an effort to attempt successful demonstration of the concepts.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Resource Assessment and Exploration	9.7	10.5	10.0	10.0	9.0	49.2
Environmental, Legal, and Institutional Research	3.4	3.5	2.5	1.0	.5	10.9
Resource Utilization	16.9	17.5	18.3	14.9	11.0	78.6
Advanced Research And Technology	10.0	9.5	10.0	9.8	7.0	46.3
TOTAL	40.0	41.0	40.8	35.7	27.5	185.0

TASK 6–SUPPORTING PROGRAMS

A. ENVIRONMENTAL EFFECTS $650M

Program Goal:

To establish the capability to determine and control effectively the environmental and health insults from the energy system through development of a sound technical and scientific basis for ensuring protection of the total ecosystem.

Program Objectives:

1. To determine the nature of pollutants and the quantity in which they are produced and to devise means of identifying and measuring the pollutants.
2. To determine the means by which pollutants are injected into the environment, the means by which they are diffused, and the distribution of pollutants at their final point to rest.
3. To determine the health, welfare, social, and ecological effects of pollutants on man and on all aspects of his environment.
4. To develop standards and specifications that will lead to effective protection of the environment.

Contribution to the Energy System If Success Is Achieved:

Implementation of the environmental research program described will make a vital contribution to the national energy system in three critical areas: (1) cost, (2) usability of domestic energy sources, and (3) timeliness in implementing energy system initiatives.

With respect to costs, at least $90 billion will be spent by the energy industries in the period 1971-1980 alone to meet established environmental requirements for the limits set on air and water pollutants. This amount of pollution control expenditure will add about 15% to the wholesale delivered national cost of energy over the same time period. By providing the technical and scientific environmental knowledge to be gained from this research and development program, it will be possible to develop and demonstrate environmental controls in conjunction with developing energy technology rather than having to rely on the costly retrofit programs exemplified by the current SO_x control program. It is estimated that the environmental cost to achieve the broad environmental objectives could in this manner be reduced to less than 10% of the wholesale delivered national cost of fuel.

The technological development and implementation of coal-based energy systems for near-term energy self-sufficiency must be sensitive to the effects that residuals from the system will have on health, welfare, and the ecological system. If this sensitivity is incorporated into the development and implementation process, these domestic resources can be broadly utilized in harmony with the environment. These effects act as a constraint on the technical requirements for control, the siting of the system, and the value of the system as a producer of energy. Further, knowledge of the effects of the system before it is implemented will avoid the enormous costs associated with the need to retrofit controls on an operational system or to cleanup the wastes once they have been discarded. The environmental research program will provide the technical basis for understanding these environmental consequences and for balancing the environmental and energy system costs to the society in an equitable manner.

While in theory the environmental research program does not add 1 BTU to the energy balance, in practice achievement of the energy supply forecasts made by each technology panel are dependent on demonstrating to a concerned and increasingly sophisticated public that environment impacts are understood and controllable to an acceptable level. Recent history has demonstrated the delays that can occur owing to the lack of a sound understanding of energy-related environmental questions. Examples of these delays which have affected energy supplies have been the Alaska pipeline and delays in nuclear licensing. Delays also affected implementation of environment controls, as exemplified by litigations of utilities against installation and operation of SO_x flue-gas cleaning technology. The environmental research program would provide the basic understanding necessary to evaluate and measure environmental impacts, determine their effects, and develop and implement timely and minimum cost environmental controls.

Successful implementation of this environmental research program will affect all aspects of the energy program and could be the definitive determinant of optimal energy source use and of the feasibility of specific technology approaches. Disruption of the energy program can be prevented by anticipating potential problems related to each technology and by determining as rapidly as possible the effects on health, ecosystems, and society. Perhaps the largest barrier to be faced is the need to convince energy-related technologists and planners that this seemingly distractive commitment must be made at the outset to prevent very major disruptions in energy production.

Program Plan:

1. **Pollutant Characterization, Measurement and Monitoring**

The research programs in the FY 1975-1979 period will:

a. Develop and apply methods to determine the characteristics of pollutants associated with existing and future energy systems and technologies.

b. Improve precision and accuracy of ambient and source measurement methods and procedures for controlling radiological pollutants.

c. Develop continuous ambient and source measurement methods and procedures for pollutants for which no standard has been established (e.g., fine particulates, sulfate, nitrate).
d. Develop quality assurance procedures for environmental monitoring and measuring activities.
e. Develop and demonstrate advanced monitoring techniques, i.e., remote and in situ sensors.
f. Develop and implement data acquisition, retrieval, and assessment procedures permitting maximum Federal, regional, and local application of monitoring information.
g. Develop more precise performance specifications for calibration of instrumentation used to measure pollutant concentrations.

2. **Environmental Transport Processes**

Specific research activities in the FY 1975-1979 will determine:

a. Cooling-system plume behavior.
b. Atmospheric interactions in both dry and wet-scrubbed plumes from fossil energy systems (especially respirable sulfate-particle formation, SO_2 oxidation rate, interaction with urban pollutants, and NO_X behavior).
c. Dispersion of plumes in rough terrain.
d. Low-level dispersion pathways and ultimate fates of radionuclides from nuclear plant releases, especially at low wind speeds and including building wake effects.
e. Thermal and pollutant dispersion pathways and ultimate fates in streams, lakes, and groundwaters.
f. Physical and chemical transformation of pollutants in streams and lakes.
g. Thermal and pollutant diffusion in characteristic coastal waters.
h. Physical and chemical transformation of pollution in coastal waters.
i. Transfer mechanisms of atmospheric sulfur and nitrogen oxides to soils and economic crops.
j. Impact of moisture and heat release on local climate.
k. Model for precipitation scavenging of sulfur.
l. Dry deposition of atmospheric pollutants.

3. **Effects: Health, Ecological, Welfare and Social**

Specific health-effect research activities in the FY 1975-1979 time period are:

a. Strengthening of scientific bases for existing primary ambient air quality standards. Although these standards were formulated upon the best available information at the time of their promulgation, there is a pressing need to place these standards on as firm a scientific basis as possible before they are implemented. Gaps in knowledge are particularly evident with respect to nitrogen oxides.
b. Evaluation of health effects associated with exposures to air

pollutants for which ambient air quality standards do not presently exist. These include effects of fine particulates and suspended sulfates, as well as known or suspected carcinogenic hydrocarbons.

c. Evaluation of health effects associated with exposures to trace metals and persistent chemicals. Although these are in reality multimedia problems, airborne exposures can be important. Current strategies for long-term control of lead mobile source emissions and for control of lead and cadmium stationary source emissions are dependent upon availability of additional health effects information.
d. Evaluation of health consequences resulting from the impact of fuels and fuel additives upon regulated as well as nonregulated pollutants. Work includes safety assessment of catalysts to be used in emission control systems for automobiles as well as protocol development for safety assurance testing.
e. Definition of effects of simultaneous exposure to a number of air pollutants. This includes assessment of nonpulmonary effects due to air pollution, such as decreased resistance to infection, and impact upon health of future generations via teratogenic or mutagenic effects.
f. Investigation of long-term low-level effects of fossil fuel and radioactive pollutants. This will include studies of genetic and late somatic effects and is of particular importance because such effects will ultimately aid in the determination of the safe levels for pollutants in the air, water, land, foods, etc.
g. Development of means of combating adverse effects of pollutants on exposed humans. Such efforts are needed to decrease harmful effects in cases of acute, intermittent, and long-term low-level exposures.
h. Provision of information on health effects essential to cost-benefit-risk decisions in the choice of energy systems when diverse, competing technologies exist.

Specific ecological effects research in the FY 1975-1979 time period will:

a. Assess the environmental effects and impacts of coal, oil, oil-shale, uranium, and geothermal extraction techniques and predict ecosystem effects, permitting enhancement of benefit-cost-risk ratios by suitable land management policy.
b. Determine the environmental effects of radionuclide, hydrocarbon, and other fuel transport, storage, or waste releases during energy conversion and waste disposal. This will include determining the accumulation ratios and transfer rates of secondary pollutant dispersal through the food chains and other pathways and determining strategies for concentration and/or decontamination in order to minimize residual long-term ecosystem effects, including those impinging on man.
c. Determine pollutant pathways and toxicities so as to guide routine

and nonroutine releases from energy conversion and reprocessing plants. Both geochemical and ecosystem studies will be conducted to provide guidelines and criteria for siting of process facilities and disposal areas for both liquid and solid wastes generated by both nuclear and nonnuclear plants.

d. Determine the ecosystem costs of thermal shocks from power plant waste-heat release, of entrainment and impingement in the cooling systems, and of cooling tower blow-down as well as the impact of anti-fouling additives. Additionally, the ecosystem impacts and synergistic effects of effluents, such as radioactive materials, trace metals, noxious gases, organic compounds and other substances produced during energy generation, will be evaluated, and management strategies will be instituted for minimizing these impacts.
e. Develop biological indices (species, diversity, fecundity, natality, mortality, etc.) for ecosystem impact evaluation. A systems approach encompassing laboratory, greenhouse, microcosm, and large-scale field experimentation will be used to address the problem. This systems approach requires a model that is structured in such a way that those subsystems most affected by pollution can be sensed. A more detailed analysis of these components will then be made with a view to assessing the site, time, and mechanism of potential pollution effects so as to guide siting to the least environmental damaging places.
f. Conduct large-scale ecosystem studies on dedicated, controlled-access parcels of land and water, such as environmental research parks, and through the biome studies developed under the International Biological Program.
g. Produce a number of relatively simple, reliable estimators of ecological impact and estimate the extent and duration of observed effects using the above capabilities and data base.

Social and welfare effects research in the FY 1975-1979 time period will address:

a. The assessment of material deterioration problems in the field at present.
b. The factors affecting erosion of stone–characterization and parametric evaluation.
c. The study of pigment degradation in artistic and other works.
d. The assessment of construction metals and their uses in construction, art, and transportation.
e. Development of a reasonable standard protocol for societal assessment techniques to be used by different energy research and development groups (opinion surveys, handbooks, etc.).
f. Development of and testing of models of value changes in impact assessments. Compare results of system analyses used by all groups.
g. Implementation and dissemination of results (in lay terms) to Government policy-making bodies, etc.

4. **Environmental Assessment and Policy Formulation**

Priority research in the FY 1975-1979 time period will:

a. Determine the ability of existing and proposed institutional structures for energy decision making to accurately represent the environmental concerns of all segments of the population.
b. Develop methodologies for intercomparing the environmental risks and benefits of highly disparate energy systems.
c. Lead to improved quantification of both environmental costs and benefits to society and development of techniques by which the cost of pollution control can be more effectively internalized.
d. Develop methodologies for synthesizing information produced by the environmental research programs.
e. Analyze alternative implementation techniques for reducing environmental impact (e.g., environmental impact statements, environmental standards, economic incentives).

Supporting Evidence:

It is clear that a sound base of scientific capability exists for this work. No major difficulties with scientific feasibility are foreseen in achieving the goals. Few engineering problems are anticipated, but close cooperation between biologists, environmental scientists, and technology development engineers will be required to minimize environmental impacts of present and new technologies. The major potential barriers are: (1) inadequate communication between the environmental scientists and the energy technology developers and (2) lack of established policy for the timely incorporation of environmental impact data into the development and implementation of energy systems and associated technology.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Pollutant Characterization, Measurement and Monitoring ...	13.3	18.5	21.1	21.4	22.0	96.3
Transport of Pollutants	20.5	24.0	23.0	23.0	19.5	110.0
Effects Research	69.1	76.4	78.4	95.0	94.8	413.7
Environmental Assessment and Policy Formulation	3.0	3.0	6.0	8.0	10.0	30.0
TOTAL	105.9	121.9	128.5	147.4	146.3	650.0

B. BASIC RESEARCH $300M

Program Goal:

To explore basic phenomena, processes, and techniques in those physical, chemical, biological, environmental, and social sciences areas bearing on energy and to ensure the development of new basic knowledge in these areas.

Program Objectives:

1. Materials

a. To understand the effects of high-temperature environments and thermal shock on material strength, microstructural changes of surface, and bulk properties. To provide the understanding needed to synthesize new materials suitable for energy applications under these environments.
b. To understand radiation effects, void formation, sputtering, ion-penetration effects of individual ions from nuclear reactions, and embrittlement by hydrogen and radiation.
c. To better understand superconductivity, electronic conduction at high temperatures, insulator breakdown, electrolyte behavior, and ion conductance phenomena relevant to energy production and utilization.
d. To understand the corrosion processes related to energy systems, including stress and sulfur corrosion, grain boundary penetration, and liquid-metal compatibility.
e. To understand photovoltaic properties, effects of impurities, and new semiconductors.
f. To understand the properties of ceramic materials including strength and resilience.

2. Chemical, Physical, Engineering Sciences

a. To enlarge our understanding of hydrogen production by thermochemical, photochemical, and biochemical processes from nonfossil sources including water. To expand our understanding of hydrogen storage systems, principally as hydrides.
b. To understand catalysis and how surfaces catalytically alter reaction mechanisms sufficiently to be able to design and identify new catalysts and catalytic techniques, to identify and understand the role of reactive intermediates, to understand the structure of enzymes and how they effect catalytic alteration of reactions, including immobilization.
c. To understand kinetic and heat-transfer processes which affect combustion efficiencies and other energy processes.
d. To provide needed thermodynamic data on low-temperature liquids, high-temperature gases, liquid-metal alloys, hydrogen-

producing reactants, and intermediates, and to enlarge understanding of theory of solutions and complex reaction equilibrium.

e. To understand turbulent mixing in the atmosphere and ocean, in polymer solutions, and in two-and-three-phase flow. To be able to effect more efficient reactions by understanding and applying the principles of turbulent mixing fronts and flows in porous media.
f. To understand the chemical and physical interactions involved in separation processes. To understand laser stimulated interactions as applicable in isotope separation.
g. To provide needed nuclear properties for new fuels and other nuclear materials. To better understand interactions in molecular, atomic, and nuclear physics, including low- and high-energy interactions.
h. To improve understanding of electrochemical processes including oxygen reduction mechanisms in aqueous solutions, ion mobilities in solid electrolytes, electrode potentials, overpotential foaming, and current density limits.
i. To be able to measure pollutants and/or trace elements in the ppm and ppb ranges, measure transport and thermodynamic properties, and to measure particle-size distributions in submicron range.

3. Biological

a. To understand the bioconversion of animal and plant wastes to usable fuels including the photosynthetic process and the fixation of nitrogen.
b. To understand detoxification of energy-related wastes and the biological effects of toxic substances.
c. To understand the aspects of hydrology, oceanography, climatology, and meteorology which are most affected by energy systems, including dynamics affecting transport and disposal of thermal and material loads at local, regional, and global levels.
d. To understand the ecosystem, particularly the interactions resulting from energy production and utilization.
e. To enlarge understanding of geochemistry and environmental geology, including faulting, rupture, slope stability, seismology, and rock and soil mechanics.

4. Plasmas

a. To understand the behavior of plasmas, the factors that affect their interactions with electromagnetic fields and radiation, and direct energy conversion systems.
b. To encourage thinking about very large energy supplies such as orbital solar stations, colliding-beam fusion reactions, kinetic energy of ocean currents, rotational energy of spin and orbital motion of the earth, and nuclear energy storage concepts.

5. **Mathematical and Social**

   a. To develop mathematical and computer techniques for handling large and complex technical and socioeconomic energy models. To further develop mathematical approaches to energy problems.
   b. To understand social and psychological responses, including motivational studies and national attitude analyses, as related to changing energy situations. To better understand the energy needs for population support.
   c. To develop techniques needed to understand the effects of national regulatory policy and international relations on the dynamics of energy research and development.

Contributions to the Energy System If Success Is Achieved:

The overall benefits of research are to ensure development of efficient energy concepts, including the identification of new means for meeting energy requirements, and to provide the base of knowledge that will facilitate solutions to currently unanticipated problems, thus reducing national costs of energy utilization. The recommended research is aimed mainly towards obtaining knowledge that will ultimately lead to greater social and economic benefits from energy utilization and that will lead to a lessened impact on our energy resource base and on our environmental and ecological systems.

Specifically, research on materials should narrow the gaps in the fundamental understanding needed to improve, control, and predict the properties of materials utilized in the exceptionally hostile environments of energy processes. Superconducting materials research is expected to make very long distance transmission of electricity possible, providing savings in transportation costs and flexibility in siting of power plants. Research in chemical, physical, and engineering science areas should lead to more efficient and environmentally acceptable utilization of our resources. Such research could lead, for example, to economical production of hydrogen from water or renewable nonfossil sources. Advances in catalysis, a field ripe for exploitation, could significantly affect the economics of such conversion processes as coal liquefaction and gasification. Basic biological research will increase our knowledge of biochemical generation of fuels from organic materials and the biological and environmental effects of toxic effluents. Plasma research supports conversion techniques, such as MHD, fusion, gas lasers and thermionic devices. Contributions from discoveries of entirely new concepts could be revolutionary in nature and could alter the entire approach to energy production and utilization. Basic work in the mathematical and social sciences leads to improvements in many fields, especially in the socioeconomic area where better understanding could result in a more stable and responsive technical, socioeconomic, and political system.

Program Plan:

Part of the multidirectional research program is designed to find answers to questions now visible. Another part is intended as insurance against unknown future barriers to development progress. A very small part of the multidirectional research effort is to encourage creativity and imagination along lines not yet chartable in the long-term concerns for renewable energy.

The greatest value is realized from research when fruition precedes the demand for implementation. For example, research on fusion reactor materials problems is not expected to impact in the same time frame as research on catalysis for coal conversion processes. However, because of the lead time required to provide the understanding to resolve the materials problems of the fusion reactor, it is imperative that materials and catalysis research be accelerated as soon as possible. Every effort is expected to plan the research so as to anticipate the needs of future energy developments while at the same time providing the fundamental support needed for currently developing programs. The most promising proposals fo. research that address the specific objectives cited above will be supported as necessary to expand basic understanding.

Since research frequently suggests quite new lines of development, not contemplated when the program was first defined, flexibility must be assured to most effectively capitalize on new advances.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Materials	8	11	12	12	12	55
Chemical, Physical, Engineering	16	22	24	24	24	110
Biological	12	15	17	18	18	80
Plasmas	3	4	5	4	4	20
Mathematical	4	6	8	9	8	35
TOTAL	43	58	66	67	66	300

C. MANPOWER DEVELOPMENT $50M

Program Goal:

To support the energy research and development program by ensuring that technical and managerial manpower skills are available in quantity and quality sufficient to meet the needs of the program.

FY 75-79 Program Objectives:

1. To enlarge educational faculty capabilities to educate and train technical manpower in the skills required to conduct energy research and development.
2. To enhance the effectiveness of managerial personnel in Government and industry in planning and executing programs in energy research and development.
3. To enlarge the base of manpower skilled in energy and energy-related research and development by supporting student participation in energy and energy-related studies and training activities.
4. To enlarge manpower training capabilities in energy research and development organizations to retrain and redirect technical manpower at all levels.

Contributions to the Energy System If Success Is Achieved:

A five-year $10 billion Federal program in energy research and development represents at least 50% increase over previous projections. Manpower requirements will be increased similarly. At an average rate of $2 billion per year and an average cost per technical man-year of $50,000, the energy research and development program would employ 40,000 scientists, engineers, and technicians. Currently, only half that number are employed in federally supported energy research and development. While the potential for redistribution of technical manpower is high, reorientation or retraining is still necessary to a significant degree, and major growth in the longer term must come from the students now in universities.

The proposed funding level for manpower development would support a program that would reach over 2000 people annually, many of them faculty and managers responsible for education and training of the future manpower pool.

In recent years, Government support for such a program has diminished; this is reflected in a lack of Government direction in the development of manpower to meet national needs.

Program Plan:

To lay the proper foundation for a program of education and training directed to the development of a manpower base for energy research and development, initial emphasis must be on reorienting the faculty and managers responsible for such training. FY 75 funding would be used primarily for conducting or supporting institutes, special courses, workshops, conference, and off-campus appointments for university faculty currently teaching courses in science or technology or conducting research in science and engineering fields.

Program funding will support students or postgraduates who are pursuing studies in science and engineering. Traineeships, scholarships, research stipends, and post-doctoral fellowships would be granted that would permit them to pursue studies and research in energy and energy-related subjects.

Finally, a moderate program of special courses, workshops, and conferences for managers would orient managers to the particular problems they will face in augmenting the technical manpower forces under their control.

Once a foundation has been laid by establishing a base of educators that would produce the needed manpower, emphasis can be shifted to the student or trainee, and more direct benefits should be forthcoming.

A cooperative program with national laboratories and contractors would lead to the retraining and reorientation of technical workers whose skills were inappropriate to specific needs. Government funding would support external educational assistance, manpower increases needed to conduct training programs, and stipends necessary to support trainees while undergoing training.

Supporting Evidence:

Research and student education conducted in U.S. universities is largely dependent on the source of support funds received and the stipulations attached to those funds. Programs offered and course structures are also dictated by the perceived need for graduates in particular disciplines. The need for a greatly enlarged effort in energy research and development has not been widely perceived, and Government funding for energy research and development has been somewhat stable. What is even more significant is the relatively new perception that coal would play a major role in energy supply for the remainder of this century.

It can be expected that this need for scientists and engineers capable of working on all aspects of the energy problem will be reflected in future support to U.S. universities, but a lead time is inherent to this shift in emphasis. Therefore, it is imperative that the Federal Government initiate such a program to reduce that lead time to the minimum practical.

Budget:

	Dollars in Millions					
	1975	1976	1977	1978	1979	Total
Faculty Orientation	1.5	2.4	3.0	3.0	3.0	12.9
Managerial Training and Orientation	0.5	0.6	0.5	0.5	0.4	2.5
Student & Postgraduate Support	1.5	2.5	4.5	5.0	5.5	19.0
Industry/Laboratory Manpower Dev. Program	1.5	3.5	4.5	3.8	2.3	15.6
TOTAL	5.0	9.0	12.5	12.3	11.2	50.0

Appendix B

MAJOR RESEARCH AND DEVELOPMENT STRATEGY OPTIONS

Ten strategy options are available to policy makers whose goals are self-sufficiency, environmental improvement, and low energy cost. These are listed in Table B-1.

The first option (Class I) seeks balanced attainment of all three goals. Emphasis on the environmental goal (Class II) requires that the major effort go to obtaining and maintaining a clean environment. The options differ within that priority according to whether the secondary emphasis is placed on security, prosperity, or a balanced effort to achieve both. Classes III and IV place first priority on attaining security and prosperity, respectively, with

Table B-1.—POSSIBLE RESEARCH AND DEVELOPMENT STRATEGIES (RELATIVE PRIORITIES AMONG GOALS)

I.	Balanced Attainment of All Three Goals	
II.	A.	Environment—Security—Prosperity
	B.	Environment—Prosperity—Security
	C.	Environment—Balanced Security/Prosperity
III.	A.	Security—Prosperity—Environment
	B.	Security—Environment—Prosperity
	C.	Security—Balanced Environment/Prosperity
IV.	A.	Prosperity—Security—Environment
	B.	Prosperity—Environment—Security
	C.	Prosperity—Balanced Environment/Security

corresponding follow-up choices among the remaining goals. Implications of the four major strategies are discussed in the following sections.

Analysis of Research and Development Strategy Options

Class I. Balanced Attainment of Environment/Security/Prosperity. This approach holds that the Nation is in reasonably good shape as regards each goal and that there are no clear preferences for priorities among the three. A research and development program would be structured to make gradual progress toward each goal. This progress would be uneven, to be sure, as different technologies became economically viable at different rates, but the overall trend would be one of steady improvement in all three areas. If a big breakthrough occurred in one area, research and development funds would be shifted out of that area into the other two. If one area failed to show reasonable progress, it would draw research and development money from the other two until it began to show more movement. The "something-for everybody" character of this option makes it attractive. The difficulty is that it postpones attainment of any one goal until all of them can be attained.

Class II. Environment First. The Class II options proceed from a judgment that economic prosperity and security are adequate for the moment and that a clean environment should be the first priority. Research and development would focus on identifying and removing undesired environmental effects of energy technologies. Ways to use resources cleanly even at higher prices for energy would be a major research and development effort. Environmental quality would be the determining factor when considering the introduction of new processes or the advisability of increasing imports.

Among options IIA, IIB, and IIC, proponents would differ with respect to what should be done once satisfactory progress had been made toward a clean environment. Some would seek security or self-sufficiency next; others would concentrate on lowering costs; and still others would pursue both on a balanced basis, thereby postponing the time of attainment of both.

Class III. Security First. This approach holds that the Nation is too vulnerable to the interruption of crucial energy supplies and that its first task is to regain energy self-sufficiency. The energy research and development program would focus on finding domestic substitutes for imports. As set out in Chapter 5, option IIB is the recommended strategy.

The options within this class differ with respect to the priority between the follow-on objectives, with corresponding implications for the establishment of a specific research and development program.

Class IV. Prosperity First. This set of options completes the list of choices. It would place the major research and development emphasis on achieving low energy costs. Individual options in the class again differ with respect to the priority assigned the two follow-on objectives, clean environment and security.

CRITERIA FOR FUNDING FEDERAL PROGRAMS

The criteria discussed below are listed and rated in Table B-2. In every case, an individual subprogram can be rated "high," "medium," or "low" for each criterion. The differences among these ratings provide guidance for relative funding priorities.

Research and Development Phase

Adequacy of Scientific Base. This is the state of chemical, physical, geologic, and other knowledge about the physical properties and location of various fuel sources. Identification of areas of limited knowledge may suggest important possibilities for developing from basic research the means to increase supply or enhance the efficiency of energy production and use. Prospects for advances depend upon the availability of researchers and the active interest of university centers and industry.

Probability of Future Technological Success. Basic research must be translated into proof-of-concept experiments and pilot and demonstration plants, or their equivalent in other programs. This process sometimes exposes gaps in basic knowledge; lack of component hardware may cause substantial delays. Reasonable assessment of technological feasibility must examine such potential difficulties in an attempt to estimate the "elasticity" of the research and development results to investment—how much positive effect greater funding would have in terms of earlier success or higher probability of success.

Feasible Absorbable Investment. This means the amount of money that can be profitably expended on the project's prospective rate of return. While it is always possible to spend more money, the law of diminishing returns inevitably applies.

Public and Government Consensus That Project Is Acceptable. Primarily from the point of view of environmental integrity, but also from the points of view of health, safety, and security, any new program or increased funding for a program must be measured against public acceptability in the research and development phase and in later stages of production. Although these considerations may be important only in later phases, they should be recognized early in the planning and research and development stage.

Implementation and Production Phase

Production Capability. Can the technology be implemented by the private sector at a profit? This depends on the price of the product relative to its cost. Significant new programs may require massive capital investment by industry and/or Government. Numerous supporting industries will be required for construction, operation, and maintenance of such plants. Availability of capital and of labor must be evaluated on a regional basis with efforts made to minimize possible labor shortages and other dislocations. The ongoing production costs as well as the research and development investment must be estimated to establish the economically viable sale price of the product. To the extent that particular fuels can substitute for each other, their relative costs will influence project viability. The specific constraints are listed individually in Table B-2.

Environmental. Emission-control standards have greatly influenced the choice of fuels for power plants and vehicles. Such standards result from policy decisions based on data regarding hazards. Assessment of hazards should be included in program proposals to ensure balanced decisions. Environmental ill effects must be attributed a meaningful and substantial "cost" in that assessment. Clearly, fuel sources that disrupt the environment relatively less in the stages from mining to burning or disposal, or whose health hazards are relatively less, should be favored. Secondary and higher order undersirable effects, such as the problem of the water supplies required for coal and shale conversion plants, must be anticipated and cost-accounted as well.

Payoff Phase

Timing of Payoff. One of the goals of the energy program is to increase supplies as soon as possible. Accordingly, an assessment of the ability of the research and development program to achieve economic production capability earlier as a result of greater funding is important in determining the level and timing of funding. Estimates of the period of economic use of exhaustible fuel sources should include not only the estimated beginning of useful production but also forecasts of their lifetimes.

Economics of Payoff. If the probability of a program's success, the expected time of payoff, and the costs of creating the product are known, estimates can be made of the product's price and of the demand for it at varied prices. If the price of a new energy-generating system will be higher than the anticipated market price for substitutable products, it will not be economically viable.

Other Considerations

Security. It may be necessary to subsidize production from otherwise uneconomic sources to minimize dependence on foreign oil sources. For example, coal liquefaction and shale retorting may require special support in the form of subsidies or price guarantees to ensure their contribution to total supply as replacements for imported oil.

Political. Deviations from decisions based solely on economic considerations may be required. Decision makers may wish to maintain employment in various parts of the country so that capital investment is distributed throughout the country and among industries or to protect population centers and wilderness areas from unseemly exploration and mining.

Regional Aspects. Certain energy research and development programs may have limited payoff on a national basis, but sufficient local or regional payoff to be justified. Solar energy for space heating in the South and Southwest and geothermal sources in the West appear promising even though total energy production in BTU's is relatively small compared to national needs.

Environmental. Many environmental constraints can be included in the costs of energy production. Some environmental effects, however, are not readily corrected by investments of dollars and effort. These are considered under this category.

Determination of Relative Priorities—An Illustration

The considerations used to set priorities among candidate energy research and development programs are displayed in Table B-2. Ratings based on evaluations contained in the subpanel report in this area compared to subpanel reports regarding other programs have been assigned. The matrix shown is a systematic way to record estimates and arrange them in a manner that facilitates comparisons. The comparisons are the basis for ranking the programs. The energy research and development programs are ranked illustratively on the basis of the criteria indicated. Each program has been assigned a numerical value for each criterion: 3, 2, or 1, on the basis of high, medium, or low desirability, respectively. The reader may choose to substitute other criteria and weights. For example, projects judged to have the highest potential for Savings or Enhancement in Petroleum have been given a 3. Projects offering lower but still substantial potential savings have been given a 2, and those with the lowest potential are assigned a 1 in that column. Those with near-term timing receive a 3, mid-term a 2, and long-term a 1. Illustrative program rankings (totals) are given at the right.

The unweighted total score gives equal importance to each of the criteria. Since certain criteria are more important than others, another criteria weighting scheme was devised. The single criterion deemed most important in each of the three phases (I. Research and Development, II. Implementation and Production, and III. Payoff) was given a weight of 3, the criterion deemed second most important was given a weight of 2, and all other criteria were weighted 1. Other weights could be substituted. In this case, a value of 3 in a criterion weighted 3 generates a contribution of 9 to the total score, a value of 2 in a criterion weighted 1 generates a total score contribution of 2, etc. The total weighted rating for each program summed over all criteria is also shown in Table B-2.

Other schemes could be applied in a similar manner. For example, another approach would be based on multiplicative rather than additive weights, totaling the indicators in each of the three successive phases. This method would tend to favor more strongly those programs having good prospects in each phase, at the expense of those having the same additive but less even prospects. The particular scheme used does not seem to make too much difference. Projects having more-immediate payoffs are generally ranked higher than longer term payoff projects, no matter what scheme is used.

Table B-2.—CRITERIA FOR FEDERAL PROGRAM PRIORITIES

(Weights 3 High, 2 Medium, 1 Low Spending Priority)

I R&D Phase — II Implementation and Production Phase

PROGRAM AREA \ CRITERIA	Adequacy of Scientific Base	Probability of Future Technological Success	Feasible Absorbable Investment	Project is Acceptable	Public and Govt Consensus That Project is Acceptable	Expected Price/Cost of Production	Cost of Substitutes	Environmental Acceptability	Need for Government Role	Adequacy of Resource Reserves	Labor Available
Weighting		3X			2X	3X	2X				
Resource Assessment	3	3	1		3	3	3	3	2	3	3
Mining Coal and Shale	3	3	2		2	3	3	1	2	3	2
Surface Mining	3	3	2		2	3	3	1	3	3	2
Underground Mining	3	3	2		2	3	3	2	2	3	2
Oil Shale Mining and Reclamation	2	3	2		2	2	3	1	2	3	2
Energy and Fuel Transportation Distribution, and Storage	1	3	1		3	2	2	2	1	3	3
Coal and Shale Processing and Combustion	3	3	3		3	2	3	3	3	3	3
Clean Combustion of Coal	3	3	3		3	3	3	3	3	3	3
Coal to Pipeline Gas	3	3	3		3	2	2	3	2	3	3
Coal Liquefaction	2	3	3		2	2	3	2	3	3	3
Support R&D for Coal	3	2	2		3	2	2	3	3	3	2
Pollution Control Technology Coal	3	2	3		3	3	3	3	2	3	2
Conversion Techniques	2	3	3		3	2	2	3	2	3	3
Low BTU Gas	3	3	3		3	2	2	3	2	3	3
High Temp Gas Turbines	2	3	3		3	3	2	3	2	3	3
Magnetohydrodynamics	1	2	2		3	2	2	3	3	3	3
Other (Fuel Cells, Use of Waste Heat)	2	2	1		3	2	3	3	2	2	3
Oil and Gas	3	3	2		3	3	3	2	1	2	3
Geothermal	1	2	2		3	2	1	2	2	2	3
Solar	1	2	1		3	1	1	3	3	3	3
Building Heating and Cooling	3	3	1		3	2	2	3	3	3	3
Other (Centralized)	1	2	2		3	1	1	3	3	3	3
Fusion	1	1	2		3	2	1	3	3	3	2
Confinement	1	1	2		3	2	1	3	3	3	2
Laser	1	2	2		3	2	1	3	3	3	2
Fission	3	3	3		3	3	3	2	2	3	2
LMFBR	3	3	3		3	3	3	2	2	3	2
Other	3	3	3		2	3	2	2	2	3	2
Advanced Transportation Systems	2	1	2		3	2	3	3	2	3	3
Automobile and Truck	1	1	2		3	2	3	3	2	3	3
Air	3	1	1		3	1	3	3	2	3	3
Rail and Bus	2	2	2		3	2	3	3	2	3	3
Ship(Nuclear)	3	2	2		3	3	3	2	1	3	2
Conservation (End Use Sector)	3	3	2		3	3	3	3	3	3	3
Environment											
Multidirectional Res											

II Implementation and Production Phase III Payoff Phase IV. Noneconomic Consideration

CRITERIA: Hardware Development	Private Capital Available	BTU's Supplied or Conserved	Saving or Enhancement in Petroleum	Timing (Near, Mid, Long)	Project Score (Unweighted)	Project Score (Weighted)	Federal Regulatory	Environmental	Security	Political	Regional Distribution	PROGRAM AREA
			2X	3X								Weighting
3	2	3	3	3	41	68	1					Resource Assessment
2	3	3	3	3	38	64	3					Mining Coal and Shale
1	3	3	3	3								Surface Mining
2	3	3	3	3								Underground Mining
2	3	3	3	3								Oil Shale Mining and Reclamation
2	3	3	2	2	33	54	2					Energy and Fuel Transportation, Distribution, and Storage
												Coal and Shale Processing and
2	2	3	3	3	42	67	3					Combustion
2	2	3	3	3								Clean Combustion of Coal
2	3	3	3	3								Coal to Pipeline Gas
2	1	3	3	2								Coal Liquefaction
2	1	3	3	3								Support R&D for Coal
1	1	3	3	3								Pollution-Control Technology Coal
1	2	3	2	2	36	57	1					Conversion Techniques
2	2	3	2	2								Low BTU Gas
1	2	3	2	2								High Temp Gas Turbines
1	2	3	2	2								Magnetohydrodynamics
2	2	2	2	1								Other (Fuel Cells, Use of Waste Heat)
3	3	3	3	3	40	67	3					Oil and Gas
2	2	1	1	2	28	45	1					Geothermal
1	1	2	1	1	27	40	1					Solar
1	1	2	2	1								Building Heating and Cooling
1	1	2	1	1								Other (Centralized)
1	1	3	2	1	29	43	2					Fusion
1	1	3	2	1								Confinement
1	1	3	2	1								Laser
2	3	3	2	2	39	63	3					Fission
2	2	3	2	2								LMFBR
2	3	3	2	1								Other
1	2	3	3	2	35	54	2					Advanced Transportation Systems
2	3	3	3	2								Automobile and Truck
2	2	3	3	2								Air
1	1	3	3	2								Rail and Bus
1	1	3	3	2								Ship (Nuclear)
3	2	3	3	3	43	70	3					Conservation (End Use Sector)
												Environment
												Multidirectional Res

Given the array of potential research and development programs, the mix of programs that can be recommended does not vary too much even when strikingly different strategies are adopted. The criteria can be given extremely high or low weights for environmental acceptability, for example, or for price without drastically altering the ranking of programs. On the other hand, the approach of seeking information to quantify these parameters may become more useful as progress is made on several major programs. Then the projections of costs and technological capacity to overcome environmental constraints can be better evaluated and compared among subprograms.

Illustrative Use of the Criteria Matrix

Rating a Single Program. The basis for rating one program area, Energy and Fuel Transportation, Distribution, and Storage, is described below to illustrate the potential use of the criteria matrix. Subprograms in transmission include demonstration high-voltage a-c and d-c electricity transmission projects, both above ground and below ground, and the use of superconducting underground cables. Storage subprograms include development of sodium-lithium batteries, superconducting magnets, and a flywheel facility. Transportation subprograms include work on surface and underwater arctic ships.

Research and Development Phase. Because much proof-of-concept laboratory work will be required in these programs, Adequacy of the Scientific Base was given a rating of 1. Probability of Future Technological Success received a 3, a high rating. Feasible Absorbable Investment, given the laboratory stage of many subprograms, was considered relatively low and assigned a 1. The projects would improve efficiency and might improve the environment (through underground transmission and submarine tankers having lower spill potential), resulting in a high Acceptability rating of 3.

Implementation and Production Phase. The projects in this area fall in the middle range of the Price/Cost of Production rankings, resulting in a rating of 2. These projects received a Cost of Substitutes ranking of 2 because most of the prospective benefits could be achieved by burning more coal. The necessary Government Role received a 1 rating owing to the short-term payoff of the subject projects and the existence of many industry programs in these areas. Resource Reserves to meet the need to transmit electricity continuously are excellent and are rated 3. Adequate Labor and Capital are available for a rating of 3, but some associated Hardware Development is a challenge, resulting in a rating of 2.

Payoff Phase. If the projects are successful they offer the prospect of conserving substantial BTU's of energy (rating of 3). This would be coal conservation rather than a saving in Petroleum, so the latter is rated 2 as is the Timing criterion.

On the basis of the program rankings, the energy research and development programs have been ordered in priority in Table B-3. The ordering does differ, but not substantially so, between the weighted and unweighted methods. In general, those programs which emerge with highest priorities are those with nearest term potential payoffs.

Table B-3.—ILLUSTRATIVE PROGRAM PRIORITIES BASED ON CRITERIA

Weight Criteria	Total Rank	Unweighted Criteria	Total Rank
Conservation	(70)	Conservation	(43)
Resource Assessment	(68)	Coal and Shale Processing	(42)
Oil and Gas	(67)	Resource Assessment	(41)
Coal and Shale Processing	(67)	Oil and Gas	(40)
Mining Coal and Shale	(64)	Fission	(39)
Fission	(63)	Mining Coal and Shale	(38)
Conversion Techniques	(57)	Conversion Techniques	(36)
Advanced Transportation Systems	(54)	Advanced Transportation Systems	(35)
Energy and Fuel Transportation Distribution and Storage	(54)	Energy and Fuel Transportation Distribution and Storage	(33)
Geothermal	(45)	Fusion	(29)
Fusion	(43)	Geothermal	(28)
Solar	(40)	Solar	(27)

Rating Two Competing Programs. The basis for assigning weights to two closely related programs is described below to illustrate the rationale by which different weights were given to competing programs. Both programs, enhanced oil and gas production and coal liquefaction, have the same goal—production of refinery feed stock.

Research and Development Phase. Adequacy of the Scientific Base is considered excellent in oil recovery, but poor for the development of economically viable coal liquefaction. Both programs are considered to offer high probabilities of Future Technological Success. More work must be done in coal prior to demonstrating economic feasibility, and a larger list of priority projects exists, implying greater Feasible Absorbable Investment here than in oil and gas. Consensus of Acceptability is good for both projects, but coal liquefaction is less acceptable both on the basis of requiring extensive mining and the use of valuable water resources.

Implementation and Production Phase. Coal liquefaction is expected to have worse Price/Cost prospects than enhanced oil and gas recovery. Both proposals augment the supplies of high Cost Substitutes, namely, oil. Environmental Acceptability of both is less than optimal, with debits in both mining and in the risk of oil spills. Need for a Government Role is far greater in coal liquefaction than in oil, where the time of payoff is much shorter and better technology already exists. Abundant Resource Reserves of coal are known to exist, but the extent of exploitable oil reserves is less certain. Labor is Available in both areas, but Hardware Development is less advanced in coal liquefaction. Private Capital is judged to be readily available to implement enhanced recovery of oil but is much less so for coal liquefaction due to the latter's longer term payoff and less certain economics; also the more fragmented coal industry lacks the financial resources of the oil industry.

Payoff Phase. Both coal liquefaction and enhanced oil recovery offer the prospect of enhancing both the BTU's and Petroleum Savings. Timing is more favorable for oil recovery than coal liquefaction.

Project Priority and Project Funding

Programs given the highest priorities—conservation, oil and gas production, and utilization of coal—have been budgeted more liberally than those programs of lesser priority in terms of size and term of payoff. The dollar amounts proposed for individual programs cannot be ranked in the same fashion as the priority, since the overriding criterion is how much funding can be prudently spent. A relatively massive infusion of Federal funding is proposed in the area of conservation. A very helpful increment of Federal assistance to the huge expenditures of the oil and gas industry is included, anticipating that the bulk of investment in these areas will be derived from private sources.

In the case of coal conversion, a variety of ambitious programs has been proposed for substantial funding in conjunction with a substantial contribution from industry consistent with the anticipated capacity to generate the people, hardware, and initial methodologies to push ahead with major pilot and development stage projects. For programs of long-term and mid-term payoff that lack significant private interest at present, such as the breeder and fusion programs, continued support has been proposed to ensure the energy future without interfering with the concentration of the accelerated spending program on shorter term prospects. In the cases of direct and indirect solar and geothermal applications, very large increases in spending have been recommended; however, the dollar amounts are much smaller than those for programs already involving massive construction costs for demonstration plants.

ALLOCATION OF FEDERAL FUNDS AMONG TIME PERIODS

The allocation of Federal funds among time periods by program elements, shown in Table B-4, provides a breakdown of the program elements given in Table 2-1. The key emphasis used in making these time-period determinations is the earliest projected commercial introduction of a technology derived from the combined Federal—industry development rather than the date of successful completion of the research and development program. There are obvious difficulties in assessing whether certain programs will be introduced in the short-term or mid-term, but the allocation is made through the best estimate available at this time.

Table B-4.—ALLOCATION OF FEDERAL FUNDS AMONG TIME PERIODS BY PROGRAM ELEMENTS

Self-Sufficiency Task	Short-Term Objectives ($ Millions)	Mid-Term Objectives ($ Millions)	Long-Term Objectives ($ Millions)
1. Conserve Energy and Energy Resources			
End-Use Conservation	135	15	
Improved Management	60		
High-Temperature Gas Turbine	210	105	
Advanced Cycles, Fuel Cells, and Other	110	100	
Advanced Auto Propulsion	260	40	
Rail, Bus, Ship, and Air Systems	205		
Energy and Fuel Transportation Distribution, and Storage	180	20	
Subtotal	1,160	280	
2. Increase Domestic Production of Oil and Gas			
Oil and Gas	310		
Resource Assessment	120	30	
Subtotal	430	30	
3. Substitute Coal for Oil and Gas on a Massive Scale			
Mining	285	40	
Direct Combustion	200		
Synthetic Fuels	855	415	
Common Technology	350	30	
Subtotal	1,690	485	
4. Validate the Nuclear Option			
Safety, Enrichment, HTGR, and Other	1,100	145	
Breeder Reactors		2,845	
Subtotal	1,100	2,990	
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible			
Fusion			1,450
Solar	50	50	100
Geothermal	85	100	
Subtotal	135	150	1,550
TOTAL	4,515	3,935	1,550

For each major program element, the subprograms and projects were individually analyzed. Examination of the program objectives, program plan, and contribution to the energy economy following successful research and development leads to the determination of those items which are definitely oriented towards early application or those items which are specifically geared for later introduction. Occasionally, estimated divisions of funding amounts were made when the desired information was not sufficient to make a clear determination.

ESTIMATING INCREMENTAL ENERGY VALUES RESULTING FROM RESEARCH AND DEVELOPMENT

The increments in energy savings and energy production that can be expected in 1980 and 1985 as a result of the research and development program are derived by analysis of the expected degree of implementation provided in the technical panel reports. The analysis was performed utilizing the Reference Energy System developed by Brookhaven National Laboratory. The reason for this type of analysis is that many of the proposed technologies will compete with each other for the same market application. This means that only the most efficient and economical technology will contribute to self-sufficiency. Also, when the combined potential of all technologies exceeds the annual requirements, the excess in one sector (e.g., electricity production) cannot be transferred to another sector (e.g., automobile transportation).

The Reference Energy System depicts a total network flow from supply sources through refining, conversion, and distribution to the final utilizing devices. Economic costs and technical efficiencies are included for each element of the energy system. The systems analysis can show the relative magnitude of impacts based on the assumption of successful research and development and timely implementation of the technology. By utilizing the technical panels' input data, the Reference Energy System provides a consistent framework for evaluating energy resource allocation and consumption patterns.

The energy-supply constraints, technical efficiencies of energy processes, and cost information permit one to examine the interactions within the entire energy system and develop the most likely energy future. By restricting the level of imported fuels and analyzing the types of energy sources which can satisfy a particular end use, the model will permit new, higher cost technologies to compete for the unsatisfied demands until the most-efficient resource allocation is found.

COMPARISON OF AGENCY PROJECTIONS AND RECOMMENDED PROGRAMS

It is impossible to provide any firm estimate of what the FY 1975-1979 level of funding would have been for Federal energy research and development in the absence of the President's June 29, 1973, initiative. No official figures exist. The closest approximation to the programs that might have been conducted are agency five-year planning projections submitted during the FY 1975 budget cycle. An early draft of this report stated these amounts as $6622 million. More-precise definition of energy research and development programs and elimination of duplication resulted in the more-accurate estimate of $5931 million shown in Table B-5.

Table B-5.—FEDERAL ENERGY RESEARCH AND DEVELOPMENT OBLIGATIONS BY INDIVIDUAL PROGRAM ELEMENT, FY 1973-1975

	($ Millions)				
	Annual Budgets			FY 75-79 Programs	
Self-Sufficiency Task	Actual FY 73	Planned FY 74	Recommended FY 75	Recommended	Agency Projections
1. Conserve Energy and Energy Resources	52.8	62.3	166.2	1,440	95
Reduced Consumption	12.1	22.3	29.9	210	15
Increased Efficiency	40.7	40	136.3	1,230	80
2. Increase Domestic Production of Oil and Gas	20	19.5	51.7	460	90
Production	12.8	11.2	31.7	310	50
Resource Assessment	7.2	8.3	20.0	150	40
3. Substitute Coal for Oil and Gas on a Massive Scale	88.8	167.2	405	2,175	842
Mining			45	325	
Direct Combustion			30	200	
Synthetic Fuels			240	1,270	
Common Technology			90	380	
4. Validate the Nuclear Option	395.8	517.3	731.7	4,090	3,672.3
Safety, Enrichment, HTGR, and Other	129.7	151.7	216.2	1,245.7	1,091.5
Breeders	266.1	365.6	515.5	2,844.3	2,580.8
5. Exploit Renewable Energy Sources to the Maximum Extent Feasible	82.8	123	217.5	1,835	1,232
Fusion	74.8	98.7	145.0	1,450	1,132
Solar	4.2	13.2	32.5	200	80
Geothermal	3.8	11.1	40.0	185	20
TOTAL	640.2	889.3	1,572.1	10,000	5,931.3
Supporting Programs (incremental Federal funding to present programs)					
Environmental Effects				105.9	650
Basic Research				43	300
Manpower Development				5	50
				153.9	1,000

These projections assume substantial increases over the funding and pacing levels of current programs and include the initiation of large (and as yet unapproved) new construction projects for test and demonstration purposes in later program stages. Futhermore, the $5931 million is the sum of all agency requests rather than an independent overall coordinated program review. Thus, the total $5931 million almost certainly contains duplicate programs. It does not reflect the relative pacing and funding-level priorities that would only have led to a more-constrained estimate in the context of a balanced overall program review.

Clearly, the recommended program represents more than a doubling of the level of Federal effort devoted to energy research and development. Because of the uncertainty of the agencies' planning projections, Table B-5 also displays the data of Table 2-3 on recent budget levels. These permit a more meaningful comparison that shows the trend of actual spending experience in recent years compared to the current plan for the next five years.

Appendix C

CORNELL WORKSHOP PARTICIPANTS

FOSSIL FUEL OPTION

Workshop Members

William Gouse, Jr. (Chairman)
Director, Office of Research and Development
U.S. Department of the Interior

Glenn Beeman
Vice President, Purchasing
Commonwealth Edison
Chicago, Illinois

Lloyd Elkins
Production Research Director
Amoco Production Company
Tulsa, Oklahoma

Ernst Habicht
Staff Scientist
Environmental Defense Fund
Setauket, New York

Fred A. L. Holloway
Vice President, Science and Technology
Exxon Corporation
New York, New York

John O'Leary
Director of Licensing
U.S. Atomic Energy Commission

Eric H. Reichl
Vice President
Consolidation Coal Company
Library, Pennsylvania

Arthur M. Squires
Chairman, Department of Chemical Engineering
City College of New York

Consultant

Harry Perry
Staff Member
National Economic Research Associates, Inc.

SHORT RANGE NUCLEAR OPTION

Workshop Members

Alvin M. Weinberg (Chairman)
Director, Oak Ridge National Laboratory

John E. Cantlon, Provost
Michigan State University

W. Kenneth Davis
Vice President for Thermal Power
Bechtel Power Corporation
San Francisco, California

J. Lee Everett, President
Philadelphia Electric Company
Philadelphia, Pennsylvania

D. E. Ferguson
Division Director, Chemical Technology
Oak Ridge National Laboratory

Milton Levenson
Director, Nuclear Power
Electric Power Research Institute
Palo Alto, California

H. G. MacPherson
Department of Nuclear Engineering
University of Tennessee

INSTITUTIONAL ARRANGEMENTS

Workshop Members

Thomas O. Paine (Chairman)
Senior Vice President
Technology Planning & Development
General Electric Company
New York, New York

Carl E. Bagge, President
National Coal Association

John Corcoran, President
Consolidation Coal Company
Pittsburgh, Pennsylvania

Shearon Harris
Chairman of the Board
Carolina Power & Light Company
Raleigh, North Carolina

Leif H. Olsen
Senior Vice President and Economist
First National City Bank
New York, New York

M. L. Sharrah
Vice President and General Manager
Research & Energy
Continental Oil Company
Staford, Connecticut

Stephen A. Wakefield
Assistant Secretary for Energy
and Minerals
U.S. Department of the Interior

James E. Watson
Manager–Power
Tennessee Valley Authority

LONG RANGE NUCLEAR OPTION

Workshop Members

Hans Bethe (Chairman)
John Wendell Anderson Professor of Physics
Cornell University

Sol Buchsbaum
Executive Director, Research Communications,
Sciences Division
Bell Labs
Holmdel, New Jersey

Milton Levenson
Director, Nuclear Power
Electric Power Research Institute
Palo Alto, California

Chauncey Starr, President
Electric Power Research Institute
Los Angeles, California

Walter Zinn (Retired)

TECHNICAL REVIEW PANEL
MEMBERSHIP AND CONSULTANTS

Panel I

RESOURCE ASSESSMENT

Members

Harold L. James, Chairman
U.S. Geological Survey
U.S. Department of the Interior

Robert D. Nininger
U.S. Atomic Energy Commission

Glen Kendall
Environmental Protection Agency

Ernest Loeb
U.S. Department of Commerce

H. F. York
U.S. Bureau of Mines
U.S. Department of the Interior
Pittsburgh, Pennsylvania

Thane H. McCulloh
U.S. Geological Survey
U.S. Department of the Interior
Seattle, Washington

John W. Gableman, Executive Secretary
U.S. Atomic Energy Commission

Consultants

James F. Davis
General Manager, Uranium Exploration
Union Pacific Mining Corporation

D. Verle Harris
Professor of Geology
Pennsylvania State University

Wilbur C. Helt
Director, Engineering
and Statistical Service
National Coal Association

Charles D. Masters
Chief, Office of Energy Resources
U.S. Geological Survey

Alex Mills
U.S. Bureau of Mines
U.S. Department of the Interior

John D. Moody
Senior Vice President
for Exploration and Producing
Mobil Oil Corporation

C. Melvin Swinney
Manager of Energy Resources
Research and Development
Southern California Edison Co.

J. Frederic Weinhold
Energy Policy Project
Ford Foundation

James A. Wilson
Past–President
The American Association
of Petroleum Geologists

Panel II

MINING–COAL AND SHALE

Members

William Schmidt, Chairman
Bureau of Mines
Department of the Interior

James A. Curry
Division of Forestry, Fisheries and
Wildlife Development
Tennessee Valley Authority

George Davis
U.S. Geological Survey
U.S. Department of the Interior

Robert MacLauchlan
Plant Sciences Division
Soil Conservation Service
U.S. Department of Agriculture

John McWilliams
Bureau of Mines
U.S. Department of Interior

Carrow T. Prout, Jr.
Plant Sciences Division
Soil Conservation Service
U.S. Department of Agriculture

Ray Thacker
Office of Research & Development
Environmental Protection Agency

Carl W. Conner, Executive Secretary
Division of Construction
U.S. Atomic Energy Commission

Consultants

M. K. Barlow
Bethlehem Mines Corporation
Bethlehem, Pennsylvania

A. L. Barrett
Lemar Company
Cloucester, Virginia

Roger Bay
Forest Service
U.S. Department of Agriculture

E. P. Berg
Bucyrus–Erie Company
South Milwaukee, Wisconsin

Thomas Bethell
United Mine Workers of America

James Boyer
Bituminous Coal Research
Monroeville, Pennsylvania

Joseph R. Brennan
National Coal Association

L. J. Burger
WABCO Group of American Standard
Peoria, Illinois

A. William Calder
Joy Manufacturing Company
Franklin, Pennsylvania

Thomas Crocker
Bureau of Mines
U.S. Department of the Interior
Spokane Mining Research Center
Spokane, Washington

Richard Dick
Bureau of Mines
U.S. Department of the Interior
Twin Cities Mining Research Center
Minneapolis, Minnesota

R. L. Drollinger
Harnischfeger Company
Milwaukee, Wisconsin

Thomas V. Falkie
Mineral Engineering Department
College of Earth and Mineral Science
Pennsylvania State University

John G. Ferries
Geological Survey
U.S. Department of the Interior

Charles T. Ford
Bituminous Coal Research
Monroeville, Pennsylvania

Robert Saltsman
Bituminous Coal Research
Monroeville, Pennsylvania

Donald K. Simpson
American Mining Congress

Milford Skow
Bureau of Mines
U.S. Department of the Interior

John P. Strange
Mine Safety Appliance Company
Pittsburgh, Pennsylvania

Kelly Strebig
Bureau of Mines
U.S. Department of the Interior
Twin Cities Mining Research Center
Minneapolis, Minnesota

Woods C. Talman
U.S. Steel Corporation
Pittsburgh, Pennsylvania

Steven Utter
Bureau of Mines
U.S. Department of the Interior
Denver Mining Research Center

Al Van Besien
Bureau of Mines
U.S. Department of the Interior
Denver Mining Research Center

E. M. Warner
Joy Manufacturing Company
Franklin, Pennsylvania

Gordon Wood
Geological Survey
U.S. Department of the Interior

Leonard A. Wood
Geological Survey
U.S. Department of the Interior

James C. Justice
Bluestone Coal Corporation
Beckley, West Virginia

William Kleysteuber
Bureau of Mines
U.S. Department of the Interior
Pittsburgh Mining and Safety
Research Center

Richard M. Lahn
Sierra Club

E. W. Littlefield
Utah International Inc.
San Francisco, California

Thomas Martin
Bureau of Mines
U.S. Department of the Interior
Spokane Mining Research Center

William McClain
Oak Ridge National Laboratory

Wayne McCurdy
Office of Coal Research
U.S. Department of the Interior

Sylvia Milanese
Mining Enforcement and
Safety Administration

E. A. Moulder
Geological Survey
U.S. Department of the Interior

Chuck Phillips
U.S. Soil Conservation Service
U.S. Department of Agriculture

Donald Pierce
United Mine Workers of America

William Poundstone
Consolidation Coal Company
Pittsburgh, Pennsylvania

William J. Powell
American Mining Congress
Washington, D.C.

John Y. Richards
Joy Manufacturing Co.
Washington, D.C.

Ann Roosevelt
Friends of the Earth

James Garvey
Bituminous Coal Research
Monroeville, Pennsylvania

John Geffken
Office of Coal Research
U.S. Department of the Interior

Harold J. Gluskoter
Illinois State Geological Survey
Urbana, Illinois

B. E. Grant
Peabody Coal Company
St Louis, Missouri

W. A. Haley
Caterpillar Tractor Company
Peoria, Illinois

Warren Hall
Director
Office of Water Resources Research
U.S. Department of the Interior

David S. Harper
Mining Progress, Inc.
Charleston, West Virginia

David S. Harwood
Geological Survey
U.S. Department of the Interior

Robert G. Heers
Kaiser Steel Corporation
Oakland, California

Ronald Hill
Environmental Protection Agency
Cincinati, Ohio

Larry Hobart
American Public Power Association
Washington, D.C.

Thomas E. Howard
Joy Manufacturing Co. (Canada Ltd.)
Cambridge, Calt
Ontario, Canada

Louis Hunter
National Independent Coal
Operators Association
Richlands, Virginia

R. H. Jeffrey
Jeffrey Manufacturing Company
Columbus, Ohio

Harry Johnson
Office of the Assistant Director–Energy
U.S. Department of the Interior

Panel III

FUEL TRANSPORTATION, DISTRIBUTION, AND STORAGE

Members

Joseph H. Seelinger, Chairman
Maritime Administration
U.S. Department of Commerce

Ellis R. Boyd, Jr.
Bureau of Natural Gas
Federal Power Commission

Richard Corey
USBM, Bureau of Coal
U.S. Department of the Interior

John A. Krynitsky
Defense Fuel Supply Center
Cameron Station
Alexandria, Virginia

Thomas J. Padden
Office of Research and Development
Environmental Protection Agency

Joe B. Work, Executive Secretary
Divison of Waste Management
and Transportation
U.S. Atomic Energy Commission

Consultants

Leo Donovan
Booz-Allen Applied Research
Bethesda, Maryland

Frank Fulton
Office of Pipeline Safety
Department of Transportation

Larry Hoffman
Mitre Corporation
McLean, Virginia

Harry A. Klester, Director
Engineering Services
Norfolk and Western Railway
Roanoke, Virginia

Olaf A. Larson, Staff Engineer
Process Research Division
Gulf Research and Development Company
Pittsburgh, Pennsylvania

Frank Salzano
Brookhaven National Laboratory

Robert W. Shaw, Jr.
Booz-Allen Applied Research
Bethesda, Maryland

James A. Sisler
Division of Waste Management
and Transportation
U.S. Atomic Energy Commission

Kenneth Treiber
Material and Equipment R&D Command
Fort Belvoir, Virginia

James K. Walters
Division of Transportation
American Petroleum Institute

Marvin M. Williamson
Division of Applied Technology
U.S. Atomic Energy Commission

Panel IV

ENERGY TRANSPORTATION, DISTRIBUTION & STORAGE

Members

F. F. Parry, Chairman
Office of the Assistant Secretary
Energy and Minerals
U.S. Department of the Interior

J. Neal Thompson
Rural Electrical Administration
U.S. Department of Agriculture

Samuel W. Fordyce
Office of Applications
National Aeronautics & Space Administration

Brian C. Belanger
Division of Applied Technology
U.S. Atomic Energy Commission

Paul A. Petzrick
Headquarters Naval Material Command
Washington, D.C.

R. Kamper
National Bureau of Standards
U.S. Department of Commerce
Boulder, Colorado

T. R. Walker
Tennessee Valley Authority

Donald W. Kuhn, Executive Secretary
U.S. Atomic Energy Commission

Consultants

Robert A. Bell
Consolidated Edison Co.
New York, New York

Ralph Gens
Bonneville Power Authority
Portland, Oregon

Edward F. Hammel
Los Alamos Scientific Laboratory

L. F. Lischer
Commonwealth Edison Co.
Chicago, Illinois

James Workman
U.S. Department of the Interior

Panel V

COAL & SHALE PROCESSING & COMBUSTION

Members

William Crentz, Chairman
U.S. Bureau of Mines
U.S. Department of the Interior

Neal P. Cochran
Office of Coal Research
U.S. Department of the Interior

John Cowles
Division of Applied Technology
U.S. Atomic Energy Commission

Robert Hangebrauck
CSL
National Environmental Research Center
Research Triangle Park, North Carolina

Gerald A. Hollinden
Power Resources Planning
Office of Power
Tennessee Valley Authority

John Manning
National Bureau of Standards
U.S. Department of Commerce

Lewis G. Mayfield
National Science Foundation

Alex Mills
U.S. Bureau of Mines
U.S. Department of the Interior

Rufus W. Shivers, Executive Secretary
Division of Applied Technology
U.S. Atomic Energy Commission

Consultants

John B. Anderson
Research and Development Sales
Combustion Engineering Company
Windsor, Connecticut

L. Berkowitz
ESSO Research and Engineering Company
Government Research Laboratory
Linden, New Jersey

W. E. Bond, Vice President
Atlantic Richfield Company
Los Angeles, California

Arthur L. Conn, Director
Government Contracts
Research and Development Department
American Oil Company
Whiting, Indiana

R. G. Daniel
Atlantic Richfield Company
Los Angeles, California

Martin A. Elliot
Texas Eastern Transmission
Houston, Texas

Brian Harney
U.S. Bureau of Mines
U.S. Department of the Interior

W. B. Harrison, Vice President
Southern Service, Inc.
Birmingham, Alabama

Jack Huebler
Institute of Gas Technology
Chicago, Illinois

T. Kelly Janes
Environmental Protection Agency
Research Triangle Park, North Carolina

Harry Johnson
U.S. Bureau of Mines
U.S. Department of the Interior

Martin Kyle
Argonne National Laboratory
Chicago, Illinois

B. G. McKinney
Tennessee Valley Authority

Jere Nichols
Oak Ridge National Laboratory

John A. Phinney
Consolidation Coal Company
Library, Pennsylvania

Paul Pitts, Vice President
Atlantic Richfield Company
Philadelphia, Pennsylvania

Charles Prien
Denver Research Institute
Denver, Colorado

H. M. Seigel
Synthetic Fuels Research Department
ESSO Research and Engineering Company
Florham Park, New Jersey

Paul W. Spaite
Cincinnati, Ohio

Panel VI

CONVERSION TECHNIQUES

Members

Robert E. English, Chairman
Power Systems Division
Lewis Research Center
National Aeronautics & Space Adm.
Cleveland, Ohio

Winfred M. Crim, Jr.
U.S. Army Engineer Power Group
Fort Belvoir, Virginia

James L. Powell
Office of Coal Research
U.S. Department of the Interior

Samuel Schneider
National Bureau of Standards
U.S. Department of Commerce

John Smith
National Environmental Research Center
CSL
Research Triangle Park, North Carolina

Donald K. Stevens
Division of Physical Research
U.S. Atomic Energy Commission

Patrick A. O'Riordan, Executive Secretary
Space Nuclear Systems Division
U.S. Atomic Energy Commission

Consultants

William H. Day
General Electric Company
Schenectady, New York

Martin U. Gustein
National Aeronautics & Space Adm.
Cleveland, Ohio

George Hill
Electric Power Research Institute
Palo Alto, California

William D. Jackson
Electric Power Research Institute
Palo Alto, California

John C. Orth
Electro Technology Division, MERDC
Fort Belvoir, Virginia

Michael Petrick
Argonne National Laboratory

William H. Podolny
United Aircarft Corp Research Labs
East Hartford, Connecticut

Harvey Schwartz
Lewis Research Center
National Aeronautics & Space Adm.
Cleveland, Ohio

George Seikel
Lewis Research Center
National Aeronautics & Space Adm.
Cleveland, Ohio

Paul W. Sapite
Cincinnati, Ohio

Panel VII

ADVANCED METHODS OF OIL AND GAS PRODUCTION FROM FOSSIL FUELS

Members

Edward H. Fleming, Chairman
Division of Applied Technology
U.S. Atomic Energy Commission

M. Marcy Williamson
Division of Applied Technology
U.S. Atomic Energy Commission

J. Wade Watkins
U.S. Bureau of Mines
U.S. Department of the Interior

Gerald Dinneen
U.S. Bureau of Mines
U.S. Department of the Interior
Laramie Energy Research Center
Laramie, Wyoming

Frank Stead
U.S. Geological Survey
U.S. Department of the Interior
Denver Federal Center
Denver, Colorado

John Bredehoeft
U.S. Geological Survey
U.S. Department of the Interior
Denver Federal Center
Denver, Colorado

John Mulhern
Environmental Protection Agency

Robert Tomihiro, Executive Secretary
Division of Applied Technology
U.S. Atomic Energy Commission

Consultants

Lee Aamodt
University of California
Los Alamos Scientific Laboratory

Charles Bliss
Arthur D. Little, Inc.
Cambridge, Massachusetts

John Dew
CONOCO
Ponca City, Oklahoma

Lloyd Elkins
Research Center
Amoco Production Company
Tulsa, Oklahoma

Gary Higgins
Lawrence Livermore Laboratory

Charles Prien
Chemical Division
Denver Research Institute
Denver, Colorado

Don Shuster
Sandia Laboratories

Panel VIII

GEOTHERMAL

Members

Gerald W. Johnson, Chairman
Division of Applied Technology
U.S. Atomic Energy Commission

Richard Green
National Science Foundation

Donald White
U.S. Geological Survey
U.S. Department of the Interior
Menlo Park, California

William C. Klostermeyer
Division of Planning
Bureau of Reclamation
U.S. Department of Interior

Donald W. Klick (USAF)
1400 Wilson Boulevard
Arlington, Virginia

Joseph E. Machurek, Executive Secretary
Division of Applied Technology
U.S. Atomic Energy Commission

Consultants

William Brigham
Stanford University
Stanford, California

David Butler
Standard Oil Company
San Francisco, California

Hamilton Hess
University of San Francisco
San Francisco, California

George V. Keller
Colorado School of Mines
Golden, Colorado

William Ogle
3801 West 44th Avenue
Anchorage, Alaska

Panel IX

SOLAR AND OTHER ENERGY SOURCES

Members

Alfred J. Eggers, Jr., Chairman
Assistant Director for Research Application
National Science Foundation

Jim D. Andrews
Energy Programs Coordinator
Naval Weapons Center
China Lake, California

Donald A. Beattie
Advanced Energy Research and Technology Division
National Science Foundation

Walter Carleton
National Program Staff
Agricultural Research Service
Agricultural Research Center, West
U.S. Department of Agriculture

James Johnson
Air Technology Branch
Environmental Protection Agency

William A. Raney
National Program Staff
Agricultural Research Service
Agricultural Research Center, West
U.S. Department of Agriculture

James Rannels
Division of Applied Technology
U.S. Atomic Energy Commission

Ronald L. Thomas
Solar Systems Section
NASA Lewis Research Center
Cleveland, Ohio

William H. Woodward
Space Power & Prop. Division
Office of Aeronautics & Space Technology
National Aeronautics & Space Administration

Robert Woods, Executive Secretary
Division of Physical Research
U.S. Atomic Energy Commission

Consultants

Harold W. Aarstad
(Howard Research and Development)
The Rouse Company
Columbia, Maryland

Marshall E. Alper
Jet Propulsion Laboratory
Pasadena, California

Landy B. Altman, Jr.
Agricultural Research Service
U.S. Department of Agriculture

William H. Avery
Applied Physics Laboratory
Johns Hopkins Laboratory
Silver Spring, Maryland

Gerald J. Barna
Stationary Power Section
NASA–Lewis Research Center
Cleveland, Ohio

Daniel T. Bernatowitz
Solar Cell Branch
NASA–Lewis Research Center
Cleveland, Ohio

H. Richard Blieden
Division of Advanced Energy Research and Technology
National Science Foundation

Alan L. Butkow
Office of Budget, Programming, and Planning Analysis
National Science Foundation

Gerald E. Carlson
Agricultural Research Center
U.S. Department of Agriculture
Beltsville, Maryland

Harry R. Carns
Cotton & Cordage Research Branch
U.S. Department of Agriculture
Beltsville, Maryland

Charles S. Chen
Office of Public Technology Projects
National Science Foundation

William Cherry
Engineering Physics Division
Goddard Space Flight Center
Greenbelt, Maryland

Robert Cohen
Division of Advanced Energy Research and Technology
National Science Foundation

William Cohen
Liquid Rockets Propulsion Research and Technology
National Aeronautics & Space Administration

Ernst M. Cohn
Solar and Chemical Power
National Aeronautics & Space
Administration

Patrick Connelly
Office of Construction Mangement–PC
General Services Administration

John Del Gobbo
Office of Public Technology Projects
National Science Foundation

Louis V. Divone
Division of Advanced Energy
Research and Technology
National Science Foundation

Lawrence Falick
Office of Programs and Resources
National Science Foundation

Howard Feibus
Research and Development Department
Consolidated Edison Co. of New York, Inc
New York, New York

Ray H. Fields
Office of Public
Technology Projects
National Science Foundation

Patrick M. Finnegan
Systems Analysis Section
NASA Lewis Research Center
Cleveland, Ohio

Richard S. Greeley
Mitre Corporation
McLean, Virginia

Lawrence Gsellman
Mitre Corporation
McLean, Virginia

Charles Hauer
Office of Public
Technology Projects
National Science Foundation

Lloyd O. Herwig
Solar Energy Program
Office of Public
Technology Projects
National Science Foundation

Harold Horowitz
Division of Advanced Energy
Research and Technology
National Science Foundation

B. C. Hudson
Deputy Group Leader
Lawrence Livermore Laboratory

James Johnson
Water Research
Programs and Projects
Oak Ridge National Laboratory

George Kaplan
Solar Systems Section
NASA–Lewis Research Center
Cleveland, Ohio

Arthur F. Konopka
Social Systems and Human Resources
National Science Foundation

Abrahim Lavi
Professor of Electrical Engineering
Electrical Engineering Department
Carnegie-Mellon University

Bill Legg
Department of the Navy
Office of the Judge
Advocate General

Daniel G. Lewis
National Power Survey Division
Federal Power Commission

Layman T. Miller
Construction and Valuation
Veterans Administration

Walter Morrow
Linc Laboratory
Massachusetts Institute of Technology

Frederick H. Morse
Department of Mechanical Engineering
College of Engineering
University of Maryland

Warren D. Rayle
Fluid Physics and Chemistry Branch
NASA–Lewis Research Center
Cleveland, Ohio

Bruce Reiss
Office of Intergovernmental
Science and Research Utilization
National Science Foundation

Joseph M. Savino
Solar Systems Section
NASA–Lewis Research Center
Cleveland, Ohio

Wigbert Siekhaus
Division of Energy and Environment
University of California
Lawrence Berkeley Laboratory

F. Smits
Bell Telephone Laboratory
Allentown, Pennsylvania

Tom Sparrow
Office of Systems Integration
and Analysis
National Science Foundation

Dwain F. Spencer
Office of Public Technology
Projects
National Science Foundation

James Stillman
Office of the Chief of Engineers
Office of Plans, Research and Systems
Headquarters, Department of the Army

Robert Stromberg
Division 5712
Sandia Laboratory

John J. Surmeier
Division of Social Systems
and Human Resources
National Science Foundation

Siegfried Thunborg, Jr.
Division 5712
Sandia Laboratory

Ivan Tobias
Grumman Aerospace
Bethpage, New York

John Tosh
U.S. Bureau of Mines
U.S. Department of the Interior

Roscoe F. Ward
Associate Dean of Engineering
University of Massachusetts

John Watson
Mitre Corporation
McLean, Virginia

Howard Wilcox
Santa Barbara, California

Robert Williams
Energy Policy Project
Washington, D.C.

Lee S. Windheim
Sr. Vice President
Leo A. Daly Company
Washington, D.C.

James W. Winfrey
National Petroleum Council
Washington, D.C.

Panel X

FISSION REACTORS

Members

Herbert J. C. Kouts, Chairman
Division of Reactor Safety Research
U.S. Atomic Energy Commission

Alton P. Donnell
Bureau of Power on Energy Matters
Federal Power Commission

Hans L. Hamester
Technology & Impact Review Branch
Office of Radiation Programs
Environmental Protection Agency

Paul G. Shewmon
Division of Materials Research
National Science Foundation

William G. Stroud
Advanced Plans Office–Code 110
NASA Goddard Space Flight Center
Greenbelt, Maryland

Long Sun Tong
Reactor Safety Research
U.S. Atomic Energy Commission

Kenneth A. Trickett
Division of Reactor Research
& Development
U.S. Atomic Energy Commission

Merrill J. Whitman
Division of Reactor Research
& Development
U.S. Atomic Energy Commission

John S. Sieg, Executive Secretary
Division of Reactor Research
& Development
U.S. Atomic Energy Commission

Consultants

Manson Benedict, Institute Professor
Massachusetts Institute of Technology
Cambridge, Massachusetts

Spencer H. Bush
Hearst Mining Building
University of California

William Hinkle
Yankee Atomic Electric Company
Westboro, Massachusetts

Howard J. Larson
President & General Manager
Allied Gulf Nuclear Services
Barnwell, South Carolina

Milton Levenson
Electric Power Research Institute
Palo Alto, California

Peter Murray
Westinghouse Electric Company
Pittsburgh, Pennsylvania

Corwin L. Rickard, Vice President
Gulf General Atomic Company
San Diego, California

Fred L. Robson
United Aircraft Corporation
Research Laboratories
East Hartford, Connecticut

Robert Williams
Energy Policy Project, Ford Foundation
Washington, D.C.

Bertram Wolfe
General Electric Company
Sunnyvale, California

Panel XI

FUSION ENERGY

Members

Robert L. Hirsch, Chairman
Division of Controlled Thermonuclear Research
U.S. Atomic Energy Commission

F. Charles Gilbert
Division of Military Application
U.S Atomic Energy Commission

James E. Leiss
Center for Radiation Research
Radiation Physics
National Bureau of Standards
Department of Commerce

Bruce J. Mann
Evaluation Branch, Radiation Operations
Environmental Protection Agency
National Environmental Research Center
Las Vegas, Nevada

Robert E. Price
Defense Nuclear Agency
Washington, D.C.

George R. Seikel
Plasma Physics Branch
Lewis Research Center
National Aeronautics and Space Administration
Cleveland, Ohio

William R. Rice, Executive Secretary
Division of Controlled Thermonuclear Research
U.S. Atomic Energy Commission

Consultants

Richard Balzhiser
Electrical Power Research Institute
Palo Alto, California

Everett Beckner
Sandia Laboratories
Sandia Corporation

Keith Boyer
Los Alamos Scientific Laboratory

Keith Brueckner
KMS Fusion Incorporated
Ann Arbor, Michigan

John Emmett
Lawrence Livermore Laboratory
University of California

Alan Haught
United Aircraft Corporation
East Hartford, Connecticut

Moshe Lubin
University of Rochester
College of Engineering and Applied Science
Rochester, New York

Phillip Mallozzi
Battelle Memorial Institute
Columbus, Ohio

Russell Meyerand
United Aircraft Corporation
East Hartford, Conn.

Tihiro Ohkawa
Gulf General Atomic Co.
San Diego, California

Corwin Rickard
Gulf General Atomic Co.
San Diego, California

Anthony E Robson
Naval Research Laboratory
Washington, D.C.

David J. Rose
Massachusetts Institute of Technology
Cambridge, Massachusetts

Ramy Shanny
Naval Research Laboratory
Washington, D.C.

Zalman Shapiro
Westinghouse Electric Corp
Pittsburgh, Pennsylvania

Wolfgang L. Wiese
National Bureau of Standards
Department of Commerce
Washington, D.C.

Jim Williams
Los Alamos Scientific Laboratory

Panel XII

CONSERVATION

Members

John H. Gibbons, Chairman
Director, Office of Energy Conservation
U.S. Department of the Interior

Jerome Rothenberg
Office of the Assistant Secretary
Policy Development and Research
Department of Housing & Urban Development

David Didion
National Bureau of Standards
U.S. Department of Commerce

John W. Markert
Office of Construction Management PCDS
Public Buildings Service
General Services Administration

Simon V. Manson
Energy Applications and Special Studies
Office of Applications
National Aeronautics and Space Administration

Maxine Savitz
Division of Advanced Technology Application
National Science Foundation

Mark Seidel
Implementation Research Division
Environmental Protection Agency

Rudy Black
Advanced Research Projects Agency
Department of Defense

Barry Riordan
Council on Environmental Quality

James King
Office of Construction Management PCDS
Public Buildings Service
General Services Administration

Jocelyn C. Waggoner, Executive Secretary
Office of Planning and Analysis
U.S. Atomic Energy Commission

Consultants

David Berg
Environmental Protection Agency

Monte E. Canfield, Jr.
Energy Policy Project
Washington, D.C.

Dennis J. Carney
Vice President, Research
U.S. Steel Corporation
Pittsburgh, Pennsylvania

James Comly
General Electric
Schenectady, New York

Gerald Decker
Dow Corporation
Midland, Michigan

Ronald Doctor
Rand Corporation
Santa Monica, California

Donald Emhiser
PPG Industries
Glass Research Center
Harmarville, Pennsylvania

Arthur P. Fraas
Oak Ridge National Laboratory

Harold A. Golle
General Foods Corporation
White Plains, New York

Walter A. Hamilton
Vice President, Public Affairs Research
The Conference Board, Inc.
New York, N.Y.

Arjun B. Makhijani
Energy Policy Project
Washington, D.C.

John Myers
The Conference Board, Inc
New York, N.Y.

Stanley Ruby
Office of the Secretary of Defense
Advanced Research Projects Agency
Arlington, Virginia

David Swan
Vice President, Technology
Kennecott Copper Corp.
New York, N.Y.

Eric A. Walker
Vice Pres , Science & Technology
Aluminum Company of America
Pittsburgh, Pennsylvania

Panel XIII

ADVANCED TRANSPORTATION SYSTEMS

Members

Ernest N. Petrick, Chairman
Chief Scientist
U.S. Army Tank Automotive Command
Warren, Michigan

Robert A. Husted/TST-46
Department of Transportation

R. D. Ginter
NASA Headquarters

Phillip Schambra
Council on Environmental Quality

John Brogan
Division of Alternative
Automotive Power Systems
Environmental Protection Agency
Ann Arbor, Michigan

Thaddeus S. Mroz, Program Manager
NASA Lewis Research Center
Power Systems Division
Cleveland, Ohio

L. A. Smith, Executive Secretary
Reactor Research & Development
U.S. Atomic Energy Commission

Consultants

Robert Adams
George Sharp Inc.
Naval Architects
New York, N.Y.

Mel Cheslow, Office of Secretary
U.S. Dept. of Transportation

Francis Critelli
U.S. Maritime Administration
Department of Commerce

Steve Ditmeyer
Dept. of Transportation
Washington, D.C.

Robert Falls, Naval Architect &
Hydrodynaminst
U.S. Maritime Administration
Dept. of Commerce

R. Giblom
George Sharp Inc.
Naval Architects
New York, N.Y.

Graham Hagey
Alternative Systems Analysis Branch
Environmental Protection Agency
Ann Arbor, Michigan

Maurice Hauschildt
Propulsion Division
Naval Ship Engineering Center

Kenneth E. Hodge
Aeronautical Operations Systems
Office of Aeronautics & Space Technology
National Aeronautics and Space
Administration

John Horgan
Advanced Industrial Studies
Pratt & Whitney Corp.
East Hartford, Connecticut

Harry W. Johnson
Study & Analysis Office
OEST-National Aeronautics and Space
Administration

Paul Johnson
Study & Analysis Office
OEST-National Aeronautics and
Space Administration

J. Lloyd Jones
Aerodynamics & Vehicles Systems Division
OEST-National Aeronautics and Space
Administration

Gerald G. Kayten
Study & Analysis Office
National Aeronautics and Space
Administration

Zelvin Levine
Maritime Technology
U.S. Maritime Administration
Department of Commerce

Carl Merz
Marine Marketing & Prop. Systems
Turbo-Power Marine Inc.
Division of United Aircraft
Farmington, Connecticut

John Milton
Safety Technology Division
U.S. Coast Guard Headquarters

Carl Schwenk
Research Division
OEST-National Aeronautics and Space
Administration

Lloyd Shure
Power Systems Division
NASA Lewis Research Center
Cleveland, Ohio

R. W. Sliger
National Maritime Research Center
Galveston, Texas

Harold Smith
Turbo-Power Marine Inc
Division of United Aircraft
Farmington, Connecticut

Don Weidhuner
Power & General Support Equipment Branch
Headquarters U.S. Army Material Command

T. Balfour
Operations & Planning for
Marine & Industrial Gas Turbines
General Electric Corporation
Schenectady, New York

J. D. Collins
Engine Research
Scientific Research Lab Building
Dearborn, Michigan

Willard Fraze
Mitre Corporation
McLean, Virginia

Harold J. Gibson
Ethyl Corporation
Ferndale, Michigan

Arnold Goldberg
The Boeing Company
Seattle, Washington

Charles M. Heinen
Vehicle Emissions Planning
Chrysler Corporation
Detroit, Michigan

S. Kaplan
MARAD Project
General Electric Corporation
Schenectady, N.Y.

Reeves Morrison
United Aircraft Corporation
East Hartford, Connecticut

John Motzer
Manager Marine Transportation
Curtiss Wright Corporation
Woodridge, New Jersey

Richard Mullineaux
General Manager
M.T.M. R&D
Shell Oil Company
Houston, Texas

Phillip S. Myers
Mechanical Engineering Dept.
University of Wisconsin

Roy Quilliam
Army Fuels Laboratory
South West Research Corp

Roger Ringham
Vice President, Engineering
International Harvester Corp.
Chicago, Illinois

Ernest S. Starkman
Vice President
Environmental Activities Staff
General Motors Technical Center
Warren, Michigan

Panel XIV

ENVIRONMENT

Members

Stanley Greenfield, Chairman
Assistant Administrator for R&D
Environmental Protection Agency
Washington, D.C.

James Liverman
Division of Biomedical and
Environmental Research
U.S. Atomic Energy Commission

Jesse Lunin
National Program Staff, SWAS
U.S. Department of Agriculture, ARC West
Beltsville, Maryland

Russell Hickey
Division of Environmental Planning
Tennessee Valley Authority

Lewis Gevantman
Program Analyst for Environmental Coordination
and Other Agency Programs
National Bureau of Standards
Dept. of Commerce

Joseph Maher, Executive Secretary
Division of Operational Safety
U.S. Atomic Energy Commission

Louis S. Clapper
Conservation Division
National Wildlife Federation
Washington, D.C.

E. R. Hendrickson
Chairman of the Board
Environmental Science and Engineering, Inc.
Gainesville, Florida

Lester Machta
Air Resources Laboratory
National Oceanic and Atmospheric
Administration
Silver Spring, Maryland

Mortimer L. Mendelsohn
Biomedical and Environmental
Research Program
Lawrence Livermore Laboratory

John M. Neuhold
Ecology Center
Utah State University

John B. Storer
Scientific Director for Pathology
and Immunology
Biology Division
Oak Ridge National Laboratory

Consultants

Stanley I. Auerbach
Environmental Sciences Division
Oak Ridge National Laboratory

Panel XV

MULTI-DIRECTIONAL RESEARCH

Members

Edward C. Creutz, Chairman
National Science Foundation

Frederick H. Abernathy
National Science Foundation

Richard R. Doell
U.S. Geological Survey
U.S. Department of Interior
Menlo Park, California

Elliot S. Pierce
U.S. Atomic Energy Commission
Washington, D.C.

F. Dee Stevenson, Executive Secretary
U.S. Atomic Energy Commission
Washington, D.C.

Consultants

Leo Brewer
Inorganic Materials Research Laboratory
University of California
Berkeley, California

Ann Carter
Brandeis University
Waltham, Mass.

Frederick de Hoffmann
Salk Institute
La Jolla, California

Gerhart Friedlander
Brookhaven National Laboratory
Uptown, New York

George R. Hill
Electric Power Research Inst.
Palo Alto, California

Howard H. Hines
National Science Foundation

Louis C. Ianniello
Atomic Energy Commission
Washington, D.C.

Sidney Law
Northeast Utilities
Hartford, Conn.

John Mehl
National Science Foundation

Ulrich Merten
Gulf Research and Development Corp.
Pittsburg, Penn.

W. L. Stewart
National Science Foundation

T. B. Taylor
International Research and Technology
Washington, D.C.

James Wei
University of Delaware
Newark, Delaware

Kent Wilson
National Science Foundation

Alex Zucker
Oak Ridge National Laboratory

Panel XVI

SYSTEMS ANALYSIS

Members

Stephen J. Gage, Chairman
Senior Staff Member For Energy Programs
Council on Environmental Quality

Leland Attaway
Office of Research and Development
Environmental Protection Agency

William Wetmore
Office of Systems Integration and Analysis
National Science Foundation

Richard F. Hill
Advisor on Environmental Quality
Federal Power Commission

David Wood
Systems Division
Office of Energy Data and Analysis
U.S. Department of Interior

Larry Ruff
Washington Environmental Research Center
Environmental Protection Agency

Marcel Grunspan, Executive Secretary
Office of Planning and Analysis
U.S. Atomic Energy Commission

Consultants

Cyril L. Comar
Cornell University
Ithaca, New York

Sam H. Schurr
Resources for the Future, Inc.
Washington, D.C.

George C Szego, President
Inter Technology Corporation
Warrenton, Virginia

J. Frederick Weinhold
Energy Policy Project
Washington, D.C.

PRINCIPAL STAFF MEMBERS

Project Director		Gorman C. Smith
Assistants		Patricia A. Boorda Gilbert S. Omenn Thomas A. Rehm
Coordinator, Cornell Workshops		Peter J. Auer
Staff Director, Technical Review Panels		Richard M. Pastore
Staff	John A. Blasy Carl W. Conner Harold E. Kneeland Joseph R. Maher Delma Snouffer	F. Dee Stevenson Robert Tomihiro Richard H. Williamson Robert M. Woods, Jr. Edwin Mampe, Jr.

The following people merit special recognition for their contributions to the preparation of this report. Many others from Government agencies, foundations, educational institutions, industry, and professional organizations gave freely of their time and talents to make this report possible. Space limitations preclude listing them all, but whatever merit the report may have is due in large measure to their efforts.

AEC .... Paul C. Bender, Secretary to the Commission
Robert E. Hollingsworth, General Manager
John P. Abbadessa, Assistant General Manager, Controller
Victor Corso, Deputy Assistant General Manager, Controller
James L. Liverman, Assistant General Manager for Biomedical & Environmental Research and Safety Programs
John M. Teem, Assistant General Manager for Physical Research and Laboratory Coordination
The Senior Management Committee comprised of National Laboratory Directors and Assistant General Managers

Support Services:

Bobbie J. Colley, Chief, Editorial Branch, Technical Information Center, Oak Ridge
Marian C. Fox, Assistant Chief, Editorial Branch, Technical Information Center, Oak Ridge
Hazel E. Whitaker, Educational Publications Officer, Publications and Reports Branch, Office of Information Services
Members of the Division of Headquarters Services

EPA .... Kurt E. Yeager

EPO .... Advisory Council on Energy Research and Development
William T. McCormick, Jr., Staff Assistant

GAC ..... General Advisory Committee (to the Atomic Energy Commission)

NSF ...... Paul F. Donovan, Director, Office of Energy Research and Development Policy

OMB ...... John C. Sawhill, Associate Director for Natural Resources, Energy & Science
Hugh Loweth, Energy and Science Division
Patricia Mooney, Budget Examiner
James A. Walker, Management Associate

U. S. GOVERNMENT PRINTING OFFICE : 1973 O - 528-134

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

50-286

December 13, 1973

RECEIVED DEC 14 1973 U.S. ATOMIC ENERGY COMMISSION

Mr. Daniel R. Muller
Assistant Director
for Environmental Projects
Directorate of Licensing
Office of Regulation
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Muller:

This is in response to your letter of October 17, 1973, requesting comment on the AEC's Draft Environmental Statement related to the proposed issuance of an operating license to the Consolidated Edison Company of New York, Inc. for the Indian Point Nuclear Generating Plant, Unit No. 3 (Docket No. 50-286), located in Westchester County in the State of New York. Two operating nuclear generating units are located on the site.

These comments by the Federal Power Commission's Bureau of Power staff are submitted in compliance with the National Environmental Policy Act of 1969, and the August 1, 1973, Guidelines of the Council on Environmental Quality, and are directed to the need for the capacity of the 965-megawatt Indian Point Unit No. 3, and related bulk power supply matters.

In preparation of these comments, the Bureau of Power staff has considered the AEC's Draft Environmental Statement, the Applicant's Environmental Report and Supplements thereto, related reports made in accordance with the Commission's Statement of Policy on Reliability and Adequacy of Electric Service (Docket No. R-362); and the staff's analysis of these documents, together with related information from other FPC reports. The staff generally bases its evaluation of the need for a specific bulk power supply facility upon long-term considerations as well as upon the load supply situation for the peak load period immediately following the availability of the new facility. It should be noted that the useful life of Indian Point Unit No. 3 is expected to be 30 years or more. During that period the unit will make a significant contribution to the reliability and adequacy of the electric power supply in the Applicant's service area.

The Applicant is an electric utility, whose service area includes New York City and the major portion of Westchester County. The Applicant is a member of the Northeast Power Coordinating Council (NPCC), which coordinates the planning of members' bulk power generating and transmission facilities for the regional area which includes New England, New York, and the Canadian provinces of New Brunswick and Ontario. In addition, the Applicant is a member of the New York Power Pool (NYPP), the operating pool for the State of New York, which coordinates the planning and operation of the members' generating and transmission facilities. NYPP has established a regional reliability standard which requires each member system by 1975 to maintain an installed reserve capacity at least equal to that required to provide an 18 percent reserve margin during its most recent annual peak load period. NYPP utilizes centralized economic dispatch techniques to operate the members' bulk power facilities on a single control area basis.

The discussion and conclusions regarding the need for the capacity of the 965-megawatt Indian Point Unit 3, contained in the AEC's Draft Environmental Statement, are concurred in by the staff of the Bureau of Power. The capacity, load, and reserve data presented in the draft environmental statement agree with the latest information available to the staff, and demonstrate the need for the unit on the Applicant's, the NYPP, and the NPCC systems.

Since the publication of the draft environmental statement, fuel oil supplies from the Middle East have been curtailed. With the exception of 1,130 megawatts of baseload nuclear capability, the Applicant's baseload and peaking generating capability is dependent upon oil and natural gas fuels. About

3,350 megawatts of oil-fired baseload capacity could be converted to pulverized coal fuel, if an adequate coal supply could be established. However, in view of the impact that the current oil shortage is having on the electric utility industry, it seems prudent to make use of nuclear power sources to the extent possible.

The discussion of alternatives to the Indian Point Unit 3 and associated transmission lines is considered adequate.

The Bureau of Power staff concurs with the conclusion that new capacity such as that represented by the 965-megawatt Indian Point Unit 3 is needed to meet the projected load requirements and provide reliability of bulk power supply in the power supply areas involved.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power

New York State

LEGISLATIVE ANNUAL

1974

Published by
NEW YORK LEGISLATIVE SERVICE, INC.
299 Broadway, New York, N. Y. 10007

CONTENTS

The mounting toll of injuries and deaths arising out of vehicular accidents and emergencies at home shows the necessity for new, improved statutes covering emergency medical services. The federal government, through the U. S. Department of Transportation, has placed New York under increased pressure to enact new emergency care legislation by stating that a continuation of federal funds for New York's highway safety activities may be dependent upon "the passage of legislation to provide a regulated training and certification program for ambulance attendants by the close of the 1974 Legislative Session". Unless corrective measures are taken, New York State could lose approximately $40 million in federal funding for highway safety programs and highway construction, according to the Director of the Division of Interdepartment Traffic Safety Coordination, New York State Department of Motor Vehicles, because our highway safety program, a good part of which is emergency medical services, has been evaluated as inferior.

It is important that New York State develop community-wide emergency medical services systems to meet the standards established by the Federal Emergency Services Act of 1973. Regional Emergency Medical Services Councils, created by this bill, would establish community-wide systems and federal funding could be available on both a State and regional basis.

As much local control as possible is maintained through regional councils, which are also charged with the responsibility of determining public need prior to approving the establishment of new ambulance services; regional councils will coordinate local emergency service programs which should result in more local EMT courses as well as public awareness of available emergency medical resources.

Voluntary ambulance services have the option of continuing in operation as they have been, or upgrading training and equipment to become certified. Should they indicate an intent to become certified, State funds would be available to assist them in procuring necessary equipment and training. Workmen's Compensation benefits may be available to enrolled members of certified voluntary services.

This bill, which is the culmination of 18-months' study by the Senate Health Committee and a series of statewide public hearings by the Senate and Assembly Health Committees, is designed to upgrade our emergency medical services through the recognition and utilization of existing ambulance services which, through improved coordination and training, should provide every citizen in need of emergency care the best possible care within the shortest possible time.

The immunity provisions of the present Section 3021 of the Public Health Law are expanded to include all EMT's rendering emergency services without the expectation of monetary compensation, whether or not on behalf of an ambulance service.

The registration provisions of this bill are not intended to include emergency rescue and first aid squads organized pursuant to the provisions of Section 209-b(1) of the General Municipal Law and operating solely for the purposes set forth in that section. However, rescue and first aid squads which do regularly transport sick and disabled persons to and from hospitals as well as ambulance services organized pursuant to subsection (2) of 209-b would be covered under the registration provisions.

Governor's Memorandum

Con Ed facilities, purchase S. 10677A, Langley Ch. 369

Public Service Law: § 66; Public Authorities Law: §§ 1001, 1005, 1009, 1012, adds 1001-a. The purpose of this bill is to help assure continuity of electric power to the people of the New York City metropolitan area by authorizing the Power Authority of the State of New York to acquire power generation facilities of Consolidated Edison.

The bill would amend the Public Authorities Law to permit the Power Authority to acquire and complete base load generating, transmission and related facilities necessary or desirable to assist in maintaining an adequate and dependable supply of electricity for public corporations, governmental agencies and electric corporations within the metropolitan area of the City of New York. Acquisition would be limited to facilities located in Westchester County and New York City, and the sale of power generated by the facilities would be limited, to the extent feasible, to consumers of electricity in that area.

The bill would expressly state the policy that any cost savings realized in the production or delivery of electricity by reason of PASNY's acquisition of facilities shall be passed on to consumers.

In addition, the bill would provide:

—that no profit may be earned by a municipality reselling PASNY power to an electric utility;

—that any contract for the sale of PASNY power directly to an electric utility shall provide for termination in the event of the utility's failure to pay its bills promptly but that in the event of such termination, the utility shall nonetheless continue to deliver the PASNY-generated power to such consumers as PASNY shall direct;

—that PASNY shall transmit copies of its proposed contracts to the Governor before public hearings are held thereon;

—that contracts between a municipality and an electric utility for the transportation of electricity shall be filed with the Public Service Commission.

For a variety of reasons, Consolidated Edison, the electric corporation that supplies electricity to all of New York City and most of Westchester County, now finds itself in an extremely poor cash situation jeopardizing the availability of dependable electric power supplies to the people and job-producing businesses in its service area.

In order to assure continuity of power, the bill would enable emergency assistance to Consolidated Edison by authorizing the Power Authority of the State of New York to acquire and complete Consolidated Edison plants now under construction. The plants whose acquisition is contemplated are Astoria 6 and Indian Point 3. Acquisition of these two plants could both provide Consolidated Edison with immediate cash and relieve it of further investment burdens for the completion of the two plants without reducing its present base load capacity.

Electricity produced by the acquired plants could be sold to governmental bodies, the Metropolitan Transportation Authority, the New York City Transit Authority, the Port Authority of New York and New Jersey or to Consolidated Edison itself. If the power is sold to Consolidated Edison, of course, it would be resold only in a manner which would insure the continued tax exemption of Power Authority bonds In any event, the bill would require that the electricty produced in the acquired facilities would be sold, to the extent feasible, for the benefit of consumers of electricity in New York City and Westchester County. It is anticipated that Consolidated Edison will continue to provide transmission and delivery of the electricity produced at the acquired plants but the bill would also authorize the Power Authority to acquire transmission facilities should that prove necessary to insure continued delivery.

The bill would expressly state as a part of the policy of the Power Authority Act that any cost savings resulting from the contemplated transaction be passed on to consumers. To provide additional protection for consumers, the bill would provide that a municipality purchasing power from PASNY and selling it to Consolidated Edison for resale could realize no profit on that transaction. Furthermore, all PASNY contracts would be submitted to the Governor prior to public hearing rather than only after public hearing as is now the case. In this way, the Governor would have additional time to solicit, receive and evaluate comments on proposed contracts and, if necessary, suggest modifications.

The Public Service Commission is now planning a comprehensive study of Consolidated Edison's long-term strengths and weaknesses. The acquisitions authorized by this bill would permit Consolidated Edison to overcome its severe short-term problem. The two complementary approaches will help insure a dependable supply of electricity, at a reasonable cost, for consumers in metropolitan New York.

Memorandum of The Department of Environmental Conservation

Env. Cons. Facilities Corp.; powers — A. 10996A, Sears **Ch. 1046**
S. 9584A. B. Smith et al.

Public Authorities Law: amends §§ 1281, 1283, 1284, 1290, adds §§ 1285-b, 1290-a. The purpose of this bill is to permit the New York State Environmental Facilities Corporation to finance the construction of a project or projects, including sewage treatment works, sewage collecting systems, solid waste disposal facilities, air pollution control facilities, water management facilities, and storm water collecting systems, in the state, pursuant to loan agreements, mortgages, contracts or other instruments with any person or persons, including individuals, firms, partnerships, public utilities, associations or corporations organized or existing under the laws of the

State or any other State, exclusive of municipal corporations or state agencies. Such loans must include provision for the reimbursement to the Corporation of all costs incurred in connection with the financing of the project by requiring the inclusion in such loan agreements, mortgages, contracts or other instruments, provision for fees or other charges. This bill permits any such loans to small businesses to be guaranteed by lease guarantees or bond insurance issued by any agency of the United States of America. Implementation of this bill should not only facilitate the protection and promotion of the health of the inhabitants of the State by the prevention of further pollution and the abatement of existing pollution of the air, land and waters of the State, but also should attract, encourage and develop economically sound commerce and industry in the State as well as prevent deterioration to existing commercial and industrial enterprises, thereby improving employment opportunities and preventing unemployment and economic deterioration in all areas of the State.

Section 1281 of the Public Authorities Law would be amended by the proposed bill. The definitions therein of "sewage treatment works," "solid waste disposal facility," "person," "air pollution control facility," and "water management facility," are amended to provide a broader concept so as to include the components of such facility as would be constructed by an industry. Such definitions in the existing law are restricted primarily to municipal facilities. The definition of "cost" is broadened to include the cost of lease guarantees or bond insurance that will insure the payment of some loans to small businesses. Also, the inclusion of the phrase "whether said facility serves one or more purposes in addition to the primary purpose of abating or controlling such pollutants," in the definitions of water management facility and solid waste disposal facilities lend to the realization of the growing concept of resource recovery and the industrial utilization of by-products from the treatment and disposal processes.

The purposes of the Corporation as set forth in Subdivision 1 of Section 1283 of the Public Authorities Law are extended to include the financing of sewage treatment works, sewage collecting systems, air pollution control facilities, water management facilities, storm water collecting systems and solid waste disposal facilities by the Corporation on behalf of persons.

Subdivision 3 of Section 1284 is amended to provide for the issuance of non-negotiable notes.

A new Section 1285-b is added to Title Twelve of the Public Authorities Law which would empower the Corporation to extend credit and make loans to a person or persons for the construction of a project provided the Corporation deems such credit or loan to be in the public interest and that the Commissioner of Environmental Conservation certifies that such credit or loan is for a project that is intended to meet or exceed State environmental standards.

Paragraph (c), Subdivision 1 of Section 1290 of the Public Authorities Law is amended to provide for the issuance of special obligation bonds or notes of the Corporation payable solely from revenues, service charges, proceeds or other payments derived on account of mortgage loan or other agreements, fees and charges with such person or persons. Provision is also made that no funds, assets or other monies of

McKINNEY'S
1974 SESSION LAWS
OF NEW YORK

Comprising
Authentic Text of the Laws
Together With Other
Valuable Legislative and Executive Materials

Volume 1

197th SESSION—1974
Laws of the Regular Session
Chapters 1 to 779

Laws of the Extraordinary Session
Chapters 588 to 592, 599, 605, and 740

ST. PAUL, MINN.
WEST PUBLISHING CO.

New York City—Generating, Transmission Facilities—Electric Service

Memorandum relating to this chapter, see page 3002

CHAPTER 369

An Act to amend the public authorities law and the public service law, in relation to the acquisition and completion of generating and transmission facilities by power authority of the state of New York in order to maintain an adequate and reliable supply of electricity in the metropolitan area of the city of New York and throughout the state.

Approved and effective May 17, 1974.

Passed on message of necessity. See Const. art. IX, § 2(b)(2), and McKinney's Legislative Law § 44.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. The third and fourth unnumbered paragraphs of section ten hundred one of the public authorities law, such third paragraph having been added and such fourth having been amended by chapter four hundred eighty-nine of the laws of nineteen hundred seventy-two, are hereby amended to read as follows:

It is further declared that there is a shortage of dependable power capacity in the southeastern part of the state and that the public interest requires that the authority assist in alleviating such shortage by providing such base load generating facilities as may be necessary or desirable to contribute to the maintenance of an adequate and dependable supply of electricity for the metropolitan transportation authority, its subsidiary corporations, ~~and~~ the New York city transit authority, the port authority of New York and New Jersey, the city of New York, the state of New York, the United States, other public corporations and electric companies within the metropolitan area of the city of New York within the state of New York.

It is further declared (i) that there should be full cooperation among private and public entities including the authority, municipal corporations and rural electric cooperatives engaged in power generation, transmission and distribution and in associated developmental and service activities, (ii) that it is desirable that the authority and the utilities which with the authority constitute the New York power pool exchange comparable cost, performance and operating data with respect to generation by nuclear means particularly reflecting the effect of the authority's tax-free status, (iii) that it is desirable and reasonable that the authority sell power and energy from its projects other than the Niagara and Saint Lawrence hydroelectric projects, not needed for its high load factor industrial, municipal, rural electric cooperative and public transportation customers to other members of the New York power pool for resale without discrimination under their respective tariffs and (iv) that it is desirable that the authority, in order to cooperate in New York state atomic and space development authority's program for maximum development and peaceful use of atomic energy, utilize nuclear fuel supplied by New York state atomic and space development authority ~~provided it is available and its utilization is not to the significant economic disadvantage of the authority and not operationally infeasible~~ to the extent deemed advisable by the trustees.

§ 2. Title one of article five of such law is hereby amended by adding thereto a new section, to be section ten hundred one-a, to read as follows:

§ 1001–a. Emergency provisions for the metropolitan area of the city of New York

The legislature hereby finds and declares that extraordinary circumstances, including excessive costs, shortages of supply, and the inflated price of fuel threaten the capacity to provide utility service essential to the continued safety, health, prosperity and well-being of the people of the metropolitan area of the city of New York and, by reason of the interconnection and interdependence of electric facilities, the reliability of such service throughout the state and require emergency action by the state and its agencies. It is therefore declared that:

1. To preserve reliability of electric service in the metropolitan area of the city of New York and throughout the state and to assist in deterring further extraordinary increases in rates for electric service the authority should provide such supplemental electricity for such use in the metropolitan area of the city of New York as is consistent with continuing and maintaining the exemption of interest on authority bonds from the income tax imposed by the Internal Revenue Code of the United States [1] and regulations and ruling thereunder.

2. It is essential that such electricity be provided at the earliest practicable time.

3. The authority should be authorized to acquire completed or partially completed generation, transmission and related facilities and fuel and fuel contracts.

4. Any cost savings realized in the production or delivery of electricity by reason of any such acquisition by the authority should be passed on to consumers.

[1] 26 U.S.C.A. (I.R.C.1954) § 1 et seq.

§ 3. The third unnumbered paragraph of section ten hundred five of such law as added by chapter four hundred eighty-nine of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

The authority is further authorized to construct and/or acquire and complete such base load generating, transmission and related facilities as it deems necessary or desirable to assist in maintaining an adequate and dependable supply of electricity by supplying power and energy for the metropolitan transportation authority, its subsidiary corporations, ~~and~~ the New York city transit authority, the port authority of New York and New Jersey, the city of New York, the state of New York, the United States, other public corporations and electric corporations within the metropolitan area of the city of New York within the state of New York; provided, however, that the acquisition of completed or partially completed facilities shall be limited to facilities located in New York city or Westchester county and the energy and power generated by such facilities shall be used, to the extent feasible, for the benefit of electric consumers in that area, and provided, further, that transmission facilities shall not be so acquired pursuant to this paragraph unless such acquisition is necessary to assure delivery of power and energy produced by any acquired generating facility.

§ 4. Paragraph g of subdivision five of section ten hundred five of such law, such subdivision having last been amended by chapter two hundred ninety-four of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

g. That the rates, services and practices of the purchasing, transmitting and/or distributing public agencies or companies in respect to the power generated by such projects shall be governed by the provisions and principles established in the contract, and not by regulations of the public service commission or by general principles of public service law regulating rates, services and practices and that in the event any such public agencies or companies which purchase power from the authority shall sell any such power for resale, such sale for resale shall be made at rates no higher than those at which the power was purchased from the authority.

§ 5. Paragraph d of subdivision six of section ten hundred five of such law, such subdivision having been added by chapter two hundred ninety-four of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

d. That the rates, services and practices of the purchasing, transmitting and/or distributing public agencies and rural electric cooperatives in respect to the power and energy from such projects shall be governed by the provisions and principles established in the contract, and not by regulations of the public service commission or by general principles of public service law regulating rates, services and practices and that in the event any such public agencies or cooperatives which purchase power from the authority shall sell any such power for resale, such sale for resale shall be made at rates no higher than those at which the power was purchased from the authority.

§ 6. Paragraph e of subdivision six of section ten hundred five of such law is hereby renumbered to be paragraph f and such subdivision is hereby amended by adding thereto a new paragraph to be paragraph e, to read as follows:

e. In the case of a contract with an electric corporation entered into on or after May first, nineteen hundred seventy-four (i) for assurances by the electric corporation of prompt and timely payment of all bills rendered by the authority and that failure to make such prompt and timely payment shall be grounds for immediate termination of the contract, and (ii) that in the event the contract is so terminated, the electric company will wheel to such purchasers as the authority may direct the power and energy that would have been sold to the electric company had the contract not been terminated.

§ 7. Subdivision seven of section ten hundred five of such law, as last amended by chapter two hundred ninety-four of the laws of nineteen hundred sixty-eight is hereby amended to read as follows:

7. To proceed with the physical construction or completion of any project authorized by this title, including the erection of the necessary dams, power houses and other facilities, instrumentalities and things necessary or convenient to that end, and including also the erection of such transmission lines as may be necessary to conduct electricity to ~~industrial~~ users located at or near the site; and including also the acquisition, by contract only with the owners thereof, of transmission lines or the use of such transmission lines, available or which may be made available, to conduct electricity to such point or points at which the electricity is sold by the authority to any person, corporation or

association, public or private, engaged in the business of distribution and sale of electricity to ultimate consumers or if the authority is unable to so acquire by contract the ownership or use of such transmission lines, including also the erection by the authority of transmission lines necessary for such purposes; and thereafter to maintain and operate the project in accordance with the provisions and policy of this title. The authority is specifically authorized to undertake the construction of any project in one or more steps as it may find economically desirable or advantageous, and as it may agree with the appropriate Canadian and/or United States authorities. Whenever in this title reference is made to "project",* it shall be understood to refer to such part of any project authorized by this title as may from time to time be in existence or immediately projected.

§ 8. Paragraphs b and c of subdivision eight of section ten hundred five of such law, such subdivision having been added by chapter two hundred ninety-four of the laws of nineteen hundred sixty-eight, are hereby amended to read as follows:

b. With respect to construction, completion, acquisition, ownership and/or operation of baseload ~~nuclear~~ generating facilities, fuel, docks, sidings, loading or unloading equipment, storage facilities and other subsidiary facilities and disposition of the output of such generating facilities.

c. With respect to construction, acquisition, ownership, operation and/or use of transmission facilities.

§ 9. Subdivision ten of section ten hundred five of such law, as added by chapter two hundred ninety-four of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

10. ~~To~~ When the trustees deem it advisable, to utilize nuclear fuel supplied and owned by New York state atomic and space development authority ~~unless such fuel is unavailable or unless the trustees determine that to utilize such fuel would result in a significant economic disadvantage to the authority or would not be operationally feasible~~.

§ 10. Subdivision one of section ten hundred nine of such law, such section having been amended by chapter two hundred ninety-four of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

1. After agreement upon the terms of any such contracts shall have been reached by the authority and its co-party or co-parties, the authority shall promptly transmit a copy of such proposed contract to the governor and shall hold a public hearing or hearings upon the terms thereof. At least thirty days' notice of such hearing shall be given by publication once in each week during such period in each of six newspapers within the state to be selected by the authority. Copies of proposed contracts shall be available for public inspection during such period of thirty days at the office or offices of the authority and at such other places throughout the state as it may designate.

§ 11. The first unnumbered paragraph of section ten hundred twelve of such law, as last amended by chapter nine hundred eight of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

It is hereby found and declared that the projects authorized by this title are for the aid and improvement of commerce and navigation and that such aid and improvement of commerce and navigation and the development, sale and distribution of ~~hydro-electric~~ power is primarily for the benefit of the people of the state of New York, for the improvement of their health and welfare and material prosperity, and is a public purpose, and the authority shall be regarded as performing a governmental function in undertaking such projects and in carrying out the provisions of this title, and shall be required to pay no taxes or assessments upon any of the property acquired by it for such projects or upon its activities in the operation and maintenance thereof, provided that nothing herein shall prevent the authority from entering into agreements to make payments in lieu of taxes with respect to property acquired for any project where such payments are based solely on the value of real property without regard to any improvement thereof by the authority and where no bonds to pay any costs of such project were issued prior to January first, nineteen hundred seventy-two.

§ 12. Subdivision twelve of section sixty-six of the public service law, as last amended by chapter two hundred seventy of the laws of nineteen hundred seventy, is hereby amended to read as follows:

12. Have power to require every gas corporation, electric corporation and municipality hereinafter in this subdivision called a utility to file with the commission and to print and keep open to public inspection schedules showing all rates and charges made, established or enforced or to be charged or enforced, all forms of contract or agreement and all rules and regulations relating to rates, charges or service used or to be used, and all general privileges and facilities granted or allowed by such utility; but this subdivision shall not apply to state, municipal or federal contracts, except to the extent such contracts relate to transportation of electricity. No change shall be made in any rate or charge, or in any form of contract or agreement or any rule or regulation relating to any rate, charge or service, or in any general privilege or facility, which shall have been filed by a utility in compliance with an order of the commission, except after thirty days' notice to the commission and to each county, city, town and village served by such utility which had filed with such utility, within the prior twelve months, a request for such notice and which shall be affected by such change and publication of a notice to the public of such proposed change once in each week for four successive weeks in a newspaper having general circulation in each county containing territory affected by the proposed change, which notice shall plainly state the changes proposed and when the change will go into effect. The commission for good cause shown may, except in the case of major changes, allow changes to take effect prior to the end of such thirty-day period and without publication of notice to the public under such conditions as it may prescribe. For the purpose of this subdivision, "major changes" shall mean an increase in the rates and charges which would increase the aggregate revenues of the applicant more than the greater of one hundred thousand dollars or two and one-half percent, but shall not include changes in rates, charges or rentals allowed to go into effect by the commission or made by the utility pursuant to an order of the commission after hearings held upon notice to the public. No utility shall charge, demand, collect or receive a greater or less or different compensation for any service rendered or to be rendered than the rates and charges specified in its schedule filed and in effect; nor shall any utility refund or remit in any manner or by any device any portion of the rates or charges so specified, nor extend to any person any form of contract or agreement, or any rule or regulation, or any privilege or facility, except such as are regularly and uniformly extended to all persons under like circumstances. The commission shall have power to prescribe the form of every such schedule, and from time to time prescribe by order such changes in the form thereof as may be deemed wise. The commission shall also have power to establish such rules and regulations to carry into effect this subdivision as it may deem necessary, and to modify or amend such rules or regulations from time to time. Nothing in this chapter shall be taken to prohibit a utility from

establishing sliding scale upward rates, beginning at a fixed price per unit for a small consumption and then increasing the price per unit as the consumption is increased. Whenever there shall be filed with the commission by any utility any schedule stating a new rate or charge, or any change in any form of contract or agreement or any rule or regulation relating to any rate, charge or service, or in any general privilege or facility, the commission may, at any time within sixty days from the date when such schedule would or has become effective, either upon complaint or upon its own initiative, and, if it so orders, without answer or other formal pleading by the utility, but upon reasonable notice, hold a hearing concerning the propriety of such change, provided that if such change is a major change, the commission shall hold such a hearing; and pending such hearing and decision thereon, the commission, upon filing with such schedule and delivering to the utility, a statement in writing of its reasons therefor, may suspend the operation of such schedule, but not for a longer period than one hundred and twenty days beyond the time when it would otherwise go into effect; and after full hearing, whether completed before or after it goes into effect, the commission may make such order in reference thereto as would be proper in a proceeding begun after the rate, charge, form of contract or agreement, rule, regulation, service, general privilege or facility had become effective. Provided that, if any such hearing cannot be concluded within the period of suspension as above stated, the commission may extend the suspension for a further period, not exceeding six months. The commission may, as authorized by section seventy-two, establish temporary rates or charges for any period of suspension under this section. At any hearing involving a rate, the burden of proof to show that the change or proposed change if proposed by the utility, or that the existing rate, if it is proposed to reduce the rate, is just and reasonable shall be upon the utility; and the commission may give to the hearing and decision of such questions preference over all other questions pending before it. The schedule, rates, charges, form of contract or agreement, rule, regulation, service, general privilege or facility in force when the new schedule, rate, charge, form of contract, rule, regulation, service, general privilege or facility was filed shall continue in force during the period of the suspension unless the commission shall establish a temporary rate or charge as authorized by section seventy-two.

§ 13. Notwithstanding any provision of law to the contrary, the transfer of any complete or partially completed generation or related facility to the power authority of the state of New York pursuant to this act on or before December thirty-first, nineteen hundred seventy-five shall not require the approval of any department, agency, board or commission nor shall the completion and/or operation of any such facility transferred to such authority require any license, permit or approval which would not be required if such facility were not transferred to the authority.

§ 14. If for any of the purposes of this act, including temporary construction purposes and the making of additions or improvements, the authority shall find it necessary or convenient to acquire any property (including but not limited to contract rights and other intangible personal property, construction materials, parts, fuel, maintenance and repair equipment, and other tangible personal property), whether for immediate or future use, then the authority may find and determine that such property is required for public use, and upon such due determination, such property shall be and shall be deemed to be required for such public use until otherwise determined by the authority and such determination of fact shall not be affected by the fact that such property has theretofore been taken for, or is then devoted to, a public use; but the public use in the hands or under the control of the authority shall be deemed superior to the public use in the hands of any other person, association or corporation. The authority may acquire such property by purchase or by exercise of the power of eminent domain under and pursuant to the provisions of section ten hundred seven of the public authorities law except that such provisions of section ten hundred seven of the public authorities law or of section thirty of the highway law or of the condemnation law as pertain to surveys, diagrams, maps, plans or profiles, assessed valuation, lis pendens, filing in the office of the clerk in which real property affected is situated and such other provisions as by their nature cannot be applicable to property other than real property shall not be applicable to the acquisition of such other property. In the event that property is acquired by exercise of the power of eminent domain under this section notice of such proceeding and all subsequent notices or court processes shall be served upon the owners of such property and upon the authority by personal service or by registered or certified mail, except as may be otherwise directed by the court.

Anything in this section to the contrary notwithstanding, any property to be acquired pursuant to this section, which property shall not have been used by its owner or owners or any of his or their predecessors in connection with or shall not have been acquired or manufactured by its owner or owners or any of his or their predecessors for use in connection with the construction of a base load generating facility in New York city or Westchester county prior to authority acquisition shall be acquired only by agreement with the owner or owners thereof.

§ 15. This act shall take effect immediately.

New York City—Generating, Transmission Facilities—Construction

Memorandum relating to this chapter, see page 3002

CHAPTER 370

An Act to amend the public authorities law, and a chapter of the laws of nineteen hundred seventy-four, entitled "AN ACT to amend the public authorities law and the public service law, in relation to the acquisition and completion of generating and transmission facilities by power authority of the state of New York in order to maintain an adequate and reliable supply of electricity in the metropolitan area of the city of New York and throughout the state", in relation to the acquisition of certain facilities by the power authority of the state of New York.

Approved and effective May 17, 1974.

Passed on message of necessity. See Const. art. IX, § 2(b)(2), and McKinney's Legislative Law § 44.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. The third unnumbered paragraph of section ten hundred five of the public authorities law, as amended by a chapter of the laws of nineteen hundred seventy-four, entitled "AN ACT to amend the public authorities law and the public service law, in relation to the acquisition and completion of generating and transmission facilities by power authority of the state of New York in order to maintain an adequate and reliable supply of electricity in the metropolitan area of the city of New York and throughout the state", is hereby amended to read as follows:

12/30/75 ConEd to PASNY

LIBER 7306 PAGE 736

001975365

17273

DEC 31 1975

THIS INDENTURE, made as of the 30th day of December, nineteen hundred and seventy-five,

BETWEEN CONSOLIDATED EDISON COMPANY OF NEW YORK, INC., a New York corporation, having its office and principal place of business at 4 Irving Place in the City, County and State of New York ("Con Edison") and POWER AUTHORITY OF THE STATE OF NEW YORK, a public authority created pursuant to chapter 772 of the Laws of New York of 1931 and existing under Title 1 of Article V of the Public Authorities Law of the State of New York, having its office and principal place of business at 10 Columbus Circle, in the City, County and State of New York, (the "Authority");

WITNESSETH, that Con Edison, in consideration of Ten Dollars and other valuable consideration paid by the Authority, does hereby grant and release unto the Authority, its successors and assigns forever:

All those certain plots, pieces or parcels of land, and land under water, more particularly described as PARCEL A in Exhibit A attached hereto and incorporated herein by reference, together with certain easements and grants of interests in personal property, fixtures, structures, improvements and other interests and subject to the reservations to Con Edison of easements and interests in personal property, fixtures, structures, improvements, and other interests and other matters, all as more particularly set forth in Exhibit A.

This conveyance is of premises which do not constitute all or substantially all of the assets of Con Edison. The certificate of incorporation of Con Edison does not require any consent of stockholders to the sale of property.

TO HAVE AND TO HOLD the premises herein granted unto the Authority, its successors and assigns forever.

AND Con Edison covenants that it has not done or suffered anything whereby the said premises have been encumbered in any way whatever, except as aforesaid.

AND Con Edison, in compliance with Section 13 of the Lien Law, covenants that it will receive the consideration for

REAL ESTATE STATE OF
TRANSFER TAX NEW YORK
Dept. of Taxation & Finance
00.00

this conveyance and will hold the right to receive such consideration as a trust fund to be applied first for the purpose of paying the cost of the improvement and will apply the same first to the payment of the cost of the improvement before using any part of the total of the same for any other purpose.

EXHIBIT A

DEFINITION OF MAPS: The following maps are intended to be filed simultaneously in the Office of the Clerk of the County of Westchester (Division of Land Records) with this Indenture and are referred to in this Exhibit A as "Map No. 1", "Map No. 2", and "Map No. 3", respectively:

"Map No. 1"

18703

"Power Authority of the State of New York, Indian Point - Unit No. 3, FACILITIES AND EASEMENTS, Sheet 1 of 2 Sheets, Village of Buchanan, Town of Cortlandt, County of Westchester, State of New York DWG. No. 17-1-001", prepared and certified by Alfred J. Gallerani, licensed engineer, N.Y.S. Lic. No. 38388, dated December 29, 1975, to be filed simultaneously with this Indenture in the Office of the Clerk of the County of Westchester (Division of Land Records);

"Map No. 2"

18703

"Power Authority of the State of New York, Indian Point - Unit No. 3, FACILITIES AND EASEMENTS, Sheet 2 of 2 Sheets, Village of Buchanan, Town of Cortlandt, County of Westchester, State of New York, DWG. No. 17-1-001", prepared and certified by Alfred J. Gallerani, licensed engineer, N.Y.S. Lic. No. 38388, dated December 29, 1975, to be filed simultaneously with this Indenture in the Office of the Clerk of the County of Westchester (Division of Land Records);

> In case of any discrepancy between the schematic delineations and designations of personal property, fixtures, structures, improvements and other interests on Maps No. 1 or No. 2 and the descriptions thereof in this Exhibit A, the description in this Exhibit A shall control.

"Map. No. 3"

"Power Authority of the State of New York, SURVEY MAP FOR THE ACQUISITION OF INDIAN POINT NUCLEAR GENERATING UNIT No. 3, Village of Buchanan and Town of Cortlandt, County of Westchester", prepared and certified by Vincent Burruano, licensed Surveyor, N.Y.S. Lic. No. 45869, dated January 24, 1975, revised November 21, 1975 and December 29, 1975, to be filed simultaneously with this Indenture in the Office of the Clerk of the County of Westchester (Division of Land Records).

18702

DEFINITIONS OF EASEMENT PARCELS: The following two parcels are referred to in this Exhibit A for convenience of reference as "EASEMENT PARCEL No. 1" and "EASEMENT PARCEL No. 2", respectively:

"EASEMENT PARCEL 1"

All that plot, piece and parcel of land lying and being in the Village of Buchanan, County of Westchester, owned by Consolidated Edison Company of New York, Inc., identified as all of those lands acquired by Consolidated Edison Company of New York, Inc., by the following deeds:

BEING the lands conveyed to Con Edison (i) by Indian Point Realty Corporation by deed dated December 1, 1954 and recorded in said Clerk's Office (Division of Land Records) on December 2, 1954 in Liber 5398 of Conveyances at page 340, (ii) by Indian Point Corporation by quit-claim deed dated February 13, 1959, and recorded in said Clerk's Office (Division of Land Records) on March 31, 1959, in Liber 5895 of Conveyances at page 369, and (iii) by The People of the State of New York by Letters Patent dated October 27, 1959, and recorded in said Clerk's Office (Division of Land Records) on December 14, 1959 in Liber 5973 of Conveyances, at page 289.

BEING a part of the following tax lots:

Village of Buchanan, Section 24, Block 33, Lot 1, and Town of Cortlandt, Section 24, Block 33, Lot 1, for (i) and (ii) above and Village Buchanan, Section 24, Block 33, Lot 3, and Town of Cortlandt, Section 24, Block 38, Lot 1, for item (iii), above.

EXCEPTING THEREFROM, PARCEL A, as hereafter defined and described on Map No. 3.

IT BEING AGREED, however, that none of the personal property, fixtures, structures, improvements, and other interests, herein reserved or granted and described as located on or affecting EASEMENT PARCEL 1, are located on or affect that part of EASEMENT PARCEL 1 lying north of the northerly line of the northernmost or main plant entrance road and north plant perimeter road, as now existing and delineated and designated on map No. 2 as "E-3", "E-2/E-3" and "E-2" respectively and the extension westerly into the Hudson River of the northerly line of the straight line portion of such north perimeter road in the vicinity of Turbine Generator Building No. 2.

"EASEMENT PARCEL 2"

All that plot, piece and parcel of land lying and being in the Village of Buchanan and Town of Cortlandt, County of Westchester, owned by Consolidated Edison Company of New York, Inc., identified as all of those lands acquired by Consolidated Edison Company of New York, Inc., by the following deeds:

Being the lands conveyed to Con Edison (i) by King Properties, Inc. by deed dated January 31, 1955, and recorded in said Clerk's Office (Division of Land Records) on December 22, 1955, in Liber 5538 of Conveyances, at page 404, and (ii) by Louis P. and Marie C. Palermo and Domenick and Jennie DiPietro by deed dated October 30, 1954, and recorded on November 12, 1954 in said Clerk's Office (Division of Land Records) in Liber 5392 of Conveyances, at page 29.

BEING a part of the following tax lots:

Village of Buchanan and Town of Cortlandt, Section 23, Block 32.1, Lot 6.

FURTHER IDENTIFIED as lying easterly of PARCEL A, (as hereafter defined and described by metes and bounds, which boundaries of PARCEL A are delineated on Map No.3), and easterly of Broadway, generally identified on Map No.1 and Map No.2 as "Buchanan Substation".

18703

IT BEING AGREED, however, that all of the personal property, fixtures, structures, improvements and other interests, herein reserved or granted and described as located on or affecting EASEMENT PARCEL 2, are located on or affect only that portion of EASEMENT PARCEL 2 which is within the area improved by elements of the "Buchanan Substation" as such elements are delineated and designated on Map No. 2.

"PARCEL A"

18702

ALL THOSE certain lots, pieces or parcels of land situate, lying and being in the Village of Buchanan, Town of Cortlandt, County of Westchester and the State of New York, and more particularly bounded and described as follows:

BEGINNING at a point on the northwesterly boundary line of Broadway where the same is intersected by the southwesterly boundary line of the Village of Buchanan; said point being an iron pin located at North 459, 973.773, East 604,934.334 of The New York Coordinate System- East Zone; thence along said village boundary line the following three (3) bearings and distances:

(1) North 61° 12' 30" West 1,130.00 feet;
(2) South 36° 32' 40" West 984.00 feet; and
(3) North 61° 12' 30" West 320.00 feet;

thence along the division line between property now or formerly of Georgia-Pacific Corporation on the west and Consolidated Edison Company of New York, Inc. on the east the following four (4) bearings and distances:

(1) North 23° 17' 30" East 575.00 feet;
(2) North 31° 19' 30" East 425.00 feet;
(3) North 16° 54' 30" East 675.00 feet, and
(4) North 33° 22' 50" West 597.28 feet

to a point in the high water line of the Hudson River; thence along said high water line the following two (2) bearings and distances:

(1) North 58° 40' 30" East 94.93 feet, and
(2) North 26° 13' 20" East 22.38 feet

to a point at the most southerly corner of lands now or formerly under water granted by The People of the State of New York in Letters Patent dated October 27, 1959 to Consolidated Edison Company of New York, Inc. and recorded in the Office of the Clerk of the County of Westchester on December 14,1959 in Liber 5973 of Deeds at Page 289; thence along the southwesterly and northwesterly boundary line of said grant the following two (2) bearings and distances:

(1) North 51°43'00" West 166.03 feet, and
(2) North 38°17'00" East 90.39 feet

to a point at the most westerly corner of premises conveyed by Consolidated Edison Company of New York, Inc. to New York State Atomic and Space Development Authority in Indenture dated July 26,1971 and recorded August 13, 1971 in the Office of the Clerk of the County of Westchester in Liber 7006 of Deeds at Page 298; thence along the southwesterly, southeasterly and northeasterly boundary lines of said premises the following six (6) bearings and distances:

(1) South 51°43'00" East 70.00 feet;
(2) North 31°20'43" East 88.35 feet;
(3) North 42°44'52" East 94.95 feet;
(4) North 71°46'23" East 39.42 feet;
(5) North 34°54'28" East 41.80 feet, and
(6) North 51°43'00" West 86.00 feet

to a point at the most northerly corner of said premises; thence along the aforesaid northwesterly boundary line of said grant;

North 38°17'00" East 817.43 feet

to a point; thence through property of Consolidated Edison Company of New York, Inc. the following eleven (11) bearings and distances:

(1) South 51°43'00" East 558.88 feet to a point located North 68°09'01"West, 47.50 feet distant measured radially from the center of a circular curve;

(2) Northerly, easterly and southerly along said curve a distance of 196.36 feet to a point located South 11°17'55" East, 47.50 feet distant measured radially from the center of said curve;

(3) South 38°17'00" West 19.47 feet;
(4) South 51°43'00" East 433.65 feet;
(5) South 29°14'02" East 227.28 feet;
(6) South 38°17'00" West 1229.14 feet;
(7) South 57°11'26" East 355.78 feet;
(8) South 63°41'22" East 215.25 feet;
(9) South 77°36'34" East 168.54 feet;
(10) South 63°30'45" East 229.13 feet, and
(11) South 63°43'41" East 310.02 feet

to a point on the aforesaid northwesterly boundary line of Broadway; thence along said northwesterly boundary line of Broadway:

South 36°32'40" West 757.79 feet

to the point of beginning, containing 76.5749 acres, more or less. All bearings are referred to true North at the 74°20' meridian of West Longitude.

BEING the southerly portion of lands conveyed to Con Edison (i) by Indian Point Realty Corporation by deed dated December 1, 1954 and recorded in said Clerk's Office (Division of Land Records) on December 2, 1954 in Liber 5398 of Conveyances at page 340, (ii) by Indian Point Corporation by quitclaim deed dated February 13, 1959 and recorded in said Clerk's Office (Division of Land Records) on March 31, 1959, in Liber 5895 of Conveyances, at page 369 and (iii) by The People of the State of New York by Letters Patent dated October 27, 1959, and recorded in said Clerk's Office (Division of Land Records) on December 14, 1959, in Liber 5973 of Conveyances, at page 289,

BEING a part of the following tax lots: Village of Buchanan, Section 24, Block 33, Lots 1 and 3, and Town of Cortlandt, Section 24, Block 33, Lot 1, and Town of Cortlandt, Section 24, Block 38, Lot 1.

RESERVING, UNTO CON EDISON, HOWEVER, the following described personal property, fixtures, structures, improvements, and other interests located on PARCEL A, excepting the fee to the land on which, over which, or under which erected or located:

18703

1. All right, title and interest in and to the 345 KV transmission line delineated and designated "CE-4" on Map No. 1, and associated towers, foundations, transmission lines, cables and other equipment and appurtenances together with the right, privilege and easement to transmit electric power over such transmission line, and for such purposes an easement of access thereto for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, add to and improve, replace, retire, and remove such system.

18703

2. All right, title and interest in and to the sanitary sewage treatment plant and sewers delineated and designated on Map No. 1 as "CE-1," and the associated power supply system, designated on Map No. 1 as "CE-7," together with the related

foundations, supporting structures and appurtenances; together with an easement to dispose of the effluent by percolation; together with the right, privilege and easement of access thereto for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, remove or abandon, such sanitary sewage treatment system and associated power supply and appurtenances.

3. An undivided 53 percent interest as a tenant in common with the Authority in and to that portion of the circulating water Discharge Canal lying south of a line parallel to and 135 feet south of the northerly boundary of PARCEL A, delineated on Map No. 1 and designated thereon as "PAC-3", together with the right, privilege and easement in common with the Authority to transmit cooling water and process water, surface and storm water through such portion of the Discharge Canal and for such purposes an easement of access thereto for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire and abandon such portion of the Discharge Canal; AND all right, title and interest in and to that portion of such Discharge Canal lying north of such line parallel to and 135 feet south of the northerly boundary of PARCEL A, delineated on Map No. 1 and designated thereon as "CE-12", together with the right, privilege and easement to transmit cooling water and process water, surface and storm water through such portion of the Discharge Canal and

M82703

for such purposes an easement of access thereto for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire and abandon such portion of the Discharge Canal, subject to the Authority's right privilege and easement to maintain the existing service water pumps and associated piping and bridge constructed over the Discharge Canal, together with the right, privilege and easement to draw water from the Discharge Canal, provided the exercise of such right does not interfere with or damage such Discharge Canal.

4. An undivided 53 percent interest as a tenant in common with the Authority in and to the outfall gates Control House and power and control conduits serving the Control House and the outfall gates (but omitting such portion of such power and control conduits as are found on the outfall gates and associated structures westerly of the westerly boundary of PARCEL A within lands now or formerly of New York State Atomic and Space Development Authority), and appurtenances thereto, delineated and designated on Map No. 1 as "PAC-4"; together with the necessary easement and appurtenances for connection of alternate power cables to a source within PARCEL A; together with the right, privilege and easement in common with the Authority for operation of the outfall gates; and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire and abandon such facilities, but subject to the applicable provisions

18703

of that certain lease between New York State Atomic and Space Development Authority, as Lessor, or its successor, and Con Edison, as Lessee, dated July 1, 1971, of lands now or formerly under the waters of the Hudson River delineated and designated on Map No. 1 as "ERDA-1", and marked on Map No. 3 "N.Y.S. Atomic Space Development Agency, Now or formerly, L.7006 cp. 298," conveyed to said Lessor by deed recorded in said Clerk's Office (Division of Land Records) in Liber 7006 of Conveyances, at page 298, on August 13, 1971.

18702
18703

5. An undivided 50 percent interest as a tenant in common with the Authority in and to the Meteorological Tower, the Meteorological Trailer, forward scatter meter, associated foundations, structures, supports, anchors, and other associated facilities and appurtenances, delineated on Map No. 1 and designated thereon as "PAC-8"; together with the right, privilege and easement together with the Authority, to utilize the same for collection of meteorological and other data, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire and abandon such facilities.

18703

6. The right, privilege and easement to use for purposes of emergency evacuation in common with the Authority the access roads delineated and designated on Map No. 2 as "RE-2".

7. The right, privilege and easement to use for ingress and egress for vehicles and personnel in common with Authority the access roads delineated and designated on Map No. 2 as "RE-3".

8. All right, title and interest in and to the electric panel board and telephone switching equipment located in the northerly end of the building denominated "GATE HSE." as delineated and designated on Map No. 1, and associated wires and cables and necessary easements for service lines, and appurtenances, delineated as "CE-11" on Map No. 1, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such reserved facilities.

9. The right, privilege and easement to transmit 138 KV power in either direction from Con Edison's 138 KV bus in the Buchanan Substation (as delineated on Maps No. 1 and No. 2) on EASEMENT PARCEL 2, through circuit breaker BT 2-6 and disconnecting switches BT 2-6W and BT 2-6E, through overhead

transmission line 95331, through the 138 KV switchyard on PARCEL A, and thence through underground 138 KV transmission lines 33332 L&M and two sets of 138 KV potheads to disconnecting switch BT 5-6N on EASEMENT PARCEL 1 (designated and delineated on Map No. 2 as "RE-4") and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire and remove such lines and appurtenances.

10. The right, privilege and easement for use of control cables for the 138 KV transmission system described in paragraph 9, above, from Control Building No. 3 (designated as "Control Bldg. No. 3" on Map No. 1) on PARCEL A, via tray and conduit underground to panels and terminal boxes in the Control House (designated as "Control House" on Map No. 1) in the 138 KV switchyard within PARCEL A, and thence underground to the switchyard easterly of the Superheater Building on EASEMENT PARCEL 1, designated and delineated on Map No. 2 as "RE-6", and appurtenances thereto, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire and remove such cables and appurtenances.

18703

11. The right, privilege and easement in common with the Authority to maintain sensors on the equipment bridge over the Discharge Canal for monitoring dissolved oxygen, pH, and temperature of the water in the Discharge Canal, and the associated sampling station building erected or to be erected just northerly on said equipment bridge, and connecting signal wiring running along the equipment bridge, westerly of Screen-well Structure No. 3 on PARCEL A, and from thence northerly on the west side of the waterfront roadway on PARCEL A to an electrical tunnel on EASEMENT PARCEL 1 and thence into Control Building No. 1 on EASEMENT PARCEL 1, designated and delineated on Map No. 2 as "RE-16", and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such facilities.

12. The right, privilege and easement in common with the Authority for electric transmission along the 480 Volt feeder from and to MCC 210, designated and delineated on Map No. 2 as "RE-13", installed within the Passageway Bridge (designated and delineated on Map No. 1 as "PA-18"), and for such purpose an easement of access for personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such facilities.

18703

13. The right, privilege and easement in common with the Authority to use the following facilities terminating in PARCEL A, delineated and designated as noted on Map No. 2:

(i) 4" station air line, from valve SA-33 on EASEMENT PARCEL 1 through the Passageway Bridge to the station air compressor in the heater bay in Turbine Generator Building No. 3 on PARCEL A ("RE-7");

(ii) 3" demineralized water line from valve PW-91 on EASEMENT PARCEL 1 through the Passageway Bridge to the outlet of flash evaporator in Turbine Generator Building No. 3 on PARCEL A ("RE-8");

(iii) 6" condensate make-up line from valve CT-40 on EASEMENT PARCEL 1 through the Passageway Bridge to the Boiler Feed Pump in Turbine Generator Building No. 3 on PARCEL A ("RE-9");

(iv) 1 1/2" hydrogen line, from the first valve at the hydrogen storage facility north of Screenwell Structure No. 1 on EASEMENT PARCEL 1 to the hydrogen storage facility north of Screenwell Structure No. 3 on PARCEL A ("RE-10");

together with easements of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such facilities.

14. The right, privilege and easement in common with the Authority for the flow of water through the high pressure fire protection water system on PARCEL A and connections on EASEMENT PARCEL 1, delineated and designated on Map No. 2 as "RE-17", and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such system.

15. The right, privilege and easement in common with the Authority for 6.9 KV and 13.8 KV connections to the Gas Turbine Substation and for transmission of electricity to and through equipment in the Gas Turbine Substation (the latter being designated and delineated on Map No. 1 as "PA-17"), and appurtenances, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such connections, equipment and appurtenances.

16. The right, privilege and easement in common with the Authority for use of control cables associated with said Gas Turbine Substation located on the north support truss of said Passageway Bridge, and within cable trays in the Passageway Bridge to Turbine Generator Building No. 1, which control cables are delineated and designated on Map No. 2 as "RE-11", and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such control cables.

17. The right, privilege and easement in common with the Authority to use the portion of PARCEL A delineated and designated on Map No. 2 as "RE-1", for temporary storage of excavated materials in association with construction on EASEMENT PARCEL 1, and for such purposes an easement of access

for vehicles and personnel, but subject to an obligation to restore the storage area substantially to its preexisting condition by removal of said excavated materials.

18. The right, privilege and easement in common with the Authority in and to the land under water and the waters of the Hudson River within the westerly boundary of PARCEL A for navigation, scientific and technical investigation, metering and testing, and to maintain facilities and equipment incident to such uses, and for such purposes, an easement of access for vessels and personnel to maintain, operate, inspect, repair, reconstruct, replace, and remove such incidental facilities and equipment.

19. The right, privilege and easement in common with the Authority to use the Passageway Bridge delineated and designated on Map No. 2 as "RE-14", for emergency exit from Turbine Generator Building No. 1.

18703

EXCEPTING, HOWEVER, any and all property of third parties, including, but not limited to, contractors' buildings, structures, trailers and sheds, tools, equipment, apparatus, appliances, shops and implements belonging to contractors, subcontractors, workmen or agents now or formerly engaged in the construction of the buildings, structures, improvements and appurtenances on PARCEL A.

TOGETHER with the following described personal property, fixtures, structures, improvements, easements and other interests located in EASEMENT PARCELS 1 and 2, excepting the fee to the land on which, over which, or under which erected or located:

1. An undivided 47 percent interest as a tenant in common with Con Edison in and to the outfall gates power cables running from PARCEL A underground through EASEMENT PARCEL 1 to MCC 10Z in the Screenwell Structure No.1 on EASEMENT PARCEL 1 (as delineated and designated on Map No. 1) and associated control wires from PARCEL A underground through EASEMENT PARCEL 1 to Control Building No. 1, such facilities being designated on Map No. 1 as "CEC-3", together with appurtenances, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such facilities.

18703

2. The right, privilege and easement to use the wharf (as delineated on Map No. 1) on EASEMENT PARCEL 1 and adjacent roadway connecting to PARCEL A for docking and off-loading of fuel oil only, together with the right to install a fuel barge off-loading facility similar to the present installation and associated pipeline running from the wharf to PARCEL A at such location and route and pursuant to design and plans to be approved by Con Edison, such approval not to be unreasonably withheld, together with the right to dock small boats,

and appurtenances, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire or remove such facilities.

3. The right, privilege and easement for use for emergency evacuation in common with Con Edison of the access roads delineated and designated on Map No. 2 as "E-2".

4. The right, privilege and easement for use for ingress and egress for vehicles and personnel in common with Con Edison of the access roads delineated and designated on Map No. 2 as "E-3".

5. All right, title and interest in and to the 10" high pressure fire protection water line connections from two "T" connections on EASEMENT PARCEL 1 to PARCEL A, delineated and designated as "PA-1" on Map No. 1, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove and cap such lines, AND the right, privilege and easement in common with Con Edison for the flow of water through the high pressure fire protection water system on EASEMENT PARCEL 1, delineated and designated on Map No. 2 as "E-8", and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such system.

6. All right, title and interest in and to the following facilities on EASEMENT PARCEL 1, delineated and designated as indicated on Map No. 1.

(i) 8", 4", and 2" City water lines, from and including the nearest valve on EASEMENT PARCEL 1 ("PA-2");
(ii) 2" chlorination system line, from and including valve CL 16 on EASEMENT PARCEL 1, including associated controls and heat tracing ("PA-3");
(iii) 2 1/2" carbon dioxide line, from and including valve PG-3 on EASEMENT PARCEL 1 ("PA-4");
(iv) 8" auxiliary steam line, from and including valve SB-4 on EASEMENT PARCEL 1 ("PA-5");
(v) 4" auxiliary condensate return, from and including valve UH-88 on EASEMENT PARCEL 1 ("PA-6");
(vi) 3" demineralized water line, from and including valve PW-91 on EASEMENT PARCEL 1 ("PA-7");
(vii) 4" station air line, from and including valve SA-33 on EASEMENT PARCEL 1 ("PA-8");
(viii) 6" condensate make-up line, from and including valve CT-40 on EASEMENT PARCEL 1 ("PA-9");
(ix) 1 1/2" desuperheater water line, from and including valve SBF-4 on EASEMENT PARCEL 1 ("PA-10");
(x) 2" radioactive liquid waste line, from and including valves LW 531 and LW 532 on EASEMENT PARCEL 1 ("PA-11");
(xi) 3" steam generator blow down line, from and including valve LW 530 on EASEMENT PARCEL 1 ("PA-12");
(xii) 1 1/2" hydrogen line, from and including nearest valve on EASEMENT PARCEL 1 ("PA-21");

and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire or remove and cap such lines. The aforesaid facilities and appurtenances vi, vii, viii and xii are SUBJECT TO the reservations to Con Edison set forth in paragraph 13 on page 14, above.

18703

7. All right, title and interest in and to two connections for the PARCEL A security lighting and surveillance system power line, delineated and designated on Map No. 1 as "PA-13"; and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such lines.

8. All right, title and interest in and to the underground telemetering and control cables and conduit duct banks related to 345 KV transmission, delineated and designated on Map No. 1 as "PA-14", running generally easterly from PARCEL A through EASEMENT PARCEL 1 and Broadway ending at and including cubicles C3-1 and C3-6 in Control Unit No. 1 in the Buchanan Substation on EASEMENT PARCEL 2, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such facilities.

18703

9. All right, title and interest in 138 KV underground transmission lines 33332 L&M from PARCEL A through two sets of 138 KV potheads to (but not including) disconnecting switch BT5-6N on EASEMENT PARCEL 1, delineated and designated on Map No. 1 as "PA-15", and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such

transmission lines, SUBJECT TO the reservation to Con Edison set forth in paragraph 9 on pages 11 and 12, above.

10. All right, title and interest in and to towers, foundations, equipment, fixtures, and appurtenances, and

(i) overhead 345 KV transmission lines from PARCEL A easterly across EASEMENT PARCEL 1 and Broadway to EASEMENT PARCEL 2 to the 345 KV south ring bus in the Buchanan Substation on EASEMENT PARCEL 2, to and including circuit breakers 1 and 3, pantograph switches F1-3 and 1A, disconnecting switches 1B, 3A and 3B, and associated ground switches, lightning arresters, coupling capacitor potential devices, and supporting structures and footings, but SUBJECT TO a non-exclusive easement (delineated and designated on Map No. 2 as "RE-5") retained by Con Edison for transmission of 345 KV in either direction around the Buchanan Substation south ring bus; and

18703

(ii) overhead 138 KV transmission line 95331 from PARCEL A to the 138 KV bus in the Buchanan Substation, including disconnecting switches BT2-6W and BT2-6E, circuit breaker BT2-6, lightning arresters, supporting structures and footings, SUBJECT TO the reservation to Con Edison set forth in paragraph 9 on pages 11 and 12,above;

delineated and designated on Map No. 1 as "PA-16"; and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire or remove such facilities.

11. The right, privilege and easement in common with Con Edison for 138 KV transmission through the overhead 138 KV transmission line 95332 from the Buchanan Substation on EASEMENT PARCEL 2, westerly across Broadway and EASEMENT PARCEL 1 to the

potheads at disconnecting switch BT5-6N on EASEMENT PARCEL 1, delineated and designated on Map No. 2 as "E-6"; and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire or remove such facilities.

12. All right, title and interest in and to the 13.8/6.9 KV autotransformer, a 6.9 KV breaker and switchgear and a 13.8 KV breaker and switchgear, associated structures, fixtures and footings comprising the Gas Turbine Substation on EASEMENT PARCEL 1, connecting underground 6.9 KV power line to PARCEL A and control lines to the Passageway Bridge, and appurtenances, delineated and designated on Map No. 1 as "PA-17", and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire or remove such facilities, SUBJECT TO the reservation to Con Edison set forth in paragraph 15 on page 15, above.

13. All right, title and interest in and to the Passageway Bridge, supporting structures and footings, and equipment located thereon, delineated and designated on Map No. 1 as "PA-18", ending at the south wall of Turbine Generator Building No. 1 on EASEMENT PARCEL 1, and appurtenances, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire or remove such facilities, SUBJECT TO the reservations to Con Edison in paragraphs 12, 13, 16 and 19, on pages 13, 14, 15 and 16, above respectively.

14. All right, title and interest in and to the Controlled Passageway from the northerly boundary of PARCEL A to the south wall of Superheater Building No. 1 on EASEMENT PARCEL 1, delineated and designated on Map No. 1 as "PA-19", and appurtenances, and for such purposes an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace, retire and remove such facility, together with an easement of ingress and egress to the Con Edison Health Physics facility on EASEMENT PARCEL 1.

18703

15. All right, title and interest in and to the continuation from the Passageway Bridge of the 480 Volt feeder to MCC 210, and of communication, miscellaneous control and telephone cables to the connection for each to their first respective terminal boxes in Turbine Generator Building No. 1 on EASEMENT PARCEL 1, which feeder and cables are delineated and designated on Map No. 1 as "PA-22", and for such purposes an easement of access for personnel to maintain, operate, inspect, repair, reconstruct, replace, retire, abandon or remove such wires and cables, SUBJECT TO the reservation to Con Edison in paragraph 12 on page 13, above.

16. All right, title and interest in and to the underground telemetering and control cables and conduit duct banks related to 138 KV transmission, delineated and designated on Map No. 1 as "PA-23", running easterly from PARCEL A across EASEMENT PARCEL 1 and Broadway to the Buchanan Substation on EASEMENT PARCEL 2, and for such purposes, an easement of

access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace and remove such facilities.

17. All right, title and interest in and to the 138 KV underground control cables delineated and designated on Map No. 1 as "PA-24", running from PARCEL A to the 138 KV switchyard easterly of the Superheater Building on EASEMENT PARCEL 1, and for such purposes, an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace and remove such cables, SUBJECT TO the reservation to Con Edison in paragraph 10 on page 12, above.

18703

18. The right, privilege and easement in common with Con Edison to use only that portion of the sanitary sewage treatment plant and sewers on PARCEL A from the "T" connection to existing sanitary facilities located in Turbine Generator Building No. 3 for the purpose of servicing such existing sanitary facilities, delineated and designated on Map No. 2 as "E-7", and for such purpose, an easement of access to maintain, operate, inspect, repair, reconstruct, replace and remove such facilities.

19. The right privilege and easement as owner of an undivided 50 percent interest in common with Con Edison in and to the Meteorological Tower delineated and designated on Map No. 1 as "PAC-8" to maintain existing anchors and supports for such Tower on lands of Con Edison conveyed to Con Edison by Inamly

Corporation by deed dated October 31, 1972 and recorded in said Clerk's Office (Land Records Division) on December 7, 1972, in Liber 7097 of Conveyances at page 355, being further identified as Town of Cortlandt Tax Lot 1 in Section 9.2H, and for such purposes, an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace and remove such anchors and supports.

20. All right, title and interest in and to the signal wiring for the sensors for monitoring the temperature of the water in the Discharge Canal running from PARCEL A along the west side of the waterfront roadway to an electrical tunnel on EASEMENT PARCEL 1, and thence into Control Building No. 1 on EASEMENT PARCEL 1, designated and delineated on Map No. 1 as "PA-25", and for such purposes, an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace and remove such signal wiring SUBJECT TO the reservation to Con Edison set forth in paragraph 11 on page 13, above.

21. All right, title and interest in and to the 4" service line for the air bubbler running from the nearest valve on EASEMENT PARCEL 1 north of Screenwell Structure No. 1 along the waterfront to PARCEL A, delineated and designated on

18703

Map No. 1 as "PA-20", and for such purposes, an easement of access for vehicles and personnel to maintain, operate, inspect, repair, reconstruct, replace and remove such service line.

GENERAL COVENANTS

Each party mutually and reciprocally agrees, with respect to any right, privilege or easement granted or reserved herein for access for vehicles or personnel in order to maintain, operate, inspect, repair, reconstruct, replace or remove any facility located on land the fee of which is owned by the other: If the parties have agreed by any separate executory agreement that such maintenance, operation, inspection, repair, reconstruction, replacement or removal is the obligation of the fee owner of the land, no such right, privilege or easement shall be exercised as long as such separate agreement shall be in effect and as long as the fee owner of such land shall not be in default of performance of an obligation thereunder beyond any period provided in such agreement for cure of default after notice thereof, or, in absence of such express provision for cure after notice, beyond a reasonable period for cure of any default after notice thereof. Nothing in the preceding sentence shall limit the reservation to Con Edison in paragraph 1 on page 7, above, with respect to the 345 KV transmission line delineated and designated on Map No. 1 as "CE-4".

Each party mutually and reciprocally agrees with respect to those grants or reservations herein of an ownership interest in personal property, fixtures, structures, improvements or other facilities ("facilities"), located on land the fee of which is owned by the other, referred to in paragraphs 1, 2, 3, 4, 5, 8 and 18 of reservations, and paragraphs 1, 2, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17 and 18, 20 and 21 of additional grants, on pages 7 through 10, 11, 16, 17, 18, 19 through 21, 22 through 24 and 25, above, such grant or reservation includes an easement to maintain such a facility in place, and where necessary, an easement of support.

18703

The parties agree that except for the temporary easements hereinafter conveyed, any right of access or other right, privilege or easement herein reserved or granted to one party burdening the lands of the other shall continue as long as:

(i) The party benefiting therefrom continues to maintain a nuclear generating station on its lands to which such right, privilege or easement is appurtenant;

(ii) Any facility on the lands of the other, or any permitted reconstruction or replacement thereof, to which such a right, privilege or easement pertains, continues to be maintained by either party; and

(iii) The party benefiting therefrom continues to have an interest therein either as an essential requirement of its operation of a nuclear generating station on its own lands, as a condition of its license or permit therefor, or by contract or agreement with the other party.

The Authority and Con Edison mutually and reciprocally agree that the exercise by the party benefiting therefrom of any of the reservations and appurtenant rights herein granted, shall at all times be subject to the right of the owner of the fee to reasonably regulate such exercise.

It is further mutually and reciprocally agreed that no part or all of the undivided interests of the Authority and Con Edison as tenants in common in any facilities and improvements thereto shall be transferred, conveyed or assigned to any third party unless the party desiring to convey or assign, after the receipt of a bona fide written offer from a third party to purchase part or all of such interest, shall have in writing offered to sell such interest to the other tenant in common, on terms and conditions at least as favorable as those contained in said bona fide offer, and shall have held such offer open for at least 180 days, provided that if the other tenant in common does not accept such offer within such period of 180 days, such offer shall be deemed to have been declined and the party desiring to sell shall be free to accept such bona fide offer and thereafter upon receipt of any necessary approval of any governmental body then having jurisdiction, to transfer, convey or assign to said third party such interest pursuant to the terms of such bona fide offer. None of such facilities or improvements in which the parties have undivided interests shall be subject to partition or sale for division; such rights to partition or sale for division being hereby effectively waived, surrendered and released by the parties.

The covenants, waivers, surrenders and releases in the preceding paragraph shall (a) be binding upon and inure to the benefit of the Authority and Con Edison and their respective successors and assigns, and the mortgagees, receivers, trustees or other representatives of each of them and of their respective successors and assigns, and shall run with the interest hereby conveyed, and (b) be applicable not only to the facilities and improvements herein conveyed but also to all facilities or improvements now or hereafter made thereto by the parties acting together.

The parties agree that no rights shall accrue under Real Property Actions and Proceedings Law Sections 512 and 522 or analogous common law doctrines of adverse possession or prescription by reason of the variation of fences from common property lines, but this agreement will not survive a conveyance of any parcel abutting on such a presently common property line to a third party.

ALSO, TOGETHER WITH the right, privilege and easement to use the following described facilities in common with Con Edison for a term of five years from the date hereof (collectively, the "five-year easements"), limited in each case to an easement for the Authority to retain in place, inspect, abandon and retire the facilities, and, (i) in the event the parties have not agreed in a separate, executory agreement for Con Edison to maintain, operate, repair, reconstruct, and replace any of such facilities, or (ii) in the event that such separate, executory agreement shall no longer be in effect or that Con Edison shall be in default of performance of an obligation thereunder beyond any period provided in such agreement for cure of defaults after notice thereof, or, in absence of such express provision for cure after notice, beyond a reasonable period for cure of any default after notice thereof, a right of access for vehicles and

18703

and personnel in order to maintain, operate, repair, reconstruct and replace any of such facilities The five year easements are as follows:

(a) City Water Supply.

Water storage tank, meter house, related equipment, and water main; fire water pumps and equipment for the high pressure fire protection water system in the Superheater Building, all on EASEMENT PARCEL 1, which serve facilities referred to in paragraph 5 on page 18, and paragraph 6(i) on page 19, above;

(b) Chlorination Supply.

A sodium hypochlorite tank, a feed pump, a metering station, a motor control and chlorination control panel, and associated and wiring, all on EASEMENT PARCEL 1, which serve facilities referred to in paragraph 6(ii) on page 19, above;

(c) Carbon Dioxide Supply.

Carbon dioxide tanks, a regulating system, and related piping and wiring, all on EASEMENT PARCEL 1, which serve facilities referred to in paragraph 6(iii) on page 19, above;

(d) Auxiliary Steam Supply.

Five steam boilers located in the Superheater Building, together with related piping, wiring, controls, and condensate return piping; oil tanks; off-loading facilities, and related piping, all on EASEMENT PARCEL 1, which serve facilities referred to in paragraph 6(iv), (v) and (ix) on page 19, above;

18703

(e) Demineralized Water Supply.

A water treatment plant, 120,000 gallon water tank, and related piping, wiring and controls, all on EASEMENT PARCEL 1, which serve facilities referred to in paragraph 6(vi) on page 19, above;

(f) Radioactive Liquid Waste Facility.

Radioactive liquid waste facility, including waste evaporator, drumming facility, associated wiring, piping and controls, all on EASEMENT PARCEL 1, which serve facilities referred to in paragraph 6 (x) on page 19, above;

(g) Steam Generator Blow-Down Treatment Facility.

Steam generator blow-down treatment facility, including filters, demineralizers, flash tanks, associated wiring, piping and controls, all on EASEMENT PARCEL 1, which serve facilities referred to in paragraph 6 (xi) on page 19, above;

(h) Station Air Supply.

Air compressor in the Superheater Building, and associated piping and wiring, all on EASEMENT PARCEL 1, which serve facilities referred to in paragraph 6(vii) on page 19, above.

SUBJECT TO:

18702

1. State of facts shown on Map No. 3.

2. Compliance of the buildings, improvements, facilities and systems hereinabove conveyed with applicable

laws and regulations, to the extent applicable to the Authority.

3. Any state of facts which an accurate survey might show or a personal inspection might disclose.

4. Fencing Agreement recorded in the Office of the Clerk of the County of Westchester (Division of Land Records) in Liber 1154 of Conveyances, at page 327.

5. Conditions in Letters Patent granted by The State of New York to Bonner Brick Company recorded in said Office in Liber 1716 of Conveyances, at page 160.

6. Conditions in Letters Patent granted by The State of New York to Consolidated Edison Company of New York Inc., recorded in said Office in Liber 5973 of Conveyances, at page 289.

7. Rights to take and use clay and sand and easement of right of way recorded in said Office in Liber 1061 of Conveyances, at page 74.

8. Reservations of easement and rights contained in instrument recorded in said Office in Liber 2387 of Conveyances, at page 137.

9. Easement granted by Indian Point Corporation to Algonquin Gas Transmission Company recorded in said Office in Liber 5024 of Conveyances, at page 44, and in Liber 5035 of Conveyances, at page 146, as modified by Liber 6517 of Conveyances, at page 34, and by Liber 6712 of Conveyances, at page 401.

10. Utility Easement granted to Georgia-Pacific Corporation recorded in said Office in Liber 6756 of Conveyances, at page 257.

11. Easement granted to American Telephone and Telegraph Company recorded in said Office in Liber 6757 of Conveyances, at page 467.

12. Easements and reservations or right of any utility or power company for right of way, pipes, sewers, electric transmission and distribution lines, telegraph and telephone lines and other similar purposes presently located on PARCEL A.

13. Rights of Con Edison or others to the natural and unobstructed flow of any water course crossing PARCEL A.

18703
18702

14. Rights of the Federal Government to enter upon and take possession without compensation of lands within PARCEL A and EASEMENT PARCEL 1 now or formerly lying below the high water mark of the Hudson River.

15. Rights of The People of The State of New York in those portions of PARCEL A and EASEMENT PARCEL 1 now or formerly under the waters of the Hudson River.

16. Rights of the public generally to use that portion of PARCEL A and EASEMENT PARCEL 1 lying below the high water line of the Hudson River.

17. Rights of tenants and other persons in possession.

IN WITNESS WHEREOF, Con Edison and the Authority have duly executed this deed the day and year first above written.

LIBER 7306 PAGE 773

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

By Arthur Hauspurg
Arthur Hauspurg
its President

(SEAL)

Attest:

its Assistant Secretary

POWER AUTHORITY OF THE STATE OF NEW YORK

By
James A. Fitzpatrick
its Chairman

(SEAL)

Attest:

its Assistant Secretary

STATE OF NEW YORK, COUNTY OF NEW YORK ss.:

On the 30th day of December 1975, before me personally came James A. Fitzpatrick to me known who being by me duly sworn, did depose and say that he resides at No. 62 Beekman Street, Plattsburgh, New York, that he is the Chairman of Power Authority of the State of New York, the corporation described in and which executed the foregoing instrument; that he knows the seal of said corporation; that the seal affixed to said instrument is such corporate seal; that it was so affixed by order of the Board of Trustees of said corporation, and that he signed his name thereto by like order.

Robert P. Selya

ROBERT P. SELYA
Notary Public, State of New York
No. [illegible]
Qualified in New York County
Commission Expires March 30, 19 76

STATE OF NEW YORK, COUNTY OF NEW YORK ss:

On the 30th day of December 1975, before me personally came Arthur Hauspurg to me known who being by me duly sworn, did depose and say that he resides at No. 5 John Jay Place, Rye, New York 10580, that he is the President of Consolidated Edison Company of New York, Inc., the corporation described in and which executed the foregoing instrument; that he knows the seal of said corporation; that the seal affixed to said instrument is such corporate seal; that it was so affixed by order of the Board of Trustees of said corporation, and that he signed his name thereto by like order.

Edward Philip Scharfenberger

EDWARD PHILIP SCHARFENBERGER
Notary Public, State of New York
No. [illegible]
Qualified in Queens County
Commission Expires March [illegible] 7

Title No. 6152207

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

TO

POWER AUTHORITY OF THE STATE OF NEW YORK

DEED

December 30, 1975

Tax lots affected:

Village of Buchanan:
Section 24, Block 33, Lots 1 and 3; Section 23, Block 32.1, Lot 6.

Town of Cortlandt:
Section 24, Block 33, Lot 1; Section 24, Block 38, Lot 1; Section 23, Block 32.1, Lot 6; Section 9.2H, Lot 1.

RECORD AND RETURN BY MAIL TO:

Scott B. Lilly, Esq.
General Counsel
Power Authority of the State of New York
10 Columbus Circle
New York, New York 10019

CAHILL GORDON & REINDEL
EIGHTY PINE STREET
NEW YORK, N. Y. 10005

LIBER 7306 PAGE 775

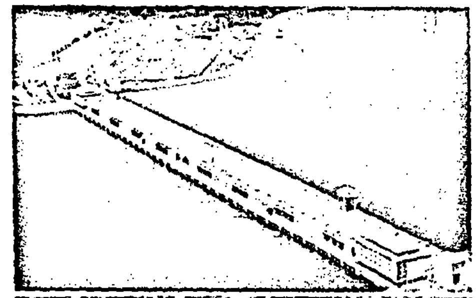
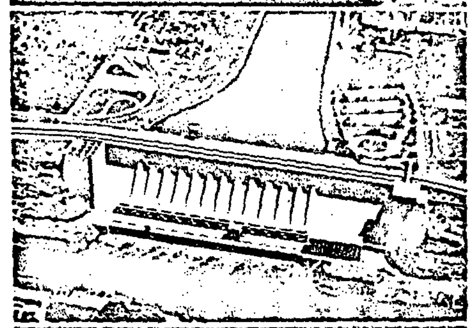
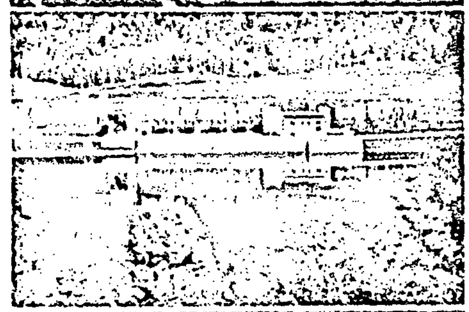
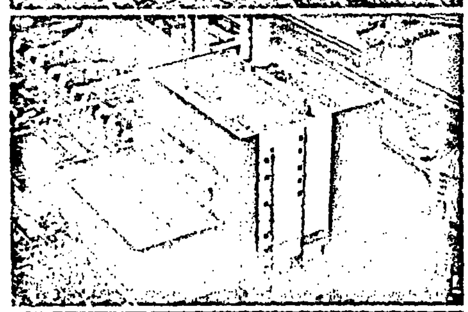
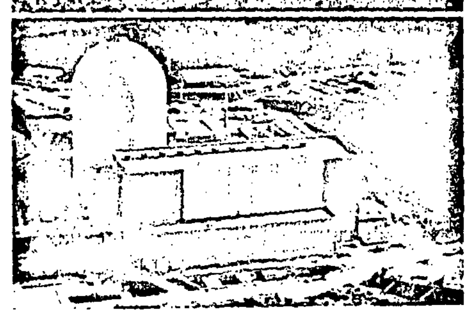
The Title Guarantee Company

Stat'y Chg. 1
Rec'd'g Chg. 58.50
Filing Chg.
Cross Ref'ng
Cert Exempt
Total 59.50
Cov'd 1 | Exmd
53112
Returned

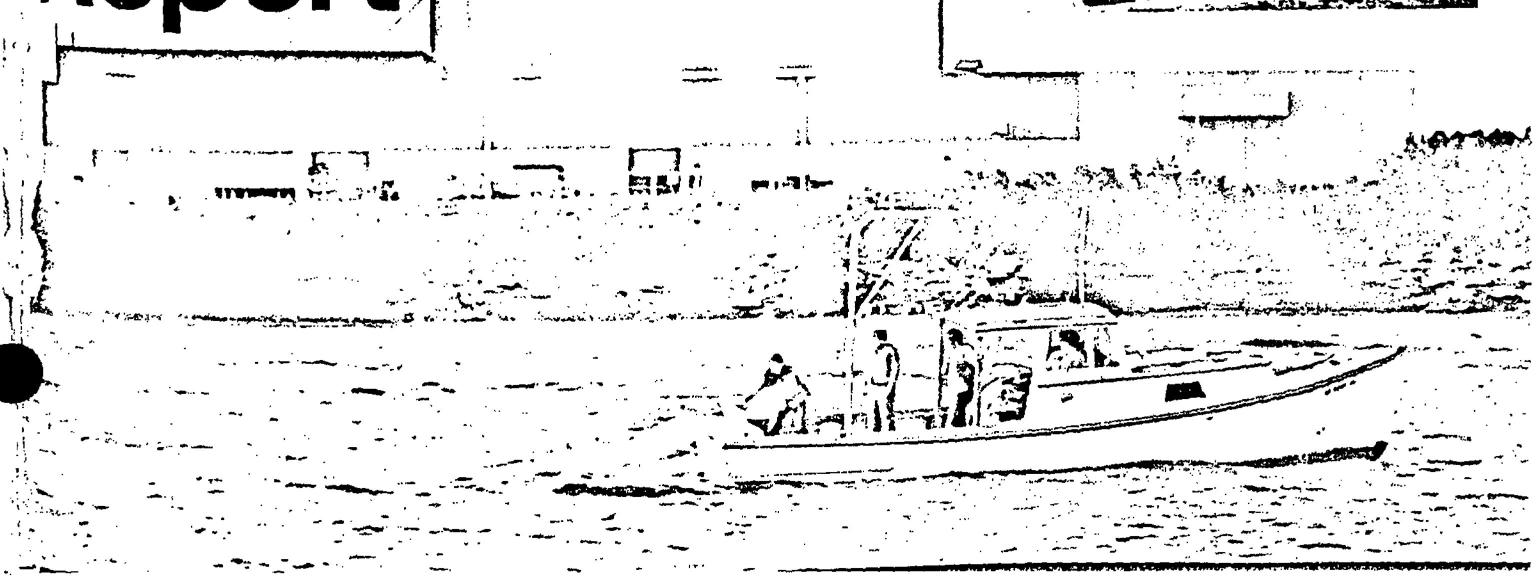
The foregoing instrument was endorsed for record as follows: The property affected by this instrument is situate in the TOWN OF CORTLANDT County of Westchester, N.Y. A true copy of the original DEED recorded DEC. 31, 1975 at 12:42 PM

GEORGE R. MORROW, County Clerk.

Power Authority of the State of New York

1975 Annual Report



1975 Annual Report

March 25, 1976

To the Governor, Legislature and Comptroller of the State of New York

Pursuant to the provisions of Sections 1002 and 2500 of the Public Authorities Law, Power Authority of the State of New York herewith submits its Forty-Fifth Annual Report covering the 1975 calendar year.

Respectfully,

James A. FitzPatrick, *Chairman*
George L. Ingalls, *Vice-Chairman*
William J. Ronan, *Trustee*
Raymond J. Lee, *Trustee*
Richard M. Flynn, *Trustee*

George T. Berry, *General Manager and Chief Engineer*
Lewis R. Bennett, *Assistant General Manager*
Scott B. Lilly, *General Counsel*
Wilbur L. Gronberg, *Assistant General Manager—Engineering*
John W. Boston, *Director of Power Operations*
Thomas F. McCrann, Jr., *Controller*
John C. Bruel, *Secretary*

Power Authority of the State of New York
10 Columbus Circle
New York, New York 10019

James A. FitzPatrick

George L. Ingalls

William J. Ronan

Raymond J. Lee

Richard M. Flynn

Power Authority of the State of New York, a public benefit corporation of the State, brought its first nuclear power plant on line in 1975. It previously had financed and built three hydroelectric projects.

The Authority is completing two additional power plants for 1976 operation and has five more generating and transmission facilities in various stages of licensing and construction. Completion of these facilities will increase the Authority's capacity to more than 10 million kilowatts.

Authority projects are built without use of tax monies or state credit for purposes specified by the Legislature and Governor. They are financed by sale to private investors of Authority bonds. The projects are operated and bonds are retired using revenues from operations.

The Authority's operating plants are the 800,000-kilowatt St. Lawrence Project near Massena, the 2,400,000-kilowatt Niagara Project near Niagara Falls, the 1,000,000-kilowatt Blenheim-Gilboa Pumped Storage Power Project in Schoharie County, and the 821,000-kilowatt James A. FitzPatrick Nuclear Power Plant in Oswego County. Transmission lines built by the Authority link the projects with the state power grid.

The Authority is composed of five trustees appointed by the Governor with advice and consent of the State Senate to serve overlapping terms of five years.

A wholesale power supplier, the Authority sells its electricity to municipal systems and rural electric cooperatives, to private utilities for resale to retail customers, to specific industries and to the Plattsburgh Air Force Base. Power allocations have been made to Vermont and to a group of rural cooperatives in Pennsylvania and New Jersey in accordance with federal law and licenses affecting the Niagara and St. Lawrence projects. The Authority expects to extend service to public agencies in the Metropolitan New York area with the 1976 completion of the Astoria 6 fossil fired plant and the Indian Point 3 nuclear plant.

Highlights of 1975

Generation

Authority generates about 25 percent of electricity produced in state

Niagara and St. Lawrence produce 24.4 billion kilowatt hours (kwh)

Blenheim-Gilboa generates 1.2 billion kwh

FitzPatrick Nuclear Plant produces 2.1 billion kwh after start of operations

Acquisition and Construction

Indian Point 3 Nuclear Plant purchased and is 99 percent complete

Astoria 6 unit approximately 77 percent complete at year-end

Power Marketing

Trustees approve contracts for six municipal customers

Power allocations increased for 25 municipal systems and rural electric cooperatives

Rural and residential users of Authority power save $61 million

Licensing and Future Construction

Massena to Plattsburgh transmission line approved

Massena to Utica transmission line hearings continue

Prattsville area studied as alternative to Breakabeen Project

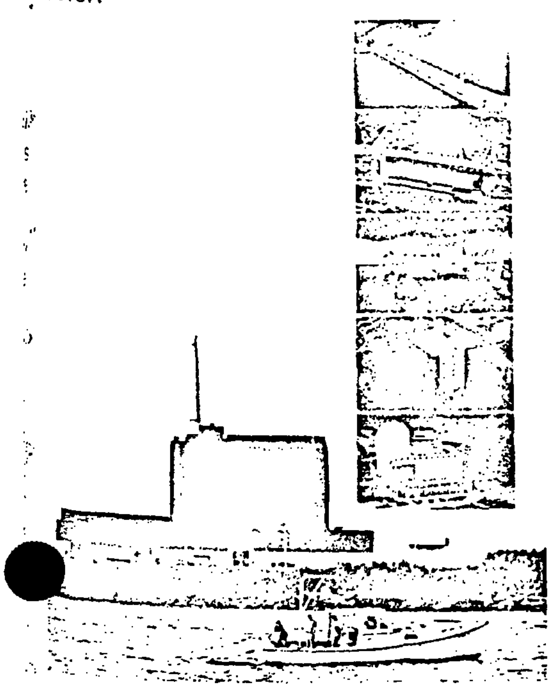
Cementon plant applications filed with State and Federal licensing agencies

Staten Island fossil-fired application awaits docketing

Financing

Acquisition and construction program financed with $910 million bonds in 1975 and January, 1976

Cover:



Moses-Saunders Power Dam, St. Lawrence Project

Moses Plant, Niagara Project

Blenheim-Gilboa Project

Astoria 6 Generating Plant

Indian Point 3 Nuclear Plant

FitzPatrick Nuclear Plant

Back Cover: Long Sault Dam at St. Lawrence

Indian Point 3 Nuclear Power Plant

C The Authority in 1975 acquired the 965,000-kilowatt Indian Point 3 nuclear power plant in Westchester County from Con Edison, completing a 1974 legislative authorization to purchase two partially-completed plants from the utility.

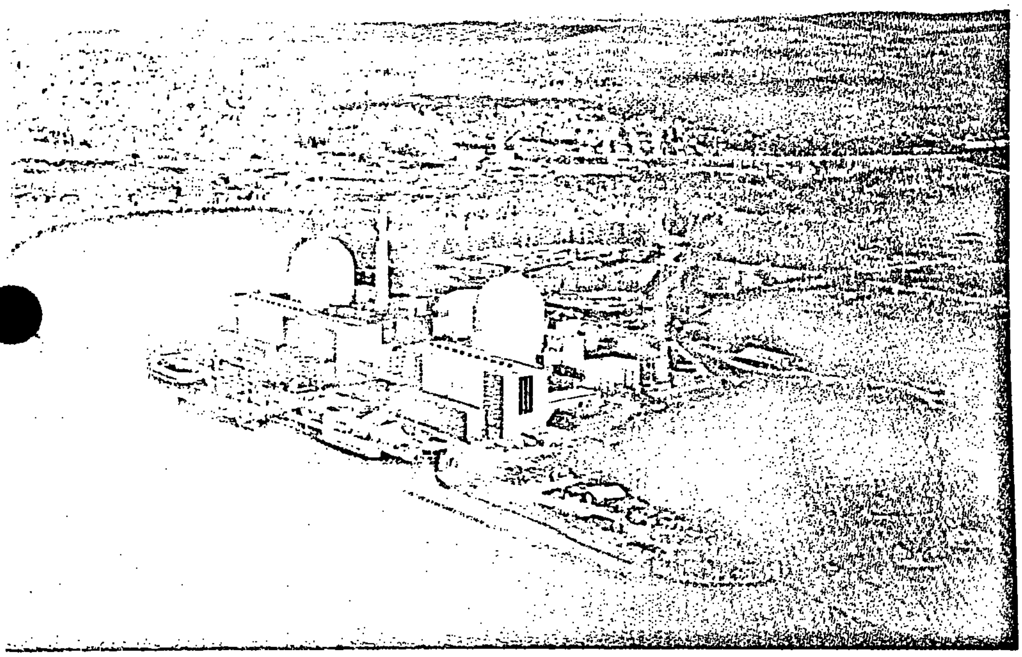
The plant is scheduled to serve public agencies and other customers in New York City and Westchester County beginning in the second half of 1976. D

Indian Point 3 is located on the east bank of the Hudson River in the Village of Buchanan near Peekskill.

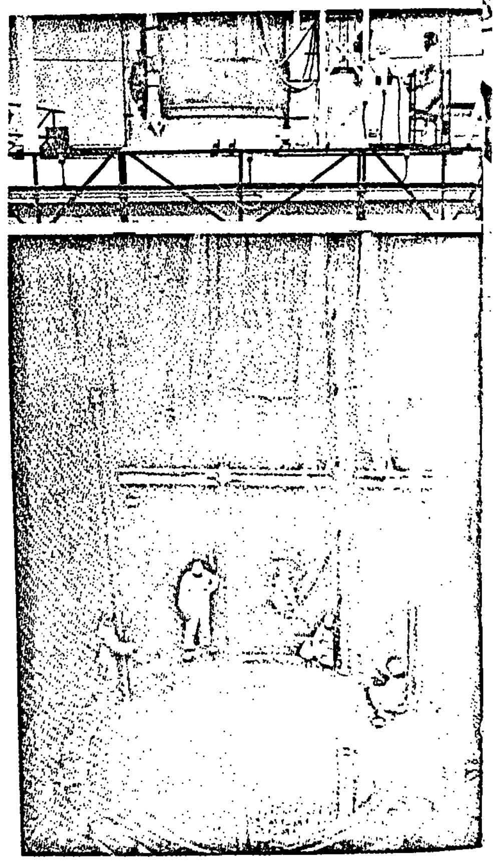
The plant uses a pressurized water reactor, in which water is heated by the energy of controlled nuclear fission in the reactor fuel core. The water, kept from boiling by the increased pressure in the reactor, flows past a heat exchanger, where its high temperature creates steam in a separate system that is connected to the turbine-generator.

Pre-operational testing is underway at the plant, which has received an operating license from the Nuclear Regulatory Commission (NRC). The license was amended to permit acquisition of the plant by the Authority. Con Edison will operate the plant for the Authority temporarily. The Authority expects to file an application to operate the plant in 1976.

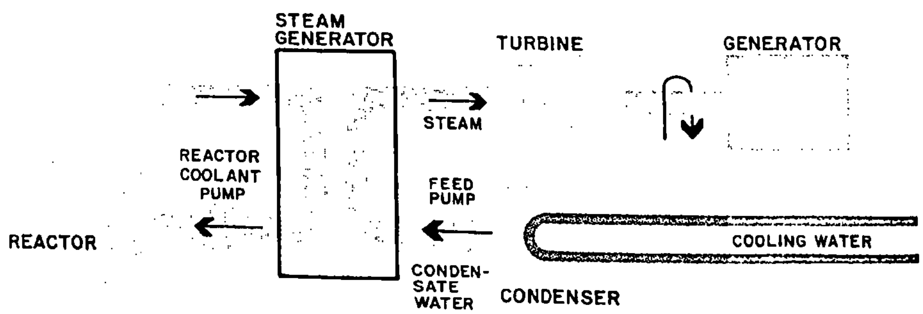
The plant will have an initial rating of 873,000 kw, which is expected to increase to 965,000 kw after about two or three years of operating experience. The annual amount of electricity produced at the lower rating would require the burning of about 8,300,000 barrels of oil or 2,100,000 tons of coal in a fossil-fired plant.



Indian Point complex at Buchanan; unit 3 at right was purchased in December, 1975, from Con Edison which retains ownership of other two units



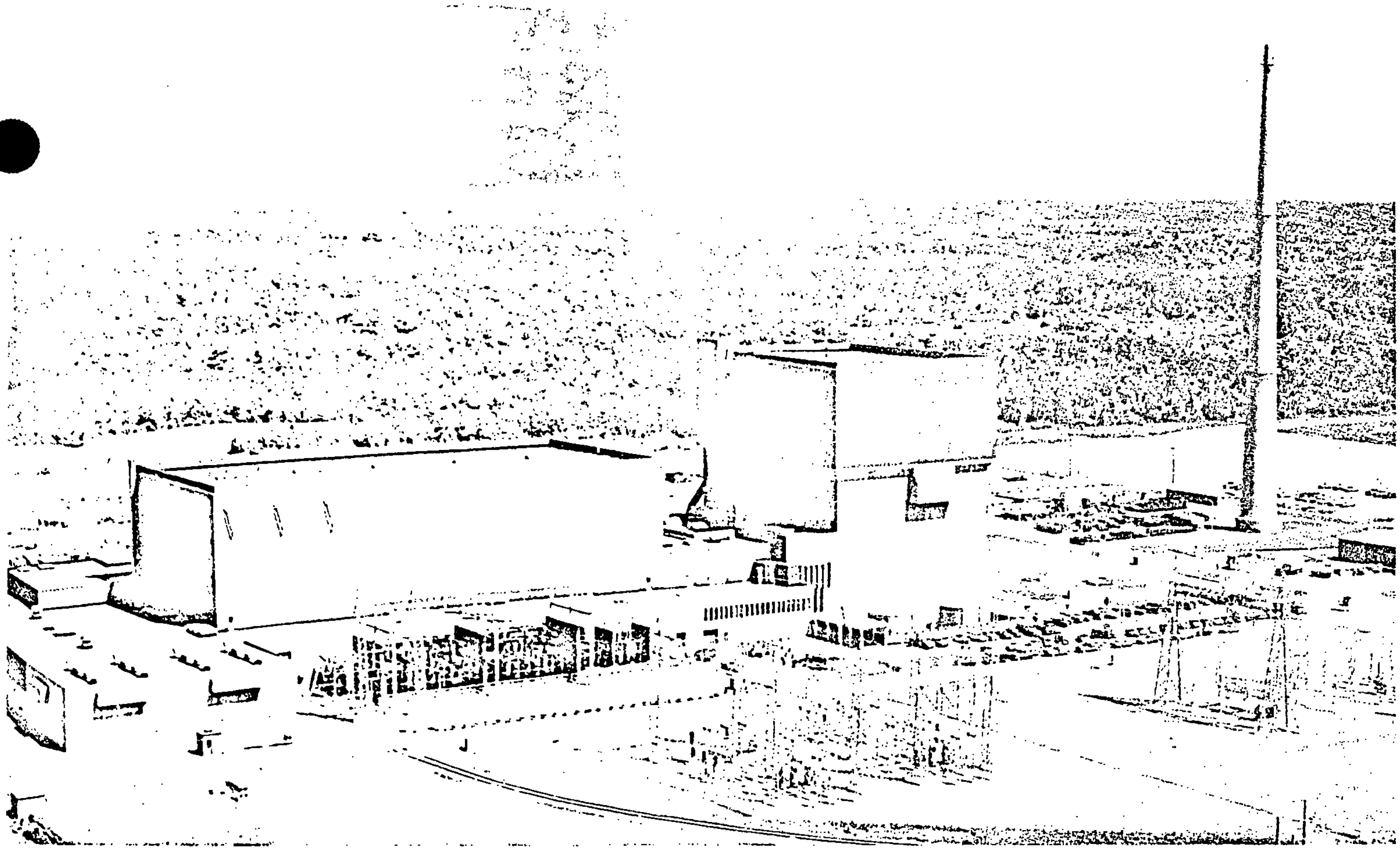
Loading fuel in Indian Point 3 reactor



PRESSURIZED WATER REACTOR PLANT

James A. FitzPatrick Nuclear Power Plant

John D. Leonard, Jr., Resident Manager



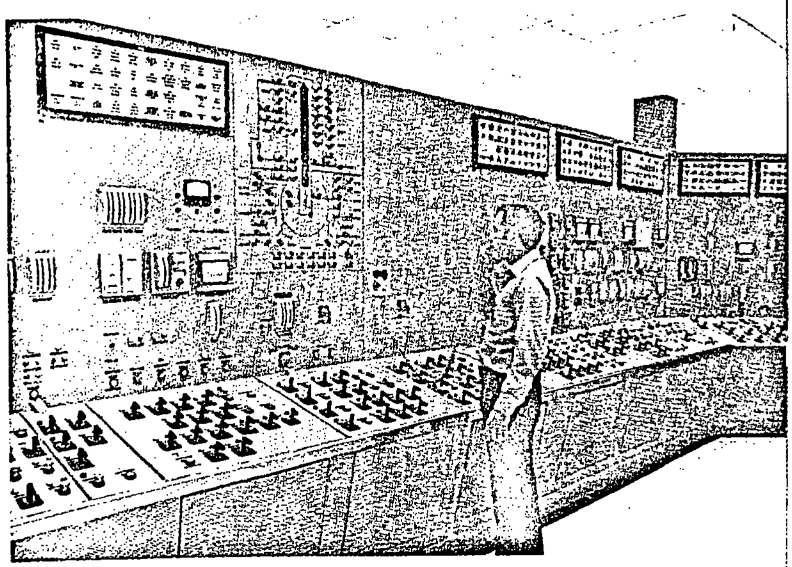
The James A. FitzPatrick Nuclear Power Plant began partial commercial operation on July 28, and by year-end had delivered more than 2.1 billion kwh of electricity to eligible industries and all seven of the state's private utilities for distribution to their retail customers. The Authority's existing municipal and rural electric cooperative customers will begin purchasing nuclear power when their growth requires allocations.

During the year, the rigorous testing program was continued. This involved numerous shutdowns and startups, inspections and constant surveillance to insure that all components meet the highest standards of reliability and safety.

Located on the south shore of Lake Ontario in the Town of Scriba, about seven miles northeast of Oswego, the plant is the Authority's first nuclear facility and was the fifth licensed for operation in New York State. It has a capability of 821,000 kw and an anticipated annual output of approximately five billion kwh. To produce that much energy in a fossil-fired plant would require the burning of about 7,800,000 barrels of oil or 1,900,000 tons of coal.

Commercial operation began seven years and two months after enactment of 1968 legislation directing the Authority to build nuclear plants to meet the increasing needs of its existing municipal and rural electric cooperative customers, to provide for expansion of high-load-factor industries, to firm the capacity of the Niagara and St. Lawrence hydroelectric projects and to assist in maintaining a dependable supply of electricity in the state.

On May 20, 1970, the Atomic Energy Commission issued a construction permit after review of the plant design and a public hearing conducted by an independent Atomic Safety and Licensing Board.



Control Room at FitzPatrick Plant

1974

Annual Report to Congress

Part One: Operating and Developmental Functions

Part Two: Regulatory Functions

ATOMIC ENERGY COMMISSION
UNITED STATES OF AMERICA

U.S. Atomic Energy Commission

January 17, 1975

Sirs: We have the honor to submit herewith the Annual Report of the United State Atomic Energy Commission for 1974 as required by the Atomic Energy Act of 1954.

Respectfully,

UNITED STATES ATOMIC ENERGY COMMISSION

Dixy Lee Ray, Chairman

CONTENTS

Part One—Operating and Developmental Functions

Chapter 1—Reorganization

Chapter 2—The AEC: 1946–1975

Chapter 3—Energy Research and Development

Chapter 4—Breeder Reactors

Chapter 5—Public Health and Safety

Chapter 6—Fusion Research

Chapter 7—Environmental Research

Chapter 8—Biomedical Research

Chapter 9—Physical Research

Chapter 10—Nuclear Materials

Chapter 11—National Security

Chapter 12—Management of Radioactive Waste

Appendix

Part Two—Regulatory Functions

Chapter 13—Nuclear Regulation in 1974

Chapter 14—1974 Nuclear Power Licensing

Chapter 15—Fuels and Materials Licensing

Chapter 16—Nuclear Materials and Plant Protection

Chapter 17—Regulatory Operations

Chapter 18—Nuclear Standards Development

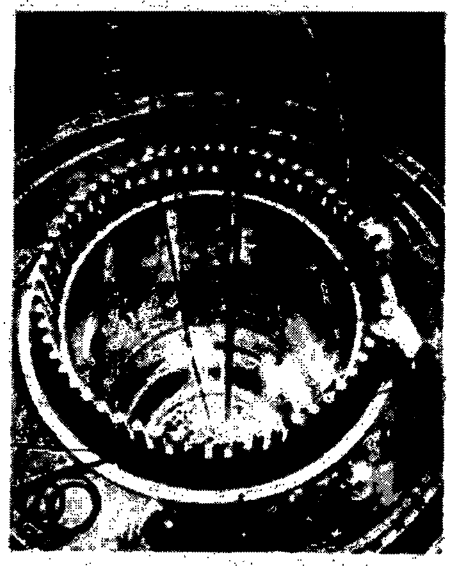
Chapter 19—Public Participation in Regulation

Chapter 20—State and International Liaison

Appendices

Chapter 14—1974 NUCLEAR POWER LICENSING

From this control room at Commonwealth Edison Co.'s Zion nuclear power station, every phase of the operations of the two 1,100 megawatts generating units is observed around the clock. The operators monitor approximately 1,000 indicator lights and dials which keep them in constant touch with every operation.



The first 600-pound fuel bundle at the Duane Arnold Energy Center is lowered into the nuclear reactor. The reactor contains a grid guide structure, control rods, and water.

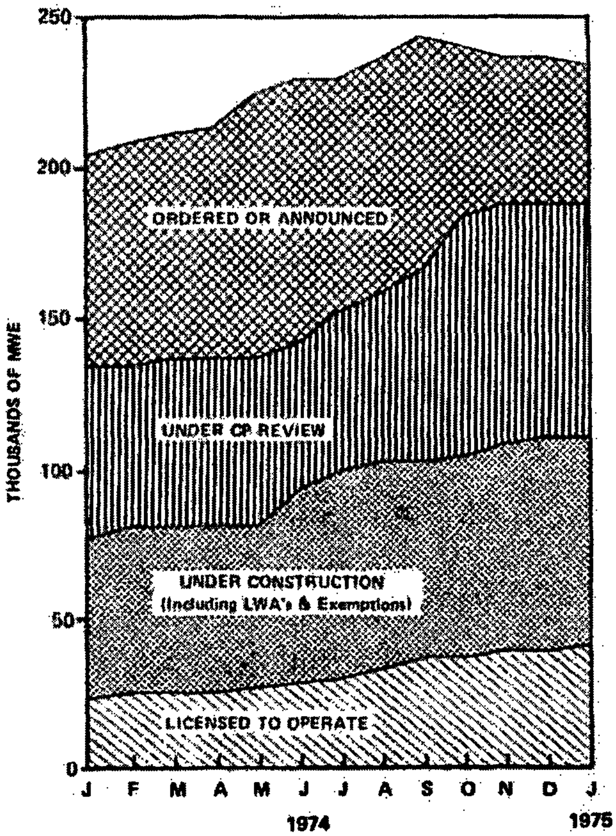
STATUS OF NUCLEAR ELECTRIC POWER

The continuing high output of AEC licensing decisions resulted in the addition of 14 nuclear power units to the Nation's generating capacity during 1974—the largest number of operating licenses issued in any one year, comparing with 13 in 1973 and 9 in 1972. Also, during this period, construction starts were authorized through a combination of construction permits, exemptions and Limited Work Authorizations for additional facilities with a combined capacity nearly equal to that of all nuclear power plants installed to date. These actions were achieved without any sacrifice in the quality of Regulatory health, safety and environmental reviews.

The addition of about 11,800 net electrical megawatts (MWe) during the year increased nuclear electric generating capacity to nearly 36,000 MWe—50 percent over the 1973 yearend total—represented by 53 licensed units located in 23 States. Nuclear plants as of December 31, 1974, accounted for 7.5 percent of all installed electric generating capacity in the United States, compared with 5.5 percent at the end of 1973.

Under the impact of worsening financial conditions and some scaling down of projected future energy demand, utilities announced deferral of over 50 percent of all nuclear power projects during the latter half of the year.

NUCLEAR POWER CAPACITY



(Status as of the first of each month)

By December 1, the effect of delays and cancellations announced by utilities with respect to the 194 nuclear units which were under construction, in licensing review, ordered or announced on June 30, 1974, was as follows:

- Of 60 with construction permits, 45 were delayed and 2 were cancelled.
- Of 84 units under construction permit review by the AEC Regulatory staff, the planned operating dates of 42 were postponed and 4 were cancelled.
- Of 50 units that had been ordered or announced by utilities, 24 were announced as being delayed from 1 to 5 years in planned operation dates and 8 were cancelled.

Despite these deferrals, at yearend there were 233 nuclear units in operating, being built or planned, representing an aggregate capacity of 233 nuclear units in operation, being built or these, the number operating or in the regulatory process totaled 190, an increase of 39 over the number of these facilities under Regulatory surveillance or review at the end of 1973.

Operating License Actions

During 1974, operating licenses were issued for 14 nuclear power plants having an aggregate electrical capacity of 11,808 MWe. In addition, one 90 percent license issued in 1973 was upgraded to full power.

Cooper Station. On January 18, Nebraska Public Power District received a full power operating license for its 778-MWe boiling water unit, Cooper Nuclear Station, located on the west bank of the Missouri River near Brownville, Neb. The plant achieved initial criticality (fission chain reaction) on February 21.

Arnold. Iowa Electric Light & Power Co. received a license on February 22 authorizing full power operation at 569 MWe of the Duane Arnold Energy Center nuclear unit, a boiling water reactor. The facility, which is located near the Village of Palo in Linn County, Iowa, achieved criticality on March 24.

Prairie Island Units 1 and 2. On April 5, Northern States Power Co. received a full power license for Unit 1 of its nuclear station located about 6 miles northwest of Red Wing, Minn. Unit 1 had been authorized to operate at 20 percent in August 1973, and at 90 percent in December 1973.

On October 29, a full power license was issued for Prairie Island Unit 2 at the same site. Licensing of both units was authorized in an April 2 initial decision by an Atomic Safety and Licensing Board after an extensive public hearing; however, construction of Unit 2 was not complete at that time.

The similar units use pressurized water reactors and each has an electrical capacity of about 530 megawatts at full power.

Three Mile Island 1. On April 19, Metropolitan Edison Co. was licensed to operate its Three Mile Island 1 nuclear unit, located in Londonderry Township, Dauphin County, Pa., at 19 percent of full power. Power was restricted until the sodium thiosulfate storage tank for the reactor building spray system was repaired and returned to service. On June 24 the license was amended to authorize full power operation at 819 MWe.

Initial criticality of the pressurized water reactor was achieved on June 5, and commercial operation was begun on September 2.

Arkansas 1. Arkansas Power & Light Co. received a license on May 21 authorizing operation of the Arkansas Nuclear One, Unit 1, located near Russellville in Pope County, Ark. At full power the pressurized water reactor will have an electrical output of 850 megawatts. Initial criticality was achieved on August 6, 1974.

Browns Ferry 2. Tennessee Valley Authority received a license on June 28 authorizing operation of the second unit of its three-unit Browns Ferry plant located near Decatur in Limestone County, Ala. The license authorized fuel loading, low power testing and operation at one percent of full power. On August 2 the license was amended to authorize operation at full power.

Each of the three units of the Browns Ferry station uses a boiling water reactor and each has a generating capacity of about 1,065 MWe. A full power license for Unit 1 was issued in December 1973. Unit 3 is expected to be completed and ready for fuel loading in about a year.

Peach Bottom 3. On July 2, Philadelphia Electric Co. was licensed to operate at full power its Peach Bottom Unit 3 nuclear unit near the town of Lancaster in York County, Pa. The 1,065-MWe boiling water reactor achieved initial criticality on August 6.

Full power operating licenses for Units 2 and 3 of the Peach Bottom station were the subject of a public hearing conducted by an Atomic Safety and Licensing Board. The board had authorized issuance of a full power license for Unit 2 in September 1973, but deferred decision on Unit 3 pending further consideration of water quality matters related to the combined discharge from both units.

After a further hearing on Unit 3 in January 1974, the board issued its decision authorizing issuance of a license on June 14. As a condition of licensing the board required that a closed-cycle cooling system be installed and in operation by January 1, 1977. Operation of the facility with the once-through cooling system, using forced draft (open cycle) helper cooling towers to partially cool the water before discharge will be permitted until then.

Oconee 3. The third 886-MWe pressurized water reactor at Duke Power Co.'s three unit facility, Oconee Nuclear Station, was licensed on July 19 for full power operation. The plant, which is located in Oconee County, S.C., achieved initial criticality on September 6.

Calvert Cliffs 1. Baltimore Gas & Electric Co. was issued a full power license on July 31 for its 845-MWe pressurized water reactor designated the Calvert Cliffs Nuclear Power Plant, Unit 1. The plant is located 45 miles from Washington, D. C., in Calvert County, Md.

The Chesapeake Environmental Protection Association had requested a hearing to consider the environmental effects of the plant's once-through cooling system, but withdrew the request when an agreement was reached between the parties.

Hatch 1. A low power operating license for Unit 1 of the Edwin I. Hatch Nuclear Plant in Appling County, Ga., was issued to Georgia Power Co. on August 6. The initial license permitted only fuel loading, low power testing, and operation at one percent of full power until certain construction items and preoperational tests were completed and approved by the Regulatory staff. Full power operation was authorized on October 13.

Unit 1 uses a boiling water reactor with an electrical capacity of about 786 megawatts. Unit 2, of similar size and type, has been under construction at the site since December 1972, and is expected to be completed in September 1977.

Rancho Seco. Sacramento Municipal Utility District received a license on August 16 to operate its 913-MWe pressurized water reactor plant, the Rancho Seco Nuclear Station, Unit 1, located in Sacramento County, Calif.

FitzPatrick. On October 17, pursuant to an Initial Decision of an Atomic Safety and Licensing Board on November 12, 1973, the Power Authority of the State of New York received a full power license for its 821-MWe boiling water reactor facility designated the James A. FitzPatrick Nuclear Power Plant. The plant is located adjacent to the Niagara Mohawk Power Corp.'s Nine Mile Point site on Lake Ontario in Oswego County, N.Y. Niagara Mohawk will operate the plant for the Power Authority. The reactor achieved criticality on November 17.

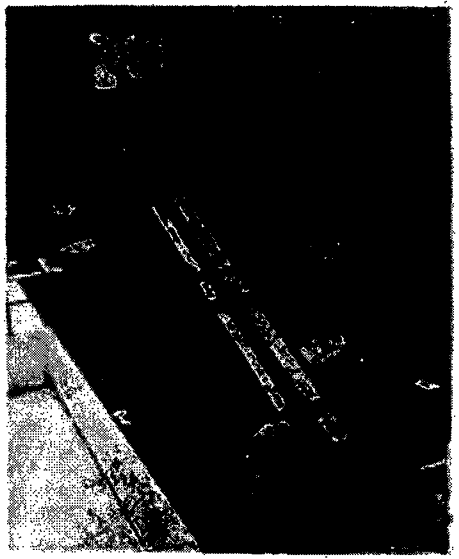
STATUS OF NUCLEAR POWER PLANTS — JAN. 1, 1976

Number Of Units		Rated Capacity (MWe)
* 53	LICENSED TO OPERATE	38,000
** 63	CONSTRUCTION PERMIT GRANTED	63,000
25	Under Operating License Review	25,000
38	Operating License Not Yet Applied For	38,000
74	UNDER CONSTRUCTION PERMIT REVIEW	83,000
**10	Site Work Authorized, Safety Review in Process	10,000
64	Other Units Under CP Review	73,000
29	ORDERED	33,000
14	PUBLICLY ANNOUNCED	17,000
233	TOTAL	232,000

*In addition, there are two operable AEC-owned reactors with a combined capacity of [illegible] MWe

**Total of units under construction (Construction Permit Granted plus Site Work Authorized): 73 units, 74,000 MWe

NP1-15



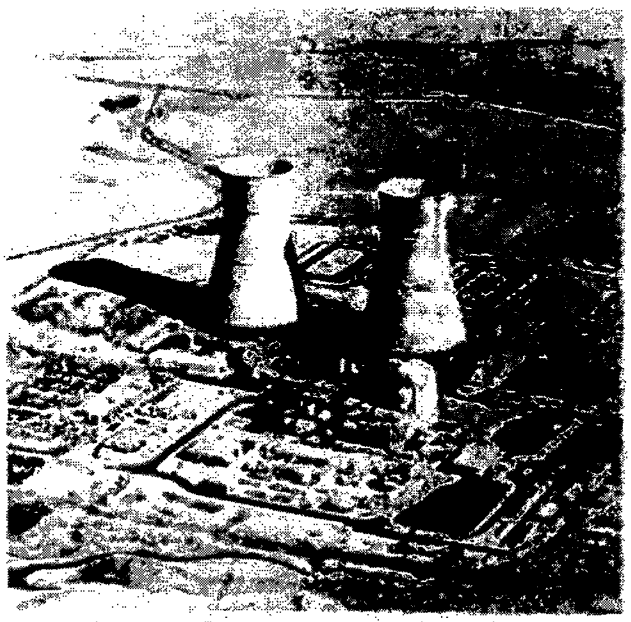
Unloading of nuclear fuel at the Calvert Cliffs nuclear power plant near Lusby, Md.

Cook 1. An initial operating license authorizing fuel loading of Unit 1 of the Donald C. Cook Nuclear Power Plant near Benton Harbor, Mich., was issued on October 25 to Indiana and Michigan Power Co. and Indiana and Michigan Electric Co. This is the first plant utilizing the ice condenser concept for emergency core cooling. The initial license, which authorized fuel loading and some testing, was amended on December 20 to permit operation at core power levels not to exceed 81% of rated thermal power until further authorization by the AEC. In addition, a temporary restriction on operation of the facility was imposed, pending installation by the licensee of additional safety restraints and barriers.

A public hearing had been requested to consider the operating license, but the issues were settled among the intervenors, the applicant, and the AEC. Units 1 and 2 of the Cook plant have been under construction since March 1969. Each unit uses a pressurized water reactor and each will have an electrical capacity of 1,060 megawatts. The plant site is on Lake Michigan in Berrien County near the city of Bridgman and about 11 miles southwest of Benton Harbor.

Brunswick 2. Carolina Power & Light Co. received a full power license for its 821-MWe Brunswick Unit No. 2 on December 27. The boiling water reactor is located near Southport in Brunswick County, N.C.

Included above are the first nuclear units licensed to operate in the states of Iowa, Arkansas, Maryland, Georgia and North Carolina.



The 913-megawatt Rancho Seco nuclear power plant in Sacramento County, Calif., is the largest nuclear plant in the United States licensed to operate at a "dry site" (not located by a body of water). Water requirements for the plant are obtained from a pumping station located 5 miles from the plant on the Folsom South Canal. The plant's liquid radioactive waste system has been designed to process liquid wastes for reuse in the plant without discharge to the environment during normal operating conditions.

Table 1. NUCLEAR POWER PLANT OPERATING LICENSES ISSUED IN 1974

Unit	Location	Net MWe	Type	Utility
Cooper	Brownville, Neb.	778	BWR	Nebraska Pub. Pwr. Dist.
Duane Arnold	Palo, Iowa	569	BWR	Iowa Elec. Light & Pwr. Co.
3 Mile Island 1	Goldsboro, Pa.	819	PWR	Metropolitan Edison Co.
Arkansas 1	Russellville, Ark.	850	PWR	Arkansas P&L Co.
Browns Ferry 2	Decatur, Ala.	1,065	BWR	Tennessee Valley Authority
Peach Bottom 3	Lancaster, Pa.	1,065	BWR	Philadelphia Elec. Co.
Oconee 3	Seneca, S.C.	886	PWR	Duke Power Co.
Calvert Cliffs 1	Lusby, Md.	845	PWR	Baltimore Gas & Elec. Co.
Hatch 1	Baxley, Ga.	786	BWR	Georgia Power Co.
Rancho Seco	Clay Station, Calif.	913	PWR	Sacramento Mun. Ut. Dist.
FitzPatrick	Scriba, N.Y.	821	BWR	Pwr. Auth. St. of N.Y.
Prairie Island 2	Red Wing, Minn.	530	PWR	Northern States Pwr. Co.
Cook 1	Bridgman, Mich.	1,060	PWR	Indiana & Mich. Elec. Co.
Brunswick 2	Southport, N.C.	821	BWR	Carolina P&L Co.

Construction Authorizations

Through a combination of construction permits, limited work authorizations and exemptions, the AEC authorized construction starts during 1974 on 33 nuclear units representing a total of 35,323 net MWe (construction of 2 1,113-MWe units were later cancelled by one utility). This brought the total number of nuclear plants under construction at December 31, 1974, to 73 units representing an aggregate capacity of some 75,000 MWe.

Construction Permits Issued

The 23 construction permits issued during the year included the first nuclear units designated for the states of Indiana, Mississippi, Texas and Louisiana. Of these, early site work was initiated on 14 units under LWA's in advance of the construction permit issuance, enabling varying degrees of improvements in the utilities' construction schedules.

Construction permits were issued in 1974 to:

- Northern Indiana Public Service Co., on May 1, for the Bailly Generating Station, located in Porter County, Ind., adjacent to Indiana Dunes National Lakeshore. The boiling water reactor plant will have a net capacity of about 648 MWe. (On September 13, the Joint Intervenors appealed to the U.S. Court of Appeals to reverse the Commission's issuance of the construction permit and to stay construction pending judicial review. On October 16 the court ordered a stay in dewatering activities at the site and ordered the Commission to hold further administrative proceedings on NIPSCO's proposal to construct a slurry wall. The Commission's proceedings were still in process at yearend.)
- Duquesne Light, Ohio Edison, Pennsylvania Power, Cleveland Electric Illuminating, and Toledo Edison Companies, on May 3, for Unit 2 of the Beaver Valley Power Station in Beaver County, Pa. Unit 2, similar to Unit 1 already under construction at the same site, will use a pressurized water reactor designed to produce 852 MWe.
- Philadelphia Electric Co., on June 20, for the 2-unit Limerick Generating Station on the Schuylkill River in Montgomery County, Pa., 21 miles northwest of Philadelphia. Each boiling water reactor unit will have a capacity of about 1,065 MWe.
- Niagara Mohawk Power Corp., on June 24, for Unit 2 of the Nine Mile Point Nuclear Plant, seven miles from Oswego, N.Y. The boiling water reactor plant will have a capacity of 1,080 MWe.
- Georgia Power Co., on June 28, for the 4-unit Alvin W. Vogtle Nuclear Plant, 26 miles southeast of Augusta in Burke County, Ga. Each 1,113-MWe unit will use a pressurized water reactor. Some non-safety related site preparation activities had been permitted under a limited work authorization issued in May. (Units 3 and 4 of the Vogtle plant were later cancelled by Georgia Power Co., and the completion dates for Units 1 and 2 were delayed.)
- Virginia Electric and Power Co., on July 26,

for Units 3 and 4 of the North Anna Nuclear Power Station in Louisa County, Va., about 40 miles north-northwest of Richmond, where Units 1 and 2 are under construction. Each of the new units will use pressurized water reactors designed for 907 MWe initial output. The permits require VEPCO to fulfill additional seismic and environmental conditions during the construction period.

- Northeast Nuclear Energy Co., on August 9, for Unit 3 at the Millstone Nuclear Power Station at Waterford, Conn. Preliminary construction work had been authorized in June under an LWA. Unit 3 will use a pressurized water reactor with a capacity of approximately 1,156 MWe.
- Mississippi Power & Light Co. and Middle South Energy, Inc., on September 4, for the 2-unit Grand Gulf Nuclear Station in Claiborne County. Miss., following an LWA issued in May. Each 1,250-MWe unit will be powered by a boiling water reactor.
- Public Service Electric and Gas Co. and Atlantic City Electric Co., on November 4, for the 2-unit Hope Creek Generating Station adjacent to the Salem nuclear station now under construction in Salem County, N.J. The 1,067-MWe boiling water reactor units had been initially proposed for construction on Newbold Island in Burlington County, but the site was changed in response to Regulatory staff recommendations.
- Louisiana Power & Light Co., on November 14, for the Waterford Steam Electric Station Unit 3 located on the Mississippi River near Taft, St. Charles Parish, La. The pressurized water reactor facility will have an initial capacity of about 1,113 MWe. LWA's issued in May and July permitted early site work to begin.
- Tennessee Valley Authority, on December 24, for the Bellefonte Nuclear Plant, Units 1 and 2, located seven miles from Scottsboro in Jackson County, Ala. Each of the two units will use a pressurized water reactor and is designed for 1,213 MWe output. An LWA had been issued in September.
- Virginia Electric and Power Co., on December 20, for Units 3 and 4 at the Surry Power Station in Surry County, Va., following the issuance of LWA's in October. Each 859-MWe unit will use a pressurized water reactor.
- Texas Utilities Generating Co., on December 19, for the 2-unit Comanche Peak Electric Station in Somervell County, Tex. An LWA issued in October permitted some work at the site of the twin 1,150-MWe pressurized water reactors.

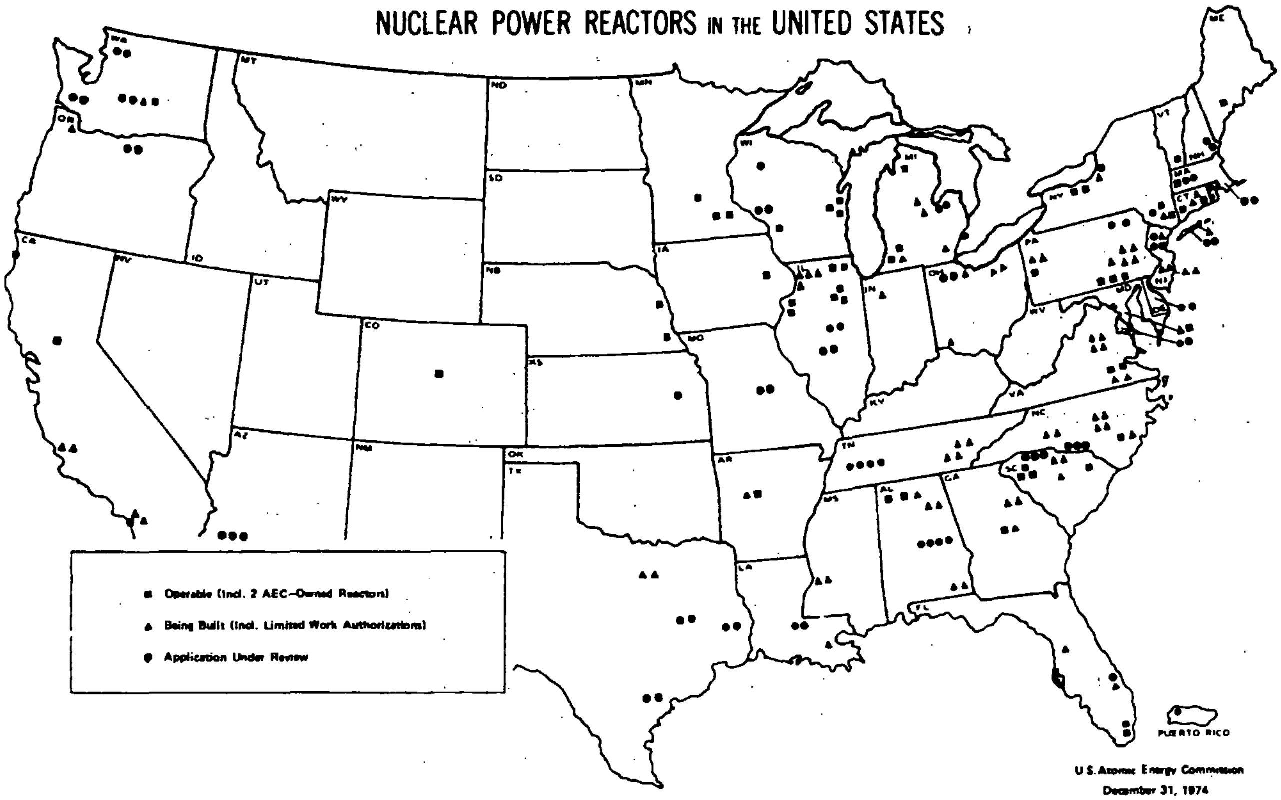
Other Construction Activities Authorized

At yearend, limited site preparation and construction had been authorized for 12 other units, either by exemptions or LWA's, in advance of final decisions on construction permit applications:

- Exemption granted to Commonwealth Edison Co. on January 14 to conduct soil stabilization work at the site of its planned 2-unit Byron Plant in Ogle County, Ill. Additional work at the plant site was authorized by an LWA issued on December 13.
- Exemption granted to Carolina Power & Light Co. on January 14 to construct temporary buildings and do excavation at the site of its proposed 4-unit Shearon Harris plant near Raleigh, N.C. Some work allowed by the exemption was temporarily restricted by the Atomic Safety and Licensing Board pending a hearing requested by intervenors. The restrictions were lifted following an April 3 Board decision.
- LWA issued to Duke Power Co. on May 16 to perform non-safety related site preparation activities at the site of its proposed 2-unit Catawba Nuclear Station at Lake Wylie, S.C.
- LWA issued to Cleveland Electric Illuminating Co. on October 21 for preliminary work at the site of the proposed Perry Nuclear Power Plant, Units 1 and 2, near Painesville, Ohio. The LWA includes several restrictions and conditions imposed by the Licensing Board.

Actions on Siting Problems

During the year, intensive investigations were conducted of geological faults at four sites where nuclear power plants were under construction or in operation. In addition, a special study



resolved problems relating to possible hurricane-induced flooding at one site, and extensive studies were undertaken in connection with the possible construction of offshore power stations.

North Anna Site Problem. In May 1973 Virginia Electric and Power Company (VEPCO) notified the Regulatory staff that a geologic fault zone had been discovered in the containment excavations for its four-unit North Anna Power Station. The excavations had been made in connection with the proposed construction of Units 3 and 4. The excavation for Units 1 and 2

Table 2. NUCLEAR POWER PLANT CONSTRUCTION PERMITS ISSUED IN 1974*

Units	Location	Net MWe per unit	Type	Utility
Bailly 1	Gary, Indiana	648	BWR	Northern Indiana Pub. Serv. Co.
Beaver Valley 2	Shippingport, Pa.	852	BWR	Duquesne Light Co.
Limerick 1 & 2	Pottstown, Pa.	1,065	BWR	Philadelphia Elec. Co.
Nine Mile Pt. 2	Scriba, N.Y.	1,080	BWR	Niagara Mohawk Power Co.
Vogtle 1, 2, 3 & 4**	Waynesboro, Ga.	1,113	PWR	Georgia Power Co.
North Anna 3&4	Mineral, Va.	907	PWR	Virginia Elec. & Power Co.
Millstone 3	Waterford, Conn	1,156	PWR	Northeast Nuclear Energy Co.
Grand Gulf 1&2	Port Gibson, Miss	1,250	BWR	Mississippi P&L Co.
Waterford 3	Taft, La.	1,113	PWR	Louisiana P&L Co.
Hope Creek 1&2	Salem, N.J.	1,067	BWR	Public Service Elec. & Gas Co.
Surry 3&4	Gravel Neck, Va.	859	PWR	Virginia Elec. & Power Co.
Bellefonte 1&2	Scottsboro, Ala.	1,213	PWR	Tennessee Valley Authority
Comanche Peak 1&2	Glen Rose, Tex.	1,150	PWR	Texas Utilities Generating Co.

* Does not include Limited Work Authorizations issued in advance of construction permit decisions.
** Vogtle Units 3 and 4 were cancelled by Georgia Power Co. in 1974.

had already been filled through construction. Extensive investigations and evaluations were made by VEPCO and the Regulatory staff to determine the potential impact of the faulting on the safety of the plant. These investigations led the Regulatory staff to find that the North Anna faults are not capable as defined in Appendix A to 10 CFR Part 100 and that Lake Anna (the nearby reservoir created as part of the project) lacks the potential for causing earthquakes in the fault zone. A "capable fault," as defined in Appendix A ("Seismic and Geologic Siting Criteria for Nuclear Power Plants") to 10 CFR Part 100, is a fault which has exhibited one of the following characteristics: (1) movement at or near the ground surface once within the past 35,000 years or movement of a recurring nature during the past 500,000 years; (2) macro-seismicity instrumentally determined demonstrating a direct relationship with the fault or a structural relationship with the fault; or (3) a structural relationship to a capable fault such that movement on one could reasonably be expected to be accompanied by movement on the other. In view of these findings the staff reaffirmed, in February 1974, its earlier conclusion that the North Anna site geology and proposed seismic design parameters are satisfactory.

On October 17, 1973, prior to the completion of the staff's evaluation, the Director of Regulation ordered VEPCO to show cause why construction activities for Units 1 and 2 should not be suspended. The show cause order led to contested public hearings early in 1974. After hearing the evidence, a Licensing Board decided on June 27, 1974, that the North Anna geological fault zone was not capable and that construction activities for Units 1 and 2 should not be suspended. Intervenors have appealed that decision to the Appeal Board.

After the decision on the faulting question by the Licensing Board, public hearings on the proposed construction of Units 3 and 4 were concluded, the Licensing Board rendered a decision and construction permits were issued on July 26, 1974. The construction permits include a condition requiring VEPCO to complete and operate for one year a dense seismic network to conclusively demonstrate whether seismic activity is associated with faults at the site and, if so, whether Lake Anna is affecting that activity. The data from that effort must be analyzed and the results published by VEPCO within 18 months. Construction of all four units was suspended by VEPCO during the year because of financial problems.

Faulting at Summer Site. In November 1973, excavation for the Virgil C. Summer nuclear plant revealed new evidence of faulting which prompted a reevaluation of the adequacy of the facility's seismic design features. On December 7, 1973, an order was issued by the Director of Regulation to South Carolina Electric & Gas Co. to show cause why construction work on major structures should not be suspended until completion of the investigation. The applicant did not oppose the order and construction was suspended. Subsequent review by the Regulatory staff of the applicant's investigations confirmed earlier findings on the adequacy of the seismic design, and the order suspending construction was rescinded on February 15, 1974.

Seismic Questions at Indian Point Site. In May 1974 the AEC received a petition from the Citizen's Committee for the Protection of the Environment requesting that the Consolidated Edison Co. of New York, Inc. be ordered to show cause why the operating licenses for Indian Point Nuclear Generating Plant Units 1 and 2 and the construction permit for Unit 3 should not be revoked. The petition was based on contentions that the design assumptions about earthquakes at the site are erroneous or, at a minimum, of doubtful validity. Of specific concern were the assumptions that the Ramapo Fault is not a capable fault and that the peak ground acceleration value is 0.15g. The contentions were investigated by the AEC Regulatory staff. Following field trips, consultations with the applicant and its consultants, the New York State Geological Survey, the New Jersey Bureau of Geology and Topography, and the U.S. Geological Survey (advisors to the AEC), the Regulatory staff concluded that the assumptions used in developing the seismic design parameters were valid and conservative and that the assumed "safe shutdown earthquake" was adequately conservative.

San Onofre Site Problem. In June and September 1974 the Southern California Edison Co. (SCE) advised the AEC Regulatory staff that anomalous geologic features, possibly faults, had been discovered during excavations for Units 2 and 3 at the San Onofre site near San Clemente, Calif. During the summer and fall of 1974, the Regulatory staff and its advisors (the U.S. Geologic Survey) and SCE and consultants concluded investigations at the site. As a result of these investigations, the Regulatory staff concluded that the geologic features were not capable faults and were not considered to be hazardous to the safety of the San Onofre site.

Crystal River Flood Protection. Flood protection became an issue during the operating license review of the Crystal River Nuclear Power Plant. The location of the plant on the Gulf of Mexico, 70 miles north of Tampa, may be exposed to severe hurricanes during the 40-year life of the plant. The applicant (Florida Power Corp.) and the Regulatory staff differed on the methods of analyzing hurricane flooding and on the protection level that should be required. Both the applicant and the staff undertook extensive investigation of historic hurricanes and their storm surges. The issue was resolved by incorporating into the design features that provide protection to levels up to 33 feet above local mean low water.

Offshore Nuclear Power Stations. The application by Offshore Power Systems for a license to manufacture floating nuclear power plants and the application by Public Service Electric & Gas Co. for a permit to construct the Atlantic Generating Station at a location about 3 miles off the New Jersey coast have necessitated evaluation of offshore sites. The requirements for protecting plants at offshore locations during severe storms are being established on the basis of the applicant's extensive hydraulic model studies and staff evaluation of the proposed breakwater and its enclosed floating nuclear plants. It is clear that the state of art of coastal engineering is being extended in view of the fact that the breakwater will have to be capable of withstanding extremely severe wave action in an ocean environment. In addition to plant protection, there must be an assurance that the presence of the breakwater does not alter near-shore currents and change the pattern of shoreline erosion. Extensive field measurements and model studies are continuing.

Standardization Developments

During 1974, significant progress was made toward the goal of standardized nuclear power plants which was enunciated by the Commission in April 1972. The AEC regards standardization as the single most important means for minimizing the impact of the design and licensing process on the overall schedule for getting nuclear power plants on line.

The procedural options made available to applicants by the AEC to facilitate the standardization of nuclear power plants are:

- **Reference System**—a generic design of an entire facility or major portion thereof can be reviewed once and utilized repeatedly by reference without further review in individual applications for licenses.
- **Duplicate Plants**—the design for several identical plants that would be constructed within a limited time by one or more utilities at one or more sites can be reviewed once.
- **License to Manufacture**—the design of an entire facility can be reviewed once for manufacture at a central location. The preapproved facilities can then be moved to specific utility sites for construction and operation.

As an expansion of the duplicate plant option, a policy for "replication" was established in 1974. Replication provides for the reuse of an approved plant of recent design. The AEC regards replication as an interim option with a duration of perhaps 2 to 4 years before a sufficient library of reference system designs is accumulated.

Each of these standardization approaches is based on the reuse of approved plant designs.

In April 1974, the Commission issued proposed rules to implement the Reference Systems and Duplicate Plants options. These rules are designated as Appendices N and O of 10 CFR Part 50. Regulations for the License to Manufacture concept were issued in 1973 as Appendix M to Part 50.

A report entitled "Programmatic Information for the Licensing of Standardized Nuclear Power Plants" was made available to the public in August. This report provides guidance for those involved with the Reference Systems and Duplicate Plants options regarding the preparation, staff review, and utilization of these designs, and responds to many questions raised by design organizations and utilities. An additional document, "Policy and Procedures for the Replication of Custom Plant Designs", provides guidance to those interested in pursuing the replication approach to standardization.

For the most part, the industry's response to the Commission's standardization program has been gratifying, particularly with respect to manufacturers of nuclear steam supply systems. By the end of 1974, all reactor vendors and a limited number of architect-engineering firms were participating in the standardization program, and a considerable number of utilities had applied for permits to build "standard" plants. All standardization options were active, including the replication approach. *Table 3* indicates standardization applications under review as of December 31, 1974.

Table 3. STANDARDIZATION APPLICATIONS UNDER REVIEW

(As of December 31, 1974)

Project	Applicant	Option *	Date docketed	Comments
GESSAR	General Electric Co.	1	7/30/73	Nuclear Island standard design
CESSAR	Combustion Engineering	1	12/19/73	Nuclear steam supply system (NSSS) standard design
Floating Nuclear Plant (FNP) 1-8	Offshore Power Systems, Inc.	3	7/5/73	Entire plant design
Atlantic 1 & 2	Public Service Electric Gas Co.	3	3/1/74	Reference FNP
Byron/Braidwood	Commonwealth Edison Co.	2	9/20/73	Two duplicate units at each of two sites.
RESAR-41	Westinghouse Electric Corp.	1	3/1174	NSSS standard design
B-SAR-241	Babcock & Wilcox Co.	1	5/14/74	NSSS standard design
WNP-3 & 5	Washington Public Power Supply System	1	8/2/74	Reference CESSAR
Cherokee/Perkins	Duke Power Co.	1 & 2	5/24/74	Six units located at two sites; reference CESSAR
SNUPPS	Kansas Gas & Electric Co. Kansas City Power & Light Co. Union Electric Co. Northern States Power Co. Rochester Gas & Electric Co.	2	6/21/74	Five duplicate units located at four sites.
SWESSAR	Stone & Webster	1	6/28/74	Standard balance-of-plant (BOP) designs to mate with NSSS designs
South Texas 1 & 2	Houston Light & Power Co.	1	7/5/74	Reference RESAR-41
Jamesport 1 & 2	Long Island Lighting Co.	2(R)	9/6/74	Replicates Millstone 3
WUP 1-6 (Koshkonong 1 & 2)	Wisconsin Elec. Power Co. Madison Gas & Electric Co. Wisc. Pwr. & Light Co. Wisc. Public Service Co.	2	8/9/74	As many as six units to be located on three sites
Hartsville 1-4	Tennessee Valley Authority	1	11/11/74	TVA/STRIDE, single site, references GESSAR
Palo Verde 1-3	Arizona Public Service Co.	1	10/2/74	References CESSAR
GASSAR	General Atomic	1		NSSS standard design; tendered 9/20/74
GESSAR-251	General Electric Co.	1		2nd round NSSS standard design; tendered 9/6/74
C.F. Braun SSAR	C. F. Braun	1	12/20/74	Standard BOP design for the BWR nuclear island

* 1 = Standard Design
2 = Duplicate Plants
3 = License to Manufacture
R = Replication

Other Applications and Reviews

During 1974, utilities tendered 22 applications for the construction of a total of 45 nuclear power reactors. Of these and previously tendered applications, 20 covering 45 plants were docketed for formal review after undergoing the AEC's acceptance review by which it is determined whether the application is sufficiently complete for docketing. At year-end, two applications covering 2 plants were in the acceptance review stage.

Several special projects also were under review.

LMFBR Application Rejected

In November, the Regulatory staff declined to docket the application to build the proposed Clinch River Breeder Reactor Plant near Oak Ridge, Tenn., because the application lacked sufficient information for formal review. The application for a permit to construct the nation's first large-scale demonstration liquid metal fast breeder reactor (LMFBR) was submitted to the Regulary organization in mid-October by the Project Management Corp. and the Tennessee Valley Authority, and consisted of the environmental report and site-related information from the preliminary safety analysis report for initial review.

The major areas in the two reports indentified as deficient in information were concerned with meteorology, geology and seismology, the aquatic environment, the radioactive waste systems, and postulated accidents involving the reactor core.

While rejecting formal docketing for a detailed review schedule pending correction of the deficiencies, the Regulary staff announced it would proceed to review those sections of the application and accompanying reports which it deemed sufficiently complete.

The Clinch River facility is proposed to be a 380-MWe plant using a sodium-cooled, fast-neutron reactor fueled with a mixture of plutonium and uranium oxides.

Nuclear Ship Program

The Maritime Administration through its "Competitive Nuclear Merchant Ship Program" is sponoring the development by Babcock & Wilcox Co. of a nuclear reactor propulsion system for merchant ships.

In April 1974, MARAD submitted a preapplication preliminary safety analysis report to the AEC for a licensability evaluation of the use of this system in large crude oil carriers. If the application of nuclear power to merchant ships satisfies AEC reactor safety requirements and U.S. Coast Guard requirements, MARAD proposes to subsidize the construction of three supertankers starting as early as fiscal 1975.

The AEC pre-application review has highlighted several areas that will require new regulations or legislative changes.

The AEC and the U.S. Coast Guard are developing a memorandum of understanding on the licensing of nuclear merchant ships to reduce duplication of effort in carrying out overlapping regulatory responsibilities. As presently proposed, the AEC would have responsibility for radiological health and safety, including nuclear plant safety, and the Coast Guard would be responsible for ship safety, ship design and operation and overall environmental protection. Each agency would be responsible for its own license and certification conditions and its own regulations. Each agency could call upon the special capability of the other for assistance.

Generic Safety Studies

The Regulatory staff continuously conducts studies of unclear plant safety issues that might apply to a class of reactor or all reactors, using new information arising from reviews of applications, operating experience and research programs.

Emergency Core Cooling. In December 1973, the Commission announced new requirements for the performance of emergency core cooling systems (ECCS) for light-water-cooled nuclear power plants. These systems are engineered backup safety features built into nuclear power plants to provide emergency cooling for the fuel in the highly unlikely event of loss of the normal reactor coolant water.

In its decision after a 2-year public rulemaking hearing (see AEC 1973 Annual Report to Congress), the Commission directed that new calculations of ECCS performance using revised evaluation models (for which certain required and acceptable features are specified in the new rules) be submitted to the AEC by August 4, 1974, for each operating plant for evaluation by the Regulatory staff. The four water-cooled reactor manufacturers developed the required new ECCS evaluation models to be used to analyze the various plants.

As a result of its review, the Regulary staff found that some features of the new calculational models submitted were not completely consistent with the requirements specified in the ECCS rule and identified modifications that should be made. The ACRS also reviewed some aspects of the models and reported that the specific modifications required by the Regulatory staff would make the models consistent with the rule. In such instances, the ECCS rule provides that the Director of Regulation will impose changes in operating limitations for each reactor to assure compliance with the criteria. The operating limitations control the maximum amount of heat that may be generated by any given group of fuel rods in the reactor core. The changes imposed by the Regulatory staff could result in temporary reduction of power levels for some reactors. Orders were issued in late December 1974 to 45 operating plants imposing the appropriate changes in operating limitations. It is believed that operators of affected reactors will be able in many cases to meet the revised limits without derating power outputs by making control rod adjustments, minor changes in plant features, and other techniques.

Pressure vessel study. A Regulatory staff report published in mid-1974, "Analysis of Pressure Vessel Statistics from Fossil-Fueled Power Plant Service" (WASH-1318), concluded that the upper limit (99% confidence level) probability of a disruptive failure in any one nuclear reactor vessel during any service year is in the range of one in a million to one in 10 million. The study used a conservative estimate of the failure probability range derived from experience with nonnuclear vessels and a conservatively estimated factor of improvement resulting from the superior quality level achieved in the design and construction of nuclear reactor vessels, in addition to the available experience with nuclear reactor vessels.

Fuel densification. The problems of nuclear fuel densification which can cause undesirable increases in uranium oxide fuel pellet temperature (see AEC Annual Report to Congress for 1973) have been essentially resolved. This phenomenon resulted in temporarily-imposed reductions of power for several power reactors in the past two years. Major advances in fuel manufacture have been achieved from experimental studies sponsored by U.S. vendors. Changes in the fabrication process have produced more stable fuels, and improved analytical methods have been developed to assess densification effects in older fuels still in use.

Other safety studies. At year-end, the Regulatory staff was completing or continuing studies on a variety of generic topics including fuel rod bowing, anticipated transients without scram, protection against missiles generated by tornadoes and turbine failures, potential explosions on transportation routes near reactor sites, and protection of plant control rooms from potential releases of hazardous chemicals used in power plant operation.

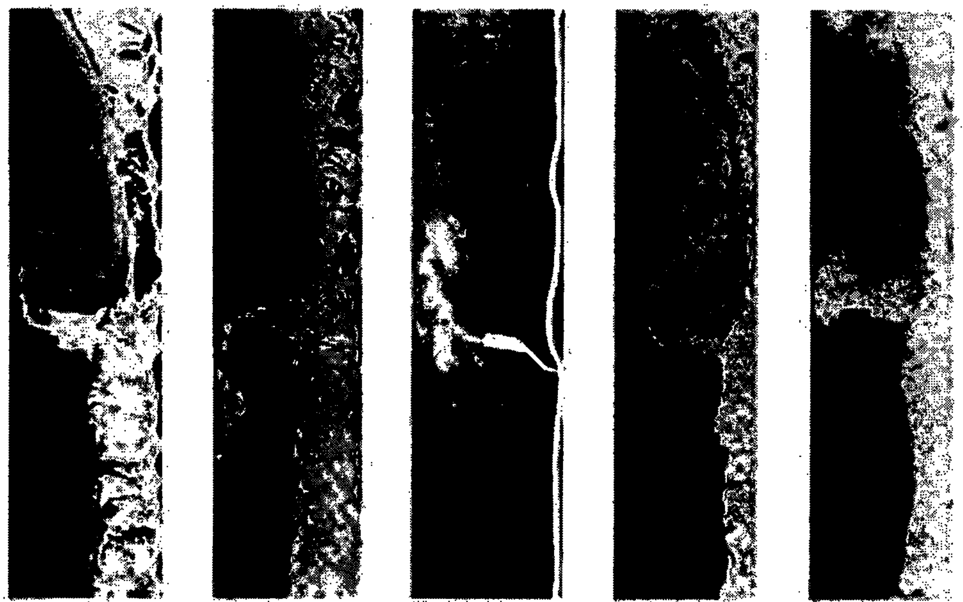
New fuel assembly designs from some of the vendors were reviewed and approved during the year. The new assemblies feature more fuel rods of proportionately smaller diameters. This produces improved safety margins by achievements of a lower linear heat generation rate, a lower centerline fuel temperature, a smaller inventory of fission gases within the fuel rod, and a larger margin to critical heat flux.

During the year, substantial Regulatory staff effort was devoted to a technical review of the draft report on the Reactor Safety Study (Rasmussen Report) sponsored by the Commission, which was released in August (see chapter 5 of Part I, "Operating and Developmental Functions"). Regulatory comments were supplied to the AEC's Reactor Safety Study staff.

Environmental Protection Activitie[s]

In August the AEC placed in effect a new part to its regulations (10 CFR Part 51) which implements new guidelines of the Council on Environmental Quality concerning the preparation of environmental impact statement[s] and consolidates as far as possible all policies

THERMAL SCANNER IMAGERY
SURRY NUCLEAR POWER PLANT



13:10 EDT MARCH 14, 1974 | 17:20 EDT MARCH 14, 1974 | 08:30 EDT MARCH 15, 1974 | 11:32 EDT MARCH 15, 1974 | 15:35 EDT MARCH 15, 1974

(Aircraft Altitude: 2,000 feet)

Environmental effects scans taken from an Aerial Radiological Measuring System plane showing surface water thermal patterns in the effluent cooling water stream from the Surry (Va.) nuclear power plant on the James River.

and procedures for implementing the National Environmental Policy Act in AEC licensing and public rulemaking proceedings. The regulation was published in proposed form in November 1973 (see AEC Annual Report to Congress for 1973, page 59).

Regulatory environmental reviews frequently result in conditions in construction permits and operating licenses which require licensees to take specific measures to protect the environment. These may range from the relocation of transmission lines and upgrading of construction practices to major modifications such as the redesign of condenser cooling systems, water intake structures, and radioactive waste systems.

The sudden imposition of a broad range of environmental protection requirements three years ago to fulfill NEPA requirements as mandated in the *Calvert Cliffs* court decision contributed to a major nuclear power plant licensing logjam. The backlog of environmental reviews thus created was eliminated by the fall of 1973 through management initiatives and Regulatory staff augmentation. Further efficiencies introduced in 1974 with the new limited work authorization procedures provided for expedited environmental reviews which are reducing the time involved in this area to a minimum as a pacing factor in the licensing process.

Proposed AEC-EPA Coordination

In November, the AEC issued for public comment a proposed second memorandum of understanding with the Environmental Protection Agency on carrying out each agency's responsibilities under the Federal Water Pollution Control Act amendments of 1972.

In view of some duplication of information needed in AEC and EPA licensing proceedings, the proposed memorandum provides for development of EPA regulations and procedures for issuance of "preliminary determinations" on the water quality and biota impacts of nuclear projects. These determinations would be made as far in advance as possible before AEC actions authorizing construction or licenses, in contrast to the present practice of requiring such determinations when a plant is ready for operation—some six years after the start of construction. In this way, significant changes in plant design or location following the AEC's environmental review, and possibly after construction has begun, could be avoided.

The proposed agreement provides for procedures to see that environmental reports submitted to the AEC with nuclear facility applications contain sufficient data to meet both EPA's and the States' need for FWPCA review purposes and the AEC's needs for preparing environmental statements. It also provides for consideration of holding combined or concurrent hearings on EPA's preliminary determinations and AEC's construction permits; close contact between the agencies in environmental reviews; and cooperation with State and regional authorities to assure timely issuance of required water quality certifications under section 401 of FWPCA and discharge permits under section 402.

(On December 9, 1974, the U.S. Court of Appeals for the 10th Circuit ruled in *Colorado Public Interest Research Group* v. *EPA*, that EPA is required by the provisions of the FWPCA amendments to issue radioactive effluent discharge permits for individual nuclear power plants.)

Antitrust Activities

The AEC is required by the 1970 amendments to the Atomic Energy Act to conduct prelicensing antitrust reviews of all applications for nuclear reactors or other production or utilization facilities for commercial use. The AEC holds a hearing when recommended by the Attorney General and also considers whether antitrust issues raised by other persons should be the subject of a hearing. Antitrust hearings are held separately from those on environment, health and radiological safety matters. Antitrust reviews are conducted concurrently with other licensing reviews to prevent this activity from becoming the controlling factor in the time required for the licensing process.

The antitrust review by the AEC and the Attorney General focuses on whether or not the activities under the license will create or maintain a situation inconsistent with antitrust laws or policy underlying those laws.

Hearings

During the past year, an Atomic Safety and Licensing Board completed the first antitrust evidentiary hearing (Consumer Power Co.'s application to construct Midland Units 1 and 2). The board held 47 days of hearings. An initial decision is expected in early 1975.

An evidentiary antitrust hearing was also undertaken in connection with Alabama Power Co.'s application to construct Farley Units 1 and 2. By the end of the year, 11 days of hearings had been held in connection with this application. Prehearing conferences for another hearing, scheduled to be undertaken in 1975, (Davis-Besse and Perry Units of Cleveland Electric Illuminating Co. et al.) were also conducted and pretrial discovery started. In addition, a show-cause hearing for Louisiana Power & Light's Waterford 3 Unit was held. In the Waterford case, after an initial decision by the licensing board, the Director of Regulation was authorized to issue a construction permit with certain antitrust conditions.

Antitrust proceedings for other facilities involving two other applicants (Duke Power Co. and Georgia Power Co.) were terminated upon settlement on license conditions in lieu of an evidentiary hearing.

Antitrust Review

It is significant that during 1974, while the Attorney General rendered antitrust advice in connection with 21 applications, in no case did he recommend a hearing. In connection with 10 applications, the Attorney General recommended that no hearings be required provided that certain commitments made by the applicants to the Department of Justice are imposed as AEC license conditions. At year end, the Attorney General had under review 15 additional docketed matters.

Early Submittal of Information

On September 25, 1974, the Commission published in the *Federal Register* amendments to its regulations that provide for earlier submission of information needed for the antitrust review of applications to construct and operate nuclear power plants. They require that the information requested by the Attorney General be furnished to the AEC at least 9 months, and may be furnished as early as 36 months, before other parts of the construction permit application are filed for acceptance review. This early filing will permit the Attorney General and the AEC to complete the antitrust review process, including hearings where necessary, in advance of or concurrently with the other reviews.

Indemnity and Insurance

The Price-Anderson Act of 1957 provides for a system of private insurance and government indemnity totaling $560 million to pay public liability claims for personal injury and property damage in the unlikely event of a major nuclear incident. In anticipation of the expiration of the Price-Anderson Act on July 31, 1977, the Joint Committee on Atomic Energy conducted public hearings in January and March 1974 on a number of possible alternative approaches to provide financial protection to the public.

In May, the JCAE held hearings on proposed legislation submitted by the AEC to modify and extend the provisions of the Price-Anderson Act. The bill (H.R. 15323) as finally passed by the House and Senate provided for a 5-year extension of the Act to August 1982, with the following major changes: Government indemnity would be phased out for most licensed commercial facilities as private insurance became increasingly available; the current $560 million limit of liability would float upward as new reactors were licensed by the AEC with no ultimate fixed limit on liability; and indemnity coverage would be extended to certain nuclear incidents that might occur outside U.S. territorial limits. The legislation also provided for the AEC to establish retrospective premiums to be assessed against facility licensees. These premiums would be collected in the event of a nuclear incident.

Due to a provision of the extension bill which would have allowed the Congress by concurrent resolution to rescind the legislation within 30 days after the JCAE submitted its evaluation of the Rasmussen Reactor Safety Study, the President vetoed the legislation on October 12. Although he expressed support of all other provisions of the bill, he viewed the rescission feature as violating the Constitution by requiring, in effect, final approval of the President before the Congress had given its final approval of the legislation. He also expressed concern that this feature would place the source of funds for prompt payment of public liability claims in doubt and that uncertainty over nuclear liability protection "would also adversely affect that private investment which will be necessary as nuclear power assumes its vital role in meeting the nation's energy requirements."

The JCAE announced on November 20 that it would not seek to override the President's veto during the 93rd Congress. Joint Committee members expressed their complete endorsement of the substantive features of H.R. 15323 and recommended that the legislation be given priority consideration upon the convening of the 94th Congress.

The AEC is studying, as requested by the JCAE, the feasibility of extending Price-Anderson indemnity coverage to possible incidents arising from the illegal diversion of nuclear materials.

1974 Indemnity Operations

As of December 31, 1974, 116 indemnity agreements with AEC licensees were in effect. Indemnity fees earned by the AEC during the year totaled $3,314,515, bringing the total fees collected since inception of the program to $8,990,419.

No claims have been made under the AEC's indemnity agreements with licensees during the 17 years of the program's existence.

Premium Refunds

During the year, the two private nuclear energy liability insurance pools paid to policy holders the eighth annual refund of premium reserves under their Industry Credit Rating Plan. The refunds total $1,434,580, which is 68.8 percent of all the premiums paid by the affected policyholders in 1964, and approximately 97.5 percent of the reserve established from these premiums.

Under the rating plan, a portion of the annual premiums is set aside as a reserve for either payment of losses or ultimate return to policyholders. The amount of the reserve available for refund is determined on the basis of loss experience of all policyholders over the preceding 10-year period.

Advisory Committee on Reactor Safeguards

The Advisory Committee on Reactor Safeguards is a statutory body made up of experts in the various disciplines needed to conduct reviews related to the safety of nuclear facilities. Its purpose is to provide advice to the Commission concerning the hazards of proposed or existing reactor facilities and spent fuel processing plants and the adequacy of proposed reactor safety standards, and to perform such other duties as the Commission may request.

In addition to review of license applications referred to it in accordance with Section 182b of the Atomic Energy Act, the ACRS continued during 1974 to provide input to the Commission's program for developing safety-related standards and guides and the review of standardized nuclear plants as well as proposed changes in the regulatory program to provide for more effective review of standard plants. The committee has provided advice and recommendations regarding several generic matters related to water-cooled power reactors, including a report on the integrity of reactor pressure vessels for light-water power reactors, a summary of the status of unresolved generic items related to these facilities, and reviews of the safety research programs for both water-cooled and liquid-metal-cooled breeder reactors.

During the year, the ACRS held 12 regular meetings of the committee, 1 special meeting of the full committee and 103 meetings, site visits and facility tours by subcommittees and working groups. These meetings included one of the biological and environmental effects of plutonium, and several related to the environmental effects of nuclear plants including the transportation of spent nuclear fuel, the adequacy of modified reactor fuel designs and various other generic matters in addition to the specific projects reviewed.

During 1974, the ACRS provided reports on 10 licensed nuclear facilities related to plant operation and reports on 14 power reactors at the construction permit stage of review. These efforts included preliminary review of the Atlantic Generating Station, the first proposed offshore floating nuclear power plant, and the Gas-Cooled Fast Breeder Reactor concept. The ACRS also provided reports to the Commission regarding operation of the A4W/AIG–USS NIMITZ class nuclear powered aircraft carrier, an advanced nuclear steam supply system for nuclear-powered merchant ships, and a continuing evaluation of the Savannah River production reactors. In addition, the committee approved and/or provided comments on 15 Regulatory Guides and proposed analytical models to implement final AEC criteria for emergency core cooling systems.

The committee implemented a policy whereby a large number of internal ACRS documents relating to its activities will be made available to the general public with a minimum number of deletions. These few deletions will be made in order to protect the collegial nature of the committee's deliberations. In addition to this effort to provide the public with a more complete understanding of the nature and scope of its activities, the ACRS and its subcommittees held 93 meetings during 1974 that were open to members of the public. Comments from the public were received and considered at several of these meetings.

Members of the ACRS also participated in several foreign and international meetings dealing with the design, fabrication and inspection of nuclear steam supply systems and their components.

McKINNEY'S
1975 SESSION LAWS
OF NEW YORK

Comprising
Authentic Text of the Laws
Together With Other
Valuable Legislative and Executive Materials

198th SESSION—1975

Laws of the Regular Session

Chapters 1 to 867 (End)

Laws of the Extraordinary Session

Chapters 868 to 870 (End)

ST. PAUL, MINN.
WEST PUBLISHING CO.

Statutes—Technical Amendments

CHAPTER 464

An Act to amend the agriculture and markets law, the commerce law, the education law, the environmental conservation law, the executive law, the general municipal law, the highway law, the parks and recreation law, the public lands law, the public service law, the public authorities law, the transportation law, the New York state defense emergency act, the transportation capital facilities development act, and chapter four hundred thirteen of the laws of nineteen hundred sixty-five, entitled "An act to provide for an interstate compact with the states of New Jersey and Connecticut to create the tri-state transportation commission and prescribing the functions, powers and duties thereof and to repeal chapter three hundred sixteen of the laws of nineteen hundred sixty-four, entitled 'An act to provide for an interstate compact with the states of New Jersey and Connecticut to create the tri-state transportation commission and prescribing the functions, powers and duties thereof', relating thereto", and to repeal articles sixteen, nineteen-e and twenty-six of the executive law, in relation to transferring certain local services and functions now provided by the office for local government and the commissioner thereof, and the office of planning services and the director thereof, to the department of education and the commissioner thereof, the department of state and the secretary thereof, and the division of the budget and the director thereof, and abolishing the office for local government and the office of planning services, certain of their functions, and functions previously performed by the commissioner of local government and the director of the office of planning services.

Approved July 24, 1975, effective as provided in section.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. The executive law is hereby amended by adding thereto a new article, to be article six-a, to read as follows:

ARTICLE 6-A—SERVICES TO LOCALITIES

Sec.
150. Legislative findings.
151. Definitions.
152. General functions, powers and duties.
153. Specific powers, functions and duties.
154. Community affairs advisory board.
155. Fire services advisory board.

§ 150. Legislative findings

The legislature hereby finds and declares that:

1. Strong local government has been a major positive factor in the political, economic and social development of the state;

2. The future welfare of the state depends in large measure on the effectiveness of local government and of its relationships to state government;

3. Population shifts and other economic and social trends have brought new problems to local government;

4. The state has the responsibility toward local government to coordinate state services and information for the benefit of local government, to assist in the solution of its problems, and otherwise to help local government in making itself as strong and effective as possible;

5. The need for a more rational planning process requires a high degree of local, state and interstate cooperation;

6. The need for a single state agency to review and comment on local planning efforts of statewide significance, state agency planning and interstate planning commission programs is recognized;

7. A common data base developed by the official state planning agency in conjunction with planning efforts at all levels of government is essential to effective planning; and

8. State planning and development policies should promote planning programs among state agencies and between levels of government that maximize environmental and economic benefits to the localities.

§ 151. Definitions

As used in this article, the term "municipalities" shall include public corporations as defined in subdivision one of section sixty-six of the general construction law and special districts as defined in subdivision sixteen of section one hundred two of the real property tax law.

§ 152. General functions, powers and duties

The department of state, by and through the secretary of state or duly authorized officers or employees, shall have the following functions, powers and duties:

1. To assist the governor in coordinating the activities and services of those departments and agencies of the state having relationships with municipalities to the end of providing more effective services to such municipalities.

2. To keep the governor informed as to the problems of municipalities and to advise and assist in formulating policies with respect thereto and utilizing the resources of the state government for the benefit of municipalities.

3. To serve as a clearinghouse, for the benefit of municipalities, regarding information relating to their common problems and to the state and federal services available to assist in the solution of those problems.

4. To refer municipalities to the appropriate departments and agencies of the state and federal governments for advice, assistance and available services in connection with particular problems.

5. To advise and assist municipalities in the solution of particular problems.

6. To conduct studies and analyses of the problems of municipalities and to make the results thereof available as the secretary may deem appropriate.

7. To encourage and assist cooperative efforts among municipalities in developing among themselves solutions of their common problems.

8. To encourage expansion and improvement of training made available to municipal officials, in cooperation with municipalities and the organizations representing them.

9. To consult with and cooperate with municipalities and officers, organizations, groups and individuals representing them, to the end of more effectively carrying out the functions, powers and duties of the department.

10. To encourage and facilitate cooperation and collaboration among agencies and levels of government, and between government and the private sector, for the protection and development of human, natural and man-made resources.

11. To advise and assist municipalities in the performance of their planning and development activities.

12. To aid and assist, in the provision and coordination of state technical assistance and services in connection with the planning and development activities of municipalities.

13. To provide assistance and guidance to municipalities and, as appropriate, to the private sector, through the compilation, formulation and dissemination of necessary information, projections and techniques relating to development of resources.

14. To undertake any studies, inquiries, surveys or analyses necessary for performance of the functions, powers and duties of the department through the personnel of the department or consultants, or in cooperation with any public or private agencies.

15. To adopt, amend or rescind such rules, regulations and orders as may be necessary or convenient for the performance of its functions, powers and duties under this article.

16. To enter into contracts with any persons, firm, corporation or governmental agency, and to do all other things necessary or convenient to carry out the functions, powers and duties expressly set forth in this article.

17. To effectuate the purposes of this article, and to enable the department properly to carry out its functions, powers and duties, the secretary of state may request from any state department or agency or from any municipality, and the same are hereby authorized to provide, appropriate assistance, services and data.

18. To coordinate the programs and activities of departments, divisions, boards, bureaus, commissions or agencies of the state or of any municipality of the state in providing fire safety information, publicity and instruction and to cooperate with federal or private agencies and voluntary committees providing such information, publicity and instruction.

19. To maintain liaison with public and private agencies or committees concerned with the development or execution of plans and programs for providing fire safety information, publicity and instruction and to assist in the development and execution of such plans and programs.

20. To organize, operate, maintain and to encourage and assist in the organization, operation or maintenance of special services and programs for firemen as well as the appropriate facilities therefor.

21. To make studies and analyses and develop and execute and assist in the execution of plans for the efficient utilization of the resources and facilities of the state in matters related to fire safety and fire mobilization and control.

22. To prepare and recommend to the legislature and the governor legislative proposals relating to municipalities.

23. With the approval of the governor, to accept and administer as agent of the state any gift, grant, devise or bequest, whether conditional or unconditional, including federal grants, for any of the purposes of this article. Any moneys so received may be expended subject to the same limitations as to approval of expenditures and audits as are prescribed for state moneys.

§ 153. Specific powers, functions and duties

The department of state shall have the following specific powers, functions and duties:

1. (a) To act as the official state planning agency for all of the purposes of sections seven hundred one and seven hundred three of the federal housing act of nineteen hundred fifty-four, as heretofore and hereafter amended, except as otherwise provided by law.

(b) To act as agent for, and enter into contracts and otherwise cooperate with, the federal government in connection with the authority referred to in paragraph (a) of this subdivision, and as such agent to administer any grant or advance of funds for the assistance of any such activities to the state, or through the state to the governing bodies of municipalities, legally constituted metropolitan or regional planning agencies, and tribal councils or other legally constituted tribal bodies for planning for an Indian reservation located within the territorial jurisdiction of the state of New York, complying with the provisions of such grants or advances.

(c) To present any claim, other than claims required by law to be presented by the commissioner of transportation, to the federal government or any agency or official thereof with respect to the funds made available for the purposes specified in paragraphs (a) and (b) of this subdivision.

(d) To enter into a contract or contracts with any municipality, legally constituted metropolitan or regional planning agency, or tribal council or other legally constituted tribal body for planning for an Indian reservation located within the territorial jurisdiction of the state of New York, in connection with the authority provided in paragraph (a) of this subdivision for grants to be made to such municipality, planning agency or tribal council or other legally constituted tribal body by the state, within amounts appropriated therefor, for planning projects approved by the secretary, which contracts shall provide that the approved cost of a planning project, over and above the amount which may be received from federal grants therefor, shall be borne in an amount not to exceed one-half thereof by the state pursuant to such contracts and the remainder thereof out of local funds appropriated therefor by such municipality, planning agency or tribal council or other legally constituted tribal body.

2. To act as the official agent of the state for the purpose of administering, carrying out and otherwise cooperating with the federal government in connection with the provisions of the federal Appalachian regional development act of nineteen hundred sixty-five as heretofore and hereafter amended; to apply for, accept, and expend funds made available by the federal government pursuant to such federal acts and enter into any necessary contracts or compacts in connection therewith; and to take any further action which may be required under the terms of any such federal act.

3. To act as the official agent of the state for the purpose of administering, carrying out and otherwise cooperating with the federal government in connection with the provisions of the federal public works and economic development act of nineteen hundred sixty-five, as heretofore and hereafter amended; to apply for, accept, and expend funds made available by the federal government pursuant to such federal acts and enter into any necessary contracts or compacts in connection therewith; to review and approve overall economic development programs prepared under the provisions of such federal acts as to the qualifications of the area or district organization and the adequacy and reasonableness of such programs, and every political subdivision of the state, or private or public non-profit organization or association submitting an overall economic development program to the federal government must submit such overall economic development program for review by the department of state; to act on behalf of the political subdivisions of the state in connection with making findings that projects for which financial assistance is sought under the provisions of such federal acts are consistent with an overall program for the economic development of the area; and to take any further action which may be required under the terms of any such federal acts, including but not limited to delineating economic development districts and economic development regions and providing for the administration of such districts and regions in any manner deemed appropriate by the department, except that with regard to section three hundred two of such act, the governor shall designate the official agent of the state for the purpose of administering, carrying out and otherwise cooperating with the federal government in connection with the provisions of such section.

4. To act as the official agent of the state for the purpose of administering, carrying out and otherwise cooperating with the federal government in connection with the provisions of the federal fire prevention and control act of nineteen hundred seventy-four and any federal laws amendatory or supplemental to such act hereafter enacted; to apply for, accept, and expend funds made available by the federal government pursuant to such act; and to enter into any necessary con-

tracts or compacts pursuant to such federal acts in connection therewith and to take any further action which may be required under the terms of any such federal act.

5. (a) To make or contract to make, within appropriations therefor, state grants to municipalities to cover fifty per centum of the costs to municipalities of preparing applications to the federal government for federal assistance for the planning of comprehensive city demonstration programs as authorized under title one of the demonstration cities and metropolitan development act of nineteen hundred sixty-six as modified by the provisions of title I of the housing and community development act of nineteen hundred seventy-four, and any federal laws as heretofore and hereafter amended, as such costs shall be certified by the municipality and approved by the secretary of state.

(b) In the case of municipalities which have contracted with the federal government for a federal grant to assist in financing the costs of planning comprehensive city demonstration programs under the authority referred to in paragraph (a) of this subdivision, to make or contract to make, within appropriations therefor, state grants to such municipalities to cover fifty per centum of the net cost to the municipality of undertaking and completing such planning, exclusive of any federal assistance, as such net cost shall be certified by the municipality and approved by the secretary of state, but in no event shall such state grants exceed one-eighth of the federal grant.

(c) In the case of municipalities which have had applications approved by the federal government for federal assistance for the planning of comprehensive city demonstration programs under the authority referred to in paragraph (a) of this subdivision, but for which federal funds are not then available, to make or contract to make, within appropriations therefor, state grants to such municipalities in an amount not to exceed ninety per centum of the reasonably anticipated costs of undertaking and completing such planning, as such costs shall be certified by the municipality and approved by the secretary of state; provided, however, that no such grant shall be made unless the municipality agrees to repay such grant out of federal funds made available to the municipality for such planning, when and to the extent such federal funds are made available.

(d) In carrying out the functions, powers and duties prescribed in paragraphs (a), (b) and (c) of this subdivision and in developing plans and applications under title one of the housing and community development act of nineteen hundred seventy-four, to provide such technical assistance to the municipalities as the secretary of state determines to be appropriate.

6. The department of taxation and finance is hereby designated to accept and receive all grants and advances from the federal government pursuant to the provisions of sections seven hundred one and seven hundred three of the federal housing act of nineteen hundred fifty-four and the provisions of the federal Appalachian regional development act of nineteen hundred sixty-five and the federal public

works and economic development act of nineteen hundred sixty-five and the federal fire prevention and control act of nineteen hundred seventy-four, as such acts may be amended from time to time, which are provided for the purposes specified in subdivisions one, two, three, four and five of this section and all moneys so accepted and received shall be deposited by the department of taxation and finance in special funds for use exclusively for the purposes for which such grants or advances were made. Payment from such special funds shall be made upon audit and warrant of the comptroller upon vouchers approved by the secretary.

7. Nothing contained in this section shall be deemed to derogate or detract in any way from the functions, powers and duties prescribed by law of any state department or agency or any municipality, nor to interrupt or preclude the direct relationships of any such department or agency with any such municipality for the carrying out of such functions, powers and duties.

§ 154. Community affairs advisory board

1. The governor shall appoint a community affairs advisory board for the purpose of advising and assisting the secretary of state as he may request from time to time, (a) in carrying out the functions, powers and duties of the department set forth in this article, (b) in evaluating and making recommendations on federal and state legislation relating to municipalities, (c) in evaluating and making recommendations on federal and state programs administered by the department of state pursuant to this article and on such other federal and state programs relative to municipalities, and (d) on such other matters as the secretary shall determine.

2. The board shall consist of nine members to be appointed by the governor, by and with the advice and consent of the senate. The secretary of state or his delegate shall act as secretariat for the board. The governor shall designate a chairperson from the members of the board to serve as such at the pleasure of the governor.

3. In appointing the members of the advisory board the governor shall provide representation for counties, cities, towns and villages as well as representation of the broad interests of the state in all local governments.

4. All members of the advisory board shall serve for terms of three years, such terms to commence on April first and expire on March thirty-first; provided, however, that of the members first appointed three shall be appointed for one-year terms expiring on March thirty-first, nineteen hundred seventy-six, and three shall be appointed for two year terms expiring on March thirty-first, nineteen hundred seventy-seven.

5. The advisory board shall meet regularly at least four times in each year. Special meetings may be called by the chairperson and shall be called at the request of the secretary of state. The agenda and meeting place of all regular or special meetings shall be made available to

the public in advance of such meeting, and all meetings of the advisory board shall be open to the public.

6. No member of the advisory board shall be disqualified from holding any other public office or employment, nor shall any such office of employment be forfeited by reason of the members appointment hereunder, notwithstanding the provisions of any general, special or local law, ordinance or city charter.

7. The members of the advisory board shall receive no compensation for their services but shall be allowed their actual and necessary expenses incurred in the performance of their duties hereunder.

§ 155. Fire services advisory board

1. The governor shall appoint a fire services advisory board for the purpose of advising and assisting the secretary of state as he may request from time to time, (a) in carrying out the functions, powers and duties of the department with respect to fire safety services, policies and programs, (b) in evaluating and making recommendations on courses of instruction for training of firemen of fire departments of the state, public corporations and districts, and private industry, (c) in evaluating and making recommendations on federal and state legislation and programs relating to fire safety service, policies and programs, (d) reviewing and approving the state building conservation and fire prevention code, and (e) upon such other matters as the secretary may request.

2. Such board shall consist of thirteen members to be appointed by the governor, by and with the advice and consent of the Senate, for terms of three years, such terms to commence on April first and expire on March thirty-first provided, however, that of the members first appointed four shall be appointed for one-year terms expiring on March thirty-first nineteen hundred seventy-six, and four shall be appointed for two year terms expiring on March thirty-first, nineteen hundred seventy-seven. The governor shall designate one member of the board as the chairman thereof. The secretary of state or his delegate shall act as secretariat for the board. The governor shall designate from among the members of such board a chairman who shall serve as chairman at the pleasure of the governor.

3. The membership of such board may include representatives of civic and fireman's organizations and state and local officials.

4. Such board shall meet regularly at least four times in each year. Special meetings may be called by the chairman and shall be called by him at the request of the secretary of state. The agenda and meeting place of all regular or special meetings shall be made available to the public in advance of such meeting, and all meetings of the advisory board shall be open to the public.

5. No member of such board shall be disqualified from holding any other public office or employment, nor shall he forfeit any such office or employment by reason of his appointment hereunder, notwithstanding the provisions of any general, special or local law, ordinance, county or city charter.

6. The members of such board shall receive no compensation for their services but shall be entitled to receive their actual and necessary expenses incurred in the performance of their duties hereunder.

§ 2. Subdivision two of section thirty-one-d of the agriculture and markets law, as added by chapter four hundred thirty-seven of the laws of nineteen hundred seventy-three, is hereby amended to read as follows:

2. The commission shall consist of fifteen voting members. The members of the commission shall be appointed by the governor by and with the advice and consent of the Senate. The governor shall also designate one of the members as chairman. The term of office of each member shall be three years. The commissioner of agriculture and markets, the ~~director of the office of planning services,~~ secretary of state, the dean of the New York state college of agriculture, the commissioner of commerce and the commissioner of environmental conservation shall serve as non-voting members of the commission.

§ 3. Subdivision two of section thirty-one-e of such law, as added by chapter four hundred thirty-seven of the laws of nineteen hundred seventy-three, is hereby amended to read as follows:

2. To assist ~~the office of planning services~~ the department of state and the department of environmental conservation in relation to harmonizing the demands placed on land by urban growth with the goal of maintaining and preserving land for agricultural uses, maintaining a quality environment for agriculture and improving relations between farm and non-farm users of land;

§ 4. Subdivisions two, five, six and eight of section three hundred three of such law, such section having been added by chapter four hundred seventy-nine of the laws of nineteen hundred seventy-one, subdivision two thereof having been added by chapter three hundred ninety of the laws of nineteen hundred seventy-three, subparagraph four of paragraph a of subdivision two thereof and subdivision six thereof having been amended by chapter five hundred fifty-two of the laws of nineteen hundred seventy-four, are hereby amended to read as follows:

2. Upon the receipt of such a proposal, the county legislative body:

a. shall thereupon provide notice of such proposal by publishing a notice in a newspaper having general circulation within the proposed district and by posting such notice in five conspicuous places within the proposed district. The notice shall contain the following information:

(1) a statement that a proposal for an agricultural district has been filed with the county legislature pursuant to this article;

(2) a statement that the proposal will be on file open to public inspection in the county clerk's office;

(3) a statement that any ~~municipality~~ municipality whose territory encompasses the proposed district or any landowner who owns at least ten per cent of the land proposed to be included within the proposed modification of the proposed district may propose a modification of the proposed district in such form and manner as may be prescribed by the commissioner of environmental conservation;

(4) a statement that the proposed modification must be filed with the county clerk and the clerk of the county legislature within thirty days after the publication of such notice;

(5) a statement that at the termination of the thirty day period, the proposal and proposed modifications will be submitted to the county planning board and county agricultural advisory committee, and that

deletions by ~~strikeouts~~

thereafter a public hearing will be held on the proposal, proposed modifications and recommendations of the board and committee;

b. shall receive any proposals for modifications of such proposal which may be submitted by such landowners or municipalities within thirty days after the publication of such notice;

c. shall, upon the termination of such thirty day period, refer such proposal and proposed modifications to the county planning board, which shall, within forty-five days, report to the county legislative body the potential effect of such proposal and proposed modifications upon the county's planning policies and objectives;

d. shall simultaneously, upon the termination of such thirty day period, refer such proposal and proposed modifications to the agricultural districting advisory committee, which shall, within forty-five days report to the county legislative body its recommendations concerning the proposal and proposed modifications, and;

e. shall hold a public hearing in the following manner:

(1) The hearing shall be held at a place within the proposed district or otherwise readily accessible to the proposed district;

(2) The notice shall contain the following information:

(a) a statement of the time, date and place of the public hearing;

(b) a description of the proposed district, any proposed additions and any recommendations of the planning board or advisory committee;

(c) a statement that the public hearing will be held concerning:

(i) the original proposal;

(ii) any written amendments proposed during the thirty day review period;

(iii) any recommendations proposed by the agricultural districting advisory committee and/or the county planning board.

(3) The notice shall be published in a newspaper having a general circulation within the proposed district and shall be given in writing to those municipalities whose territory encompasses the proposed district and any proposed modifications, the persons owning land within such a proposed district or any proposed modifications, the commissioner of environmental conservation, the agricultural resources commission and the ~~director of the office of planning services~~ secretary of state.

5. The commissioner of environmental conservation shall have sixty days after receipt of the plan within which to certify to the county legislative body whether the proposal, or a modification of the proposal, is eligible for districting and whether districting would be consistent with state environmental plans, policies and objectives. The commissioner of environmental conservation shall submit copies of such plan to the agricultural resources commission and to the ~~director of the office of planning services~~ secretary of state, who shall have thirty days within which to report their respective determinations to the commissioner of environmental conservation. The commissioner of environmental conservation shall not certify the plan as eligible for districting unless, (a) the agricultural resources commission has determined that the area to be districted consists predominantly of viable agriculture land, and, (b) the ~~director of the office of planning services~~ secretary of state, has determined that the districting of the area would not be inconsistent with state comprehensive plans, policies and objectives.

6. Within sixty days after the certification of the commissioner of environmental conservation that the proposed area is eligible for districting, and that districting would be consistent with state environmental plans, policies and objectives, the county legislative body may hold a public hearing on the plan, except that it shall hold a public

hearing if the plan was modified by the commissioner of environmental conservation or was modified by the county legislative body after they held the public hearing required by paragraph e of subdivision two of this section and such modification was not considered at the original hearing. Notice of any such hearing shall be in a newspaper having general circulation in the area of the proposed district and individual notice, in writing to those municipalities whose territory encompass the proposed district and proposed modifications, the persons owning land in the proposed district and proposed modifications, the commissioner of environmental conservation, the agricultural resources commission and the ~~director of the office of planning services~~ secretary of state. The proposed district, if certified without modification by the commissioner of environmental conservation, shall become effective thirty days after the termination of such public hearing or, if there is no public hearing, ninety days after such certification unless its creation is disapproved by the county legislative body within such period. Provided, however, that if, on a date within the thirty days after the termination of such public hearing or, if there is no public hearing, within the ninety days after such certification, the county legislative body approves creation of the district, such district shall become effective on such date. Provided, further, that notwithstanding any other provision of this subdivision, if the commissioner modified the proposal, the district shall not become effective unless the county legislative body approves the modified district; such approval must be given on a date within the thirty days after the termination of the public hearing; and the district, if approved, shall become effective on such date. Before approving or disapproving any proposal modified by the commissioner, the county legislative body may request reports on such modified proposal, from the county planning board and the agricultural districting advisory committee.

8. The county legislative body shall review any district created under this section eight years after the date of its creation and every eight years thereafter. In conducting such review, the county legislative body shall ask for the recommendations of the county planning board and the agricultural advisory committee, and shall, at least one hundred twenty days prior to the end of the eighth year and not more than one hundred eighty days prior to such date, hold a public hearing at a place within the district or otherwise readily accessible to the district upon notice in a newspaper having a general circulation within the district and individual notice, in writing, to those municipalities whose territory encompass the district, the persons owning land within the district, the commissioner of environmental conservation, the agricultural resources commission and the ~~director of the office of planning services~~ secretary of state. The county legislative body, after receiving the reports of the county planning board and the agricultural districting advisory committee and after the public hearing, may terminate the district at the end of such eight year period by filing a notice of termination with the county clerk and the commissioner of environmental conservation, or may modify the district in the same manner as is provided in subdivisions four, five, six and seven of this section relating to the creation of a district. If the county legislative body does not act, or if a modification of a district is rejected, the district shall continue as originally constituted, unless the commissioner of environmental conservation terminates such district, by filing a notice thereof with the county clerk, because: (a) the agricultural resources commission has determined that the area in the district is no longer predominantly viable agricultural land, or (b) the continuance of the district would not be consistent with state environmental plans, policies, and objectives,

deletions by ~~strikeouts~~

or (c) the ~~director of the office of planning services~~ secretary of state has determined that the continuance of the district would not be consistent with state comprehensive plans, policies and objectives, except, however, if the commissioner of environmental conservation certifies to the county legislative body that he will not approve the continuance of the district unless modified, such modified district may be established in the same manner provided in subdivision six of this section.

§ 5. Subdivisions one and four of section three hundred four of such law, subdivision one having been amended by chapter eight hundred sixty-four of the laws of nineteen hundred seventy-four and subdivision four having been amended by chapter seven hundred twelve of the laws of nineteen hundred seventy-two, are hereby amended to read as follows:

1. Four years after the effective date of this act, the commissioner of environmental conservation may create agricultural districts covering any land in units of two thousand or more acres not already districted under section three hundred three, if (a) the agricultural resources commission has determined that the land encompassed in a proposed district is predominantly unique and irreplaceable agricultural land, and had recommended that the commissioner of environmental conservation establish an agricultural district for such area; (b) such district would further state environmental plans, policies and objectives; (c) the ~~director of the office of planning services~~ secretary of state has determined that such proposed district would be consistent with state comprehensive plans, policies and objectives and (d) the director of the division of the budget has given ~~his~~ approval of the establishment of such area.

4. The commissioner of environmental conservation shall review any district created under this section, in consultation with the agricultural resources commission, the ~~director of the office of planning services~~ secretary of state and the director of the division of the budget, eight years after the date of its creation and every eight years thereafter. Each such review shall include consultations with local elected officials, planning bodies, agricultural and agribusiness interests, community leaders, and other interested groups, and shall also include a public hearing at a specified time and at a specified place either within the district or easily accessible to the proposed district, notice of such hearing to be published in a newspaper having general circulation within the district. In addition, the commissioner shall give notice, in writing, of such public hearing to persons owning land in the district. After any such review, the commissioner of environmental conservation may modify such district so as to exclude land which is no longer predominantly unique and irreplaceable agricultural land or to include additional such land, provided: (a) the agricultural resources commission had recommended the exclusion or inclusion of such land; (b) such modification would further state environmental plans, policies and objectives; (c) the ~~director of the office of planning services~~ secretary of state has determined that such modification would be consistent with state comprehensive plans, policies and objectives; and (d) such modification has been approved by the director of the division of the budget; provided, further, that if the commissioner modifies the district to include additional land, he shall hold another public hearing, on the same type of published and written notice. Then the commissioner may again modify or dissolve the district, but he may not modify it to include land not included in the proposed modifications upon which the second hearing was held. After any such review the commissioner of environmental conservation shall dissolve any such district if (a) the agricultur-

al resources commission has determined that the land within the district is no longer predominantly unique and irreplaceable agricultural land or (b) the continuation of the district would not further state environmental plans, policies and objectives, or (c) the ~~director of the office of planning services~~ secretary of state has determined that the continuation of the district would be inconsistent with state comprehensive plans, policies and objectives. A modification or dissolution of a district shall become effective in the same manner as is provided for in subdivision three of this section, except that in the case of dissolution, a notice of dissolution shall be filed instead of a map.

§ 6. Subdivision four of section three hundred five of such law, as amended by chapter seven hundred twelve of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

4. Limitation on the exercise of eminent domain and on the advance of public funds. a. Any agency of the state, any public benefit corporation or any local government which intends to acquire land or any interest therein, provided that the acquisition from any one actively operated farm within the district would be in excess of ten acres or that the total acquisition within the district would be in excess of one hundred acres, or which intends to advance a grant, loan, interest subsidy or other funds within a district for the construction of dwellings, commercial or industrial facilities, water or sewer facilities to serve nonfarm structures, shall at least thirty days prior to such action file a notice of intent with the commissioner of environmental conservation, containing such information and in such manner and form as he may require. Such notice of intent shall contain a report justifying the proposed action including an evaluation of alternatives which would not require action within the agricultural district.

b. Upon receipt of such notice, the commissioner shall thereupon forward a copy of such notice to both the agricultural resources commission and the ~~director of the office of planning services~~ secretary of state. The commissioner, in consultation with the agricultural resources commission and the ~~director of the office of planning services~~ secretary of state, shall review the proposed action to determine what the effect of such action would be upon the preservation and enhancement of agriculture and agricultural resources within the district, state environmental plans, policies and objectives, and state comprehensive plans, policies and objectives.

c. If the commissioner finds that such proposed action might have an unreasonably adverse effect upon such goals, resources, plans, policies or objectives, the commissioner shall issue an order within such thirty day period to such agency, corporation or government directing such agency, corporation or government not to take such action for an additional period of sixty days immediately following such thirty day period.

d. During such additional sixty day period, the commissioner shall hold a public hearing concerning such proposed action at a place within the district or otherwise easily accessible to the district upon notice in a newspaper having a general circulation within the district, and individual notice, in writing, to the municipalities whose territory encompass the district, the agricultural resources commission, the ~~director of the office of planning services,~~ secretary of state and the agency, corporation or government proposing to take such action. On or before the conclusion of such additional sixty day period, the commissioner of environmental conservation shall report his findings to the agency, corporation or government proposing to take such action, to any public agency having the power of review of or approval of such action, and, in a manner conducive to the wide dissemination of such findings, to the public.

e. The commissioner of environmental conservation may request the attorney general to bring an action to enjoin any such agency, corporation or government from violating any of the provisions of this subdivision.

f. This subdivision shall not apply to any emergency project which is immediately necessary for the protection of life or property.

§ 7. Subdivision (a) of section one hundred sixteen of the commerce law, as amended by chapter eight hundred twenty-seven of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

(a) There is hereby created, within the New York state department of commerce, a board to be known as the New York state job incentive board. Its members shall be the commissioner of commerce, the commissioner of taxation and finance, the industrial commissioner, ~~the commissioner for local government,~~ the commissioner of agriculture and markets, ~~the director of the office of planning services~~ secretary of state, and the commissioner of housing and community renewal, the chairman of the state board of equalization and assessment, and such other state officer as the governor shall designate, all serving ex officio and without salary.

§ 8. Subdivision four, paragraph a of subdivision five and subdivision six of section eight hundred seven-a of the education law, subdivision four having been amended by chapter two hundred seventy-nine of the laws of nineteen hundred sixty-two, paragraph a of subdivision five having been amended by chapter seven hundred of the laws of nineteen hundred seventy-one, and subdivision six having been amended by chapter forty of the laws of nineteen hundred sixty-five, are hereby amended to read as follows:

4. The ~~director of the division of fire safety of the office for local government in the executive department~~ commissioner of education shall prescribe the form of the fire inspection report. ~~The commissioner of education~~ and shall furnish a supply of such form to school authorities.

a. The report of any fire inspection shall be filed in the office of the school authorities and~~, in the case of private schools, the report also shall be filed in the office of the director of division of fire safety of the office for local government in the executive department and, in the case of public schools, the report also shall be filed~~ with the commissioner of education. All such reports so filed in any public office shall be kept as public records for at least three years after which period they may be destroyed.

6. It shall be the duty of the commissioner of education~~, in the case of public schools, and the director of the division of fire safety, in the case of private schools,~~ to ascertain annually whether the inspections of school buildings required by this section have been made and the reports of the inspection have been filed in their respective offices. The commissioner of education~~, in the case of public schools, and the director of the division of fire safety, in the case of private schools,~~ shall review the reports of inspection filed pursuant to this section and may make recommendations to the school authorities with respect to any problems relating to school fire safety noted in such reports. The commissioner of education, ~~in the case of public schools, and the director of the division of fire safety, in the case of private schools,~~ may inspect or cause to be inspected at any reasonable time for fire prevention and fire protection purposes the school buildings required to be inspected by this section.

§ 9. Subdivisions two, four, five and six of section eight hundred seven-b of such law, subdivisions two and six having been amended by chapter two hundred sixty-four of the laws of nineteen hundred seventy-one, and subdivisions four and five having been added by chapter seven hundred sixty-six of the laws of nineteen hundred sixty-four, are hereby amended to read as follows:

2. The annual fire inspection shall be made between the first day of January and the first day of June of every year and the report thereof shall be filed by the college authorities in the places required by subdivision five of this section no later than the sixteenth day of June of each year~~, except that the time limitations of this subdivision and of paragraph d of subdivision three of this section shall not be applicable where such annual inspection of the buildings under the jurisdiction of a public college is regularly performed by the division of fire safety of the office for local government~~.

4. The ~~director of the division of fire safety of the office for local government in the executive department~~ commissioner of education shall prescribe the form of the fire inspection report~~. The commissioner of education~~ and shall furnish a supply of such form to college authorities.

5. The report of any fire inspection shall be filed in the office of the college authorities and~~, in the case of private colleges, the report also shall be filed in the office of the director of the division of fire safety of the office for local government in the executive department and, in the case of public colleges, the report also shall be filed~~ with the commissioner of education. All such reports so filed in any public office shall be kept as public records for at least three years after which period they may be destroyed.

6. It shall be the duty of the commissioner of education~~, in the case of public colleges, and the director of the division of fire safety, in the case of private colleges,~~ to ascertain annually whether the inspections of buildings under the jurisdiction of a college required by this section have been made and the reports of the inspection have been filed in their respective offices. The commissioner of education~~, in the case of public colleges, and the director of the division of fire safety, in the case of private colleges,~~ shall review the reports of inspection filed pursuant to this section and may make recommendations to the college authorities with respect to any problems relating to building fire safety noted in such reports. The commissioner of education~~, in the case of public colleges, and the director of the division of fire safety, in the case of private colleges,~~ may inspect or cause to be inspected at any reasonable time for fire prevention and fire protection purposes the buildings required to be inspected by this section.

§ 10. Subdivision two of section 3-0303 of the environmental conservation law, as amended by chapter four hundred of the laws of nineteen hundred seventy-three, is hereby amended to read as follows:

2. The department shall submit such plan to the Governor and to the ~~Office of Planning Services~~ Department of State on or before ~~July first, nineteen hundred seventy-three~~ October first, nineteen hundred seventy-five, and thereafter shall submit periodic revisions of such plan to the governor and to the ~~Office of Planning Services. The Office of Planning Services~~ Department of State. The Department of State shall review such plan and such revisions and shall submit a report thereon together with such recommendations within sixty days as it may deem appropriate to the Governor. ~~Such plan and such revisions shall become effective upon approval by the Governor and~~

~~shall serve thereafter as a guide to the public.~~ The governor shall approve, approve with modifications, or reject such plan within sixty days.

§ 11. Section 5-0101 of such law, as amended by chapter four hundred of the laws of nineteen hundred seventy-three, is hereby amended to read as follows:

§ 5-0101. Continuation of state environmental board; membership

There is hereby continued within the department the State Environmental Board, which shall consist of ~~sixteen~~ fifteen members, including the Commissioner of Environmental Conservation as chairman; the Commissioner of Health as vice chairman; the Commissioners of Agriculture and Markets, Commerce, Transportation, Parks and Recreation, ~~the Office for Local Government in the Executive Department,~~ the Secretary of State, the Chairman of the Public Service Commission, the Industrial Commissioner and members to be appointed by the Governor with the advice and consent of the Senate. None of the members appointed by the Governor shall be officers or employees of any state department or agency and each shall be, by professional training or experience and attainment, qualified to analyze and interpret matters of environmental concern. Of such ~~seven~~ six members, one shall be representative of conservationists of the state and shall be familiar with matters pertaining to the utilization of the natural resources of the state, one shall be representative of industry and as such shall be employed by a manufacturer or public utility, one shall be representative of agriculture and shall be familiar with matters pertaining to agriculture and ~~four~~ three shall be from the fields of public health, natural sciences, urban studies or other disciplines relating to the environment, ecology or natural resource management. ~~The Director of the Office of Planning Services and the chairman of the Council of Environmental Advisors shall be entitled to attend and participate in the meetings of the board but shall have no vote.~~

§ 12. Subdivision one of section 36-0107 of such law, as added by chapter eight hundred thirty-nine of the laws of nineteen hundred seventy-four, is hereby amended to read as follows:

1. Upon receipt of notification by a local government of its formal identification as a flood prone community, the department, in conjunction with the ~~director of the office of planning services~~ secretary of state, shall provide technical assistance as required to the local government in the preparation of programs necessary to qualify for the national flood insurance program. Such assistance shall include assistance in the development of joint programs by two or more local governments and the provision of model flood hazard regulations.

§ 13. Subdivision two of section 36-0111 of such law, as added by chapter eight hundred thirty-nine of the laws of nineteen hundred seventy-four, is hereby amended to read as follows:

2. The commissioner shall assist state agencies in determining and evaluating flood hazards and alternative protective measures, and shall establish standards and procedures to govern the review by the commissioner of potential flood hazards at proposed construction sites of state, and state-financed facilities. Such standards and procedures shall become effective upon their approval by the ~~directors~~ director of the division of the budget and the ~~office of planning services~~ secretary of state, and shall ensure that reviews thereunder shall be coordinated with those of appropriate environmental impact statements,

project notification and review systems, and state capital construction funding requests.

§ 14. Article sixteen of the executive law is hereby repealed.

§ 15. Article nineteen-E of such law is hereby repealed.

§ 16. Article twenty-six of such law is hereby repealed.

§ 17. Section eight hundred three of such law, as amended by chapter three hundred forty-eight of the laws of nineteen hundred seventy-three, is hereby amended to read as follows:

§ 803. Adirondack park agency

There is hereby created in the executive department, the Adirondack park agency, which shall consist of the following members: the commissioner of environmental conservation, the ~~director of the office of planning services,~~ secretary of state, the commissioner of commerce and eight members to be appointed by the governor by and with the advice and consent of the senate. The governor shall designate a chairman from among the members appointed to the agency, who shall serve at the governor's pleasure. None of the members appointed by the governor shall be officers or employees of any state department or agency.

Five members appointed by the governor shall be full-time residents within the Adirondack park provided, however, that no two such members shall be residents of the same county except for such members initially appointed before January first, nineteen hundred seventy-three, who may be reappointed for additional successive terms. Three members appointed by the governor shall be residents of the state outside the Adirondack park. Not more than five appointed members shall be of the same political party.

All appointments shall be made for terms of four years; provided that the first member appointed by the governor pursuant to the increase of members ~~appointed by him~~ from seven to eight shall be appointed for a term expiring on the thirtieth day of June, nineteen hundred seventy-six. Each of such appointed members of the agency shall hold office for the term for which he was appointed and until his successor shall have been appointed and qualified or until he shall resign or be removed in the manner provided by law. In the case of any vacancy other than one arising by expiration of term, an appointment to fill the vacancy shall be made for the remainder of the unexpired term.

The members of the agency, except those who serve ex officio, shall receive one hundred dollars per diem, not to exceed five thousand dollars per annum compensation for their services as members of the agency, and each of them, except those who serve ex officio, shall be allowed the necessary and actual expenses which he shall incur in the performance of his duties under this article.

A majority of the members of the agency shall constitute a quorum for the transaction of any business or the exercise of any power or function of the agency and affirmative vote by a majority of the members of the agency, except as is otherwise specifically provided in this article, shall be required to exercise any power or function of the agency. Votes of any member shall be cast in person and not by proxy. The agency may delegate to one or more of its members, officers, agents and employees, such powers and duties as it deems proper.

The commissioner of environmental conservation, and the commissioner of commerce and the ~~director of the office of planning services~~ secretary of state may, by official authority filed in their respective agencies, and with the Adirondack park agency, designate a deputy or other officer ~~of his agency~~ to exercise his powers and perform his duties, including the right to vote, on the agency.

§ 18. Subdivision three of section one hundred nineteen-s of the general municipal law, as amended by chapter one hundred eighteen of the laws of nineteen hundred seventy-four, is hereby amended to read as follows:

3. No municipal corporation, whether acting individually or jointly with one or more other municipal corporations, shall submit to the United States, or any agency or instrumentality thereof, any project application for one or more mass transportation capital projects or one or more airport or aviation capital projects, any application for one or more transportation demonstration projects or any federal mass transportation operating assistance, unless the application or applications therefor shall have been first approved by the state commissioner of transportation as being a part of or consistent with a statewide comprehensive master plan for transportation promulgated by him and approved by the governor on the recommendation of the ~~office of planning coordination~~ department of state or, in the absence of any such statewide plan, any other recognized long-range regional transportation plan approved by the commissioner or, in the absence of any such regional plan, sound transportation development policy and planning concepts.

§ 19. Subdivision b of section one hundred nineteen-u of such law, as added by chapter two hundred fifty-three of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

b. The term "~~commissioner~~ secretary" means the ~~commissioner for local government~~ secretary of state.

§ 20. Section one hundred nineteen-v of such law, as added by chapter two hundred fifty-three of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

§ 119-v. **Powers and duties of the ~~commissioner~~ secretary**

The ~~commissioner~~ secretary shall:

a. Promulgate and amend from time to time such rules and regulations as he shall deem necessary, proper or desirable to carry out the provisions and purposes of this article, including priority criteria, and to assure the appropriate coordination of comprehensive studies and reports with other state or local agencies interested or concerned with the particular municipal service being studied and with other available state and federal financial aid programs. The comprehensive study and report shall be designed to develop such information as may be required by the ~~commissioner~~ secretary, including but not limited to: technical and economic feasibility; cost estimates for construction, property rights and equipment, acquisition and contingencies and for engineering, legal and other services, proposed methods of financing; and estimates of first costs and subsequent total annual costs of construction, acquisition, administration, operation and maintenance of recommended activities. Such study shall also include such additional information as may be prescribed by the ~~commissioner~~ secretary. The scope or the area of a study shall not be less than that determined by the ~~commissioner~~ secretary as necessary for adequate evaluation of the proposed municipal service. Such study shall not include the preparation of contract documents or detailed construction design and engineering drawings and specifications;

b. Receive applications of local agencies for state aid, pursuant to this article, in such form and containing such information as he shall prescribe;

c. Review and approve the area and scope of any comprehensive study prior to its execution;

d. Approve applications for state aid pursuant to this article and advise local agencies and the participating municipalities of the approval of their applications for state aid;

e. Execute contracts for consultant services necessary for such studies and reports jointly with the local agency requesting state aid therefor;

f. Approve the amount of compensation to be paid for such consultant services and the methods of determining such compensation;

g. Receive, review and approve final reports of local agencies prior to final payment;

h. Approve vouchers for the payment of state aid grants pursuant to the provisions of this article;

i. Make an estimate of the annual funds necessary to carry out the provisions of this article and request such amounts for inclusion in the executive budget;

j. Perform such other and further acts as may be necessary, proper or desirable to effectuate the provisions of this article.

§ 21. Section one hundred nineteen-w of such law, as added by chapter two hundred fifty-three of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

§ 119–w. Powers of local agencies

A local agency may:

a. Apply to and contract with the ~~commissioner~~ secretary for state aid pursuant to this article for comprehensive studies to be undertaken on and after the first day of September, nineteen hundred sixty-eight;

b. Select the person or firm to perform necessary consultant services for a comprehensive study and report and enter into contracts for such services; provided, however, that the ~~commissioner~~ secretary shall also be a party to any such contract;

c. Expend money received from the state pursuant to this article only for purposes consistent therewith.

§ 22. Section one hundred nineteen-x of such law, as added by chapter two hundred fifty-three of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

§ 119–x. Local planning coordination

Whenever an application for state aid pursuant to this article shall be filed with the ~~commissioner~~ secretary, the local agency shall give notice thereof to the local planning board by filing with such board one copy of the application. Within forty-five days of such notice, the local planning board may file with the ~~commissioner~~ secretary an advisory opinion evaluating the need for the comprehensive study and report and its compatibility with other planning studies or needs of the area. The ~~commissioner~~ secretary shall take no final action upon an application for such forty-five day period or until the receipt of such advisory opinion, whichever occurs earlier.

§ 23. Section one hundred nineteen-y of such law, as added by chapter two hundred fifty-three of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

§ 119–y. State aid

The ~~commissioner~~ secretary may, in the name of the state, make or contract to make, within appropriations therefor, a state grant for payment to a local agency to cover seventy-five per cent of the costs, as determined by ~~him~~ the secretary, of the preparation of a comprehensive study and report.

§ 24. Section one hundred nineteen-z of such law, as added by chapter two hundred fifty-three of the laws of nineteen hundred sixty-eight, is hereby amended to read as follows:

§ 119–z. Limitations

Nothing in this article contained shall be held to repeal, limit or modify the jurisdiction, powers and duties of any state or local department, board, district, commission or authority, or any public corporation, or other agency, now or hereafter possessed, or to invalidate or modify, in whole or in part, any decision, order, license, permit, approval, or other act, issued or taken heretofore or hereafter by such department, board, district, commission, authority, or public corporation or other agency, or to nullify, abate or otherwise affect any rights acquired or action taken heretofore or hereafter pursuant to such decision, order, license, permit, approval, or other act. State aid for comprehensive studies and reports pursuant to this article shall not be available for such studies and reports for which state aid is available pursuant to sections twelve hundred sixty-three-a and thirteen hundred sixty-two of the public health law or section four hundred forty-six of the conservation law. In the event that state or federal aid is available pursuant to other provisions of law for the preparation of comprehensive studies and reports, the ~~commissioner~~ secretary may reject applications for state aid pursuant to this article.

§ 25. Section twenty-two of the highway law, as added by chapter six hundred eighty of the laws of nineteen hundred seventy-three, is hereby amended to read as follows:

§ 22. Multi-use areas adjacent to and recreational, natural and scenic areas along state highways

The commissioner of transportation is hereby authorized and empowered to acquire property in order to provide multi-use areas adjacent to state highways and recreational, natural and scenic areas along, but not necessarily contiguous to, state highways. Such multi-use areas may be utilized for, but not limited to walking, hiking, bicycle, trail-bike, recreational vehicle and snowmobile trails and the installation of public utilities. Such acquisitions shall constitute a state highway purpose. Property acquired for multi-use areas shall be such as to complement the highway facilities by providing the multi-use areas adjacent to the highway facilities. Property acquired for recreational, natural and scenic areas along, but not necessarily contiguous to, state highways shall consist of predominantly unimproved, natural or scenic areas suitable to serve the recreational needs of the expanding population of the state, or desirable to preserve the natural or scenic resources of the state, and shall lend itself to restoration, preservation or enhancement as a recreational, natural or scenic area or provides visual access from the highway to such an area. The commissioner is hereby authorized to undertake work of construction, improvement, restoration, preservation or enhancement of such areas and the expense of such work may be a proper charge against funds available for the construction, reconstruction, improvement or maintenance of state highways. The commissioner shall submit plans for such acquisitions and work to ~~the office of planning services~~ the department of state the office of parks and recreation and the department of environmental conservation for review and recommendation prior to such acquisitions and work being undertaken. Such acquisitions and work, and any agreements entered into in connection therewith, shall not be undertaken unless approved by the director of the budget. Such acquisitions and work in multi-use areas may be undertaken pursuant to a written agreement with a person, firm, corporation, public authority, city, county, town, village, or state department or agency, which agreement shall provide for the funding of such acquisitions and work. Such acquisitions and work in recreational, natural or scenic areas may be undertaken in cooperation with other state departments or agencies and provision shall be made for the funding of such acquisitions and work. Any real property which the commissioner deems necessary for the purposes of this section may be acquired and disposed of by him in the name of the people of the state of New York according to the procedure provided in this chapter for the acquisition and disposition of property for state highway purposes. The provisions of this chapter shall also control the meaning of property as used herein, the manner in which possession of such property may be obtained and the circumstances under the procedure by which it may be sold or exchanged. Adjusted claims for such acquisition and awards and judgments of the court of claims made in respect thereto shall be paid out of the state treasury from moneys available for the purposes of this section. All state departments, agencies, counties, towns and villages are hereby authorized to enter into agreements with the commissioner of transportation for the purposes of this section.

§ 26. Subdivision two of section 3.15 of the parks and recreation law is hereby amended to read as follows:

2. The office shall submit such plan and periodic revisions of such plan to the ~~office of planning services~~ department of state and the governor. The ~~office of planning services~~ department of state shall review such plan and such revisions and shall submit a report thereon, together with such recommendations as it may deem appropriate, to the governor. Such plan and revisions shall become effective upon approval by the governor and shall serve thereafter as a guide for the development, protection and management of parks and recreation facilities.

§ 27. Subdivision four-a of section three of the public lands law, as last amended by chapter eight hundred twenty-seven of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

4-a. Notwithstanding any other provision of this chapter or other statute, the commissioner of general services, upon the application of any person or corporation, may lease to the highest responsible bidder furnishing the required security after advertisement for sealed bids has been published in a newspaper or newspapers designated for such purpose, for a term not to exceed ninety-nine years, to such applicant interests in real property including but not limited to air rights, subterranean rights and others, when such are not needed for present public use.

Such lease shall contain proper covenants to assure the payment of adequate consideration for the interests leased, and to further protect the state as is deemed necessary by said commissioner.

Where the superintendence of the interest leased is vested in some officer or in a state department or a division, bureau or agency thereof, or in a public authority created or continued under the public authorities law, the commissioner may grant such rights only upon written request and consent of such officer or head of such department, division, bureau or public authority.

Said lease shall not be effective until approved as to form by the attorney general of the state~~, and provided further that such lease shall be approved by the office of planning services~~.

The development of any leasehold granted pursuant to this subdivision shall be subject to the zoning regulations and ordinances of the municipality in which said property is located.

§ 28. Paragraph (a) of subdivision two of section one hundred twenty-two of the public service law, having been added by chapter two hundred seventy-two of the laws of nineteen hundred seventy, subparagraph ii having been amended by chapter eight hundred twenty-seven of the laws of nineteen hundred seventy-two, subparagraph iii having been added by chapter two hundred seventy-three of the laws of nineteen hundred seventy, subparagraphs iv and v as renumbered by chapter two hundred seventy-three of the laws of nineteen hundred seventy, and subparagraph vi as added by chapter three hundred forty-eight of the laws of nineteen hundred seventy-three, is hereby amended to read as follows:

(a) a copy of such application on

i. each municipality in which any portion of such facility is to be located, both as primarily proposed and in the alternative locations listed. Notice to a municipality shall be addressed to the chief executive officer thereof and shall specify the date on or about which the application is to be filed;

ii. the commissioner of environmental conservation, the commissioner of commerce and the ~~director of the office of planning services~~ secretary of state;

iii. each member of the legislature through whose district the facility or any alternate proposed in the application would pass;

iv. in the event such facility or any portion thereof is located within its jurisdiction, the Hudson river valley commission;

v. in the event such facility or any portion thereof is located within its jurisdiction, the St. Lawrence-eastern Ontario commission.

vi. in the event such facility or any portion thereof is located with the Adirondack park, as defined in subdivision one of section 9–0101 of the environmental conservation law, the Adirondack park agency.

§ 29. Paragraph (d) of subdivision one of section one hundred twenty-four of such law, as amended by chapter eight hundred twenty-seven of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

(d) the ~~office of planning services~~ secretary of state.

§ 30. Paragraph (a) of subdivision two of section one hundred forty-two of such law, as added by chapter three hundred eighty-five of the laws of nineteen hundred seventy-two, such paragraph viii thereof having been added by chapter three hundred forty-eight of the laws of nineteen hundred seventy-three, is hereby amended to read as follows:

(a) a copy of such application on

i. each municipality in which any portion of such facility is to be located, as primarily proposed or in the alternative locations listed. Such copy to a municipality shall be addressed to the chief executive officer thereof and shall specify the date on or about which the application is to be filed;

ii. each ex officio member of the board and on the chairman of the board for transmission to the appointed member as soon after his appointment as practicable;

iii. the attorney general;

iv. the ~~director of the office of planning services~~ secretary of state;

v. each member of the state legislature in whose district any portion of the facility is to be located, as primarily proposed or in the alternative locations listed;

vi. in the event such facility or any portion thereof, as primarily purposed or in the alternative locations listed, is located within its jurisdiction, the Hudson river valley commission;

vii. in the event such facility or any portion thereof, as primarily proposed or in other alternative locations listed, is located within its jurisdiction, the St. Lawrence-eastern Ontario commission.

viii. In the event that such facility or any portion thereof, as primarily proposed or in the alternative locations listed, is located within the Adirondack park, as defined in subdivision one of section 9-0101 of the environmental conservation law, the Adirondack park agency.

§ 31. Paragraph (e) of subdivision one of section one hundred forty-four of such law, as added by chapter three hundred eighty-five of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

(e) the ~~office of planning services~~ secretary of state;

§ 32. Section one hundred forty-nine-b of such law, as added by chapter three hundred eighty-five of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

§ 149-b. Long-range electric system planning

Each electric corporation shall prepare and submit annually to the department, at a public hearing upon such notice and at such time and place as the department shall determine, its long-range plan for future operations drawn pursuant to regulations issued by the commission. Such corporations shall concurrently deliver a copy of such plans to the secretary of state. Such plans shall include:

1. a forecast of demand for the next ten years specifying anticipated load duration, including peak loads;
2. identification of generating capacity to be utilized in meeting such demands, including capacity to be provided by others on a contractual basis;
3. an inventory of (a) all major utility facilities operated by such corporation including the dates for completion and operation of facilities under construction and the dates of the retirement of facilities in operation, and (b) of land owned by the corporation and held for future use as a major steam electric generating facility site;
4. anticipated expenditures for research in the areas of electric generation and transmission and pollution abatement and control during the next year;
5. such additional information as the commission may by regulation require to carry out the purposes of this section.

§ 33. Subdivision two of section fifteen of the transportation law, as amended by chapter eight hundred twenty-seven of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

2. The department shall submit such plan to the governor and to the ~~office of planning services~~ department of state on or before September first, nineteen hundred sixty-eight, and thereafter shall submit appropriate revisions of such plan to the governor and to the ~~office of planning services~~ department of state from time to time as such revisions are made. The ~~office of planning services~~ department of state shall review such plan and such revisions and shall submit a report thereon, together with such recommendations as it may deem appropriate, to the governor. Such plan and such revisions shall become effective upon approval by the governor and shall serve thereafter as a guide to the public and publicly assisted development of transportation facilities and services in the state.

§ 34. Section thirty of such law, as amended by chapter eight hundred twenty-seven of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

§ 30. Urban transportation planning

Notwithstanding section seven hundred thirty-four of the executive law or any other law, the commissioner shall have power to sponsor, conduct and undertake urban transportation studies and to act as the state planning agency for metropolitan or regional urban transportation planning and for state and interstate comprehensive urban transportation planning and for research and coordination activity related thereto in connection with the provisions of and for the purposes set forth in section seven hundred one of the federal housing act of nineteen hundred fifty-four, as amended, when such studies and activity relate primarily to the development of a transportation plan. In exercising his powers under this section the commissioner may act jointly with and otherwise cooperate with ~~the office of planning services in the executive department or~~ any ~~other~~ state office or agency, and in order to carry out the purposes of this section the commissioner may enter into contracts or agreements with any person, firm, corporation or governmental agency. The commissioner may act as agent for or enter into contracts and otherwise cooperate with the federal government in connection with the provisions of section seven hundred one of the housing act of nineteen hundred fifty-four, as amended, to the extent that such section relates to assistance of urban transportation planning, and as such agent administer any grant or grants for the assistance of urban transportation planning to the state or through the state to its local governing bodies and to regional and metropolitan planning agencies, complying with the provisions of such grants or advances. The department of taxation and finance is hereby designated to accept and receive all grants or advances from the federal government for the purpose of this section. All monies so accepted and received shall be deposited by the department of taxation and finance in a special fund for use exclusively for the purposes for which such grants or advances were made. Payment from the said fund shall be made upon audit and warrant of the comptroller upon vouchers approved by the commissioner. The commissioner is hereby authorized to present any claim to the federal government or any agency or official thereof with respect to the funds made available for the purposes of this section pursuant to section seven hundred one of the housing act of nineteen hundred fifty-four, as amended. ~~Except where urban transportation studies relate primarily to the development of a transportation plan, nothing in this section shall be deemed to limit or restrict the existing powers of the office of planning services to conduct transportation studies or surveys or to perform any other related function as an integral part of such office's planning program under section seven hundred one of the housing act of nineteen hundred fifty-four, as amended.~~

§ 35. Section fifty of such law, as amended by chapter eight hundred twenty-seven of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

§ 50. Statewide transportation planning

Project coordination with statewide transportation plan. Upon review of a proposed municipal project submitted to the commissioner under section forty-nine herein, the commissioner may transmit, within a reasonably prompt time, advisory comments to the Utica transit authority with regard to such project's being a part of or consistent with a statewide comprehensive master plan for transportation promulgated by him and approved by the governor upon the recommendation of the ~~office of~~

~~planning services~~ department of state or, in the absence of any such statewide plan, any other recognized long-range regional transportation plan approved by the commissioner or, in the absence of any such regional plan, sound transportation development policy and planning concept. If the commissioner finds such a project to be in conflict with such statewide plan, regional plan or transportation development policy and planning concept, the Utica transit authority shall before undertaking such project, upon the request of the commissioner, state in writing to the commissioner its reasons for undertaking the project notwithstanding such conflict. In no event, however, shall the Utica transit authority submit to the United States or to the State of New York, or any agency or instrumentality of them, an application for a federal or state project unless the application shall have been first approved by the commissioner as being part of or consistent with such statewide plan, regional plan or transportation development policy and planning concept.

§ 36. Section fifty-one of such law, as amended by chapter eight hundred twenty-seven of the laws of nineteen hundred seventy-two, is hereby amended to read as follows:

§ 51. Comprehensive regional planning

Project coordination with comprehensive regional planning. Prior to undertaking a municipal project, the Utica transit authority shall comply with the provisions of this section.

Where a proposed municipal project is to be located in whole or in part, within the jurisdiction of a multi-county regional planning board which has adopted a regional comprehensive plan, the Utica transit authority proposing such project shall submit a description of the project to such regional planning board. Such regional planning board shall advise the Utica transit authority within fifteen days of the date of such submission as to whether or not the proposed project has a significant regional impact. If the regional planning board determines that the proposed project does not have a significant regional impact, it shall certify that it is not in substantial conflict with the board's regional comprehensive plan. If the proposed project is determined to have a significant regional impact, the regional planning board shall determine, within thirty days from date of the submission of the project description, whether or not it is in substantial conflict with its regional comprehensive plan. In making such determination, the regional planning board may also consider whether the proposed project is properly coordinated with other existing or proposed projects within the region. If the regional planning board determines that such project might be in substantial conflict with its regional comprehensive plan, the regional planning board may issue an order to the Utica transit authority directing that such authority not undertake or continue such project for an additional period of forty-five days immediately following such thirty day period. During such additional forty-five day period, the regional planning board shall further review the project and shall hold a public hearing concerning such project. On or before the conclusion of such forty-five day period and after the public hearing, the regional planning board shall determine whether or not such project is in substantial conflict with its regional comprehensive plan, and report its determination to the Utica transit authority sponsoring such project, to the commissioner of transportation, to any other public agency having the power of review or approval of such project, and in a manner conducive to the wide dissemination of such determinations, to the public. If the regional planning board determines that the proposed project is in substantial conflict with its regional comprehensive plan, the Utica transit authority shall before undertaking such project state in writing to the regional board its reasons for undertaking the project notwithstanding such determination of substantial conflict.

Regional planning boards may adopt rules and regulations establishing standards and procedures, consistent with this section, for the review of projects hereunder, and which may exclude specified kinds of projects from such review. Such procedures may contain provisions allowing for informal discussion of preliminary and informal plans for a project subject to review and for preliminary approval or recommendations by the board with respect to the project. Before adopting such rules and regulations, the regional planning board shall consult with the ~~state office of planning services~~ department of state, which ~~office~~ may make recommendations concerning such standards and procedures.

In the event a proposed project is to be located, in whole or in part, in an area not within the jurisdiction of a multi-county regional planning board which has adopted a comprehensive regional plan, the functions, powers and duties conferred in this section upon such a regional planning board shall apply to the county planning board or boards of any county wherein such project is to be located, in whole or in part, if such county planning board has adopted a comprehensive master plan. In the event there is no such county planning board which had adopted a comprehensive master plan, such functions, powers and duties may be carried out by the ~~state office of planning services~~ department of state.

The regional comprehensive plan referred to under this section shall embody the policy recommendations of the regional planning board for the comprehensive development of the region, and shall include statements of policies, goals and objectives. Before such regional comprehensive plan is adopted by the regional planning board, it shall be certified to by the ~~director of the office of planning services~~ secretary of state as being adequate for the review purposes of this section. The comprehensive master plan of a county referred to under this section shall embody the same elements as herein prescribed with respect to a regional comprehensive plan, and shall similarly be certified to by the ~~director of the office of planning services~~ secretary of state.

§ 37. Section four of chapter four hundred thirteen of the laws of nineteen hundred sixty-five, as re-entitled by chapter three hundred thirty-three of the laws of nineteen hundred seventy-one "An act to provide for an interstate compact with the states of New Jersey and Connecticut to create the tri-state regional planning commission and prescribing the functions, powers and duties thereof and to repeal chapter three hundred sixteen of the laws of nineteen hundred sixty-four, entitled 'An act to provide for an interstate compact with the states of New Jersey and Connecticut to create the tri-state transportation commission and prescribing the functions, powers and duties thereof, relating thereto", as last amended by chapter three hundred thirty-three of the laws of nineteen hundred seventy-one, is hereby amended to read as follows:

§ 4. The five members of the tri-state regional planning commission from this state shall be the chairman of the planning commission of the city of New York, the state commissioner of transportation, the state commissioner of housing and community renewal, the ~~director of the state office of planning services~~ secretary of state and the chairman of the metropolitan transportation authority by virtue of and so long as they shall hold such offices.

§ 38. Subdivision three of section two-a of the public lands law, as added by chapter nine hundred fifty-seven of the laws of nineteen hundred seventy-four, is hereby amended to read as follows:

3. If within thirty days of the giving of such notice, any state agency entitled to notice pursuant to subdivision one hereof objects to the action proposed by the commissioner by filing notice to such effect with the commissioner of general services, such proposed action shall be reviewed by ~~a review committee composed of the secretary to the governor,~~ the director of ~~the division of~~ the budget, and the ~~director of the office of planning services~~ secretary of state. ~~The review committee~~ They shall affirm or reverse the proposed action by the commissioner and ~~its~~ that decision shall be final. If ~~the committee affirms~~ they affirm the proposed action or ~~fails~~ fail to render a determination within six months of the date of the notice referred to in subdivision one, the commissioner may thereupon effect such transfer or declaration of abandonment.

§ 39. Subdivisions four and six of section three of title one of chapter seven hundred seventeen of the laws of nineteen hundred sixty-seven, constituting the transportation capital facilities development act, as amended by chapter one thousand forty-eight of the laws of nineteen hundred seventy-three,* are hereby amended to read as follows:

4. The commissioner is hereby authorized to receive and review such applications and to approve such applications, within the amounts available therefor under the transportation capital facilities bond acts, as are part of or consistent with the statewide comprehensive master plan for transportation. The commissioner shall submit copies of any application so approved to the governor, to the director of the budget and to the ~~office of planning services~~ department of state with such recommendations as he may deem appropriate.

6. The commissioner shall prepare and file with the governor, the director of the budget ~~and with the office of planning services,~~ the secretary of state, the chairman of the assembly ways and means committee and the chairman of the senate finance committee for ~~its~~ their review and evaluation an annual report on the scope and results of construction undertaken pursuant to this act.

§ 40. Subdivisions one, two, three and four of section twelve hundred eighty-two of the public authorities law, subdivisions one, two and three having been amended by chapter seven hundred forty-four of the laws of nineteen hundred seventy and subdivision four having been amended by chapter two hundred eighty-five of the laws of nineteen hundred seventy-one, are hereby amended to read as follows:

1. The "New York state pure waters authority" is hereby reconstituted and continued as the "New York state environmental facilities corporation". Reference in any provision of law, general, special or local, or in any rule, regulation or public document to the New York state pure waters authority shall be deemed to be and construed as a reference to the corporation continued by this section. The corporation shall be a body corporate and politic constituting a public benefit corporation. Its membership shall consist of seven directors: the commissioner of environmental conservation who shall be chairman and chief executive officer of the corporation, the commissioner of health, the ~~commissioner of the office for local government~~ secretary of state, and four directors appointed by the governor by and with the advice and consent of the senate. The directors appointed by the governor who are not state officers, shall serve for terms of six years each, provided, however, that of the directors first appointed, two shall serve for terms of

* Laws 1973, Ch. 1048 was submitted to the voters at the general election of 1973 and failed of passage.

deletions by ~~strikeouts~~

two years, the remaining two for terms of four and six years, respectively, from January first next succeeding their appointment. The appointed members of the New York state pure waters authority in office on the effective date of this act shall be deemed to be directors first appointed in accordance with the foregoing and shall hold office for the balance of the terms for which they were severally appointed. Any vacancy occurring otherwise than by expiration of term shall be filled in the same manner as the original appointment for the balance of the unexpired term. ~~The governor shall appoint a president of the corporation, with the advice and consent of the senate, who shall be chief executive officer of the corporation and who shall serve at the pleasure of the governor. The president may be one of the directors appointed by the governor.~~

2. ~~The president shall be paid the salary prescribed by the corporation for such position.~~ Each director~~, including the president,~~ shall be entitled to reimbursement for his actual and necessary expenses incurred in the performance of his official duties and, except in the case of the commissioner of environmental conservation, the commissioner of health, ~~the commissioner of the office for local government and the president~~ and the secretary of state, a per diem allowance of fifty dollars when rendering service as such director, provided that the aggregate of such per diem allowance to any one director in any one fiscal year of the corporation shall not exceed the sum of twenty-five hundred dollars.

3. Such directors other than the commissioner of environmental conservation, the commissioner of health~~,~~ ~~the commissioner of the office for local government and the president~~ and the secretary of state may engage in private employment, or in a profession or business, subject to the limitation contained in sections seventy-three and seventy-four of the public officers law. The corporation shall, for the purposes of sections seventy-three and seventy-four of the public officers law, be a "state agency," and such directors shall be "officers" of the corporation for the purposes of said sections.

4. Four directors of the corporation shall constitute a quorum for the transaction of any business or the exercise of any power of the corporation. For the transaction of any business or the exercise of any power of the corporation, the corporation shall have power to act by a majority of the directors present at any meeting at which a quorum is in attendance. The corporation may delegate to one or more of its directors, or its officers, agents and employees, such powers and duties as it may deem proper. The commissioner of environmental conservation, the commissioner of health and the ~~commissioner of the office for local government~~ secretary of state may, by official proxy, filed with ~~the president,~~ and approved by the corporation, designate ~~a deputy commissioner or the counsel~~ an officer in their respective department or office, to perform, in their absence, their respective duties under this article. The term "director" as used in this subdivision shall include such persons so designated as provided herein. The designation of such persons shall be deemed temporary only and shall not affect the civil service or retirement rights of any persons so designated.

§ 41. Section eighteen hundred thirty of such law, as added by chapter four hundred forty-three of the laws of nineteen hundred sixty-one, is hereby amended to read as follows:

§ 1830. Cooperation and assistance from other state agencies

The department of commerce, the department of labor, the banking department, the ~~office for local government~~ department of state and all other state agencies shall cooperate with and assist the authority in the

~~fulfilment~~ fulfillment of its corporate purposes and in the exercise of its corporate powers under this title and may render such services to the authority within their respective functions as may be requested by the authority.

§ 42. Subdivisions one, two and three of section twenty-four hundred thirty-three of such law, subdivisions one and two having been amended by chapter seven hundred thirty-seven of the laws of nineteen hundred seventy-three, and subdivision three having been added by chapter nine hundred two of the laws of nineteen hundred seventy-two, are hereby amended to read as follows:

(1) There is hereby created the state of New York municipal bond bank agency. The agency shall be a body corporate and politic constituting a public benefit corporation. Its membership shall consist of seven directors as follows: the comptroller or a director appointed by the comptroller who shall serve until ~~his~~ a successor is appointed, the ~~commissioner of the office for local government~~ secretary of state, the director of the budget, the chairman of the New York state housing finance agency and three directors to be appointed by the governor with the advice and consent of the senate, at least one of whom shall be an elected official of a municipality as defined in this title. The directors first appointed by the governor shall serve for terms ending two, three and four years, respectively, from January first next succeeding their appointment. Their successors shall serve for terms of four years each. Directors shall continue in office until their successors have been appointed and qualified. In the event of a vacancy occurring in the office of a director by death, resignation or otherwise, the governor shall appoint a successor with the advice and consent of the senate to serve for the balance of the unexpired term. Each director appointed by the governor shall be a citizen of the United States and a resident of the state. The chairman of the New York state housing finance agency shall serve as chairman of the agency.

(2) The powers of the agency shall be vested in and exercised by no less than four of the directors then in office. The ~~commissioner of the office for local government~~ secretary of state and the director of the budget, each may appoint a person from their respective office, division or agency to represent such director, respectively, at all meetings of the agency from which such director may be absent. Any such representative so designated shall have the power to attend and to vote at any meeting of the agency from which the director so designating him as a representative is absent with the same force and effect as if the director designating him were present and voting. Such designation shall be by written notice filed with the chairman of the agency by each of the said directors. The designation of such persons shall continue until revoked at any time by written notice to the chairman by the respective director making the designation. Such designation shall not be deemed to limit the power of the appointing director to attend and vote at any meeting of the agency.

(3) The directors shall serve without salary, but each director, except for those who serve ex officio, shall be entitled to reimbursement for his actual and necessary expenses incurred in the performance of his official duties, and, except in the case of the comptroller, the ~~commissioner of the office for local government~~ secretary of state, and the director of the budget, a per diem allowance of one hundred dollars when rendering services as such director, provided that the aggregate of such per diem allowance to any one director in any one fiscal year shall not exceed the sum of five thousand dollars.

§ 43. Subdivision one of section twenty of chapter seven hundred eighty-four of the laws of nineteen hundred fifty-one, constituting the New York state defense emergency act, as amended by chapter fifty-nine of the laws of nineteen hundred seventy, is hereby amended to read as follows:

1. There is hereby created in the executive department of state civil defense commission to consist of the commissioner of transportation, the chairman of the public service commission, the superintendents of banking and insurance, the commissioners of health, education, social services, commerce, agriculture and markets, conservation, housing and community renewal, ~~local government,~~ general services, the industrial commissioner, the chairman of the workmen's compensation board, the director of the division of veterans' affairs, the secretary of state, the superintendent of state police, the chief of staff to the governor, two local directors to be selected by the governor and one additional member, to be appointed by the governor by and with the consent of the senate. The member so appointed by the governor may be the state director. In the event of a vacancy on the commission caused by the resignation, death, or inability to act of the member appointed by the governor, the state director appointed pursuant to this section shall act in place and stead of such member until a successor is appointed. The governor shall designate one of the members of the commission to be the chairman thereof. The commission may provide for its division into subcommittees and for action by such subcommittees with the same force and effect as action by the full commission. The members of the commission, except for those who serve ex officio, shall be allowed their actual and necessary expenses incurred in the performance of their duties under this article but shall receive no additional compensation for services rendered pursuant to this article.

§ 44. Section two hundred nine-e of the general municipal law, as last amended by chapter three hundred fifty-eight of the laws of nineteen hundred sixty-four, is hereby amended to read as follows:

§ 209-e. Fire mobilization and mutual aid plan

~~1. Definitions. As used in this section, the following terms shall mean:~~

~~a. Commissioner. The commissioner of the office for local government in the executive department.~~

~~b. Director. The director of the division of fire safety of the office for local government in the executive department.~~

~~2~~ 1. Plan. The ~~director~~ secretary of state shall prepare a state fire mobilization and mutual aid plan ~~and shall present such plan to the commissioner for approval. Such plan~~ which may provide for the establishment of fire mobilization and mutual aid zones of the state. Upon ~~approval by the commissioner and~~ the filing of the ~~approved~~ plan in the office of the department of state such plan shall become the state fire mobilization and mutual aid plan. Such plan may be amended from time to time in the same manner as originally adopted.

~~3~~ 2. Regional fire administrators. The ~~director, with the approval of the commissioner,~~ secretary of state may appoint and remove a regional fire administrator for each fire mobilization and mutual aid zone established pursuant to the state fire mobilization and mutual aid plan. Before he enters on the duties of the office, each regional fire administrator shall take and subscribe before an officer authorized by law to administer oaths the constitutional oath of office, which shall be administered and certified by the officer taking the same without compensation and shall be filed in the office of the department of state.

~~4~~ 3. Regulations. The ~~director, with the approval of the commissioner,~~ secretary of state may make regulations and issue orders which he may deem necessary to implement the state fire mobilization and mutual aid plan and carry out the purposes of this section.

~~5~~ 4. Powers. Whenever a county, city, town, village or fire district shall request, or whenever the governor shall determine that the public interest so requires, the ~~commissioner and the director~~ secretary of state shall possess and exercise the powers, functions and duties set forth in the state fire mobilization and mutual aid plan.

~~6~~ 5. Standard thread. The state fire mobilization and mutual aid plan shall prescribe a standard hose thread for the state, and each county, city, town, village or fire district not equipped with the same may be required either to recut its threads to such standard or provide adaptors whereby the same may be brought to such standards.

~~7~~ 6. Records. The ~~director~~ secretary of state shall keep a permanent public record of the activations of the state fire mobilization and mutual aid plan, showing how, when and where it was activated and when such activation was terminated.

§ 45. The state fire mobilization and mutual aid plan in force on the effective date of this chapter shall continue in force and effect until amended in the manner provided by section two hundred nine-e of the general municipal law. Any reference in such plan to the division of safety or the bureau of fire mobilization and control; and its chief, acting chief and field representatives shall be deemed to refer to the department of state or a duly authorized subdivision thereof; and the secretary of state or duly appointed representatives.

§ 46. The division of the budget shall operate the state clearinghouse, as the governor may direct, for such project or plan proposals and the coordination thereof as may be required to facilitate review of such project or plan proposals by agencies of the state or federal governments.

§ 47. 1. The secretary of state shall administer the state's coastal zone management program, and is hereby designated as the single state agency for the receipt and administration of federal grants pursuant to the federal coastal zone management act of nineteen hundred seventy-two, and any federal laws amendatory or supplemental to such act heretofore or hereafter enacted; to apply for, accept, and expend funds made available by the federal government in connection therewith; and to enter into any necessary contracts or compacts pursuant to such federal acts.

2. The department of taxation and finance is hereby designated to accept and receive all grants and advances from the federal government pursuant to the provisions of the federal coastal zone management act of nineteen hundred seventy-two, as such act may be amended from time to time, which are provided for the purposes specified in subdivision one of this section and all moneys so accepted and received shall be deposited by the department of taxation and finance in a special fund for use exclusively for the purposes for which such grants or advances were made. Payment from such special fund shall be made upon audit and warrant of the comptroller upon vouchers approved by the commissioner.

§ 48. Whenever the office of planning services or the director thereof is referred to or designated in any general, special or local law or in any rule, regulation, executive order, contract or other document, such reference or designation shall be deemed to refer to the department of state or the secretary of state, respectively, and whenever the office for local government or the commissioner for local government is referred to or designated in any general, special or local law or in any rule, regulation, executive order, contract or other document, such reference or designation shall be deemed to refer to the department of state or the secretary of state, respectively.

§ 49. No existing right or remedy of any character shall be lost, impaired or affected by reason of this act.

§ 50. For the purpose of succession all functions, powers, duties, rights and obligations transferred and assigned to, devolved upon and assumed by the department of state and the secretary of state pursuant to this act, the department of state shall be deemed and held to constitute the continuation of the office of planning services and the office for local government, and not a different agency or authority.

§ 51. The office for local goverment and the commissioner for local government, and the office of planning services and the director thereof, shall, with respect to the functions, powers, duties, rights and obligations which are transferred to the department of state by this act, deliver to the secretary of state all books, papers, records and property of their respective offices pertaining to such transferred functions, powers, duties, rights and obligations.

§ 52. Any business or other matter undertaken or commenced by the office for local government or the office of planning services pertaining to or connected with the functions, powers, duties, rights and obligations hereby transferred and assigned to the department of state and pending on the effective date of this act, may be conducted and completed by the department of state in the same manner and under the same terms and conditions and with the same effect as if conducted and completed by the office of planning services or the office for local government.

§ 53. All rules, regulations, acts, determinations and decisions of the office of planning services and the director thereof, or the office for local government and the commissioner thereof, pertaining to the functions herein transferred and assigned, in force at the time of such transfer, assignment, assumption or devolution, shall continue in force and effect as rules, regulations, acts, determinations and decisions of the department of state until duly modified or abrogated by the secretary of state.

§ 54. Upon the transfer of functions, powers and duties to the department of state and the division of the budget, pursuant to this act, provision may be made for the transfer to the department of state and the division of the budget of such officers and employees of the office of planning services and the office for local government as the secretary of state and the director of the budget may deem necessary for the exercise of those functions, powers and duties. Officers and employees so transferred shall be transferred without further examination or qualification and shall retain their respective civil service classification and status. For the purpose of determining the employees holding permanent appointment in competitive class positions to be transferred, such employees shall be selected within each class of positions in the order of their original appointment, with due regard to the right of preference in retention of disabled and nondisabled veterans. Any such employee who, at the time of such transfer, has a temporary or provisional appointment shall be transferred subject to the same right of removal, examination or termination as though such transfer had not been made. Employees holding permanent appointments in competitive class positions who are not transferred pursuant to this section shall have their names entered upon an appropriate preferred list for reinstatement pursuant to the civil service law.

§ 55. All appropriations or reappropriations to the office for local government and the office of planning services to the extent of remaining unexpended or unencumbered balances thereof, whether allocated or unallocated, are hereby transferred to and made available for use and expenditure by the department of state and any federal moneys advanced to the office of planning services or the office for local government, to the extent of remaining unexpended or unencumbered balances thereof, whether allocated or unallocated, are hereby transferred to and made available for use and expenditure by the agency or department of the state which is assigned by law or gubernatorial designation the function for which the federal moneys are advanced. The use or expenditure of all funds transferred in accordance with this section are subject to the approval of the director of the division of the budget for the same purposes for which originally appropriated and shall be payable on vouchers certified or approved by the secretary of state on audit and warrant of the comptroller.

§ 56. Separability. If any part of this act shall be adjudged invalid, unconstitutional or ineffective by any court of competent jurisdiction, such judgment shall not invalidate the remainder thereof, but shall be confined in its operation to the part directly involved in the controversy wherein such judgment shall have been rendered.

§ 57. This act shall take effect immediately and shall have retroactive application to April first, nineteen hundred and seventy-five with respect to all actions taken by the office for local government, office of planning services, department of state, division of the budget and department of civil service in connection with the transfer of functions, termination of employees, transfer of employees, certification of payrolls, execution of contracts and such other actions relating thereto.

Note.—Article 19-E of the Executive Law pertaining to the creation of the Office for Local Government, Article 26 of the Executive Law pertaining to the creation of the Office of Planning Services, and Article 16 of the Executive Law pertaining to fire safety functions of the Office for Local Government are repealed by this bill. Essential local services provided by these agencies will be transferred to the Department of State.

Haverstraw, Town of—Sewer Tax Warrant

CHAPTER 465

An Act authorizing the amendment of the sewer tax warrant due January first, nineteen hundred seventy-five for the town of Haverstraw for taxes for sewer district number one of such town.

Approved and effective July 24, 1975.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. Notwithstanding any error in the tax warrants issued for sewer taxes for sewer district number one of the town of Haverstraw, due January first, nineteen hundred seventy-five and more particularly the failure to include the real property of the village of Pomona in such warrants, the town of Haverstraw is hereby authorized to issue amended warrants to include real property of the village of

S-36

94th Congress } JOINT COMMITTEE PRINT
1st Session }

TOWARDS PROJECT INTERDEPENDENCE: ENERGY IN THE COMING DECADE

PREPARED FOR THE

JOINT COMMITTEE ON ATOMIC ENERGY
UNITED STATES CONGRESS

BY

Dr. Herman T. Franssen
OCEAN AND COASTAL RESOURCES PROJECT
CONGRESSIONAL RESEARCH SERVICE
LIBRARY OF CONGRESS

DECEMBER 1975

Printed for the use of the Joint Committee on Atomic Energy

94th Congress }
1st Session } JOINT COMMITTEE PRINT

TOWARDS PROJECT INTERDEPENDENCE: ENERGY IN THE COMING DECADE

PREPARED FOR THE

JOINT COMMITTEE ON ATOMIC ENERGY
UNITED STATES CONGRESS

BY

DR. HERMAN T. FRANSSEN
OCEAN AND COASTAL RESOURCES PROJECT
CONGRESSIONAL RESEARCH SERVICE
LIBRARY OF CONGRESS

DECEMBER 1975

Printed for the use of the Joint Committee on Atomic Energy

U.S. GOVERNMENT PRINTING OFFICE
61-173 WASHINGTON : 1975

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $2.55

JOINT COMMITTEE ON ATOMIC ENERGY

JOHN O. PASTORE, Rhode Island, *Chairman*
MELVIN PRICE, Illinois, *Vice Chairman*

SENATE	HOUSE OF REPRESENTATIVES
HENRY M. JACKSON, Washington	JOHN YOUNG, Texas
STUART SYMINGTON, Missouri	TENO RONCALIO, Wyoming
JOSEPH M. MONTOYA, New Mexico	MIKE McCORMACK, Washington
JOHN V. TUNNEY, California	JOHN E. MOSS, California
HOWARD H. BAKER, Jr., Tennessee	JOHN B. ANDERSON, Illinois
CLIFFORD P. CASE, New Jersey	MANUEL LUJAN, Jr., New Mexico
JAMES B. PEARSON, Kansas	FRANK HORTON, New York
JAMES L. BUCKLEY, New York	ANDREW J. HINSHAW, California

GEORGE F. MURPHY, Jr., *Executive Director*
JAMES B. GRAHAM, *Assistant Director*
ALBION W. KNIGHT, Jr., *Professional Staff Member*
WILLIAM C. PARLER, *Committee Counsel*
JAMES K. ASSELSTINE, *Assistant Counsel*
NORMAN P. KLUG, *Technical Consultant*
STEPHEN J. LANES, *Technical Consultant*
CHRISTOPHER C. O'MALLEY, *Printing Editor*

LETTER OF TRANSMITTAL

UNITED STATES SENATE,
Washington, D.C., December 16, 1975.

Hon. JOHN O. PASTORE,
Chairman, Joint Committee on Atomic Energy,
U.S. Congress, Washington, D.C.

DEAR MR. CHAIRMAN: Dr. Herman Franssen, Analyst in Science and Technology at the Library of Congress, has prepared at my request a report entitled, "Towards Project Interdependence: Energy in the Coming Decade." I believe the report to be of significant importance. I think that it should be of great interest not only to the Joint Committee on Atomic Energy, but to the Congress and the public as well.

While I am not prepared to certify the validity of all the conclusions reached by Dr. Franssen nor necessarily the priorities and emphases he describes, nevertheless, I believe that the report is important and would be a worthwhile publication by the Joint Committee. I request that it be authorized for printing as a Comittee document.

Sincerely,

HOWARD H. BAKER. Jr.

LETTER OF SUBMITTAL

THE LIBRARY OF CONGRESS,
CONGRESSIONAL RESEARCH SERVICE,
Washington, D.C., September 29, 1975.

Hon. HOWARD H. BAKER, Jr.,
Joint Committee on Atomic Energy,
U.S. Congress,
Washington, D.C.

DEAR MR. BAKER: In response to your request, we are submitting a study on United States domestic energy demand and supply and dependence on foreign oil imports for the decade from 1975 until 1985. The study is entitled: "Toward Project Interdependence: Energy in the Coming Decade."

The report includes analyses of the relationship between energy inputs and economic growth; oil and natural gas reserves, and production projections of fossil fuels, nuclear power, and synthetic fuels; world supply and demand for oil; and, projections of foreign oil imports into the United States between 1975 and 1985.

The work was done by Dr. Herman T. Franssen, Analyst in Science and Technology of our Ocean Coastal Resources Proiect.

We hope that this study will serve the needs of the Joint Committee on Atomic Energy as well as those of other committees and Members of Congress.

Sincerely,

NORMAN BECKMAN,
Acting Director, Congressional Research Service.

FINDINGS

1. Short of draconian measures to be taken by the executive and legislative branches of Government. "Project Independence" goals now seem unattainable. For a variety of reasons the contributions of coal and nuclear power—the only viable alternatives to petroleum during the next decade—are expected to fall considerably short of earlier estimates made by FEA and other executive agencies for the next ten years.

2. Assuming an early decision to decontrol the price of old oil, the decline in oil production of recent years may have reversed itself by 1977. With Alaskan oil expected to come on stream in the fall of 1977, total production will probably rise again until a final production peak will be reached during the late 1980's or early 1990's. Decontrol of domestic "old" oil may add up to 0.3 million b/d over a period of a year or more.

3. Natural gas production is likely to continue its rather rapid decline until the early 1980's when a gas pipeline may be completed in Alaska. Continuation of the peak 1973 production level would require a "Prudhoe Bay" type discovery every year between now and 1985.

4. Geothermal energy, solar energy and other unconventional sources of energy are not likely to make a major contribution to U.S. domestic energy supply during the next ten years.

5. In view of the substantial lead-times for development of oil and gas from frontier areas in Alaska and the OCS, major contributions from areas not yet leased for development cannot be expected until sometime after the early 1980's.

6. Under the assumption that energy growth rates of 2.8 to 3.1 percent per year are among the most reasonable estimates for the next ten years, this study projects an energy shortfall of between 9.0 and 9.2 million b/d (oil equivalent) in 1977; between 10.0 and 10.6 million b/d in 1980, and between 9.0 and 10.4 million b/d by 1985.

7. The contribution of imported petroleum from Western Hemisphere sources has declined during the past decade. In view of Canada's official policy to phase out petroleum exports to the U.S., and Venezuelan conservation policy, Western Hemisphere oil exports are likely to decrease further even in absolute terms. Any additional oil imports to the U.S. will have to come from the Eastern Hemisphere.

8. While West African and South East Asian oil exports to the U.S. are expected to continue to rise, most of the increased demand for Eastern Hemisphere oil will have to be satisfied by shipments from the Middle East and North Africa.

9. United States dependence on oil from the Middle East and North Africa is projected to rise from 1.3 million b/d in 1974 to between 4.5 and 4.7 million b/d in 1977, between 5.1 and 5.7 million b/d in 1980, and between 3.8 and 5.2 million b/d by 1985. Out of this total, between

3.7 and 3.9 million b/d in 1977, between 4.1 and 4.7 million b/d in 1980 and between 2.9 and 4.2 million b/d in 1985 would have to be supplied by Arab nations.

10. In view of conservation measures adopted by a number of Arab nations, a significant portion of Arab imports may have to come from countries with low-populations and limited capital absorptive capacity such as Saudi Arabia and the United Arab Emirates. Depending on oil demands of Japan, Western Europe and the rest of the world, there may be some uncertainty about availability of Arab oil in quantities significantly above and beyond the 1973–74 production level. If, as some sources indicate, the Soviet bloc is forced to meet projected energy shortfalls by 1980–1985 by importing considerable quantities of oil from the Middle East, the U.S. and world oil-supply picture will become even more clouded.

11. In spite of recent large oil discoveries in the North Sea, Alaska and Mexico, none is comparable in size to the Middle East, at least not in the non-communist world. It is possible that Siberia may become another Middle East size oil producer, but the U.S.S.R. does not now have the capital and technology to develop those petroleum resources in large volumes.

12. Among the many consequences of heavy reliance on imported oil are:

[A] An Arab oil embargo in 1977 could result in a GNP loss in the U.S. of $39 to $56 billion, and additional unemployment of 1 to 1.5 million, if the embargo were to last six months.

[B] The already low ratio of oil shipped in domestic U.S. flag tankers would drop further.

[C] Possible price increases of OPEC oil when total demand rises beyond 1973–74 OPEC production levels, and potential conflict among consumer nations over available supplies.

[D] Potential national security problems related to defense of the supply lines from the Middle East to the U.S.

[E] Ability to pay for additional oil imports will need to be reexamined.

[F] Increased possibility of environmental damage in the coastal zone as more oil must be shipped in small tankers to U.S. ports.

[G] Increased reliance on foreign oil could affect the nation's leverage in foreign policy. Energy may become the "Achilles heel" of U.S. foreign policy in the same way as agricultural shortages are for the Soviet Union.

13. In view of the recent lower estimates of ultimately recoverable oil and gas resources in the United States, maximizing coal utilization and nuclear power would significantly reduce dependence on foreign imports of oil by 1985 and beyond.

EXECUTIVE SUMMARY

PROJECT INDEPENDENCE

Almost exactly a year ago, in November 1974, the Federal Energy Administration released Project Independence Blueprint (PIB) to the Nation. It held out prospects that the Nation could achieve energy independence by 1985, provided the price of domestic oil would be allowed to rise to $11 per barrel and the Government would initiate an accelerated leasing schedule in the Atlantic and Pacific OCS and tap the potential resources of the Naval Petroleum Reserves.

Under the PIB energy supply base case, little could be done to prevent further deterioration of the domestic energy supply situation until 1977, when Alaskan oil is expected to come on stream. At a price of $7 per barrel, domestic oil supply would be about 8.9 million b/d, and at $11 per barrel, domestic supply would increase to 12.8 million b/d. Optimistic analysis of the contribution of coal, nuclear energy, natural gas and other energy sources, led PIB to conclude that even without major efforts to increase oil and gas production from offshore areas, imports of oil could be limited to 3.3 million b/d, or about one-half of the current volume of imports, by 1985.

An accelerated domestic supply scenario called for additional leasing of OCS lands off the Atlantic and Pacific coasts, and tapping of Naval Petroleum Reserves. At a price of $7 per barrel, the Nation would produce between 8.9 and 12.8 million b/d, and at $11 per barrel domestic production could reach as much as 17.0 million b/d. If 17.0 million b/d would be produced, the Nation could not only eliminate foreign imports, but in fact produce a surplus for the export market. Shale oil was expected to add another one million b/d to domestic supplies.

Natural gas was projected at 24.8 TCF under the PIB energy supply base case, and 825.5 TCF under the accelerated leasing program. Estimates for coal ran between 900 million and 2.1 billion metric tons, and nuclear energy was projected to contribute between 204 and 275 GWe, depending on assumptions made.

On the demand side, PIB assumed that the United States can have a real increase in GNP of 5% annually with an energy demand of 2.5% annually beginning now.

CRS REPORT

On the demand side this study disagrees with the contention that a GNP growth rate of 5 percent annually can be achieved with a 2.5 percent energy growth per year. In the past growth rates have been closely related to fluctuations in the GNP. For example, during the 1929–33 depression, when the decline in industrial production was severest of any period in the history of the Nation, energy consumption fell substantially. When the economy improved again, energy consumption followed a similar pattern. The same close relationship between GNP and energy growth rates was noticeable during each one of the post-war recessions.

Given time, institutional change, and sufficient investment in research and development programs, energy consumption per unit of GNP can possibly be reduced considerably. However, it seems highly unlikely that the PIB conservation scenario can be achieved by 1985 without harming the economy and/or causing a substantial adverse impact on our lifestyles.

It is impossible to forecast economic growth rates for the next ten years with any degree of accuracy, and consequently accurate energy growth rates cannot be projected. Assuming the possibility of high, low and medium economic growth rates over the period 1975–85, and the probability of some successful energy conservation measures without dramatically altering our lifestyles or limiting GNP growth rates to socially undesirable levels, this study assumes energy growth rates ranging from 2.0 to 4.0 percent. Most observers tend to agree that 4 percent growth rates would be close to recent experiences prior to the 1973 Arab oil embargo, which are not likely to reoccur in view of Arab supply constraints, high prices, and current projections of sustainable GNP growth rates. While a number of recent studies have concluded that sound GNP growth rates of 4 percent or more can be achieved with energy growth rates of no more than 2 percent, there is currently no evidence that such a large reduction in energy growth rates can be achieved without doing great damage to the economy or drastically changing lifestyles. Energy growth rates of 2.8 to 3.1 percent per year for the next decade seem more probable. These growth rates assume acceptable levels of economic growth of between 3.0 to 3.5 percent, and some success in the country's efforts to decouple energy growth from GNP growth rates. At the projected energy growth rates, energy demand will be:

[In millions b/d oil equivalent]
[In percent]

	Energy growth rates scenarios for 1977, 1980, 1985					
	2.0	2.5	2.8	3.1	3.5	4.0
1977	37.6	38.0	38.3	38.5	38.8	39.1
1980	39.9	40.9	41.6	42.2	43.0	44.0
1985	44.0	46.3	47.7	49.1	51.0	54.0

Domestic Supply of Energy

The following domestic energy supply scenario has been projected for the 1975–1985 period:

[In millions of barrels per day oil equivalent]

Source	1973	1977	1980	1985
Oil (including natural gas liquids)	10.1	[1] 10.0	11.0	12.0
Natural gas	10.6	8.9	8.0	8.9
Coal	6.4	7.4	8.2	9.7
Nuclear energy	.4	1.6	2.4	2.8
Hydropower and synthetics	1.4	1.4	2.0	2.8
Total domestic supply	28.9	29.3	31.6	38.7

[1] Assumes complete decontrol of oil.

Without decontrol of oil, production is expected to continue to decrease to 9.5 million b/d by 1977. After 1977 production will rise again due to availability of Alaskan oil. Natural gas production has been projected to continue to decline at least until the early 1980's, when Alaskan gas (and possibly some synthetic gas) will come on stream. Projections for 1985 are cautiously optimistic, especially for oil and nuclear energy. It assumes no further cancellations of nuclear plants between 1975 and 1985, and successful discovery and early production of OCS oil from new leases in the Gulf of Mexico and many of the most promising frontier areas. Finally, the 1985 domestic supply scenario assumes that the oil equivalent of 1 million b/d of synthetic fuels (syncrude, syngas, and shale oil) will be marketed.

Any difference between domestic supply and demand must be made up by importing additional liquid hydrocarbons, especially oil, the "swing fuel" *par excellence*. It is uncertain if any natural gas will still be supplied by Canada by 1985, and the volume of liquid natural gas (LNG) from Algeria and other foreign countries cannot be projected at this time due to a number of uncertainties. The price of imported LNG and dry natural gas is likely to be close to the world market oil equivalent price.

Any attempts to arbitrarily slice foreign oil imports will most probably result in higher unemployment, lowering of the GNP, and a great deal of discomfort for the American people. Assuming annual energy growth rates of 2.8 to 3.1 percent, oil and gas imports will rise rapidly until 1977. By the end of 1977 some 600,000 b/d of Alaskan oil is expected to be produced. Between 1977 and 1980 imports are likely to grow, but at a much slower pace, until the early 1980's when foreign oil imports could reach their highest level. If, however, the cautiously optimistic domestic supply scenario for 1985 cannot be attained due to additional shortfalls in one or more sources of domestic energy supply, imports could very well continue to grow with no end in sight.

PETROLEUM IMPORTS: 1977, 1980, 1985

[In millions of barrels per day oil equivalent]

Year	2.8 percent energy growth per year	3.1 percent energy growth per year
1977	9.0	9.2
1980	10.0	10.6
1985	9.0	10.4

Sources of Supply

U.S. imports of oil have gradually grown from 0.9 million b/d (13 percent of consumption) in 1950 to 6.0 million b/d (37 percent of consumption) in 1974. Natural gas imports have remained relatively small at less than 5 percent of domestic consumption. Whereas almost all imported natural gas comes from Canada, oil imports for years have come from more than 20 countries around the world. Until recent years, however, more than half of the foreign oil was obtained from "secure" sources in the Western Hemisphere, in particular from Canada and Venezuela. In view of domestic supply problems in Canada and Venezuela, oil imports from traditional Western Hemisphere suppliers will decline significantly within the next few years. This fact, coupled with projected increased future demand for foreign oil, will make the United States much more dependent on Eastern Hemisphere oil. *A careful analysis of current worldwide oil reserves leads to the inevitable conclusion that the U.S. will become highly dependent on oil from the Middle East and North Africa during the coming decade.*

DEMAND BALANCED SCENARIO OF U.S. PETROLEUM IMPORTS, BY REGION, FOR 1977, 1980, 1985.

[In thousands of barrels per day]

	1974	1977	1980	1985
Western Hemisphere:				
Canada	1,083	400	140	0
Venezuela	1,178	1,100	1,000	1,000
Other Western Hemisphere	865	1,160	1,500	1,700
Total, Western Hemisphere (oil)	3,126	2,660	2,640	2,700
Canadian natural gas: Optimistic forecast (in thousands of barrels per day oil equivalent)	450	450	450	450
Total, Western Hemisphere (oil and gas)	3,576	3,110	3,090	3,150
Eastern Hemisphere:				
Nigeria	701	800	1,000	1,000
Other Africa south of Sahara	81	120	225	325
Southeast Asia	320	430	560	700
Middle East and North Africa:				
Iran	519	800	1,000	900–1,000
Arab countries	976	3,740–3,940	4,125–4,725	2,925–4,225

Imports from the Middle East and North Africa, which amounted to slightly less than 20 percent of total imports in 1974, will probably grow to 50 percent or more just two years from now. The implications of this new reality are manifold, and include:

1. The possibility of yet another Arab oil embargo, or a reduction of available oil for export, if peace does not come to the Middle East soon. The Sinai agreement may be a first step in the right direction, but it is only a partial solution to a multi-faceted problem, calling for successful negotiations with a number of interested parties other than Egypt and Israel.

2. An oil embargo in 1977 could result in a GNP loss of $39 to $56 billion, and additional unemployment of 1 to 1.5 million, if the embargo were to last for six months. A domestic economic disaster of such proportions would most certainly spread to Western Europe and Japan, even if those nations would not become targets of another oil embargo. Hopes for major economic recovery from the current worldwide recession would be dashed under these circumstances.

3. The ever larger volume of foreign oil would have to be shipped—at least for some years to come—in foreign bottoms. The already low ratio of oil shipped in domestic tankers (less than one-fifth of total imports) would drop even further.

4. Growing dependence of the United States on Middle Eastern oil would tempt the oil cartel to raise prices as soon as the current surplus capacity begins to dry up. At some point in the not too distant future, the United States may have to compete for available supplies with its allies and other oil-importing countries. Tension among oil importing states would increase if several of the major oil producers decided in favor of lowering production to stretch available reserves. Many oil producing nations in the Middle East and North Africa, especially those countries with low populations and limited capital-absorptive capacity such as Saudi Arabia, are in a position to reduce oil output substantially without suffering any adverse impact on their domestic economies.

5. Potential national security problems related to the defense of vital supply lines from the Middle East to the United States. Strategic planners remember too well that U.S. success in denying the Japanese access to their raw material suppliers on the continent of Asia shortened the Second World War significantly. Soviet efforts to obtain bases in East Africa and possibly Angola are no coincidence.

6. Potential environmental damage to the coastal zone as more small tankers will crowd available port facilities.

7. Increased reliance on foreign oil could affect the nation's leverage in foreign policy. Energy may well become the "Achilles heel" of United States foreign policy in the same way as agricultural shortages are for the U.S.S.R.

Middle East Dependence Inevitable?

The Middle East produces about 37 percent of the world's oil, consumes only 2 percent, and controls 70 percent of the oil export markets. While both Western Europe and Japan have been highly dependent on Middle Eastern oil for several decades, the United States has only in recent years entered the era of dependence on oil imports from that part of the world. Rather than limiting their dependence on Middle East oil, there is sufficient evidence to state that the three industrial giants together will not only remain dependent, but will in fact increase their dependence on Middle East oil.

Much has been said about energy self-sufficiency in the Western world, but Melvin Conant, Deputy Director of the FEA for International Relations has recently said that even if major discoveries equivalent to the North Sea and North Slope finds were made now, we could not expect their coming into the world market on a scale of any importance for five or even ten years. In order to make a significant dent in the role of the Middle East as a supplier of oil, we would have to find this much oil every year, according to Conant. Over the past 35 years, if one excludes the Middle East and Nigeria, the non-Communist world has not even approached that figure in terms of annual average rates of discovery. In fact, despite the North Sea and North Slope finds, our annual rate of discovery outside the Middle East has only been about 50 percent of our yearly oil consumption level.

Moreover, in view of recent pessimistic U.S.G.S. and industry estimates of remaining undiscovered recoverable oil and gas resources in the United States, and less than optimistic forecasts of worldwide ultimate recoverable petroleum resources outside the Middle East and the Communist world, it seems realistic to maintain that dependence on Middle East oil will continue until the industrial world has found and produced adequate new alternative sources of energy.

Temporary OPEC oil surpluses and successful oil discoveries in the North Sea should not blind us to the realities of the world. The current OPEC surpluses are primarily due to a major recession in the entire industrial world, which was only in part caused by the quadrupling of the price of oil. The United States is well on its way toward economic recovery, Japan is following, and Western Europe is expected to start its recovery early next year. Economic recovery in the industrial world will once again stimulate demand for oil.

The rate of increase of demand for OPEC oil is likely to be slower than during the 1960's and early 1970's for a number of reasons. In the first place, the higher prices of oil are likely to continue to have a downward effect on demand. Secondly, most economic forecasters project GNP growth rates for the remainder of the 1970's to be lower than those during the pre-embargo "boom" years. Thirdly, the United Kingdom will become energy independent by the early 1980's, and Norway will become an exporter of oil. The availability of North Sea oil will probably stabilize Western European demand for Middle East oil until the early 1980's. Japanese demand for Middle East oil will continue to rise, but some of the increased demand will be met by oil imports from the People's Republic of China. The United States is the only major industrial power whose dependence on Middle East oil will grow dramatically over the next decade.

Constraints on Supply and Possible Solutions

During the decade of the 1960's and early 1970's the industrial nations relied on the Middle East and North Africa to supply the difference between non-Communist world demand for oil and supply from areas other than the Middle East and North Africa. At the lower pre-1973 prices of oil the oil producing nations of the Middle East and North Africa have indeed met growing world demand by continuing to increase supplies. The new high world market prices of oil, however, have added a new dimension, making it much more difficult to forecast oil supplies for the decade ahead. Some countries with ample reserves, large populations, ambitious development plans and subsequent large capital absorptive capacity, are indeed likely to continue to increase, or at least stabilize oil production at pre-embargo levels. Iran and Iraq are among those countries. Several other countries around the Arab Gulf have low populations and limited capital absorptive capacity. Among those countries are Saudi Arabia, the United Arab Emirates, and Kuwait. At the new high prices of oil some of these nations need produce only a fraction of their physical capacity to meet domestic economic development and military needs. Saudi Arabia, for example, might be able to meet all domestic economic development and military requirements by producing slightly more than one-third of current physical capacity. Some of the Arab Gulf countries have already initiated policies to conserve domestic resources by setting a limit on annual production. Kuwait was the first nation to do so, but several others are contemplating a similar oil conservation policy. It serves a dual purpose of maintaining high world-market prices for the commodity, while conserving precious fossil fuels for the future.

If John Moody and other well-known geologists prove correct, world oil production might peak in the late 1980's or early 1990's. It seems questionable at this time that the industrial nations by then will have succeeded in producing sufficient alternative sources of energy to replace dwindling world oil production. Hence, a policy of conserving oil for future, leaner years, may in the end prove more profitable. The alternative, maximizing production now, would have the effect of lowering the world market price, and providing the oil producers with low populations and limited capital absorptive capacity (primarily around the Arab Gulf) with enormous amounts of foreign exchange to be invested in the industrial world. Are they willing to supply the industrial world with the oil they need during the period of transition from a basically fossil fuel economy to an economy based on other sources of energy, and if so, under what conditions?

So far, Saudi Arabia, the smaller Gulf states and other countries in the above category have been willing to run substantial surpluses on their trade balances, and have put their money primarily in short-term investments in the West. The nations of the Middle East are aware that a serious worldwide oil shortage will pay havoc with the economies of the industrial world, and they have no desire to see this happen. The nations of the Middle East are in the midst of ambitious economic development plans, which will increase the degree of interdependence between them and the industrial world. The industrial countries on the other hand, should work together in removing some of the most obvious obstacles to closer cooperation between Middle East oil producers and oil consuming nations. Among the more important steps to be taken by the industrial nations are:

(a). Assistance in bringing about an early solution to the Arab-Israeli conflict along the lines proposed by moderate elements on both sides;

(b). Efforts to remove Arab fears that their direct investments will in fact serve as hostage capital, limiting Arab leverage in determining oil production levels. Oil consuming nations could do much in creating new international arrangements and guaranteees of foreign investment, designed to reduce politically inspired uncertainties.

(c). Agree to assist oil producing states in their modernization process, which will require massive transfers of technology to those countries. Modernization and industrialization of oil producing states will inevitably result in growing interdependence of oil producing and consuming nations. The former will in due time become major suppliers of refined oil products, petro-chemicals, and a great many energy-intensive products to the industrial world. The latter in turn will find a growing market for advanced technology products.

Facing growing dependence on imported oil for at least one more decade, the industrial nations can hardly afford a policy of confrontation with the producing nations. Instead, they should maintain as harmonious relationships as possible with the oil producing states and work to limit external disturbances which could threaten the security of oil supplies to the industrial world. The producers, on the other hand, need to understand that nations aspiring rapid economic development have a stake in the peaceful and orderly development of the oil industry and in the maintenance of a viable economy in the consumer nations. Consumers and producers of oil can no longer afford to go separate ways. All nations need to work together to resolve problems which affect all countries in an era of growing global interdependence.

CONTENTS

61-173 O - 75 - 2

TABLES

FIGURES

APPENDIXES

States.[2] This is particularly interesting in view of the fact that "historic" energy growth rates were projected. Historic energy growth rates are substantially higher than growth rates projected in the more current post-oil-embargo era.

TABLE 1.—FORECASTS OF U.S. TOTAL ENERGY CONSUMPTION

[In trillions of Btu's]

Source document	Base years	Base value	1970	1975	1980	1985	1990	2000
AEC, 1960	1953	41, 000		73, 000	86, 200			170, 000
SICC, 1962	1961	44, 064			[1] 82, 000			
BOM, 1962	1947 to 1962	33, 168 47, 897			85, 934			
NAS, 1962	1907 to 1960	14, 600 44, 900			[2] 61, 000 (min)			
RFF, 1963	1960	45, 250	60, 190		79, 200			135, 200
AMS, 1966 [3]	1960	48, 200			[2] 90, 300 [2] (99, 700)			174, 000 (213, 000)
SC, 1967	1960 to 1965	41, 453 50, 314	[4,5] 60, 827	[4,5] 74, 944	[4,5] 93, 374	[4,5] 118, 126		
BOM, 1968	1947 to 1965	33, 168 53, 791	64, 276	75, 605	88, 075 [2,4] 83, 900			168, 600 [4] 158, 951
CMB, 1968	1950 to 1965				[6] 97, 000			
OOG, 1968	1965	54, 000			88, 100			
TETC, 1968	1947 to 1965	30, 838 52, 350	[5] 64, 444	[5] 79, 611	[5] 97, 825	[5] 119, 597		
RRNA, 1968	1948 to 1965	54, 000			[2,4] 91, 000			[4] 155, 000
SRI, 1970	1950 to 1968	20, 152		[7] 47, 242	[2,7] 57, 589			
WEM, 1970	1947 to 1969	33, 168 66, 055			95, 145		134, 687	168, 600
EBAS, 1970	1967 to 1968	59, 135 62, 143	68, 200	83, 100	100, 000	120, 000		
RFF, 1971	1900 to 1969	9, 587 66, 055			95, 145		134, 687	190, 014
BOM, 1971	1947 to 1968	33, 168 62, 424						[8] 165, 991 –239, 109
NPC, 1971	1960 to 1970	44, 602 67, 827	67, 827	83, 481	102, 581	124, 942		
FPC, 1971	1970	68, 800	68, 800		105, 000		143, 000	
DOI, 1971				[9] 84, 800	[9] 103, 500	[9] 127, 700		
RRFF, 1971					[10] 90, 900			
PIRF, 1971				86, 200	105, 300	128, 500		
FBD, 1971					110, 000		195, 000	337, 000
MOC, 1971					[11] 101, 600			

[1] Consensus of 11 forecasts.
[2] Excluded from graph of total energy consumption forecasts given on following page.
[3] GNP growth rate of 3.5 percent per year and (4 percent per year).
[4] Excludes nonfuel uses.
[5] Hydro accounted for at kilowatt-hour energy equivalent.
[6] Converting their 17,000,000,000 barrels of oil equivalent to Btu at 5,800,000 Btu/barrel.
[7] Stationary sources only, excludes energy in transport.
[8] Range based on alternative contingencies of energy use.
[9] Mean value of several forecasts.
[10] Converting metric tons of oil at 0 039685 quadrillion Btu/ton.
[11] Converting barrels of oil at 5,800,000 Btu/barrel.

Source: "Energy 'Demand Studies', An Analysis and Appraisal," op. cit.

With the exception of the NAS, AMS, BOM, RRNA, and SRI forecasts which differ significantly from the other total energy forecast items in terms of energy uses (e.g. BOM excludes nonfuel uses), there are 19 estimates for total energy consumption in the year 1980,

[2] U.S. House of Representatives. Committee on Interior and Insular Affairs. *Energy "Demand" Studies, An Analysis and Appraisal.* 92d Congress, 2d session. Washington, D.C., Government Printing Office, 1972. *See also* table 1.

with a mean of 95,100 trillion Btu's. Fourteen of these forecasts fall within a range of about 10 percent of their mean, and all 19 fall well within a range of about 20 percent of their mean. A distinct upward revision trend in forecast values is seen for the later projections. These studies reflect the very rapid energy growth rates in the U.S. in the period 1965–1973.

The majority of the pre-embargo studies based their predictions on the following assumptions: gradual technological change, constant relative fuel prices, no major changes in government policy, unrestricted fuel availability, only moderate swings in the business cycle, and energy consumption for defense at cold war levels.[3] Forecasts of U.S. petroleum consumption were usually based on an assumption that imports would automatically fill any gap which should arise between projections of oil consumption and future domestic oil production. Annual population growth rates were most commonly assumed to be between 1.3 and 1.6 percent, and the median, commonly assumed economic growth rate was 4 percent. None of the pre-1972 studies explicitly accounts for the effects which environmental improvement activities might have on future consumption, and none of the studies took into consideration currently anticipated limitations of supply. Pre-embargo studies projected GNP growth rates but ignored the possibility that a more energy-intensive or less energy-intensive GNP might be socially optimal in the future, and they failed to recognize the possible merits of future inter-fuel substitutability.

In general, most pre-1968 studies were rather optimistic about supply and demand and did not seem to anticipate major energy supply problems through the end of the century. On the other hand, more studies since 1968 have expressed various concerns about the country's future energy supply situation. This change in attitudes most likely resulted from recent (but still pre-embargo) higher energy consumption forecasts, unexpected delays in the development of nuclear energy, and the realization that growth trends in domestic exploration, discovery, and recovery of traditional fossil fuels have failed to keep pace with domestic energy consumption.

Historic Growth Rates

Twenty-three studies undertaken between 1960 and 1971 show forecasts of annual energy growth rates in the U.S., ranging from 2.5 to 4.8 percent, while the mean is about 3.5 percent. Generally, energy growth rates have been closely related to fluctuations in the GNP. For example, during the 1929–1933 depression, when the decline in industrial production was severest of any period in the history of the U.S., energy consumption fell from 23,756 trillion Btu's in 1929 to 16,392 trillion Btu's in 1933. The pre-depression energy consumption level was not surpassed until 1940, when total gross energy inputs reached 23,908 trillion Btu's. (See table 2.)

[3] Ibid., p. 6.

TABLE 2.—U.S. TOTAL GROSS CONSUMPTION OF ENERGY RESOURCES BY MAJOR SOURCES

[In trillions of Btu's]

Year	Anthracite	Bituminous coal	Natural gas, dry	Crude oil, petroleum products, net imports	Natural gas liquids	Total mineral fuels	Hydropower	Fuel wood	Total gross energy inputs[1]
1850	109	110	----	----	----	219	----	2,138	2,357
1855	216	205	----	----	----	421	----	2,389	2,810
1860	275	243	----	3	----	521	----	2,641	3,162
1865	304	328	----	10	----	642	----	2,767	3,409
1870	503	545	----	11	----	1,059	----	2,893	3,952
1875	578	862	----	11	----	1,451	----	2,872	4,323
1880	717	1,337	----	96	----	2,150	----	2,851	5,001
1885	957	1,883	82	40	----	2,962	----	2,683	5,645
1890	1,159	2,903	257	156	----	4,475	22	2,515	7,012
1895	1,439	3,511	147	168	----	5,265	90	2,306	7,601
1900	1,410	5,431	252	229	----	7,322	250	2,015	9,587
1901	1,657	5,808	281	250	----	7,996	264	----	----
1902	1,030	6,733	299	364	----	8,426	289	----	----
1903	1,843	7,315	317	449	----	9,924	321	----	----
1904	1,797	7,155	330	534	----	9,816	354	----	----
1905	1,910	8,091	372	610	----	10,983	386	1,843	13,212
1906	1,748	8,793	411	555	----	11,507	414	----	----
1907	2,098	10,079	432	781	----	13,390	441	----	----
1908	2,037	8,478	427	820	----	11,762	476	----	----
1909	1,978	9,685	511	844	----	13,018	513	----	----
1910	2,060	10,654	540	1,007	----	14,261	539	1,765	16,565
1911	2,197	10,245	544	1,040	1	14,027	597	----	----
1912	2,038	11,402	594	1,058	1	15,093	615	----	----
1913	2,207	12,034	620	1,210	3	16,074	645	----	----
1914	2,198	10,703	632	1,320	5	14,858	676	----	----
1915	2,160	11,134	673	1,411	7	15,385	691	1,688	17,764
1916	2,106	12,631	807	1,497	11	17,052	729	----	----
1917	2,378	13,835	850	1,755	24	18,842	755	----	----
1918	2,385	14,588	771	1,911	31	19,686	750	----	----
1919	2,113	11,688	793	2,159	39	16,792	766	----	----

Year	Anthracite	Bituminous coal and lignite	Natural gas dry	Crude oil	Petroleum products net imports	Natural gas liquids	Total mineral fuels	Hydropower	Total gross energy inputs
1920	2,179	13,325	827	3,027	−393	42	19,007	775	19,782
1921	2,082	10,266	682	3,016	−342	50	15,754	656	16,410
1922	1,443	11,185	785	3,390	−319	56	16,540	675	17,215
1923	2,208	13,598	1,032	4,419	−389	90	20,958	727	21,685
1924	2,050	12,681	1,170	4,228	−464	103	19,768	685	20,453
1925	1,627	13,079	1,212	4,641	−485	124	20,198	701	20,899
1926	1,961	13,954	1,335	4,876	−545	149	21,730	765	22,495
1927	1,897	13,095	1,465	5,027	−650	179	21,013	815	21,828
1928	1,871	13,069	1,588	5,474	−711	200	21,491	890	22,381
1929	1,815	12,612	1,942	5,894	−600	246	22,909	847	23,756
1930	1,718	11,921	1,969	6,148	−496	243	21,503	785	22,288
1931	1,484	9,743	1,715	5,304	−339	200	18,107	692	18,799
1932	1,283	8,041	1,594	4,830	−240	158	15,666	726	16,392
1933	1,260	8,323	1,600	5,143	−299	144	16,171	729	16,900
1934	1,410	9,003	1,819	5,136	−318	161	17,216	721	17,937
1935	1,298	9,336	1,974	5,799	−300	169	18,276	831	19,107
1936	1,351	10,697	2,221	6,426	−302	184	20,577	841	21,418
1937	1,280	11,286	2,468	7,004	−400	208	21,846	905	22,751
1938	1,148	8,811	2,348	6,921	−456	209	18,981	899	19,880
1939	1,262	9,854	2,539	7,327	−486	221	20,717	872	21,589
1940	1,245	11,290	2,726	7,662	−175	243	22,991	917	23,908
1941	1,338	12,893	2,851	8,343	−139	364	25,650	975	26,625
1942	1,435	14,149	3,102	7,987	−320	367	26,720	1,177	27,897
1943	1,450	15,557	3,481	8,538	−310	379	29,095	1,347	30,442
1944	1,509	15,447	3,775	9,923	−662	442	30,434	1,387	31,821
1945	1,311	14,661	3,973	10,199	−580	491	30,055	1,486	31,541
1946	1,369	13,110	4,089	10,270	−283	493	29,048	1,446	30,494

See footnotes at end of table.

TABLE 2—U.S. TOTAL CONSUMPTION OF ENERGY RESOURCES BY MAJOR SOURCES—(Continued)

	Anthracite	Bituminous coal and lignite	Natural gas dry [2]	Petroleum [3]	Total fossil fuels	Hydropower [4]	Nuclear power [4]	Total gross energy inputs	Percentage change from prior year
1947	1,224	14,600	4,518	11,367	31,709	1,326		33,035	
1948	1,275	13,622	5,033	12,557	32,487	1,393		33,880	+2.6
1949	958	11,673	5,289	12,119	30,039	1,449		31,488	−7.1
1950	1,013	11,900	6,150	13,489	32,552	1,440		33,992	+8.0
1951	940	12,285	7,248	14,848	35,321	1,454		36,775	+8.2
1952	897	10,971	7,760	15,334	34,962	1,496		36,458	−0.9
1953	711	11,182	8,156	16,098	36,147	1,439		37,586	+3.1
1954	683	9,512	8,548	16,132	34,875	1,388		36,263	−3.5
1955	599	10,941	9,232	17,524	38,296	1,407		39,703	+9.5
1956	610	11,142	9,834	18,627	40,213	1,487		41,700	+5.0
1957	528	10,640	10,416	18,570	40,154	1,551	1	41,706	0.0
1958	483	9,366	10,995	19,214	40,058	1,636	2	41,696	0.0
1959	478	9,332	11,990	19,747	41,547	1,591	2	43,140	+3.5
1960	447	9,693	12,699	20,067	42,906	1,657	6	44,569	+3.3
1961	404	9,502	13,228	20,487	43,621	1,680	18	45,319	+1.7
1962	363	9,826	14,131	21,267	45,577	1,821	24	47,422	+4.6
1963	361	10,353	14,843	21,950	47,507	1,767	34	49,308	+4.0
1964	365	10,899	15,648	22,386	49,298	1,907	35	51,240	+3.9
1965	328	11,580	16,098	23,241	51,247	2,058	38	53,343	+4.1
1966	290	12,205	17,393	24,394	54,282	2,073	57	56,412	+5.8
1967	274	11,982	18,250	25,335	55,841	2,344	80	58,265	+3.3
1968	258	12,401	19,580	27,052	59,291	2,342	130	61,763	+6.0
1969	224	12,509	21,020	28,421	62,174	2,659	146	64,979	+5.2
1970	210	12,712	22,029	29,614	64,565	2,650	229	67,444	+3.8
1971	186	11,857	22,819	30,570	65,432	2,862	404	68,698	
1972	150	12,273	23,035	32,966	68,424	2,946	576	71,946	
1973	144	13,150	22,712	34,851	70,857	2,998	888	74,743	
1974	132	13,037	22,237	33,490	68,696	3,052	1,173	73,121	

[1] Gross energy is that contained in all types of commercial energy at the time it is incorporated in the economy, whether the energy is produced domestically or imported. Gross energy comprises inputs of primary fuels (or their derivatives)' and outputs of hydropower and nuclear power converted to theoretical energy inputs. Gross energy includes the energy used for the production, processing, and transportation of energy proper.

[2] Excludes natural gas liquids.

[3] Petroleum products including still gas, liquefied refinery gas, and natural gas liquids.

[4] Outputs of hydropower (adjusted for net imports or net exports) and nuclear power converted to theoretical energy inputs calculated from national average heat rates for fossil-fueled steam-electric plants provided by the Federal Power Commission. Energy input for nuclear power in 1971 is converted at an average heat rate of 10,660 B.t.u. per net kilowatt-hour based on information from the Atomic Energy Commission. Excludes inputs for power generated by nonutility fuel-burning plants, which are included within the other consuming sectors.

Source: Bureau of Mines, Office of Fossil Fuels, and Energy "Demand" Studies, An Analysis and Appraisal, op cit., pp. 16–18.
Data for 1971–74 are preliminary, and were provided by the office of fossil fuels and energy.

Similar declines in energy consumption are noticeable in the post-war recessions of 1948–1949, 1957–1958, 1960–1961, and again in 1974–1975.

TABLE 3.—*U.S. historical energy growth trends*

	Percent
1850 to 1885	2.5
1885 to 1910	4.4
1910 to 1935	0.6
1935 to 1950	3.9
1950 to 1960	2.9
1960 to 1971	4.2

Source: *Energy "Demand" Studies, An Analysis and Appraisal*, p. 62.

Post-Embargo Studies

Most recent studies, undertaken after the Arab oil embargo which led to the quadrupling of the world-market price of oil, indicate lower estimates of future growth-rates of energy consumption in the U.S. Most new estimates range from 2.0 to 3.1 percent growth in annual energy consumption.

TABLE 4.—CURRENT FORECASTS OF ENERGY GROWTH RATES IN THE UNITED STATES UNTIL 1985 (ANNUAL GROWTH RATES)

	Percent	1985 energy demand in quadrillion Btu's
Frost and Sullivan, 1975	1	82
U.S., House of Representatives, science and Government operations committees (recommended)	2	93
Conference board, 1975	1.5	87
Ford Foundation, 1975	1.4–2	91.3
Commerce Technical Advisory Board (CTAB)	3.1	108
F.E.A	2.1–2.5	98–103
Historic rate, 1947–73	3.1	108
Clark Associates, Palo Alto, 1975	3.2	
CEQ, 1974		106
Chase Manhattan, energy division	2.5–3.5	
Exxon Corp	2.7	
This study (most likely scenario)	2.8–3.1	95.4–98.

It is impossible to look into the crystal ball and "predict" with dependable accuracy the exact annual demand and supply growth rates, because the factors contributing to supply and demand cannot be estimated accurately many years into the future. In spite of these uncertainties, however, projections of the Nation's future energy environment 5, 10, or 15 years into the future must be undertaken, because it is essential to the formulation of long-term economic goals. When the variables change, projections must be updated to take into account these changes. Long-term forecasts are needed to provide government and business with necessary data for long-term planning. Long lead-times are required for the construction of nuclear reactors, coal mines, exploration for and production of offshore petroleum, construction of pipelines, etc. The necessary capital investment decisions must be made many years in advance.

Many would agree with a recent study by the Chase Manhattan energy division calling for a cautious approach in preparing energy forecasts. The authors maintain that historically, energy forecasts have proven grossly conservative, and that the poorest forecasting has been made during abnormal or transitional periods.[4] For example, a highly qualified organization predicted in 1933 that the demand for oil would reach 2.9 million b/d by 1960. The actual demand in that year was 10.1 million b/d, more than triple the predicted amount.[5] The problem with that particular estimate and other forecasts made during that period was that at that time of depression, prevailing attitudes concerning the future state of the economy and energy demand were generally pessimistic. Similar errors might be repeated again in efforts to project future energy demand and supply patterns.

[4] Chase Manhattan Bank, Energy Economics Division, *How Much Oil—How Much*, March 1975, pp. 2–3.
[5] Ibid., p. 3.

Energy and GNP Growth

There are two schools of thought on energy conservation. One school holds the view that industrial and private users of energy waste a great deal of energy and that, therefore, dramatic savings can be achieved in the short run without influencing lifestyles or business activity. Yet another school maintains that there are indeed some wasteful practices that can be corrected in the short term leading to a moderate once and for all saving in energy, and that once these energy leakages have been removed, energy demand will once again continue to grow at its historic relationship to GNP. According to this school any attempt to dampen energy demand in the short run beyond the correction of leakages, will have immediate implications for business activity and living standards.

The second group looks into the past, and maintains that the historical direct relationship between industrial production and fuel consumption in the United States cannot be disputed (figure 1).

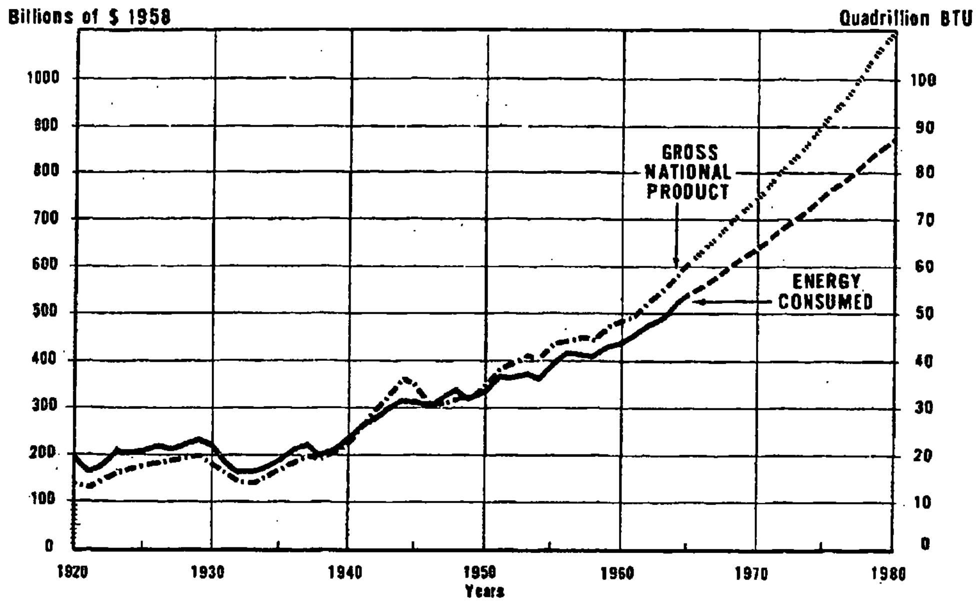


Figure 1

Source: *Energy "Demand" Studies, An Analysis and Appraisal,* op. cit., p. 65.

In a recent study on energy use and GNP, Dr. H. R. Linden, President of the Institute of Gas Technology, found that there has been indeed an amazingly precise correlation between total primary energy consumption per capita and disposable personal income per capita from 1929–1973. When disposable personal income went up in this period, so did energy in proportion. When it went down, down went energy consumption in the same slated way. This happened regardless of energy price levels, employment, war–or peacetime boom, recession, or depression.[6] Dr. Linden's study raises questions regarding the validity of applying classical concepts of price elasticity to total

[6] *The Oil and Gas Journal,* Jan. 6, 1975, p. 25.

energy demand and probably even to some of the sectoral demands. The study also shows that any attempts to curb energy use significantly should be carefully studied in view of its potential effects on the economy. Neither energy policies nor economic policies can be considered in a vacuum.

The question being asked frequently these days is whether or not energy consumption and GNP can be "uncoupled" through future conservation efforts. Project Independence Blueprint assumes that the United States can have real increase in GNP of 5 percent annually with energy demand of 2.5 percent annually. The study lists a number of consideration actions to achieve such savings, but has failed to offer a mechanism for uncoupling energy consumption and economic activities. Instead, the FEA "blueprint," shows that as a result of a sudden disruption of energy supply in the first quarter of 1974, output declined by $10 to $20 billion and caused energy-related unemployment of approximately 500,000.[7]

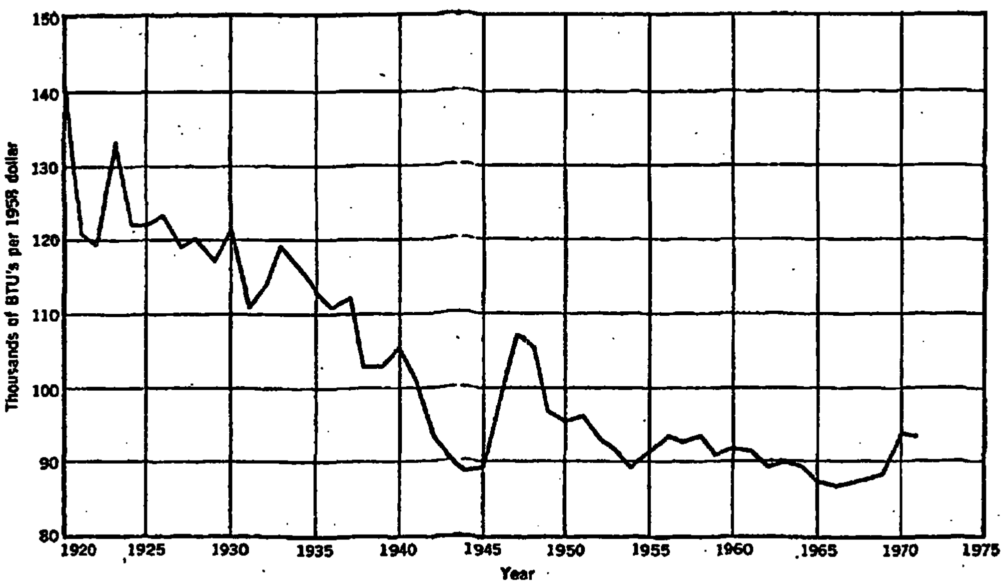


FIGURE 2.—Ratio of United States total energy consumption to real GNP

Source: *Ibid.*, p. 67.

With growing U.S. dependence on insecure sources of petroleum supply, estimated future GNP losses caused by oil supply shortfalls will rise accordingly. Estimates vary significantly, depending on the level of predisruption imports, volume of supply cutoff, and duration of any future embargo.[8] Testifying before the House Ways and Means Committee in March 1975, Assistant Secretary of State for Economic and Business Affairs, Thomas O. Enders, estimated that another embargo could idle 2 million workers and between $40 and $80 billion in lost GNP.[9] Calculations based on FEA data of the 1973–74 Arab

[7] Federal Energy Administration, *Project Independence Report*, Washington, D.C., 1974, p. 288.

[8] See table VII-7 in the FEA blueprint for Project Independence, ibid., p. 367.

[9] U.S. House of Representatives. Committee on Ways and Means. "The Energy Crisis and Proposed Solutions." Summary of testimony prepared by panelists on March 3, 4, 5, 6, 7, 10, 11, 12, 13, and 14, 1975 Washington, D.C. March 1975. p. 49.

oil embargo would suggest that another embargo 2 years from today could result in a GNP loss of $39 to $56 billion, and additional unemployment of 1 to 1.5 million, if the embargo were to last 6 months.

As far as the effects of planned conservation efforts on the economy are concerned, there are basically two schools of thought: those who argue that sustained economic growth of 3.5 to 4 percent can be achieved with energy growth rates of about 2 percent, and others who believe that some savings are possible, but not to the extent of cutting historic growth rates by one-half in the short or medium term. A proponent of the first school is S. David Freeman, a former director of the Ford Foundation energy study.[10] Representatives of the industry, on the other hand, tend to be more cautious in their projections. "Conservation," writes Dr. Linden, "is much too benign a label for this policy option in the near term. Rather it should be presented to the public as what it likely will for the foreseeable future: a policy of lower real income, reduced standards of living, reduced mobility, and possibly higher unemployment." [11]

A study undertaken by the Exxon Corporation projects that a cutback of one million b/d of oil could reduce GNP in the first year by up to 2.2 percent and increase unemployment by 0.8 percent. A cutback of 2.5 million b/d of oil by 1977 could reduce real GNP by 3.2 to 7.6 percent, and unemployment could remain in the 9 to 10 percent range.[12]

Other studies on the effects of a gasoline tax on the economy also suggest reduced economic growth rates at least over the short term. For example, one recent study on the effects of a gasoline tax on economic growth, undertaken by Data Resources Inc. for the Council on Environmental Quality and the Environmental Protection Agency, found that a tax of 10 cents or more per gallon would have a significant effect on oil consumption, and a negative effect on economic growth. Within a year, a tax of 30 cents per gallon would lower real GNP by 0.8 percent. After a period of about one year, real GNP would be 1.6 percent lower than levels projected prior to the gasoline tax, and unemployment would be higher by 0.5 percent.[13]

Reason for the delayed reaction was said to rest in the dynamic nature of the model reflecting consumer behavior. Consumers need some time to adjust to the tax. During this time they will dip into savings, but after about a year, the full effects of the tax will have worked its way through the economy.

Some students of energy policy have indicated that other industrially advanced nations in Europe have achieved a higher per capita income than the United States with lower per capita energy inputs. But, Dr. Linden claims that countries such as Switzerland, with a much lower energy-consumption to GNP ratio than the U.S., do so by emphasizing high-value goods and services and high-technology manufactured products. In contrast, countries such as the U.S. have economies dominated by highly energy-intensive industries, such as oil production and refining and basic steel and aluminum. These countries have a higher energy consumption to GNP ratio (U.S.,

---

[10] The Oil and Gas Journal," January 6, 1975, p. 25.

[11] *The Oil and Gas Journal*, Jan. 6, 1975. p. 25.

[12] Exxon Corp. Effects of Enforced Short-term Oil Consumption Curtailment on the Economy, unpublished study. New York, Apr. 18, 1975.

[13] Data Resources Corp., Inc., A Study of the Demand for Gasoline, Prepared for the CEQ, EPA (Washington, D.C., July 1974), p. VIII.

Canada, Norway, Kuwait, etc.). Dr. Linden maintains that energy-GNP ratios seem to depend primarily on the particular mix of economic activity and possibly on such factors as population density and climate rather than relative costs of energy or minor cultural differences.[14]

In view of our limited knowledge of the long-term effects of energy conservation on economic growth, the Chase Manhattan energy division expressed concern about what it called "disturbing signs of too much reliance upon untried theories, particularly in respect to radical schemes to curb use." [15] The authors fear that if government and business energy plans are based on ultra conservative forecasts of future needs, the stage will be set for progressively worsening shortages in the years ahead. Such energy shortages would restrain expansion of GNP and the level of productive employment would not rise as fast as the labor force. In that case the "cure" (conservation) could be worse than the illness itself.[16]

[AUTHOR'S NOTE: The question is not whether, but how much conservation. The question of how much leads to the question of costs, for virtually any level of conservation is plausible provided the nation is willing to bear the costs. What level of conservation entails what cost is a subject on which there is unfortunately no consensus. Some practices are clearly inefficient and wasteful.]

There is a general awareness, however, which is expressed in most current energy forecasts, that the quadrupling of the price of OPEC oil will have an effect on energy consumption. While there was little incentive to avoid energy waste when energy was cheap, the new higher prices encourage more efficient utilization. Because there is no reliable basis at this time for estimating energy waste, however, years will be needed to accumulate the evidence necessary to implement serious conservation claims without simultaneously risking injury to the economy. For example, the effects of several proposals to ration gasoline are difficult to gage. The use of gas, but permanent rationing would increase the life of the automobile and could reduce new car sales. On the other hand, consumers would have more money to spend on other goods and services.

In the short run, Congress and the Executive are faced with the dilemma of reducing U.S. dependence on foreign oil without impeding the recovery of our depressed economy.

This study is not an attempt to resolve the debate concerning the question of "decoupling" energy consumption from economic growth rates. Instead, six alternative energy growth rates for the period 1975–1985 are discussed. These include rates of 2 percent (to be achieved by significant conservation efforts, reduced economic growth, or a combination of the two); 4 percent (close to "historic" 1960–1971 energy growth rates and not likely to be continued); 2.8 and 3.1 percent (average of most recent studies and most likely growth pattern assuming no major changes in the variables).

---

[14] *The Oil and Gas Journal,* Jan. 6, 1975, p. 25.
[15] *How Much Oil—How Much Investment,* op. cit., p. 3.
[16] Ibid., p. 3.

CHAPTER II

U.S. ENERGY SUPPLY AND DEMAND BY SOURCE

The U.S. economy has gradually shifted from coal—the predominant source of energy in the early part of the century—to oil and gas which provided slightly more than three-fourths of the Nation's energy supply in 1971.

TABLE 5.—PRODUCTION OF MINERAL ENERGY FUELS AND ENERGY FOR WATER POWER IN THE UNITED STATES

[In percent]

	1900	1945	1971	1974
Coal	88.9	51.1	22.4	24.2
Crude oil	4.7	30.7	31.7	29.6
Natural gas	3.2	13.7	40.7	39.6
Water power	3.2	4.5	4.6	4.8
Nuclear power			.6	1.9

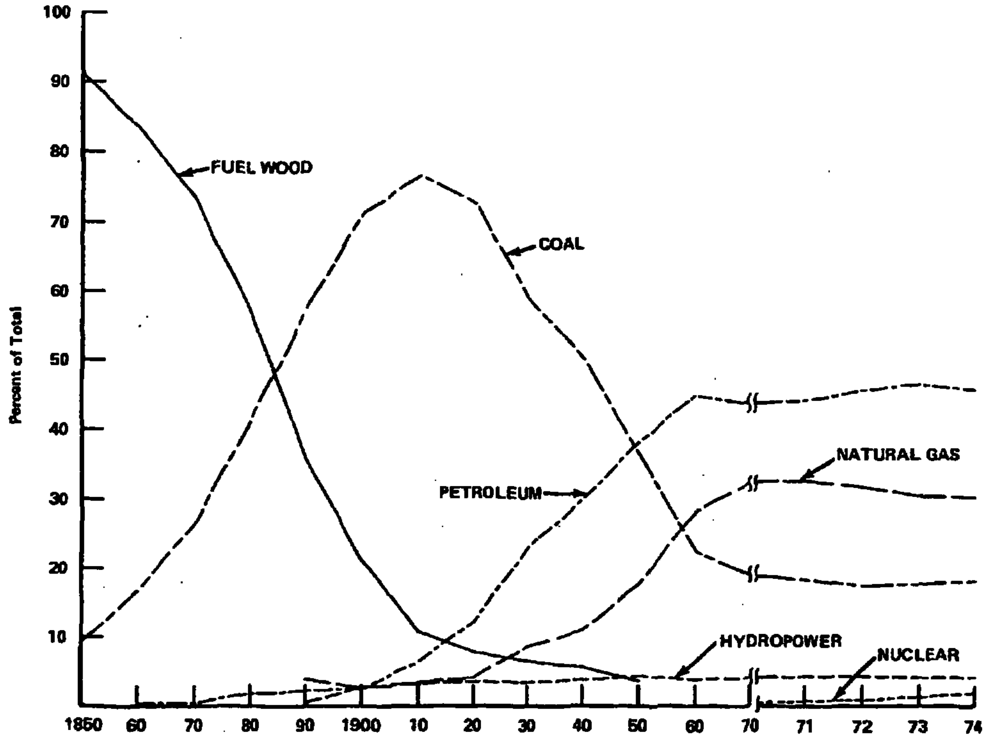
Source: U.S. Department of the Interior, Bureau of Mines, "Minerals Yearbook." 1961 vol. II, pp. 4 and 5, table 1, for 1900 and 1945; vol. I, table 7, p. 22 for 1971 (see also figure 3).

Most recent studies on future U.S. energy supplies project that by 1985, the Nation will still be dependent for more than 50 percent on oil and gas. In view of the declining oil and gas resources, however, most forecasters maintain that a return to coal and an enormous boost in nuclear energy output are among the few alternatives to overcome medium-term supply problems. In the long term (by the end of the century and beyond) non-conventional sources of energy such as solar energy and fusion power may be able to make a significant contribution to energy supplies.

The renewed interest in coal is a reversal of even rather recent energy trends. Most other studies shown in table 1 forecasted a lessening demand for coal as a percentage of total energy consumption by 1980 and beyond. Only the AEC study of 1960 and a SIIC study of 1962 projected heavier reliance on coal in 1980 and by the year 2000 than in 1970.[17] The pre-1972 studies vary considerably on the projected contributions of nuclear energy to total energy consumption. Projected contribution of nuclear energy range from 2.4 percent (National Fuels and Energy Study Group, 1962) to a high of 14.3 percent of total energy consumption by 1980 (Sartorius and Co., 1967).[18]

[17] *Energy "Demand" Studies, An Analysis and Appraisal,* op. cit., p. 26. (See table 1, p. 2.)
[18] Ibid., p. 32

U.S. Energy Consumption Patterns, 1850-1974



Source: Historical Statistics of the United States, Bureau of the Census; U.S. Bureau of Mines, 1974.

FIGURE 3

U.S. Energy Consumption Trends, 1850-1974

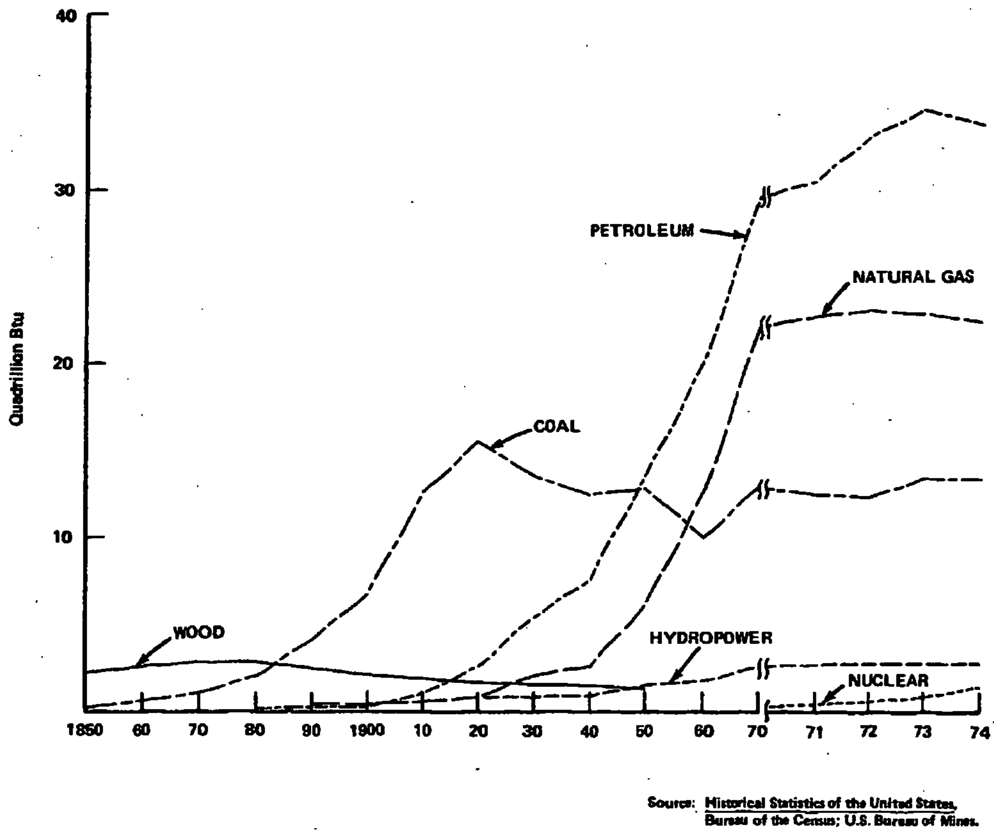


FIGURE 4

All pre-1972 studies shown in table 1 estimate a rise in consumption of oil and natural gas in absolute terms but a gradual decline of oil and gas consumption as a percentage of total energy consumption. Only a few studies projected oil consumption to rise as a percentage of total energy consumption beyond 1970 and gas consumption beyond 1975. In fact, oil production did peak in 1970 and natural gas production in 1973 (a few years earlier than expected by the Federal Power Commission).

There was general agreement (and still is) that hydropower will not increase much because most of the sites have already been developed: it is likely to remain at around 3 percent of total energy consumption.

TABLE 6.—PRE-EMBARGO FORECASTS OF U.S. ENERGY CONSUMPTION BY SOURCE

[In trillions of Btu's]

Source	Mean forecast	Ranges		
		1980	1985	2000
Coal	19,500	15,500-25,500	16,703-23,121	17,960-27,200
Nuclear	7,300	2,000-13,300	8,809-25,913	19,000-43,526
Oil	40,000	29,943-52,900	32,762-56,700	40,683-90,488
Gas	27,500	20,000-38,516	22,180-43,625	33,810-57,482
Hydro	3,000	1,400-3,895	3,118-3,500	2,550-5,492

Whereas consumption forecasts of all sources of energy varied considerably for the year 1980 (the year for which projections were most complete), discrepancies were most noticeable for oil and nuclear energy. There was a tendency for studies undertaken after 1968 to forecast much higher rates of consumption of oil and nuclear energy by 1980 than in the studies conducted prior to 1968. It is likely that the large oil discoveries in Alaska (North Slope) did affect the studies undertaken after 1968, and the fact that nuclear technology became more established during the late 1960's may also have affected forecasts made during that period.

RECENT ENERGY FORECASTS (1972–75)

Energy forecasts continued to differ considerably during the early 1970's, both on total energy demand and supply projections for the future as well as on the contribution each source is likely to make to meet total demand. However, certain new trends are noticeable in all studies. Most energy forecasts conducted during the early 1970's show significant increases in coal and nuclear energy contributions to total energy consumption by 1985. While oil and gas are estimated to continue to provide more than 50 percent of total energy consumption and output of oil is expected to rise in absolute terms, liquid hydrocarbons are projected to contribute a lower percentage to total energy consumption in 1985 than they do today. This shift away from the dominant position of petroleum as the major energy source in the United States is likely to be permanent and due to supply limitations, probably irreversible.

TABLE 7.—DOMESTIC ENERGY SUPPLY IN 1985 (PROJECTED)

[In quadmillion Btu's]

	NPC (1972)				FEA (1974)					
Case	I	II	III	IV	I	II	III	IV	CTAB (1975)	NAE (1974)
Oil	34.6	29.4	25.3	21.6	23.1	30.5	31.3	38.0	25.0	26.5
Natural gas	35.2	29.3	23.0	15.9	23.9	24.7	24.8	25.5	22.0	30.7
Coal	27.1	21.3	21.3	20.3	19.9	17.7	22.9	20.7	26.0	24.8
Nuclear	29.8	25.2	20.2	16.1	12.5	14.7	12.5	14.7	16.5	17.6

Sources: FEA, "Project Independence, a Summary," Washington, D.C., November 1974, p. 46. NPC, "U.S. Energy Outlook, a Summary Report of the National Petroleum Council," December 1972, p. 19. NAE, "U.S. Energy Prospects, an Engineering Viewpoint," Washington, D.C., 1974, derived from table on pp. 86 and 87. CTAB, "Recommendations for a National Energy Program," Washington, D.C., February 1975.

Another major trend noticeable in most forecasts undertaken in the 1970's, and in particular after the Arab oil embargo, is that projections of total energy consumption for 1985 are much lower than earlier pre-embargo estimates.

SUPPLY PROJECTION AND ENERGY SOURCE SUBSTITUTION

The United States was self-sufficient in energy until about 1950 when our domestic energy supply began to fall rapidly behind use. Coal production increased at a very slow pace, crude oil production peaked in 1970 and began to decline at about 5 percent per year, and natural gas reached its highest production in 1973 and declined by about 4 percent in 1974. Unless the price of "old" oil will soon be decontrolled oil production is likely to continue to decline until late 1977 when Alaskan crude oil from the North Slope is expected to be piped to Valdez and from there be shipped to the lower 48 States. Natural gas production is likely to decline for the indefinite future, and it is quite possible that the domestic peak production of 22.5 TCF per year in 1973 may not be surpassed in the future.

Hence, energy consumption increases will have to be met increasingly by substitute sources such as coal and nuclear power, and by imports of crude oil and liquefied natural gas. According to some observers coal production, which has remained for too long at the 1940's level, could double by 1985, and others have projected that nuclear capacity might even undergo a tenfold increase over 1973. Few, if any, studies undertaken in recent years on the subject of energy policy have projected any major contributions of esoteric sources of energy to total available supplies by 1980 or 1985. It will probably not be until the latter part of the century or early in the 21st century that solar energy, fusion power, and so forth, will make a significant contribution to total energy output.

There are several good reasons to be concerned about the future of the Nation's energy situation. Among the main causes of current pessimism about our chances to restrict energy imports to a small, manageable portion of total consumption are the following:

—recent re-evaluations of U.S. domestic oil and gas reserves and potential undiscovered oil and gas resources. The trend in both continues to move downward.

—serious capital problems have already resulted in cancellation of several nuclear powerplants and could cause a considerable slowdown in the development of all sources of domestic energy.

—fears among some experts that nuclear fuels may be in short supply beyond the early 1980's. the fast-breeder reactor (pilot plant) may not be ready until the early 1990's.

—Federal and State government regulations in support of various social values. Some new environmental rules concerning OCS oil and gas developments, strip-mining and nuclear safety (or even a nuclear powerplant moratorium) could result in a significant reduction in projected energy output.

—traditional Western hemisphere sources of oil supply are being cut, and alternative sources of supply are located in less secure regions of the world.

The various energy scenarios for the future all assume a certain energy mix, consisting primarily of oil, gas, coal and nuclear energy. All recent forecasts project a considerably higher contribution of coal and nuclear energy than most studies undertaken before the 1970's. If forecasts of coal and nuclear energy expansion cannot be met, other energy sources—in particular imported oil—will have to substitute for any shortfall. [19]

Coal

Coal is the most abundant fossil fuel in the United States. Proven reserves are estimated at 433 billion tons which is equal to more than

[19] Assuming that an average annual economic growth rate of 3 to 3.5 percent continues to be considered a desirable national goal, and assuming that energy consumption will continue to grow along with increases in GNP.

80 years of consumption at the current level (1974 production was slightly below 600 million tons). Maximum production of coal in 1985 has been estimated by the FEA at 2 billion tons/year (FEA Blueprint for Project Independence), but most recent studies—including FEA estimates under different conditions—have estimated that doubling of current production to about 1.2 billion tons/year is close to the limit of maximum expansion for the next ten years.

However, doubling of coal production is subject to constraints on demand and supply of coal. The most important constraints are related to environmental, safety, and health legislation, the price of alternative fuels, and availability of manpower, material, capital, and means of transportation. For example, the coal industry maintains that the Health and Safety Act of 1969 has resulted in a loss of production in deep mines of 25 to 28 percent.[20] There are no precise figures on limitations of output caused by environmental restrictions, but the effect of the Clean Air Act of 1970 and pending strip-mining legislation on production could be significant according to the industry and the Executive branch of the government. In order to increase coal output from about 600 million tons/year to 1.2 billion tons/year, the percentage of strip-mined coal may have to rise from 35 to 50 percent of total output. Congress passed a strip-mining bill in May of this year which was vetoed by the President on the following grounds: a) it would cause a substantial loss of energy, b) unemployment would increase, c) budget outlays would go up, and d) the cost of energy

U.S. Low-Sulfur Coal Reserves, Production, Distribution, 1973

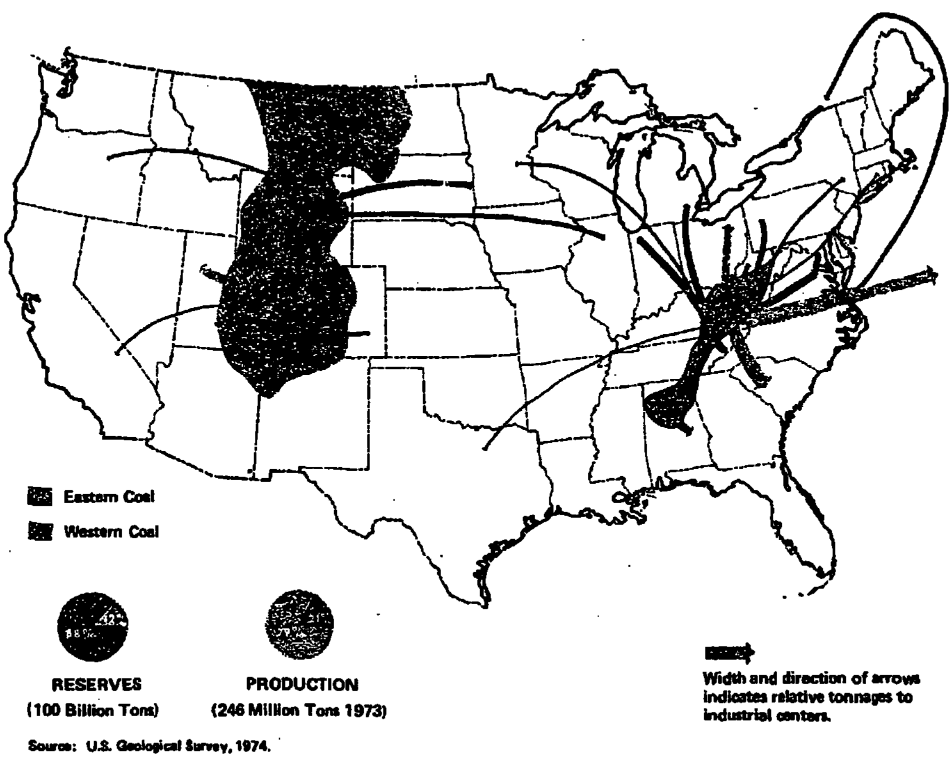


FIGURE 5

[20] *Business Week*, Jan. 27, 1975, p. 130.

would rise.[21] Congress was unable to override the veto, but similar legislation will probably be reintroduced.

Utilities as well as the coal industry also maintain that unless there is a major modification of present pollution abatement regulations, utilities will in many instances not be able to burn coal, and consequently coal companies will not be able to make the necessary investments in new mining capacity.[22] If coal production capacity atrophies, so too will the complex structure supporting the coal industry with machinery and supplies, as well as the transportation system required to move the product to market. Given this scenario, utilities would have to turn away from coal to the most likely alternative, imported foreign oil. Carl E. Bagge, president of the National Coal Association maintains that electric power companies are planning to increase the use of oil for generating electricity by 49.9 percent between 1974 and 1979.[23] In view of current FEA policy, however, it is questionable whether the industry will be allowed to meet these projections.

Any significant delays in clarifying the Nation's energy policy—and coal policy in particular—will impede development because of long lead-times. It takes 3 to 5 years to open new coal mines, about 8 months to file an environmental impact statement, 14 to 16 months to get delivery on a continuous miner, 6 to 8 years of procurement-time for draglines, several years to get delivery of draglines, and so forth.[24]

The net effect of continuing inflation, capital, manpower and material shortages, environmental legislation, transportation problems, uncertainty about pricing, growing opposition in Western States against "too rapid and too much" development, and so on could very well be that the Nation will fall short of the projected 1.2 billion tons/year of coal by 1985. It is quite possible that coal production will grow at little more than half of the annual 9 percent projected to achieve a production of 1.2 billion tons/year. In fact, the maximum amount of coal from new mines that will be available by 1983 has been estimated at between 237 and 285 million tons.[25] There is little information available on the estimated number of producing eastern coal mines that will be closed by that time. While the FEA still maintains officially that a target production figure of 1.2 billion tons/year is likely to be achieved, some FEA experts privately no longer share this optimism. Reliable sources now indicate that due to a variety of constraints, the coal industry is not likely to produce more than 900 million to 1 billion tons/year by 1985, and some experts believe that 800 million tons/year is an even more realistic projection for 1985.

As production estimates quoted for the contribution of domestic natural gas, oil and nuclear energy by the FEA and other recent energy studies are already on the high side in view of the most recent industry data (see subsections on nuclear energy, oil and gas), any shortfall in coal production is likely to be substituted by foreign oil

---

[21] "Strip-mining: A Practical Test for President Ford," *Science*, vol. 186, p. 1190.
[22] *Congressional Record*, Apr. 14, 1975, p. 5903.
[23] Ibid., S. 5903.
[24] See: Ernest Krajeski, "Coal Supply," in *Energy Self Sufficiency, How Much and How Soon*, The Mitre Corporation, McLean, Va., March 1975, p. 2.
[25] *Business Week*, Jan. 27, 1975, p. 127 (237 million tons). The higher figure is a private estimate made by a FEA coal expert.

imports. In terms of Btu's, one million short tons of eastern coal is about equal to 4 million barrels of oil, and a million short tons of western coal has the Btu equivalent of approximately 3 million barrels of oil.

Assuming a shortfall of about 300 million tons by 1985, 200 million tons being western and 100 million eastern coal, additional foreign oil imports would have to be about 2.7 million b/d (shortfall compared with FEA projection of a production of 1.2 billion short tons per year by 1985).

TABLE 8.—ESTIMATED COAL PRODUCTION AND PROJECTED SHORTFALL OF 3 MAJOR RECENT ENERGY STUDIES

[In millions of tons per year]

	CTAB study, 1975	FEA (1974) Constrained	FEA (1974) Unconstrained	National Academy of Engineering (1974)
Estimated production	1,200	1,000–900	1,100–2,100	1,200
Estimated shortfall (based on production of 900,000,000 tons per year)	300	100–0	200–1,200	300
Estimated shortfall (in millions of barrels per day oil equivalence)	2.7	0–.8	1.8–10.8	2.7

NUCLEAR POWER

Projections of the contribution of nuclear power to energy consumption by 1985 range from a low of 188 GWe (Nuclear Industry estimate) to a high of 325 GWe (Nat. Academy of Eng.). The most recent of the studies in table 7, the C.T.A.B. report, projects a medium supply of 275 GWe for 1985.

At the end of 1974 and early 1975, 53 nuclear powerplants were licensed; out of the 53, 42 units were in commercial operation and 19 were in the power ascension phase. The 53 plants have a design capacity of 34.8 GWe; but the 42 units in commercial operation are only producing 64.8% of capacity, or 22.5 GWe (due to scheduled and forced outages and other reasons).[26]

As late as 1974, the AEC estimated that nuclear reactors would produce approximately 300 GWe by 1985. However, the latest ERDA figures have lowered these estimates to 205 GWe.[27] Industry estimates are even lower than the revised ERDA estimates. According to industry sources, total scheduled commercial operation capacity of nuclear reactors will be 188 GWe by 1985, and the 205 GWe estimated by ERDA will not be achieved until after 1988.[28]

It is interesting that the new ERDA figure for 1985 is very close to the pessimistic FEA "constrained estimate" of 204 GWe. Expected shortfalls on the basis of the latest ERDA and industry figures are as follows (compare table 7):

[26] U.S. Nuclear Regulation Commission, Status Summary Report, *Operating Units Status Report, Operating Reactors,* Jan. 24, 1975, p. 1–2.

[27] Data received from the Energy Research and Development Administration, April 1975.

[28] Data received from ERDA, April 1975. One of the factors contributing to this rise is that the breeder reactor is expected to come online in 1983, according to ERDA. Industry estimates are for a later date. Moreover, ERDA's estimates reflect more optimistic resurgence of power reactor building.

TABLE 9.—ESTIMATED NUCLEAR POWER CAPACITY AND PROJECTED PRODUCTION SHORTFALL OF 3 MAJOR RECENT ENERGY STUDIES

[In GWe]

	CTAB (1975)	FEA Constrained	FEA Unconstrained	NAE (1974)
Estimated capacity	275	204–239	234–275	235
Estimated shortfall [1]	70	1–34	29–70	120
Estimated shortfall [2]	89	18–53	48–89	139

[1] Based on ERDA estimate of 204 GWe capacity by 1985.
[2] Based on industry estimates of 188 GWe capacity by 1985.

Under the assumptions of the studies in table 7, any shortfall of projected nuclear power is not likely to be made up by increased domestic output of coal, natural gas or oil. Each one of these studies has already maximized potential output of these alternative energy sources. Hence, the only substitute for any shortfall in nuclear power will be imported oil (used for electrical generation). The projected shortfall of nuclear power according to the latest ERDA and industry figures (see table 9) can be translated into an oil equivalent (table 10).

TABLE 10.—PROJECTED SHORTFALL OF NUCLEAR POWER BY 1985

[In thousands barrels per day oil equivalent]

	CTAB	FEA Constrained	FEA Unconstrained	NAE
ERDA, 1975	1,960	28–952	812–1,960	3,360
Nuclear industry, 1975	2,490	504–1,684	1,344–2,492	3,892

Including the most pessimistic FEA estimate, additional oil imports would range from 28,000 to 3,892,000 b/d, or an average of 1,789,833 b/d. Omitting the most optimistic FEA estimate, additional oil imports would average 1,950,000 b/d by 1985.

The new revised projections of nuclear power by both ERDA and the nuclear industry came after a series of construction deferrals in the fall and winter of 1974. Deferrals are caused by rapid escalation of construction costs coupled with financial problems of utilities: Other problems are related to uncertainty of demand for electricity, disputes about facility sitings, environmental issues, availability of enriched uranium for plants to be built after 1982, storage of nuclear waste, and government regulations. Bills calling for a five-year moratorium on nuclear powerplant developments have been introduced by Congress. As the lead-time between licensing nuclear reactors and completion of construction now ranges from 8 to 10 years, decisions to delay entail loss of future capacity.[29]

[29] The New York Times reported that by the end of 1974 about half of the nuclear powerplant projects in the country (112 out of 236) had been cancelled, *New York Times*, Dec. 23, 1974.

A recent decision by a U.S. Court of Appeals on April 1, 1975, which declared unlawful and set aside a construction permit issued by the AEC authorizing the building of a nuclear powerplant on the south shore of Lake Michigan, may have repercussions reaching far beyond the area. If upheld, the decision might lead to similar suits elsewhere in the country. The end result may be a further decrease in the number of projected nuclear powerplants.

Chapter III

OIL RESERVES AND PRODUCTION

Oil and natural gas have been the dominant sources of domestic energy since the 1940's when they replaced coal which had been the most important source of energy in the United States for more than half a century. Oil and gas are expected to maintain their dominant position beyond 1985, the final year covered by this study, but both coal and nuclear power are expected to gain on petroleum in terms of percentages of total energy production and consumption.

It is not possible to accurately determine the rates of production of oil and natural gas for future years, and the degree of accuracy of production forecasts tends to diminish the further one projects into the future. Because domestic production of oil and gas is directly related to the reserves of liquid hydrocarbons in the United States and to prevailing economic conditions, estimates are likely to be revised whenever major changes occur in one or both of these variables.

Oil Reserves

Proven reserves of crude oil and natural gas liquids are those which geological and engineering data demonstrate with reasonable certainty to be recoverable from known reservoirs under current economic and technical operating conditions (for a more detailed description of reserves and resources of oil, see appendix II). In the post World War II era, oil reserves (including natural gas liquids) increased gradually until 1970, when proved reserves began to decline. It is not possible to project if and when this period of decline in our reserve situation will end.

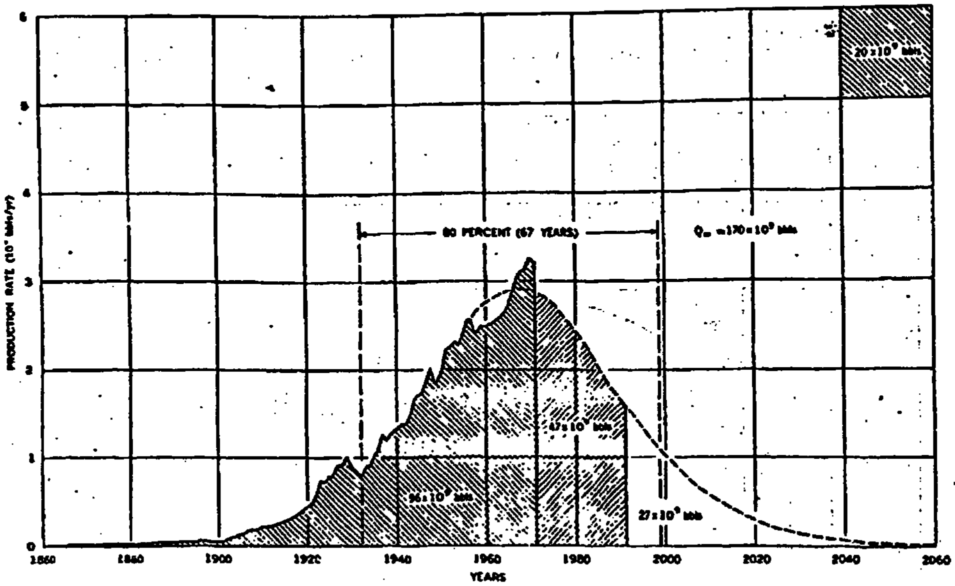
TABLE 11.—U.S. PROVED RESERVES OF CRUDE OIL AND NATURAL GAS LIQUIDS, 1965–75

[In billions of barrels]

Year	Agency	Reserves
1965	API	39.4
1966	API	39.8
1967	API	39.9
1968	API	39.3
1969	API	37.8
1970	API	46.7
1971	API	45.4
1972	API	43.1
1973	API	41.8
1974	API	41.8
1974	FEA	[1] 49.6
1974	U.S. Geological Survey	[1] 48.3
1975	API	40.6

[1] FEA and USGS figures include indicated additional reserves of crude oil, which may be produced from known reservoirs in existing fields with the aid of improved recovery techniques.

Source: American Petroleum Institute, "Annual Statistical Review," petroleum industry statistics, 1964–73, Washington, D.C. September 1974, p. 1 (1965–73 figures). 1974 and 1975 figures received from API, FEA, and the U.S. Geological Survey.



Source: U.S. House of Representatives. Committee on Ways and Means. *The Energy Crisis and Proposed Solutions*. Prepared Statements Presented to Panel Discussion on the Subject of Petroleum. 94th Congress. 1st Session. Washington, D.C. March 10, 1975, p. 32.

At present, the average percentage of oil that can be recovered from reservoirs in the United States is 32 percent (in some cases much more, in others significantly less). About 20 percent can be produced from primary recovery—oil that will flow unaided from oil reservoir rock into an oil well—and the remaining 12 percent must be produced with the assistance of secondary and tertiary techniques. These techniques require that water, steam, other chemicals, etc. be pumped back into the reservoir to enable oil to flow toward the existing well. With the aid of such technique, the United States now produces an average of 32 percent of the total oil-in-place. Estimates of the ultimate potentially recoverable oil-in-place range from a nationwide average of 40 to 50 percent, but most observers now maintain that the lower figure is likely to be the more accurate one. Assuming that advanced recovery-techniques will ultimately allow recoverability of 40 percent of oil-in-place, some 25 billion barrels of oil could eventually be added to current reserves. Hence, total recoverable oil resources from existing fields may reach 65.6 (40.6 billion barrels of current proved reserves plus 25 billion barrels potentially recoverable with assistance of advanced secondary and tertiary recovery techniques) billion barrels. This would provide a reserve/production ratio of 11:1, compared to the current 8:1.

Undiscovered Recoverable Resources of Oil

It is certain that in addition to the proved reserves additional oil will be found in the United States and in particular in Alaska and beneath the Continental Shelf. Data on undiscovered recoverable resources are no more than "guestimates", because there is no way to determine with any degree of accuracy the volume of oil that remains to be found in the United States until most of the interesting prospects have been thoroughly surveyed, and after actual exploration drilling has taken place. Hence, resources estimates continue to be subject to revision as new data become available.

TABLE 12.—UNDISCOVERED RECOVERABLE RESOURCES OF OIL (VARIOUS ESTIMATES)

[In billions of barrels]

Agency	Lower 48 States Onshore	Total
USGS (1972, Theobold, et al.)		458
USGS (1974)	110-220	200-400
USGS (1975)		50-127
NPC and AAPG	53-70	73-140
Mobil Oil Corp	11	88
M. King Hubbert (1972)	9	72
NAE (1974)	[1] 34	113
Shell Oil Corp. (Robert Nanz) 1975		110

The wide variations in resource estimates arise, in part, from the use of different predictive techniques. There are two major approaches, geological and mathematical. Although both use oil and gas exploration and production statistics, geological methods explicitly relate them to the area or volume of rock strata potentially containing oil or gas and to the technology used to extract them. Mathematical methods project future trends using past statistics—thus only implicitly considering evolutionary trends in geological and technological factors. The NPC and USGS, for example, use the geological method, Hubbert the mathematical method.[30]

Notwithstanding the considerable differences in resources estimates, recent studies in table 12 appear to agree on two points: 1) probable resources are not likely to be as large as were projected a few years ago and 2) the bulk of the undiscovered recoverable oil and gas resources are expected to be located in Alaska and off the coasts of the United States. Also, more recent studies tend to be more pessimistic about our petroleum resources potential than studies made during the 1960s. Although it is much too early to say whether the pessimistic estimates should receive more credence than optimistic evaluations, the former have been supported by 1974 drilling data. Exploratory drilling in the United States increased by more than 30% in that year while discoveries were disappointing, and total oil reserves continued to decline.

Many geologists maintain that the large onshore oil fields in the lower 48 States have already been found. Out of thousands of oil fields in the United States, 13 contained 23 percent of all the oil found in the United States, and 10 out of these 13 finds were made prior to 1940.[31] On the average only about one in 54 new field wildcat wells result in the discovery of a million barrels or more of recoverable oil or its equivalent in natural gas. Hence, in view of the extensive surveys made in the lower 48 States onshore, and the rate of discovery in this area during the past few decades, it is unlikely that many new large oil fields will be found outside Alaska and the Continental Shelf.

[30] Council on Environmental Quality, *OCS Oil and Gas—An Environmental Assessment*, Washington, D.C., April 1974, p. 2–10.
[31] *Energy Reports*, No. 86, Apr. 3, 1975, p. G–8.

TABLE 13.—U.S. PRODUCTION OF CRUDE OIL, NATURAL GAS, AND NATURAL GAS LIQUIDS (1964–74)

[In millions of barrels per day for oil and trillions of cubic feet of natural gas per year]

	1964	1966	1968	1970	1972	1974
Crude oil and condensate	7,615	8,295	9,095	9,635	9,440	8,765
Natural gas liquids	1,155	1,285	1,505	1,660	1,745	1,688
Total	8,770	9,580	10,600	11,295	11,185	10,453
Natural gas	15.3	17.5	19.4	22.0	22.5	21.3

Source: "British Petroleum Statistical Review of the World Industry, 1973," London, 1974, p. 19. Federal Power Commission, natural gas survey, vol. I, chap. 9 "Future Domestic Natural Gas Supplies" Washington, D.C. 1974 p. 20.

TABLE 14.—SELECTIVE FORECASTS OF U.S. OIL PRODUCTION

[Million barrels of oil per day]

Source	1975	1980	1985	1990	2000
National Petroleum Council (1972):					
Case:					
I	10.2	13.6	15.5		
II	10.2	12.9	13.9		
III	9.8	11.6	11.8		
IV	9.6	8.9	10.4		
Standard Research Institute (1972)	10.5	11.5		14.5	
Shell Oil Co. (1974; crude oil and NGL)	10.0	10.6	11.4	12.3	
British Petroleum (1973)	10.3	11.5	11.5		
M. King Hubbert (1974)	10.1	10.1	9.2		6.2
Department of the Interior (1974, unpublished)	10.4	11.9	14.5		13.6
Ford Foundation Energy Policy Project (1974):					
Historic growth:					
High imports		11.2	11.2		10.5
High fossil fuel		12.8	14.4		19.2
High nuclear		11.2	11.2		10.5
Technical fix:					
Base case			11.9		14.9
Low nuclear			13.7		15.2
High nuclear			11.9		11.9
MIT (1974; crude oil and NGL):					
$7 per barrel		10.5			
$9 per barrel		12.6			
$11 per barrel		14.8			
National Academy of Engineering (1974; crude oil and NGL)			12.5		
Atlantic Richfield Co. (1974)			15.3		
Hendrick S. Hauthakker (1974; crude oil and NGL):					
$4 per barrel			12.1		
$7 per barrel			15.1		
$10 per barrel			17.6		
David G. Snow (1974; crude oil and NGL)	10.2	14.6	15.5		
FEA (1974 Project Independence):					
$7 per barrel (business as usual)		11.1	11.9		
$11 per barrel (business as usual)		12.2	15.1		
$7 per barrel (accelerated development)		12.9	16.9		
$11 per barrel (accelerated development)		13.5	20.0		
CEQ (1974)			11.2		
CTAB (Commerce Department, 1975)			12.0		
Clark Associates (1974)		12.0	13.5		
This study	9.6	11.0	12.0		

In addition to Alaska, the continental shelves of the Atlantic, Pacific, and the Gulf of Mexico offer the best hopes for future major discoveries. Only about 5 percent of the continental shelf of the United States has been surveyed for oil and gas but prospects are generally considered favorable within each of the major areas.

TABLE 15.—OFFSHORE OIL ESTIMATES BY REGION

[In billions of barrels]

	USGS (1970)	USGS (1974)	NPC (1974)	Mobil (1974)	USGS (1975)
Gulf of Mexico	60	20-40	19	14	3-8
Pacific	8	5-10	17	14	2-5
Alaska	54	30-60	29	20	3-31
Atlantic	42	10-20	6	6	2-4
Total	164	65-130	71	54	10-48

Of our total 1973 production of crude oil and natural gas liquids of 10.1 million b/d, 1.8 million b/d or about 19 percent was produced from offshore areas. This is expected to rise to around 30 percent by 1985.

OIL PRODUCTION

United States oil production (including condensate and natural gas liquids) steadily increased until it peaked at 11,297,000 b/d (of which 9,180 b/d are crude oil). From 1970 onward, production has gradually declined to 10,453,000 b/d and unless the price of old oil is decontrolled soon, production is expected to decrease even further until the Alaskan pipeline brings in oil from the Alaskan fields in 1977. Production will begin to rise gradually after 1977 until sometime in the 1980's or early 1990's when the nation is expected to reach its all time peak.[32] Estimates of U.S. oil production by 1980 and 1985 differ considerably, depending on the range of assumptions made by the forecasters (see table 14). However, in light of recent re-evaluations of our potential recoverable oil resources by government agencies and private oil companies, some of the projections of future domestic oil production by the FEA and a few other forecasters are probably on the high side.

For example, FEA's Project Independence study maintains in its "business as usual" analysis that at prices of about $7 to $11 (1973 dollars), domestic oil production would increase by 1980 to 11.1 to 12.2 million b/d respectively, and by 1985 to 11.9 to 15.1 million b/d. Under FEA "accelerated development" assumptions (which included accelerated OCS leasing and opening up of Naval Reserve No. 4 in Alaska) at $7 to $11 per barrel, production in 1980 would be 12.9 to 13.5 million b/d respectively, and in 1985, 16.9 to 20.0 million b/d.[33]

This means that under the "business as usual", $7 per barrel scenario, according to the FEA's own estimates, 49.5 billion barrels of oil would need to be produced from 1974–1988 (which is more than current proved reserves in the U.S.). Under the "accelerated development" scenario, at a price of $11, cumulative production between 1974 and 1988 would need to be 73.2 billion barrels. In order to maintain an acceptable reserves-production ratio, the FEA study suggests that assuming reserves in 1988 would equal ten times the then current production rate, 92 billion barrels of producible crude oil and natural gas liquids would have to be added as reserves between now and 1988 (about 78 billion barrels of this total would be crude oil).[34]

---

[32] *Shell News*, v. 43, No. 1, 1975, p. 9. See also table 26, p. 35.
[33] Federal Energy Administration. Project Independence, *Oil; Possible Levels of Future Production*, Washington, D.C., November 1974, p. 2.
[34] Ibid., p. 5.

The 78 billion barrels of oil represent a figure larger than total undiscovered recoverable oil resources as projected by M. King Hubbert and the lower estimates of the USGS and the NPC/AAPG, and about ⅔ of the higher USGS and the NAS estimates. (See table 12.)

In a critique on Project Independence, the Commerce Technical Advisory Board (CTAB) in a report to the Department of Commerce, indicates that in order to achieve a production figure of 16 million b/d of oil, it would require a 1985 discovery rate never achieved in the last 30 years, and total footage drilled in 1985 would have to be twice the accelerated 1974 level.[35] In light of recent re-evaluations of ultimate recoverable petroleum resources in the United States, many petroleum geologists are questioning the validity of the Project Independence projections.

On the basis of the various estimates in table 14 and from many private conversations with oil company executives and government officials, one may conclude that a domestic oil production of 10 to 11 million b/d in 1980, and 11 to 12 million b/d by 1985 from all conventional sources—onshore and offshore—seems the maximum attainable. Because production from existing onshore sources could very well decline to about 5 million b/d by 1985 (5.6 incl. oil produced with tertiary recovery techniques), much of the 11–12 million b/d of oil will have to be produced from Alaskan and OCS lands. The North Slope is expected to contribute about 2 million b/d by the early 1980s, and the maximum production from Alaskan, Atlantic, Pacific and Gulf of Mexico OCS will probably not exceed 3.5 to 4 million b/d (see table 16). The final environmental impact statement on the accelerated OCS leasing plan proposed by the Department of the Interior, projects that accelerated oil and gas leasing on OCS lands could provide approximately 3.0 million b/d of oil and 12 billion cubic feet of natural gas per day.

TABLE 16.—FORECASTS OF MAXIMUM OFFSHORE OIL PRODUCTION BY 1985

[In thousands of barrels a day]

Area	FEA	CEQ	This study
Gulf of Mexico	2,100–2,500		1,500
Pacific	500–1,300		500–750
Atlantic	500	1,500	1,000–1,500
Alaska	780	500	500
Total	3,880–5,080		3,500–4,250

Assumptions underlying these estimates include a favorable government policy concerning leasing, exploration and rapid development of potential resources in frontier areas, availability of capital, etc. If OCS discoveries prove disappointing, or in case of serious delays in leasing of OCS lands, production estimates may need to be revised downward. Offshore production in fact peaked in Texas in 1968, in California in 1971, and in Louisiana in 1972. Production from the Gulf of Mexico, however, is likely to increase again as a result of large lease sales during the past few years, and California production may also grow now that drilling in the Santa Barbara Channel has been

[35] U.S. Department of Commerce, *CTAB Recommendations for a National Energy Program*, Washington, D.C., February 1975, p. 51.

resumed. But, time is of the essence. Even in areas close to established supply base and where petroleum-related infrastructure is already in existence (the Gulf Coast), development of leases may require about 3 years. Development of leases in hostile areas farther away from supply bases and infrastructure may require lead-times of 7 to 10 years.

Estimates of U.S. domestic oil production by the FEA (1974 Project Independence), the CTAB (1975 study of an advisory body to the Department of Commerce) and the National Academy of Engineering (1974) differ considerably. Because coal and nuclear power are already expected to fall short of projections made in these same studies, any shortfall of domestic oil production is likely to be met by further increases in oil imports.

TABLE 17.—ESTIMATED DOMESTIC OIL PRODUCTION AND PROJECTED SHORTFALL IN 1985

[In million of barrels per day]

	CTAB 1975	FEA (1974)		NAE (1974)
Estimated production	12	11.9–12.2	16.9–20	12.5
This study	12		12	12.0
Shortfall	0	–.1–.2	4.9–8	0

Chapter IV

NATURAL GAS RESERVES AND PRODUCTION

Natural Gas Reserves

Proven reserves of natural gas are those which geological and engineering data demonstrate with reasonable certainty to be recoverable from known reservoirs under current economic and technical operating conditions. Reserves grew rapidly until 1970 when proved reserves peaked at 290.75 trillion cubic feet (TCF). When the Nation turned rapidly to this cleanest of all fuels in the 1950's and 1960's (production grew from 6.28 TCF in 1950 to 21.9 TCF in 1970), additions to reserves could no longer keep up with increased consumption. As a result, the effective life of U.S. natural gas reserves declined from about 30 years in 1950 to 13 years in 1970 and slightly more than 10 years at present consumption rates.[36] Production of natural gas has risen rapidly until last year when it peaked at approximately 22.5 TCF in 1973.

TABLE 18.—U.S. PROVEN RESERVES OF NATURAL GAS, 1965-75

Year	Reserves	Production	Effective life of reserves (in years)
1965	286.47	16.04	17.9
1966	289.33	17.21	16.8
1967	292.91	18.1	16.1
1968	287.35	19.32	14.9
1969	275.11	20.7	13.3
1970	290.47	21.92	13.3
1971	278.80	22.49	12.4
1972	266.08	22.53	11.8
1973	249.95	22.46	11.1
1974	237.10	22.71	10.9

Source: De Golyer and MacNaughton, op. cit., p. 70. Federal Power Commission (for 1974).

Table 18 indicates that gas reserve additions increased production rates until 1968 when reserve additions were more than 7 TCF lower than production. From 1969 onward, reserve additions have been less than ½ of the production rate (with the exception of the 1970 Alaska find).

Advanced Recovery Techniques

Recovery efficiency of natural gas is much higher than that of oil (sometimes as high as 75-80 percent of the original gas-in-place), but new advanced techniques—such as fracturing of rocks with conventional or nuclear explosives—may further increase recovery efficiency in the future.

[36] DeGolyer and MacNaughton, *Twentieth Century Petroleum Statistics*, Dallas, Texas. September 1, 1974, p. 70.

Undiscovered Recoverable Resources of Natural Gas

It is certain that in addition to proved reserves more natural gas will be found in the lower 48 States, in Alaska and beneath the continental shelf. Since there is no way to determine the actual volume of resources until most prospective structures have been surveyed and an extensive exploratory drilling program has been conducted, all estimates in table 19 are subject to revision.

TABLE 19.—UNDISCOVERED RECOVERABLE RESOURCES OF NATURAL GAS (VARIOUS ESTIMATES IN TCF)

Agency	Lower 48 States onshore	Total
M. King Hubbert (1969)	377 (including offshore)	494.
M. King Hubbert (1972)	100	562.
Linden (1972)	380 to 553 (including offshore)	558 to 687.
Moore (1970)		841.
Mobil Oil Corp		443.
NPC and AAPG	550	595 to 1,227.
USGS (1974)	593 to 1,117	1,130 to 2,250.
USGS (1975)		322 to 655.
National Academy of Engineering (1974)	About 160	530.
PGC	550	1,146.

Sources: Federal Energy Administration, Project Independence Blueprint, "Natural Gas," Washington, D.C., November 1974, pp. 1–19. Washington Academy of Sciences, "Mineral Resources and the Environment," Washington, D.C., 1975. p. 89. United States Geological Survey.

The wide variations in estimates of natural gas potential stem to a large extent from different predictive techniques (see chapter III, p. 21).

However, like the estimates of potential domestic oil resources in chapter III, most recent studies tend to agree that potential resources of natural gas are not likely to be as large as projected by USGS only one year ago, and that much of the potential undiscovered resources of natural gas is likely to be located in Alaska and beneath the continental shelves.

TABLE 20.—OFFSHORE NATURAL GAS ESTIMATES BY REGION

[In trillions of cubic feet]

	USGS (1970)	USGS (1974)	NPC (1972)	Mobil (1974)	USGS (1975)
Gulf of Mexico	250–425	160–320	220	69	18–91
Pacific	15–25	10–20	25	69	2–6
Alaska	170–340	170–340	185	105	8–80
Atlantic	55–110	55–110	60	31	5–14
Total	490–900	395–790	490	274	33–191

Offshore natural gas production has increased rapidly both in absolute terms and as a percentage of total domestic production. Of a total of 22.6 TCF of natural gas produced in 1973, 3.2 TCF (or slightly less than 20 percent) was produced from offshore areas. The contribution of offshore gas could rise to about 30 percent of total domestic production of natural gas by 1985.

Natural Gas Shortage

Nineteen seventy-four signaled the sixth yearly decline in proved natural gas reserves in the country in the past seven years. Only the Prudhoe Bay discovery of 26 TCF in 1970 kept the industry from recording its 7th consecutive reserves decline in 1974.

The Bureau of Natural Gas of the Federal Power Administration warned of the pending shortage in a report in 1969:

> Evidence is mounting that the supply of natural gas is diminishing to critical levels in relation to demand . . . On the basis of current trends, only a few years remain before demand will outrun supply.[37]

In a follow-up report released in February 1972, the Bureau of Natural Gas predicted that gas production would peak in the mid-seventies (appears to have peaked in 1973), and that shortages would be of long duration leading to supply deficiencies of 9 TCF in 1980 and 17 TCF in 1990, even after optimistic allowance for new supplies from supplemental sources such as gasification of coal and gas imports.[38] No new government-industry programs have been launched between the time when the 1969 report was issued and today, and consequently it is no longer possible to insure continuing gas service continuing at 1973 levels, much less at levels necessary for sustained growth. For the next couple of years output of natural gas is likely to continue to decline at about 4 percent per year. This will result in service curtailments, widespread plant and business shutdowns and local unemployment and economic problems.[39] For the longer term, accelerated leasing of Federal lands, increased exploration incentives, and development of substitute sources of energy can provide new increments of supply. Another alternative is to substitute oil for gas (imported oil), and to import more LNG (medium to longer term).

What happened to oil production in 1970, happened to natural gas in 1973. Both reached their record high production level and production has begun to decline. Events in recent years have tended to lend credibility to the lower range of oil and gas estimates (see table 19). There has been a significant increase in the level of exploratory drilling for gas over the past several years, yet discoveries and reserve additions continue to decline. The Federal Power Commission states: "Presumably, the oil companies are drilling their best prospects but are finding fewer gas deposits of significant size."[40] For example, while drilling effort in 1973 was about one-third higher than in 1966, reserve additions declined from about 13 TCF to approximately 9 TCF, and the discovery rate diminished from 536 MCF/foot in 1966 to 254 MCF/foot in 1973. The number of significant gas discoveries (defined as fields of more than 6 billion cubic feet of ultimately recoverable proved reserves) declined from 99 in 1957 to 41 in 1967 (no later figures available).[41]

Projecting current trends into the future, the FPC maintains that the average addition to new natural gas reserves of 9 TCF for the period 1968–73 in the lower 48 States can be reasonably expected to

---

[37] Federal Power Commission, *A Realistic View of U.S. Natural Gas Supply*, Staff Report, Washington, D.C., December 1974, p. 1.
[38] Ibid., p. 2.
[39] Ibid., p. 2.
[40] Ibid., p. 5.
[41] Ibid., p. 8.

continue. This would mean that natural gas production in this instance would fall an average of 4 percent a year to 1985 when production would be 13.8 TCF.[42]

If one were to project additions to reserves equal to the average of the past 14 years since 1960, i.e. 14.7 TCF per year, production would gradually decline by 2 percent per year, reaching 17 TCF in 1985.[43]

The FPC also estimated that in order to maintain the 1973 level of gas production of 22.6 TCF, annual reserve additions must rise to the 22–24 TCF range by 1975 and then remain at that level. In view of the performance of the industry over its entire history to date and particularly in view of its performance over the last six years, the FPC does not believe this probable.[44]

Hence, further production growth appears highly unlikely at this time. Even a modest production growth rate of one percent per year (experienced between 1970–1973) would require annual reserve additions of approximately 27 TCF per year (compared with slightly over 9 TCF in 1973).

In a major natural gas survey study undertaken by the FPC in 1974, four possible supply situations were projected for the future. Case I assumed little or no change in the current situation; cases II and III were more optimistic intermediate cases; and, case IV assumed maximum supply presumed available (responding significantly to increases in the wellhead price of gas). The report indicated that case II was considered "reasonably assured" and case III was believed to be attainable.[45]

TABLE 21.—FUTURE AVAILABLE GAS SUPPLY FORECASTS

[Trillion cubic feet]

Source	Actual, 1975	Case I			Case II			Case III		
		1975	1980	1985	1975	1980	1985	1975	1980	1985
Conventional sources (United States) total	22.0	22.2	19.1	15.1	22.5	20.6	20.0	22.6	24.7	23.6
Lower 48 States	21.8	22.0	18.9	14.8	22.3	20.3	17.6	22.4	22.3	20.2
Substitute natural gas			.2	.7		.3	1.1		.4	1.3
Total domestic supply	22.0	22.2	19.3	15.8	22.5	20.9	21.1	22.6	25.1	24.9
Foreign imperial total	.8	1.4	2.1	2.2	1.8	3.8	4.2	2.2	6.1	7.7
Of which by pipeline	.8	1.0	1.0	.9	1.2	1.3	1.4	1.2	1.9	2.2
Total	22.8	23.6	21.4	18.0	24.3	24.7	25.3	24.8	31.2	32.6

Unless there is a considerable change in natural gas discoveries, even the forecasts under case II now appear to be optimistic. Privately, some experts at the Federal Power Commission agree that actual production in 1980 and 1985 is likely to be closer to the figures projected under case I. They do not expect the industry to add the 14.7 TCF of gas per year to reserves needed to produce more than 17 TCF from the lower 48 States.

Based on various personal conversations with natural gas experts at the Federal Power Commission and industry officials, it now seems

[42] Ibid., p. 12.
[43] Ibid., p. 12.
[44] Ibid., p. 13.
[45] Federal Power Commission, *National Gas Survey*, vol. I., Chapter 9, Future Domestic Natural Gas Supplied, Washington, D.C., 1974, p. 7.

likely that natural gas production will be significantly lower in 1980 and 1985 than it is today. This study's projections of total domestic production of conventional and synthetic gas for 1980 and 1985 are 17.0 and 19.0 TCF respectively. The 17.0 TCF in 1980 would be produced from the lower 48 States (onshore and offshore). By 1985, production in the lower 48 States would have stabilized at 17.0 TCF, Alaskan gas would contribute 1.5 TCF and 0.5 TCF would come from synthetic sources.

TABLE 22.—ESTIMATED DOMESTIC NATURAL GAS PRODUCTION AND PROJECTED SHORTFALL IN 1985

[In Trillions of cubic feet]

	NPC (1972) cases II and III	FEA (1974)		NAE (1974)	CTAB (1975)	EPC (1974) cases I and II
		BAU	AD			
Estimated domestic production	20.4–26.5	24–24.9	23–29	29.7	22	15.8–21.1
This study	19		19	19.0	19	19.0
Shortfall	1.4–7.5	5–5.9	4–10	10.7	3	+3.2– −2.1

Table 22 shows a production shortfall on the basis of a domestic production of natural gas of 19.0 TCF/year by 1985. Our projection is based on a recent forecast by the Federal Power Commission for the lower 48 States and on production estimates for Alaska, provided by the American Gas Association.[46]

An earlier study by the FPC (see table 21) shows that if the current rate of additions to natural gas reserves continues (9 TCF average between 1968–73), domestic production would be 15.8 TCF by 1985. Assuming a substantial improvement of the finding rate back to the 1960–73 average of 14.7 TCF per year—an assumption FPC officials privately hold overly optimistic—production would still fall short of the NPC, FEA, NAE and CTAB estimates in table 22.

Canadian imports of natural gas were estimated at 0.960 TCF by 1985. However, this cautious optimism has changed recently into pessimism when Canada announced its natural gas exports phaseout plan (see chapter VIII).

The most likely substitutes for any shortfall in natural gas production are imported oil and some liquid natural gas (conversion ratio: 1 TCF of natural gas per year is approximately 472,000 barrels of oil per day).

[46] For an analysis of the FPC study, see: *Federal Power Commission, A Realistic View of U.S. Natural Gas Supply*, op. cit.

Chapter V

U.S. DOMESTIC ENERGY FORECASTS THROUGH 1985

In the space of one hundred and seventy six years the lower Mississippi has shortened itself 242 miles. That is an average of a trifle over one mile and a third per year. Therefore, any calm person who is not blind or idiotic, can see that in the old Oolitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upward of one million three hundred thousand miles long. By the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three quarters long. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.

Mark Twain.

There is a danger of simply extrapolating current demand and supply for energy into the future. In doing so one may overlook factors that could play a major role in changing our forecasts, but which cannot be foreseen at this time. Hence, our energy demand and supply forecasts do not project what the future will be, but provide the most likely ranges of demand and supply if current trends continue. This study has singled out 1977, 1980 and 1985 for the following reasons: (1) if recent economic indicators are correct, the Nation is recovering from the worst post-war recession, and consequently energy demand is likely to soar over the next eighteen months; (2) domestic oil supply is likely to reach its lowest level in years prior to the completion of the Alaska pipeline in the fall of 1977; (3) natural gas supply is likely to continue its rapid decline, and even complete decontrol is not projected to reverse the decline within the next few years; (3) 1985 has been the target year for Project Independence; (4) by 1985 significant additional oil supplies and some additional gas supplies will be available from Alaska and the outer continental shelf; (5) provided major efforts in supporting private enterprise, the President's plan of adding 1 million b/d of synthetic fuels could be realized; (6) assuming no additional major cancellations of nuclear and coal-fired powerplants, nuclear energy and coal should play a major role in electricity generation by 1985; (7) under favorable supply conditions, the Nation could reach its highest dependence on foreign oil in the early 1980's.

In view of many uncertainties connected with energy growth rates, the effects of higher prices on demand, the degree of success of decoupling energy growth rates from GNP growth, substitution of oil for natural gas, interruption of foreign oil supplies, and so on, energy growth rates in the United States could range anywhere between 2 percent and 4 percent in the next ten years.

TABLE 23.—ENERGY DEMAND FORECASTS IN THE U.S.

[In millions of barrels per day oil equivalent]

	Percent					
	2.0	2.5	2.8	3.1	3.5	4.0
1974 (actual)	36.5	36.5	36.5	36.5	36.5	36.5
1975 (projected)[1]	36.2	36.2	36.2	36.2	36.2	36.2
1977	37.6	38.0	38.3	38.5	38.8	39.1
1980	39.9	40.9	41.6	42.2	43.0	44.0
1985	44.0	46.3	47.7	49.1	51.0	54.0

[1] 1975 energy demand estimate based on Data Resources Industry projection.

Long-term historical energy growth in the United States has averaged around 3.5 percent per year, but from the middle 1960's until the 1973 Arab oil embargo, energy demand in the U.S. grew at an all-time high of 4.5 percent. It seems unlikely, in view of the current high cost of energy, that energy demand will grow as rapidly again. On the other hand, reducing energy growth rates to 2% or less during the 1975–1985 period, without impairing sound economic growth rates averaging between 3% and 3.5%, is probably unrealistic. Hence, this study projects energy growth rates averaging between 2.8 and 3.1% for the next decade, from 1975 to 1985. Energy forecasts by the Department of the Interior for the same period as covered by this study range between 38.4 and 39.3 million b/d for 1977; between 41.0 and 43.1 million b/d in 1980; and, between 47.1 and 51.5 million b/d by 1985.[47] The estimates by the Department of the Interior assume the price of oil at $11.00 per barrel. The lower estimates assume successful conservation. The most probable energy demand projections in this study are generally within the same range as the D.O.I. forecast.

TABLE 24.—ESTIMATE OF MAJOR SOURCES OF DOMESTIC ENERGY SUPPLY IN 1985

Source	Range of estimates	Planning base
Oil	11–12 MM barrels per day	12 MM barrels per day.
Natural gas (including syngas)	15.8–24.5 T cf per year	19 T cf per year.
Coal	800–1,000 million tons per year	900 million tons per year.
Nuclear energy	188–205 GWe	188 GWe.
Hydropower	58–65 GWe	58 GWe.
Geothermal	3–8 GWe	3 GWe.
Shale oil	0.25–0.5 MM barrels per day	0.5 MM barrels per day.

TABLE 25.—FORECASTS OF MAJOR SOURCES OF ENERGY SUPPLY IN THE UNITED STATES

Source	1973	1977	1980	1985
Oil (crude and natural gas liquids) (millions of barrels per day)	10.1	10.0	11.0	12.0
Natural Gas (trillion cubic feet per year)	22.5	19.0	17.0	19.0
Coal (tons per year)	600.0	700.0	800.0	900.0
Nuclear (GWe)	21.0	55.6	87.0	188.0
Hydro (GWe)	54.0	54.0		58.0
Shale oil	0	0	.2	.5
Geothermal (GWe)	Negl	Negl	.1	3.0

On the basis of current estimates by industry and government, the following energy-supply forecast has been made:

[47] U.S. Department of the Interior. *Energy Perspectives.* Washington, D.C., February 1975, p. 54.

TABLE 26.—FORECASTS OF MAJOR SOURCES OF ENERGY SUPPLY IN THE UNITED STATES

[In millions of barrels a day oil-equivalent]

Source	1973	1977	1980	1985
Oil (crude and natural gas liquids)	10.1	[1] 10.0	11.0	12.0
Natural gas (including syngas)	10.6	8.9	8.0	8.9
Coal	6.4	7.4	8.2	9.7
Nuclear	.4	1.6	2.4	5.3
Hydro	1.4	1.4	1.5	1.7
Geothermal	Negl	Negl	.1	.2
Shale oil	0	0	.2	.5
Other (solid waste, syncrude, solar)	0	0	.2	.4
Total	28.9	29.3	31.6	38.7

[1] Supply estimate assumes complete oil decontrol. Decontrol of old oil could add as much as 300,000 barrels per day according to FEA estimates.

Note: 1 trillion cubic feet per year equals 472,000 barrels per day; 1,000,000 tons of coal equals 3,000,000 to 4,000,000 barrels of oil; 1 GWe equals 28,000 barrels per day.

These estimates are for the purpose of planning, and actual production is likely to be different from these figures, especially for projections as far into the future as 1985. However, on the basis of current knowledge, based on data collected by industry and government sources, production estimates in this study appear realistic, if not slightly optimistic, particularly for 1985. Production figures were derived by making a number of assumptions which have been discussed in earlier chapters. Suffice to summarize assumptions used in this analysis:

1. Oil production peaked in 1970 and has declined ever since. In this study we have assumed complete decontrol of old oil by 1977. Decontrol could add as much as 300,000 b/d by 1977. After 1977, oil production will increase due to availability of Alaskan crude. 1980 projection of 11.0 million b/d would come from the following sources: 6.8 million b/d from the lower 48 States onshore; 1.8 million b/d from Alaska; 0.2 million b/d tertiary recovery; 2.2 millions b/d offshore oil. Production of 12.0 million b/d by 1985 would come from the following sources: 4.9 million b/d onshore Lower 48 States; 0.6 tertiary recovery; 2.2 from Alaska; and, 3.8 million b/d from offshore sources. Estimates of offshore oil for 1980 and 1985 are high and assume successful finding rates in the OCS, and implementation of the accelerated leasing program proposed by the Administration. It also assumes significant offshore discoveries within the next few years, and shortening of the lead-times between leasing and full production. Many observers now believe that the projections for offshore oil in this study are difficult to obtain, and actual production may fall short by as much as 1 million b/d by 1980 and 1985. Assuming that significant oil discoveries are made in Naval Petroleum Reserve No. 4 on the Alaskan North Slope within the next decade, this study does not project any production from this potential source until an additional pipeline has been constructed sometime after 1985. This study also assumes successful implementation of the President's multi-billion-dollar program to aid industry in the development of synthetic fuels. Without massive Federal aid, estimates for synthetic fuels by 1985 should be decreased by at least 700,000 b/d, resulting in additional oil imports.

2. Natural gas production is expected to continue its current decline at least until the early 1980's when we project that additional supplies

from Alaska and offshore areas should become available. Continuation of the 1973 peak production of 22.5 TCF does not seem likely even if price decontrol takes place. It would mean that between 1975 and 1985 an average of 22.5 TCF would be added to reserves every year in order to maintain the current reserve-production ratio of 11 years. In the entire history of U.S. natural gas production this has only happened twice. In 1970, when the Prudhoe Bay find added 26.0 TCF to reserves, and in 1956, when 24.7 TCF were added to reserves. Average additions to reserves between 1968 and 1973 have been 9.5 TCF, and between 1960–1973 an average of 14.7 TCF were added. With the exception of the Prudhoe discovery the major decline in reserve additions set in in 1968, when additions to reserves were about 8 TCF less than the year before. In our analysis we assume some decontrol of natural gas, and expect that the upsurge in exploratory activities will reverse the current decline in reserve additions somewhat. As continuation of the 1973 peak production does not seem very realistic in view of the fact that between 1975 and 1985 a "Prudhoe"-type discovery would have to be made every year, a somewhat more realistic assumption has been made, leading to the conclusion that the current decline in reserve additions will be reversed in the near future. A return to the 1960–1973 average of 14.7 TCF of reserve additions per year seems optimistic, but quite possible. However, an immediate effect on production is not expected because of the lead-time between discovery and full production. Hence, we have concluded that production will continue to decline rapidly for some years to come, with a reversal by the end of the decade and by the early 1980's when the combination of increased exploration activities and the availability of Alaskan natural gas are likely to reverse the decline.

The 1980 projection includes 0.1 TCF of syngas; the 1985 estimate includes 1.5 TCF of Alaskan gas and 0.5 of syngas. If, however, the 1968–1973 trend prevails (with reserve additions of 9 TCF per year), production decline will continue beyond the end of the decade into the 1980's, leaving us with a production of 15.8 TCF in 1985, of which 2 TCF is Alaskan and syngas. Assuming that shortfalls in natural gas production will be made up by imported oil, such a shortfall would translate into 1.4 million b/d additional oil imports.

Coal.—U.S. coal resources are said to contain 37 times as many Btu's as the entire Middle Eastern oil reserves. However, many observers now agree that the FEA blueprint was overly optimistic in assuming that 1.2 billion tons/year would be produced by 1985. In table 25 a domestic utilization of 700 million tons in 1977 (of which 100 million Western coal); 800 million tons in 1980 (of which 200 million Western coal has been projected); and 900 million in 1985 (of which 300 million Western coal). Some analysts believe that 900 million is the maximum utilization figure for 1985, with 800 million tons as a clear possibility. Depending on the mix of Eastern and Western coal, production shortfalls again might have to be made up by importing more oil (1 to 1.5 million b/d). If, however, optimists prove to be right and production reaches 1,000 million tons in 1985, imports could be reduced by 1 to 1.5 million b/d.

Nuclear energy, the great promise of the 1960's is still expected to grow rapidly during the next ten years but not as rapidly as was projected in most energy studies of the 1960's and early 70's. Industry forecasts are for a production of 55.6 GWe in 1977, 87 GWe in 1980 and 188 GWe in 1985, provided that no additional plant cancellations occur in the next few years.

Hydropower is expected to grow slightly beyond current capacity, and geothermal energy has been projected to make a minor contribution to total energy needs by 1980.

We have assumed that the serious shortfall in natural gas production and possible shortfalls of other energy sources will be made up by importing more oil. The only short-term alternative to increasing oil imports will be rationing, which will almost certainly result in slower economic growth and higher unemployment.

Comparing our supply forecasts with energy demand projections (see table 23) for the United States by 1977, 1980, 1985, energy imports would be as follows:

TABLE 27.—PROJECTED OIL AND NATURAL GAS IMPORTS AT DIFFERENT RATES OF ENERGY GROWTH

[In millions of barrels a day oil equivalent]

Year	2 percent	2.5 percent	2.8 percent	3.1 percent	3.5 percent	4 percent
1974 (actual imports)	6.0	6.0	6	6.0	6.0	6.0
1977	8.3	8.7	9	9.2	9.5	9.8
1980	8.3	9.3	10	10.6	11.4	12.4
1985	5.3	7.6	9	10.4	12.3	15.3

These figures include natural gas imports from Canada which are now running at about 1 TCF/year (or 472,000 b/d in oil equivalent), and may continue at this rate under favorable circumstances (see section on Canada). The remainder will almost exclusively consist of crude oil and oil product imports from Eastern and Western Hemisphere sources, with some LNG (from Eastern Hemisphere sources) possible as early as 1979–80.

Given the high cost of energy and subsequent efforts to maximize conservation, energy growth rates of 4 percent are no longer considered probable in the United States. On the other hand, an energy growth rate of 2 percent could mean very slow economic growth over the next decade combined with a successful conservation program. Most forecasts today project between 2.5 and 3.5 percent energy growth per year, depending on the rate of economic growth and conservation prospects. An average annual energy growth rate of 2.8 to 3.1 percent would appear reasonable, in view of expected results from conservation measures and our national desire to continue a long-term economic growth rate of at least between 3.0 and 3.5 percent per year.

Using 2.8 to 3.1 percent energy growth rates the estimates of oil imports by 1980 and 1985, are somewhere in between the high and low estimates of recent studies undertaken by government agencies, private organizations and oil companies. The considerable differences that still exist are related to differences in projections of economic growth rates, energy growth rates, the effects of higher prices on energy demand, energy conservation policy and contributions of domestic sources of oil, gas, nuclear, coal and other sources of energy.

TABLE 28.—FORECASTS OF OIL IMPORTS

[In millions of barrels per day]

	1980	1985
Preembargo studies:		
NPC, 1972:		
4-percent energy growth, worst case analysis	17.5	21.0
4-percent energy growth, intermediate supply	11.7	15.3
ICAE, 1973	10.8	14.6
Shell Oil, 1973	14.1	17.8
Department of the Interior, 1972	9.1	13.3
Postembargo studies:		
Sherman Clark Associates, 1975	9.0	9.5
Sherman Clark Associates 1975 (major shortfalls in nuclear and coal)	15.0	17.0
Petroleum Industry Research Foundation, 1975		7.0
Gulf Oil, 1975	6.0	6.0
Mobil Oil, 1975—assuming "maximum" cooperation between Government and industry		7.0
FEA, 1975:		
Before oil tariff of $2	6.8	7.1
Removal of tariff and domestic price decontrol	5.8	6.1
Decontrol of domestic oil and $2 tariff (all 3 cases assuming current world market price of oil will remain unchanged)	4.4	3.9
Shell Oil, 1975:		
Assuming frontier development	11.0	11.0
Without frontier development	15.0	15.0
Exxon Corp., 1975	10.8	11.2
This study (most likely scenario, including natural gas)	10.0–10.6	9.0–10.4

While the domestic energy supply forecasts of table 25 appear most realistic to us in view of recent industry and independent projections, table 29 provides alternative scenarios under different supply assumptions. With the exception of case F, all other alternative scenarios assume additional shortfalls in some or more energy sources, resulting in heavier reliance on imported oil.

TABLE 29.—ALTERNATIVE ENERGY SUPPLY AND OIL IMPORT FORECAST FOR 1977

[In million barrels per day]

	A[1]	B[2]	C[3]
Oil	9.7	10.0	9.7
Natural gas	8.9	8.9	8.9
Coal	6.6	6.6	7.4
Nuclear	1.6	1.6	1.6
Hydro	1.4	1.4	1.4
Other	[4]	[4]	[4]
Total domestic supply	28.2	28.5	29.0
Oil imports	9.4–10.9	9.1–10.6	8.6–10.1

[1] No decontrol of old oil and coal production of 660,000,000 tons.
[2] Decontrol of old oil and coal production of 660,000,000 tons.
[3] No decontrol of old oil.
[4] Negligible.

TABLE 29a.—ALTERNATIVE ENERGY SUPPLY AND OIL IMPORT FORECASTS FOR 1985

[In millions of barrels a day]

	A[1]	B[2]	C[3]	D[4]	E[5]	F[6]	G[7]	H
Oil	12.0	12.0	12.0	12.0	12.0	12.0	11.0	12.0
Natural gas	[9] 7.1	7.1	8.9	8.9	8.9	10.6	7.9	8.7
Nuclear[10]	[11] 4.0	5.3	5.3	4.0	4.0	5.7	8.2	9.7
Coal	[12] 8.2	9.7	8.2	9.7	8.2	10.2	4.0	5.3
Other (hydro, geothermal, shale oil and syncrude)	2.8	2.8	2.8	2.8	2.8	2.8	2.0	2.0
Total	35.1	36.9	37.2	37.4	34.9	41.3	33.1	37.7
Oil imports	8.9–18.9	7.1–17.1	6.8–16.8	6.1–16.4	9.1–19.1	2.7–12.7	10.9–20.9	6.3–16.3

See footnotes on page 39

[1] Major shortfalls in natural gas, nuclear energy, and coal.
[2] Major shortfall in natural gas only.
[3] Major shortfall in coal.
[4] Major shortfall in nuclear energy.
[5] Major shortfall in nuclear and coal energies.
[6] High supply of coal, nuclear, and natural gas.
[7] Low domestic supply of oil, gas, coal, nuclear, and synthetics.
[8] Low domestic supply of synthetic fuels.
[9] 13.8+1.5=15.3 trillion cubic feet.
[10] Nuclear power projections by Petroleum Industry Research Foundation study of May 1975. See also Oil and Gas Journal, Aug. 4, 1975, p. 113 for an even lower projection of 122 GWe by 1985.
Natural gas assumptions under options A and B are continuation of the most recent discovery trend of 1968–73, when an average of 9.5 T cf were added to reserves. The 1.5 T cf are Alaskan gas expected to come on stream by the early 1980's. The low coal projection of 800,000,000 tons per year assumes major difficulties in obtaining large supplies of Western coal, and assumes also major additional problems related to coal demand and supply as discussed in subsection on coal. The final scenario (F) assumes major increases in natural gas reserves, from current annual additions to reserves cf 9.5 T cf to an average of 22.5 T cf between 1975 and 1985. It also means that ERDA's projections of nuclear power contribution of 205 GWe by 1985 will be realized, and that 1,200,000,000 tons of coal will be utilized as projected in FEA's Project Independence.
[11] 142 gigawatt electrical.
[12] 800,000,000 tons per year.

Alternatives to Growing Worldwide Dependence Upon Oil and Gas and Lead-Times

Some energy experts have argued that dependence on oil and natural gas could be reduced by the early 1980's by shifting energy supply to coal, nuclear and unconventional sources of energy. However, in view of the sizeable lead times required in opening up new coal mines and constructing nuclear powerplants, there are serious limitations to substituting coal and nuclear energy from oil and gas in the period covered in this study. Moreover, lead-times between exploration for oil and gas in the frontier areas, our best future prospects for petroleum development, are such that even major oil and gas discoveries in the next few years may not alter our 1977 and 1980 scenarios and may only marginally affect supply in the early 1980's.

TABLE 30.—*Estimated facility leadtimes (years from decision to startup)*

	Years leadtime
Development of proved, but nonproducing field in the Middle East	1 to 2.
Production from extensions of oil fields in the United States	1 to 3.
Surface coal mine	2 to 4.
Underground coal mine	3 to 6.
Oil, geothermal, synthetic powerplants	5.
Coal-fired powerplant	5 to 8.
Hydroelectric dam	5 to 8.
Production of oil and gas from new fields in the United States	3 to 12.
Uranium exploration and mining	7 to 10.
Nuclear powerplants	8 to 10.
Coal gasification	10 to 15.
Tar sands and oil shale	5 to 10.

Sources: National Academy of Engineering, *U.S. Energy Prospects*, op. cit., p. 92. Ronald Lewison, op. cit., p. 23.
Federal Energy Administration, *Project Independence Report*, op. cit., p. 69.

PART II

WORLD DEMAND AND SUPPLY OF PETROLEUM AND ITS RELATIONSHIP TO U.S. IMPORTS: PAST PRESENT AND FUTURE

CHAPTER VI

WORLD RESOURCES AND PROVED RESERVES OF PETROLEUM

> Petroleum is by far the most efficient and versatile of energy sources. In addition, it is the prime or only raw material for a vast array of petrochemicals. Petroleum is supreme, in fact almost unique, among possible energy sources by reason of its wide utility, [and] its unsurpassed end product versatility in refining and processing . . .
>
> LEWIS WEEKS,
> *Petroleum Geologist.*

In the period from 1970–1985 man is expected to consume more petroleum than in the entire history of the oil industry preceeding 1970. If the Arab oil embargo—and the subsequent quadrupling of the price of crude oil—had not occurred in 1973, men might have consumed more oil in the decade from 1975–1985 than in the entire history of the industry before the days of the oil embargo.

Even at the current high price of oil, John D. Moody, president-elect of the American Association of Petroleum Geologists has projected that world crude oil production "must necessarily decline by the late 1980s to early 1990s.[48]

Before discussing available oil and natural gas reserves and estimates on undiscovered recoverable petroleum resources, it is important to distinguish between oil and gas resources and reserves. Ultimate Recoverable Resources or Potential Resources are the quantities of crude oil and natural gas that are believed to be present in the sedimentary rocks of unexplored or partly explored regions and that are potentially available through intensive exploration. (See also appendix.)

[48] *World Oil*, September 1975, p. 49.

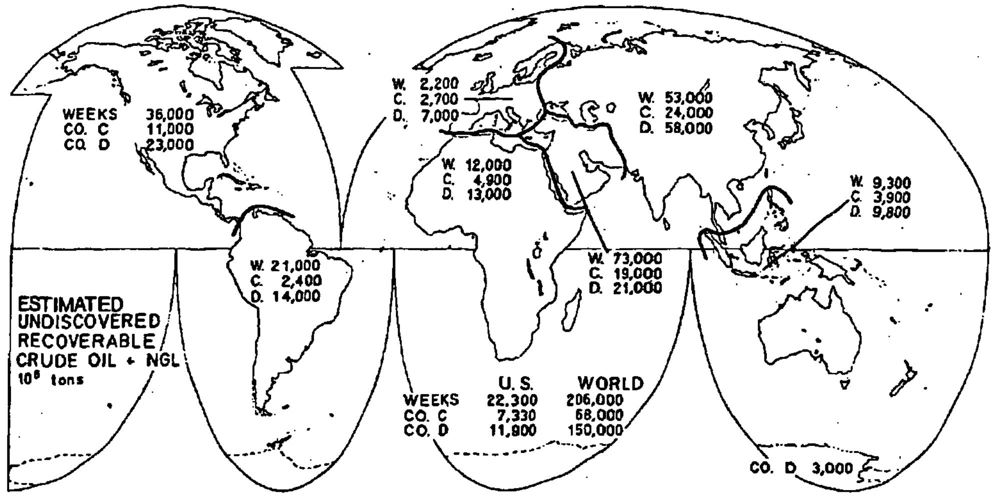


FIGURE 7. *Recoverable oil resources of the world:* Based on material from Lewis Weeks (W) published in 1960, and two major oil companies, C and D, collected respectively in 1973 and 1974. (1 metric ton is approximately 7.3 barrels of oil).

Source: National Academy of Sciences. "Mineral Resources and the Environment." *op. cit.* p. 112.

TABLE 31.—WORLD ESTIMATED ULTIMATE CRUDE OIL RECOVERY, JANUARY 1, 1975

	Discovered ultimate recovery		Undiscovered potential—resources: Expected		Undiscovered potential—resources: Range		Total recovery	
	Billions of metric tons	Billions of barrels of oil	Billions of metric tons	Billions of barrels of oil	Billions of metric tons	Billions of barrels of oil	Billions of metric tons	Billions of barrels of oil
Russia and China et al	24.3	178	40.9	300	9.5–95.5	70–700	65.2	478
United States	21.4	157	11.6	85	6.8–20.5	50–150	33.0	242
Canada	2.2	16	9.6	70	5.5–15.0	40–110	11.7	86
Total North America	23.6	173	21.2	155	13.6–34.1	100–250	44.7	328
Middle East	70.0	613	20.5	150	10.2–38.2	75–280	90.5	663
Other foreign:								
Greater North Sea	3.1	23	6.1	45	2.7–10.9	20–80	9.3	68
Other Western Europe	.5	4	1.6	12	.9–2.3	7–17	2.2	16
North Africa	7.4	54	4.5	33	2.0–8.2	15–60	11.8	87
Gulf of Guinea	4.9	35	4.1	30	2.0–6.8	15–50	8.9	65
Other Africa			1.1	8	.4–2.0	3–15	1.1	8
Northwestern South America	8.3	61	4.4	32	2.7–6.8	20–50	12.7	93
Other Latin America	3.1	23	6.8	50	3.1–13.0	23–95	10.0	73
Southeast Asia	4.4	32	4.4	32	2.5–6.8	18–50	8.7	64
Other Far East	1.2	9	7.9	58	2.7–16.4	20–120	9.1	67
Antarctica			2.7	20	.7–6.8	5–50	2.7	20
Total other foreign	32.9	241	43.6	320	27.3–68.2	300–500	76.5	561
Total worldwide	150.8	1,105	126.2	925	81.9–191.0	600–1,400	276.9	2,030

Note: 7.33 barrels equals 1 metric ton.

Source: "World Oil," September 1975, p. 49 (based on article by John D. Moody and Robert W. Esser).

TABLE 32.—ESTIMATES OF NATURAL GAS RESOURCES

[In cubic kilometers]

Continent, geographical region, and country	Estimates by other: Possible ultimate discoveries—Hendricks [1] 1965	Estimates by other: Remaining recoverable resources: Linden [2] Dec. 1971	Estimates by other: Remaining recoverable resources: USGS [3] 1973	WFC studies: Total reserves—1968 study [4]	WFC studies: Proved recoverable reserves—1974 study
(1)	(2)	(3)	(4)	(5)	(6)
Africa	96,280	48,140	9,648–96,480	2,680–4,745	5,709
Asia:					
Far East (including Peoples Republic of China)	11,330		8,796–87,960	979–1,024	2,357
Middle East	62,300		10,650–106,500	6,074–6,607	9,884
U.S.S.R., Peoples Republic of China, Mongolia	150,100				
Asia-Pacific (including European U.S.S.R.)		121,760			
U.S.S.R.			30,000–300,000	70,404	17,136
Europe (excluding U.S.S.R.)	22,650	11,330	5,736–57,360	4,255	4,513
North America:					
United States	70,790	41,260	30,000–300,000	56,640	7,556
Remaining North America	62,300		6,519–65,190	2,137	[5] 3,093
Western Hemisphere (except United States.)		53,600			
South America	45,300		10,560–105,600	1,557–1,635	1,591
Oceania			3,303–33,030	208	693
Australia, East Indies, Pacific islands	19,820				
Total world	540,870	276,090	115,212–1,152,120	144,934–147,655	52,532

[1] T. A. Hendricks. "Resources of Oil, Gas, and Natural Gas Liquids in the United States and the World," Geological survey circular 522, U.S. Department of the Interior, Washington, D.C. (1965).

[2] H. R. Linden, "The Future Development of Energy Supply Systems," a paper prepared for the Fuel Conference in Commemoration of the Golden Jubilee of the Fuel Society of Japan, Tokyo (Oct. 31–Nov. 2, 1972).

[3] J. P. Albert, et al, "Summary Petroleum and Selected Mineral Statistics for 120 Countries, Including Offshore Areas," geological survey professional paper 817, U.S. Department of the Interior, Washington, D.C. (1973).

[4] "World Power Conference Survey of Energy Resources, 1968," table 7, pp. 41–44, published by the Central Office of the World Power Conference, London, W.C.I.

[5] Canada reported natural gas as marketable gas: 1 cubic kilometer is 1,000 cubic meters which is equal to 35,300,000,000 cubic feet.

Source: The U.S. National Committee of the World Energy Conference. World Energy Conference. "Survey of Energy Resources 1974." op. cit., p. 104. To arrive at an amount of recoverable resource from Hendrick's figures for ultimate discoveries, a recovery efficiency must be assumed. Recovery efficiencies vary among producing formations; however, if 50 percent recovery is taken as a minimum value and 90 percent as a maximum value, this gives 270,000 to 487,000 cubic kilometers of gas available over the entire world. From the reported estimates, a firm consensus of the amounts of natural gas resources likely to be available throughout the world cannot be developed; these estimates are best viewed as limits bounding the amounts of available resources and as values that will be periodically revised as more data become available. Ibid, pp. 104, 105.

TABLE 33.—FREE WORLD GAS RESERVES AND PRODUCTION DATA—HISTORICAL—EXCLUDING UNITED STATES

	Units	North America and Caribbean	South America	Western Europe	Africa	Middle East	Far East and Oceania	Total
Total gas in place [1]	Trillion cubic feet	3,500.0	2,500.0	1,300.0	5,400.0	3,600.0	1,100.0	17,490.0
Discoverable gas in place [1]	do	2,200.0	1,600.0	800.0	3,400.0	2,200.0	700.0	10,900.0
Eonomic recoverable gas	do	1,545.0	1,025.0	500.0	2,260.0	1,415.0	455.0	7,200.0
Jan. 1, 1972, booked reserves [2]	do	71.0	56.0	161.0	193.0	344.0	70.0	895.0
Jan. 1, 1972, cumulative production, net [3]	do	35.0	28.0	22.0	10.0	35.0	8.0	138.0
Jan. 1, 1972, booked ultimate	do	106.0	84.0	183.0	203.0	279.0	78.0	1,033.0
Jan. 1, 1972, unbooked ultimate	do	1,439.0	941.0	317.0	2,057.0	1,036.0	377.0	6,167.6
1971 estimate gross production (Canada injection out)	do	3.4	2.5	4.8	1.6	4.5	.8	17.6
1971 estimated gas injection (Mexico only in North America)	do	.1	.9	----	----	.3	----	1.3
1971 estimated net production	do	3.3	1.6	4.8	1.6	4.2	.8	16.3
1970 estimated gas/oil ratio	Cubic feet per barrel (gross)	4,645.0	1,511.0	26,000.0	711.0	693.0	1,349.0	1,413.0
Jan. 1, 1972 reserves/production ratios net production basis	Years	22.0	35.0	34.0	121.0	82.0	88.0	55.0
Annual reserve additions: [4]								
1970	Trillion cubic feet	4.5	4.5	20.3	2.5	9.3	3.5	44.6
1968–70 inclusive	do	5.5	1.5	14.4	22.4	19.7	4.5	68.0
1962–70 inclusive	do	4.6	2.0	16.4	14.7	13.4	3.7	54.9
1971	do	.2	(1.8)	19.8	3.1	(6.2)	14.3	29.4
Production growth rates:								
1970	Percent per year	12.0	2.3	46.0	20.0	17.0	37.0	19.0
1967–70	do	11.0	2.6	40.0	23.0	15.0	21.0	----
1962–70	do	10.0	4.2	22.0	30.0	13.0	13.0	----
Booked ultimate/economic: Recoverable gas	Percent	6.9	8.2	36.6	9.0	26.8	17.1	14.3
Basis for economic recoverable reserve estimates: Utilizing discoverable gas in place listed and discoverable oil-in-place from same source broke discoverable gas in place down into associated-dissolved and nonassociated. Recovery factors of 40 percent for associated-dissolved gas and 75 percent for nonassociated gas were utilized across the board. Solution gas GOR's were used as follows to calculate associated-dissolved gas in place		1,000.0	1,000.0	1,000.0	750.0	75.00	1,000.0	----

[1] T. A. Hendricks, "Resources of Oil, Gas and Natural-Gas Liquids in the United States and the World," U.S. Geological Survey, circular 522 (1965).

[2] "Price, Nationalization Jitters Plague International Oil World," "Oil & Gas Journal" (Dec. 27, 1971), pp. 72–73.

[3] U.S. Bureau of Mines, "Minerals Yearbook" (1914–69) inclusive, with estimated data in all years where gross gas production not reported.

[4] "World Oil" data, except for 1971 which is from the "Oil & Gas Journal".

The actual quantities that ultimately will be found and produced depend on a combination of future developments in demand, economics and technology. The degree to which estimates and actual ultimate discoveries agree is a measure mainly of the validity of the estimation procedure though the adequacy of the exploratory effort may be a factor.[49]

Proved Reserves as defined by the American Petroleum Institute are the estimated quantities of crude oil which geological and engineering data demonstrate with reasonable certainty to be recoverable from known reservoirs under existing economic and technical operating conditions.

It should be emphasized that proven reserves do not include all the hydrocarbons that are expected to be produced eventually from known oil and natural gas fields, but only that amount for which recovery is certain. For example, higher prices and advanced secondary and tertiary recovery techniques may eventually add some 25 billion barrels of oil to U.S. reserves.

Estimates of undiscovered recoverable resources of oil and natural gas for the world have been compiled by oil companies and few independent geologists such as Lewis Weeks. It is beyond the scope of this paper to enter into a debate about the methodologies used by geologists to estimate those resources. Instead, a range of estimates is provided in figure 7 and tables 31, 32, and 33. The wide range of the estimates is due to differences in available information and data interpretation. According to the available information, undiscovered recoverable crude oil resources are 25 to 75 times the 1973 production of crude oil, and undiscovered recoverable natural gas resources are about 100 times 1973 production.[50]

Some of the most recent world crude oil resources estimates tend to be on the lower side of the data provided in figure 7. The 1974 study by the National Academy of Sciences estimates world undiscovered recoverable oil resources at 1,130 billion barrels, or less than twice current proved reserves.[51] John Moody recently estimated world-wide unrecovered recoverable oil resources at 925 billion barrels, and Saudi Arabia's energy minister, Sheikh Yamani said in a report on his country's oil policy that ultimate recoverable world crude oil resources are about 1,249 billion barrels, of which 636 are proved reserves.[52]

Lewis Weeks has warned against over-optimistic resources estimates by overzealous agencies. He wrote that in estimating potential (still unproved) resources, "imaginations tend to become unrestrained and the bases for calculation questionable". "This", he argues, "seems more often to be true of some government agencies, and with respect to areas of geologic types and histories which for demonstrable geological reasons have nowhere in the worldwide experience of industry yielded oil in important amounts".[53]

---

[49] American Petroleum Institute, American Gas Association, and Canadian Petroleum Association, *Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada and United States Productive Capacity as of December 31, 1973*. Vol. 28. Washington D.C., June 1974, p. 14.

[50] National Academy of Sciences, *Mineral Resources and the Environment*, Washington, D.C., February 1975, p. 92.

[51] National Academy of Sciences, *Mineral Resources and the Environment*, op. cit., p. 98.

[52] *World Oil*, September 1975, p. 49. *Middle East Economic Survey*, Vol. XVIII, no. 34, June 13, 1975, p. 2.

[53] Lewis G. Weeks, "Critical Interrelated Geologic, Economic, and Political Problems Facing the Geologist, Petroleum Industry, and Nation". *The American Association of Petroleum Geologists Bulletin*, Vol. 56, no. 10, Tulsa, Oklahoma, October 1972, p. 1925.

While most nations have estimates of proved reserves of oil and natural gas, few nations have total resource data. Consequently estimates of undiscovered recoverable resources vary significantly, and it is not possible to say that any particular estimate is more reliable than another.[54]

Very few nations provide data on natural gas liquids reserves and resources, in part because they do not utilize or market natural gas liquids. Estimates of world-wide natural gas liquids resources vary from 27,800 to 57,770 megatons.[55]

Natural gas is still primarily a "local" fuel in that its greatest exploitation is in regions such as the United States (44% of world production in 1973), Western Europe and the Soviet Union (10% of world production), where the demand is near the supply. Natural gas associated with oil in the Middle East and other non-industrial regions of the world where it cannot be immediately utilized, is re-injected into the wells, or frequently just flared. Non-associated natural gas wells are usually plugged in these areas, because transportation other than by pipeline is still at a very early stage of development. Liquified natural gas (LNG) from those regions is not likely to become a major source of imported fuel in the United States and Western Europe in the near future.

Whatever the extent of the ultimate recoverable crude oil resource estimates, additions to proved reserves will not be made until geological and geophysical studies have shown promising structures and actual exploratory drilling in those promising structures will have been undertaken.

For the period covered in this study—approximately 10 years—differences of opinion on the size of undiscovered recoverable resources are only of marginal concern. In the first place, there are sufficient proven reserves of crude oil in the world to meet worldwide demand even at the traditional annual increase of demand of 5.7 percent. It is certain that substantial additions to reserves will be made around the world, even though the current reserves/production ratio may not be maintained. Secondly, most U.S. domestic and foreign sources of oil supply for the period 1974–1985 have already been found. Weeks writes that in more and more basins the world's most accessible and cheapest, oil has been found and that the best prospects for the future are in the world's offshore areas.[56]

With the exception of mature offshore petroleum areas such as the Gulf of Mexico, however, lead-times between leasing and full production of discoveries are substantial.

Lead Times

Historically, the lead-time between offshore exploration, development and full production has ranged from 7.4 years for offshore extensions of producing onshore fields, to 10 years for offshore areas where the geology is not closely related to onshore producing areas (see table 34).

---

[54] Ibid., p. 101.
[55] Ibid., p. 106.
[56] Ibid., p. 1925.

TABLE 34.—DISCOVERY AND DEVELOPMENT TIME, IN YEARS, FOR THE GIANT OFFSHORE PETROLEUM FIELDS

[Discovery time, from initial geophysical exploration. Development time, from discovery to production rate of 1,000,000 barrels per year.]

Extent of previous geologic knowledge	Average time lapse		
	Discovery	Development	Discovery plus development
Offshore extension of producing onshore field, excluding Lake Maracaibo (7 fields)	4.4	3.0	7.4
Range of data [1]	2-8	1-6	
Offshore geology related to that of onshore producing area (25 fields)	6.4	2.6	9.0
Range of data [1]	1-12	1-4	
Offshore geology not closely related to onshore producing area (7 fields)	6.4	4.1	10.5
Range of data [1]	4-10	3-6	

[1] Data not complete for all fields.

Source: Henry L. Berryhill, Jr., "The Worldwide Search for Petroleum Offshore—A Status Report for the Quarter Century, 1947-72." Washington, D.C., 1974, p. 12.

Actual lead-time will depend on a number of variables, such as water depth, watheer, demand factors, etc.

In Nigeria, fields discovered offshore were frequently brought to production in periods of 2 to 4 years. In the North Sea geophysical exploration began in the late 1950's, drilling in 1964, the first major oil discovery in 1969 first production from British waters in October 1975, full production is not expected until the end of this decade. The time expended in the development of the North Sea as a petroleum province has been influenced primarily by interpretation of geological data (the North Sea presented a frontier in terms of geological knowledge), and the severe conditions of the sea and weather (p. 12). In the early stages of exploration, effort was directed to the central part of the basin where the large discoveries have been made (p. 13). In addition violent weather conditions and great depth called for technological innovations to develop the resources found. Hence, the time from initial discovery production in 1974 has been about 10 years.

In the United States, the lead time between exploratory drilling and production in the Gulf of Mexico has generally been three to four years. In deeper waters beyond the immediate offshore areas (areas currently being leased or to be leased in the future), industry estimates are four to five years from exploration to production.[57] The time-span for finding new fields on the continental shelf in the Gulf of Mexico would be expected to be relatively short because the northern continental shelf of the Gulf is a salt-dome province, and the nature of the targets is reasonably well understood. As the search moves away from the area of obvious targets to other areas in the Gulf, such as the carbonate banks of the Florida shelf, more subtle geologic conditions may be found that could change the time required for discovery and development.

In the Atlantic, a great deal of seismic work has already been done, but the area has not yet been drilled for oil and gas. Assuming reasonably early discovery after exploration drilling begins and that production encounters physical conditions at sea that range from somewhat more rigorous than those in the Gulf of Mexico to those that at times approach conditions typical of the North Sea on the northern part of

[57] Ibid., p. 14.

the Georges Bank, it has been estimated that a reasonable time lapse from discovery until significant production will be in the range of from six to ten years, the actual time being dependent on the depth of the water and where the resource is located.[58] As for the Gulf of Alaska, where sea conditions are similar to those of the North Sea and where climatic conditions are harsh, significant production may take from eight to twelve years depending on early discovery after initial drilling starts.[59]

Conditions in Southern California are likely to be somewhere between those of the Gulf and the Atlantic and may require into six to eight years from exploration to full production.

Hence, some offshore leases in the Gulf and Southern California could make substantial contributions to our domestic production in the early 1980's. Full production from Atlantic and Alaskan frontier areas and deep-sea leases off Southern California is not likely to be realized within the time span (1974–85) of this study.

With the exception of some speculation about the size of Mexico's resources in the Reforma field, the size of which may have an important bearing on that country's capability and willingness to export large quantities of oil, projections of U.S. oil imports from various parts of the world are based on proved reserves only. If major new discoveries are made—either onshore or near shore—anywhere in the free world, and if significant production from those discoveries can be expected prior to 1985, appropriate revisions will have to be made.

World Oil and Gas Reserves

Petroleum accumulations are found around the world, but their distribution is very unequal. Most of the oil and natural gas discovered to date is concentrated in a few geographical areas. A report issued by the Council on Environmental Quality on offshore oil and gas development in the United States provided the following figures on petroleum distribution:

> More than 85 percent of the world's hydrocarbon production plus reserves occurs in less than 5 percent (238 fields) of all producing accumulations. Even more remarkable, 65 percent of the hydrocarbons occur in slightly over 1 percent of all fields, the 55 "supergiants" (a billion barrels of oil or a trillion cubic feet of gas or more); and an astounding 15 percent occurs in two immense accumulations in the Middle East region (Ghawar field in Saudi Arabia and Burgan field in Kuwait.[60]

The Middle East and North Africa contain about two-thirds of the world's proved reserves of oil but less than one-third of the proved reserves of natural gas. The United States holds about 10 percent of the proven natural gas, and 5.4 percent of the proved oil reserves.[61] Between 1968 and 1974 net increases in petroleum reserves were recorded for each continent except North America, with Asia and Africa recording the largest increases.[62]

---

[58] Ibid., pp. 14 and 15.
[59] Ibid., p. 15.
[60] Council on Environmental Quality, *OCS Oil and Gas—An Environmental Assessment, A Report to the President,* Washington, D.C., 1974, p. 2–1.
[61] See table 35.
[62] Survey of World Energy Resources, op. cit., pp. 120 and 121.

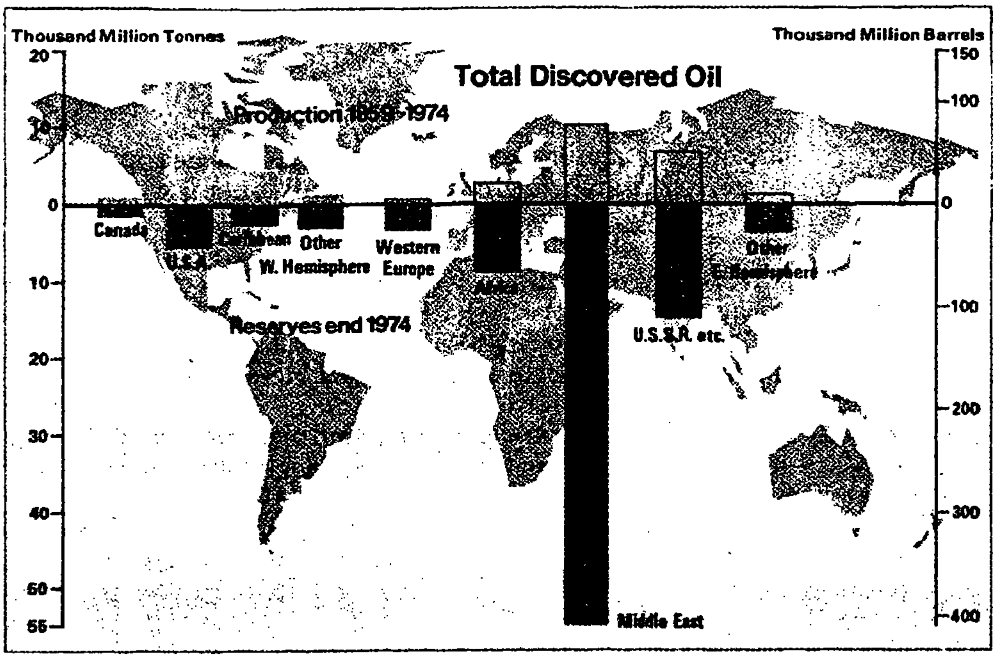


FIGURE 8.

Source: British Petroleum Company Limited, *BP Statistical Review of the World Oil Industry 1974*, London, 1975, p. 5.
The upper half shows regional cumulative oil production, 1859–1972. Production in the U.S. dominated world markets until after World War II when vast low-cost oil reserves were developed in the Middle East.

TABLE 35.—WORLD "PUBLISHED PROVED" OIL AND NATURAL GAS RESERVES AT END 1974 [1]

Country/area	Oil: In millions of barrels per day	Oil: Percentage	Natural gas (in trillion cubic feet)
United States	35.3	5.4	250.0
Canada	8.8	1.2	56.7
Caribbean	18.4	2.7	68.0
Other Western Hemishpere	22.2	3.1	32.2
Total Western Hemisphere	84.7	12.4	406.9
Western Europe	26.3	3.6	200.8
Middle East	403.4	56.3	672.7
North Africa	39.1	9.3	260.5
Other Africa	29.2		54.5
Eastern Europe	3.0	.4	2.6
Soviet Union	83.4	11.6	812.0
China	25.0	3.5	25.0
Other Eastern Hemisphere	21.0	2.9	115.8
Total Eastern Hemisphere	630.4	87.6	2,143.9
World	715.1	100.0	2,550.8
Non-Communist world	603.7	84.5	1,711.2

[1] For a detailed list of oil and natural reserves by country, see appendix, p. X. For USGS estimates on ranges of undiscovered recoverable resources of oil and gas by country, see appendix, p. X.

Source: "The Oil and Gas Journal," Dec. 30, 1974, pp. 108, 109.

Oil data do not include natural gas liquids. Few nations have good data on total resources, and the poorest data are related to natural gas liquids. Reserve information is sparce because it involves a more complete appraisal of associated and non-associated natural gas reservoirs. Also, if a nation is not utilizing or marketing natural gas liquids there is little incentive to survey reserves.[63]

At the end of 1974, the U.S. had crude oil reserves of 35.3 billion barrels; it also had reserves of natural gas liquids of 5.3 billion barrels.

Accuracy of Reserve Estimates

In many countries there are specialized institutions which estimate proved reserves, but only a few such as the U.S. and Canada publish detailed statistics. Hence, the problem is to have reliable procedures for estimating each individual deposit and the results coordinated by a competent body.

It should be emphasized that "published proved reserves" do not have the same meaning in countries where there are technical control bodies operating to well-established and approved methods as in those where methods are more rudimentary and where the results published are often based on figures produced by oil companies.[64]

Moreover, it is certain that in regions which possess very large deposits (such as Middle East) certain reserves are sometimes considered as "proved" in the case of very extensive geological structures, even when only part of the reservoir has been drilled while in the United States, for example, "proven reserves" are in actual fact "drilled reserves".[65]

Reserve/Production Ratio (Worldwide)

The world oil reserve-to-production ratio is about 35 years (37 in 1972) and is a rough measure of the lifetime of known recoverable reserves if we should continue at the 1974 production level. The energy division of the Chase Manhattan bank estimates that annual free world oil production is likely to grow at about 4 percent (7.3 percent historic growth rate), from about 16.9 billion barrels in 1974 to 21.5 billion barrels in 1980 and 26.1 billion barrels in 1985.[66]

At a rate of 4 percent increased oil demand per year, cumulative oil production between 1974 and 1985 would be approximately 255 billion barrels, leaving existing reserves of 354 by 1985 (609–255).

In order to maintain the current reserve/production ratio of about 35 years, oil reserves in 1985 would need to be about 844 billion barrels. Hence, in order to maintain current reserves/production ratios, we would need to find (844−354=490) billion barrels between now and 1985.

The study released by the Chase Manhattan Bank in March concluded:

> To meet minimum standards relative to indicated market needs, the world's proved reserves of oil should total at least 800 billion barrels by 1985. That is 225 billion or 40% more than in 1970." [67]

[63] *Survey of Energy Resources*, op. cit., p. 106.
[64] United Nations, Department of Economic and Social Affairs, *Petroleum in the 1970's*. Report of the Ad Hoc Panel of Experts on Projections of Demand and Supply of Crude Petroleum and Products, March 9–18, 1971, New York, 1974, p. 108.
[65] Ibid., p. 109.
[66] See estimates by Chase Manhattan Bank in: The Chase Manhattan Bank, Energy Economics Division, *How Much Oil—How Much Investment*, New York, March 1975, p. 5.
[67] Ibid., p. 5.

Lewis Weeks analyzed crude oil needs on the basis of the high, pre-embargo annual oil consumption growth rates and came to the following conclusion:

World production has more than doubled in each of the past two decades, to reach 48 million barrels per day in 1970. If it just doubles in each of the next two decades a minimum of 2,000 billion barrels of new oil must be added to meet the production demands of the period and still leave a 20-year supply ratio in 1990; or 1,500 billion barrels of new oil will have to be found to leave but a 10-year supply ratio." [68]

In order to understand the magnitude of the 490 billion barrels of reserves to be added between 1974 and 1985 in order to maintain the current reserve/production ratio, one should add that total world oil production between 1918 and 1973 was just a fraction below 300 billion barrels.[69]

Weeks ended his analysis of demand-supply problems, stating:

So great is the accelerating demand for energy that we truly can say that the years of the petroleum age are finite. Measured against the background of history, the years of abundant supply at supportable prices are relatively few." [70]

About a year after the Weeks' article had been published, the Arab nations began their oil boycott, followed by a quadrupling of the price of crude oil. The age of petroleum scarcity was thus suggested to the consumer in the industrialized world, and two decades of cheap oil availability which had been an important part of the rapid economic recovery of Western Europe and Japan, came to an end.

In light of the new and higher prices of oil, demand for and production of crude oil is no longer expected to grow at the historical rate of 5.7 percent, but at a considerably lower rate.

On the basis of an annual growth rate of 4 percent as projected by the Chase Manhattan Bank, we concluded that 490 billion barrels of oil would need to be added to reserves between 1974 and 1985. While this may be technically possible, it would involve vast outlays of capital and a most favorable political and economic climate.

In a major energy study conducted in 1972, the National Petroleum Council, while arguing that the industry has the technical capability to add some 450–550 billion barrels to oil reserves between 1971 and 1985, concluded that free world oil supplies will gradually tighten during the 1970–1985 period as the ready availability of low cost oil declines. Consequently, the reserve-to-production ratio in the non-communist world was projected to fall from 27 years in 1970 to 14–19 years in 1985.[71] Although the current reserve/production ratio of 35 is by no means a magic number, the declining reserves-to-production level is cause for some alarm, unless the industrial world will succeed in switching more rapidly to other sources of energy. It would mean that unless major new discoveries are made to keep up with world oil demand, our planet is likely to run seriously short of oil less than a decade after the turn of the century.

As to the distribution of future oil discoveries, the Chase study recognized the danger of overdependence on countries with low popu-

[68] Lewis G. Weeks, "Critical Interrelated Geologic, Economic, and Political Problems Facing the Geologist, Petroleum Industry, and Nation," p. cit., p. 1921.

[69] De Golyer and MacNaughton, *Twentieth Century Petroleum Statistics 1974*, Dallas, Tex., Sept. 1, 1974, p. 4.

[70] Ibid., p. 1921.

[71] National Petroleum Council, *U.S. Energy Outlook, Oil and Gas Availability*, Washington, D.C., 1972, p. 102.

lations and limited capital absorptive capacity and suggested that major efforts be made to ensure that much of the additional reserves will come from other areas than the Middle East and North Africa:

> . . . to provide the better distribution and reduce vulnerability so urgently needed, much of the increase (in oil reserves) should occur in regions other than the Middle East and Africa. Between 1970 and 1985 the reserves located in those regions should be more than doubled, if possible.[72]

To double reserves outside the Middle East and Africa, some 230 billion barrels would have to be found within the next ten years. In the 15 years between 1955 and 1970 only about 106 billion barrels of oil were found outside the Middle East and Africa.[73] Exploration elsewhere has been limited, however, by the availability of vast quantities of cheap Middle Eastern crude. The current price of oil and the access to new advanced exploration techniques coupled with the desire to diversify sources of oil supply are likely to have a favorable impact on oil outside the Middle East and Africa. But there is considerable reason to doubt that discovery rates can be accelerated, or perhaps even maintained, from recent levels. Exploration opportunities, all in harsh physical environments (the tundra, or under ice or deep waters) where progress is slow and costs are very high. Geologists have examined the possibilities quite extensively, have to the extent technology permits explored the best prospects first, and do not see much likelihood that deposits found will be on a scale comparable to those in the Middle East.

[72] *How Much Oil—How Much Investment*, op. cit., p. 5.
[73] Ibid., p. 5.

Chapter VII

WORLD PRODUCTION AND CONSUMPTION OF OIL AND GAS: SHIFTING CENTERS OF SUPPLY

There is a close relationship between oil and gas reserves and production. Areas with high reserves tend to be among the major producers, and areas where additions to reserves have for years lagged behind production (like the United States) must eventually experience a declining petroleum output.

In a 1973 study, the U.S.G.S. maintained that the major oil and natural gas producing areas of the world are shifting from North American and European Russia to Asia and Africa. This, they say, is evidenced by the fact that in 1960 the North American continent accounted for approximately 40 percent of total free world oil production and has since decreased to 26 percent in 1971. In the Soviet Union where the major production and known reserves have been located in the Volga-Urals district of European Russia, the role of that region in Soviet energy output will decline, and the center of U.S.S.R. production will shift from European Russia to Siberia.[74]

More than half of the world's natural gas production comes from North American and European Russia. However, the production figures do not represent what the distribution would be if Asia and Africa were closer to larger industrial areas where their natural gas could be sold. Eventually, growing industrialization of these producing areas and the development of economic transportation facilities for liquefied natural gas, the price competitiveness of LNG, the production decline of natural gas in the U.S., and world oil shortages are likely to increase the role of Asian and African gas producing areas rapidly.

For oil as well as for natural gas, the doubling time (time required to double production) is low for Africa and Asia, but very high for North America and other mature producing areas.[75]

This shift in petroleum production, coupled with the fact that within continents the majority of oil and gas production comes from a relatively few nations (several of them with very high petroleum reserves to population ratio), will have significant consequences for the industrial world as a whole, and for the United States, which is entering an era of growing dependence on foreign oil.

Since 1900 world production of energy has increased over tenfold. Over the past 50 years world energy production has been increasing at an average rate of 3.5 percent per year on an absolute, 2 percent per year on a per capita basis.[76] Energy growth rates have not been uniform. They declined during the depression of the 1930's and rose at a

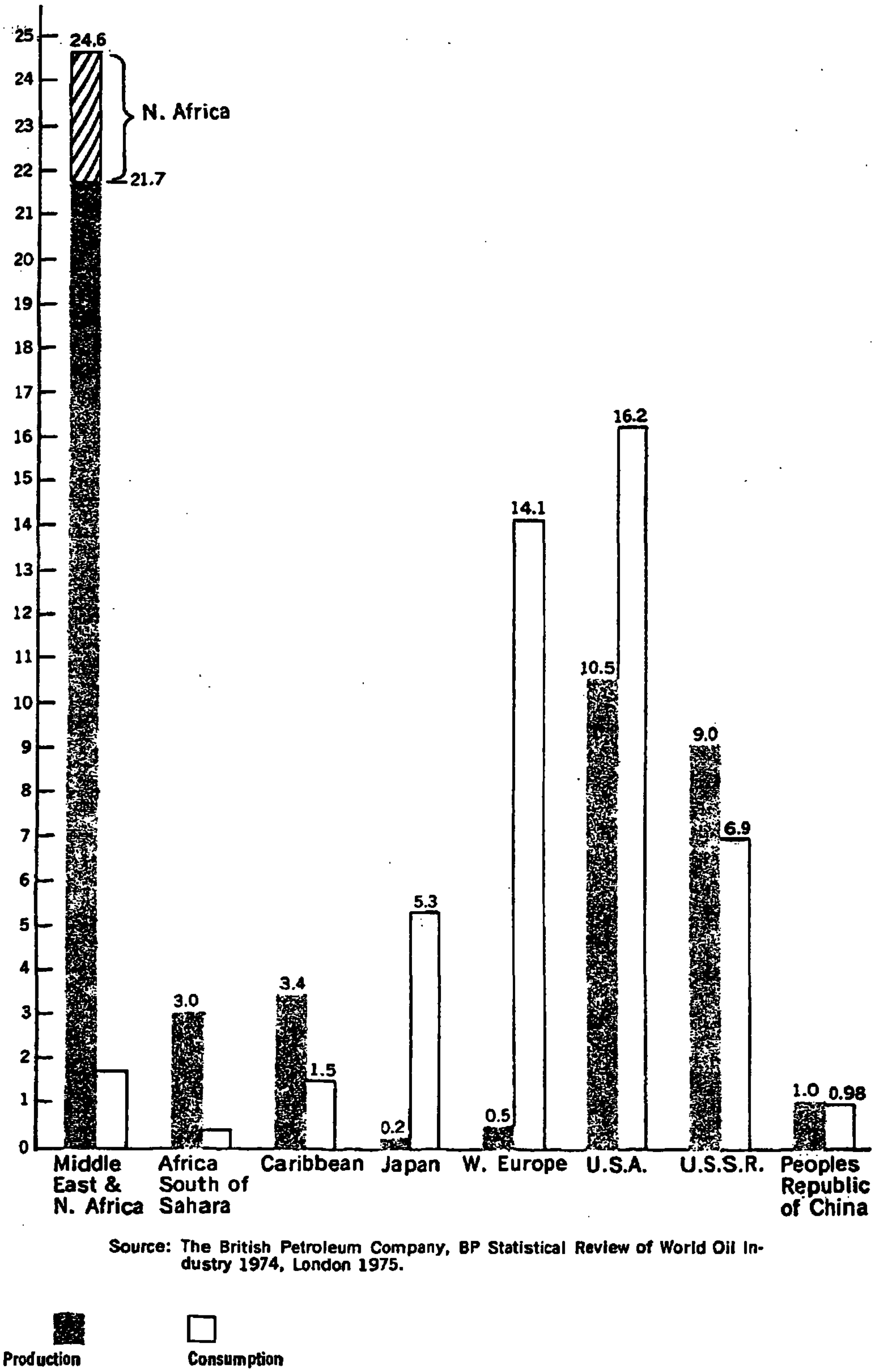
---

[74] *Summary Petroleum and Selected Mineral Statistics for 120 Countries, Including Offshore Areas,* Ibid., p. 148. Until 1940 the U.S. produced about ⅔ of the world's oil, and between 1921 and 1940, the U.S.S.R., Mexico, Iran, Romania and Venezuela became major producers. See: *Survey World Energy Resources,* 1974, op. cit., p. 125.

[75] Ibid., p. 148.

[76] *Survey of World Energy,* 1974, p. 8.

Figure 9. Crude oil production and petroleum product consumption for major producing and consuming areas in 1974 (in millions of barrels per day)



Source: The British Petroleum Company, BP Statistical Review of World Oil Industry 1974, London 1975.

higher than average rate after WW II. In the quarter century preceding the 1973 Arab oil embargo, energy growth averaged 4.8 percent per year, and between 1965 and 1973 it grew at 5.7 percent. If annual production growth continues to grow in the final quarter of the century as rapidly as in the past quarter century, the cumulative world production from 1974—2000 would be 2.25 times as large as the total amount produced from 1900 to 1974. Even if the annual amount did not grow above the current level, the world would still produce more energy in the last quarter century than in the first three quarters combined.[77]

A combination of higher prices and consequent lower demand for energy, and conscious energy conservation efforts is likely to slow down energy growth significantly, particularly in the industrialized nations.

In a recent study, the Department of the Interior projects energy growth rates for the world to slow down to 3.3 percent for the period 1972–1990, and U.S. energy consumption growing at 3 percent per year during the same period. (See table 36.).

TABLE 36.—WORLD ENERGY CONSUMPTION, BY REGION, 1960-90

[Quadrillion Btu][1]

Region	1960	1965	1970	1975	1980	1985	1990
United States	44.6	53.3	67.0	72.0	86.3	102.9	121.9
Western Europe	26.4	34.4	46.0	49.1	62.6	75.2	87.2
Japan	3.7	6.2	12.0	13.4	20.4	26.7	34.0
Sino-Soviet Bloc	39.0	45.2	58.3	63.7	82.0	94.0	109.0
Rest of World	18.0	24.3	33.6	35.7	45.0	52.1	60.4
Total	131.7	163.4	216.9	233.9	296.3	350.9	416.5

[1] Quadrillion Btu equals 500,000 barrels petroleum per day for a year equals 40 million tons of bituminous coal equals 1 trillion cubic feet of natural gas equals 100 billion kWh (based on a 10,000-Btu/kWh heat rate).

Source: U.S. Department of the Interior, "Energy Perspectives, A Presentation of Major Energy and Energy-Related Data," Washington, D.C. (Government Printing Office), February 1975, p. 6.

Other studies suggest that overall energy demand between 1974 and 1985 is likely to slow down from the 1960–73 average of 7.5% per year to between 3.5 and 4.0 percent per year.

One of the prime reasons for projecting lower energy growth rates than in the preceding two decades is related to the recent quadrupling of the price of oil. Prior to the new high-cost energy era, oil production had more than doubled between 1960 and 1970 and had almost doubled in the decade of the 50's. (See table 39.)

World Oil Consumption

World oil consumption has more than quintupled over the past 25 years, from 9.7 million b/d in 1950 to 56.0 million b/d in 1974 (see table 38). While U.S. consumption "only" tripled from about 6 to 18 million b/d, consumption in the Communist world increased by a factor ten, Western European consumption increased fourteen-fold, and Japan's consumption of oil in 1974 was 25 times higher than in 1950.

World production has been able to meet the growing demand of the industrial world, but this would not have been possible without a thirteenfold increase of Middle Eastern oil output (see table 39).

[77] *Ibid.*, p. 9.

higher than average rate after WW II. In the quarter century preceding the 1973 Arab oil embargo, energy growth averaged 4.8 percent per year, and between 1965 and 1973 it grew at 5.7 percent. If annual production growth continues to grow in the final quarter of the century as rapidly as in the past quarter century, the cumulative world production from 1974—2000 would be 2.25 times as large as the total amount produced from 1900 to 1974. Even if the annual amount did not grow above the current level, the world would still produce more energy in the last quarter century than in the first three quarters combined.[77]

A combination of higher prices and consequent lower demand for energy, and conscious energy conservation efforts is likely to slow down energy growth significantly, particularly in the industrialized nations.

In a recent study, the Department of the Interior projects energy growth rates for the world to slow down to 3.3 percent for the period 1972–1990, and U.S. energy consumption growing at 3 percent per year during the same period. (See table 36.).

TABLE 36.—WORLD ENERGY CONSUMPTION, BY REGION, 1960-90

[Quadrillion Btu] [1]

Region	1960	1965	1970	1975	1980	1985	1990
United States	44.6	53.3	67.0	72.0	86.3	102.9	121.9
Western Europe	26.4	34.4	46.0	49.1	62.6	75.2	87.2
Japan	3.7	6.2	12.0	13.4	20.4	26.7	34.0
Sino-Soviet Bloc	39.0	45.2	58.3	63.7	82.0	94.0	109.0
Rest of World	18.0	24.3	33.6	35.7	45.0	52.1	60.4
Total	131.7	163.4	216.9	233.9	296.3	350.9	416.5

[1] Quadrillion Btu equals 500,000 barrels petroleum per day for a year equals 40 million tons of bituminous coal equals 1 trillion cubic feet of natural gas equals 100 billion kWh (based on a 10,000-Btu/kWh heat rate).

Source: U.S. Department of the Interior, "Energy Perspectives, A Presentation of Major Energy and Energy-Related Data," Washington, D.C. (Government Printing Office), February 1975, p. 6.

Other studies suggest that overall energy demand between 1974 and 1985 is likely to slow down from the 1960–73 average of 7.5% per year to between 3.5 and 4.0 percent per year.

One of the prime reasons for projecting lower energy growth rates than in the preceding two decades is related to the recent quadrupling of the price of oil. Prior to the new high-cost energy era, oil production had more than doubled between 1960 and 1970 and had almost doubled in the decade of the 50's. (See table 39.)

World Oil Consumption

World oil consumption has more than quintupled over the past 25 years, from 9.7 million b/d in 1950 to 56.0 million b/d in 1974 (see table 38). While U.S. consumption "only" tripled from about 6 to 18 million b/d, consumption in the Communist world increased by a factor ten, Western European consumption increased fourteen-fold, and Japan's consumption of oil in 1974 was 25 times higher than in 1950.

World production has been able to meet the growing demand of the industrial world, but this would not have been possible without a thirteenfold increase of Middle Eastern oil output (see table 39).

[77] *Ibid.*, p. 9.

TABLE 37.—RESERVES, PRODUCTION CAPACITY, CURRENT PRODUCTION AND FUTURE PRODUCTION ESTIMATING MIDDLE EASTERN AND OTHER OPEC NATIONS

	Oil reserves [1]	Estimated current production capacity	Average daily production January to May, 1975	Spare capacity current	Average daily production 1974	Spare capacity on basis of 1974 daily production	Production capacity 1985: Institute of Petroleum	Production capacity 1985: FEA	Production capacity 1985: O.E.C.D.	Possible production level 1985–this study: 1980	Possible production level 1985–this study: 1985
Saudi Arabia	173.1	11.0	6.760	4.24	8.377	2.6	23.0	19.3	13.2	7.0–9.0	9–11
Kuwait	[2] 81.4	2.9	1.927	.97	2.844	—	3.5	—	3.3	2.5	2.5
Iran	66.0	6.5	5.094	1.41	6.182	.3	10.0	7.9	8.0	8.0	8.0
Iraq	35.0	2.8	2.367	.43	1.595	1.2	8.0	4.8	4.0	4.0	5.0
U.A.E.	33.9	3.7	1.693	2.01	1.866	1.8	5.5	[3] 6.9	2.8	2.5	3.0
Libya	26.6	2.3	1.200	1.10	1.910	.4	2.5	—	2.2	1.7	1.7
Algeria	7.7	1.3	.900	.40	1.145	.2	NA	1.4	1.1	.7	.7
Qatar	6.0	.5	.471	.03	.519	None	.5	—	—	.5	.5
Oman	6.0	.5	.325	.17	.303	.2	NA	NA	NA	—	—
Egypt	3.7	—	.170	—	.184	—	NA	NA	NA	—	—
Syria	1.5	—	.150	—	.137	—	NA	NA	NA	1.5	2.0
Tunisia	1.1	—	.105	—	.068	—	NA	NA	NA	—	—
Bahrain	.3	—	.062	—	.066	—	NA	NA	NA	—	—
Indonesia	15.0	1.8	1.110	.69	1.483	.3	3.0	1.8	2.0	2.0	2.5
Nigeria	20.9	2.4	1.547	.85	2.297	.1	3.0	2.6	2.8	2.5	3.0
Gabon	1.8	.2	.210	None	.160	Neg.	NA	NA	NA	.3	.3
Venezuela	15.0	2.9	2.395	.50	2.973	None	2.5	3.6	3.4	2.0	2.0
Ecuador	2.5	.6	.140	.36	.224	.4	NA	.4	NA	.7	.7
Total	497.5	39.4	26.626	13.16	32.333	7.6	61.5	53.1	42.8	35.9–37.9	40.9–42.9

[1] Oil reserves are estimated in billions of barrels. All other figures are in millions of barrels per day.

[2] Includes other Persian Gulf States not specifically listed.

[3] Includes Qatar.

Sources: Reserves estimated from "The Oil and Gas Journal," Dec. 30, 1974, pp. 108, 109. Estimates of current production capacity, EXXON, 1975, Average daily production January to May 1975, "The Oil and Gas Journal," maximum export production capacity: Ronald D. Kewison, "The World Crude Oil Outlook," (New York: William J. Witter, Inc., 1974), p. 10. Federal Energy Administration, "Project Independence Report" (Washington, D.C., November 1974, p. 356). O.E.C.D. "Energy Prospects to 1985," volume II, Paris, 1974, p. 113.

Middle East oil made up the difference between world demand for energy and local production. For reasons examined elsewhere in this paper, some observers doubt that several Middle Eastern states cannot be counted on to continue to supply increasing quantities of relatively expensive oil. Recognizing this, world-wide efforts will be made to supply as much oil as possible from oil development outside the Middle East and North Africa. The combination of higher oil prices and the danger of overreliance on oil supplies from countries with low population and limited capital absorptive capacity has already led to major oil exploration programs outside the Middle East and plans to shift away from petroleum to coal and nuclear energy as major sources of future energy supply.

The shift away from oil and natural gas toward alternative sources of energy will be gradual. Oil is expected to remain the largest energy source for many years to come. Between 1970–1985, oil is expected to still provide more than half of total world energy needs, or somewhere between 60 and 70 million barrels per day by 1985, for the non-Communist world.

TABLE 38.—WORLD CONSUMPTION OF PETROLEUM LIQUIDS, 1950–73

[In millions of barrels per day]

Area	1950	1955	1960	1965	1970	1971	1972	[1] 1973	1974
North America	6.1	7.8	10.5	12.4	15.9	16.4	17.6	19.6	18.0
West Europe	.9	2.3	4.0	7.5	14.7	15.4	16.5	14.3	14.2
Japan [2]	[2]	.2	.7	1.7	3.8	4.2	4.5	4.9	5.3
Other	1.9	2.2	3.2	4.9	5.1	5.1	5.1	11.2	9.0
Total non-Communist	8.9	12.5	18.4	26.5	39.5	41.1	43.7	50.0	46.5
Sino Soviet	.8	1.8	2.9	4.5	6.8	7.2	7.7	7.9	9.5
Total World	9.7	14.3	21.3	31.0	46.3	48.3	51.4	57.7	56.0

[1] Estimated.
[2] Less than 100,000 barrels per day.

Sources: Non-Communist World: Bureau of Mines "International Petroleum Annual." Sino-Soviet Nations: Various sources and estimates.

TABLE 39.—WORLD CRUDE OIL PRODUCTION, 1950–73

[In millions of barrels per day]

Producing region	1950	1955	1960	1965	1970	1971	1972	1973	1974
North America	5.5	7.2	7.6	8.6	10.9	10.9	11.0	11.0	10.7
Latin America	2.0	2.8	3.7	4.6	5.2	5.1	4.8	5.1	5.0
Middle East	1.8	3.2	5.3	8.4	14.0	16.9	18.7	21.4	21.7
North Africa	([1])	([1])	.2	1.9	4.7	3.9	3.6	3.4	2.9
West Africa	([1])	([1])	([1])	.3	1.2	1.8	2.1	2.4	2.8
Far East	.2	.4	.5	.7	1.4	1.6	1.9	2.3	2.7
Other	.1	.3	.4	.4	.4	.3	.3	.3	1.0
Total non-Communist	9.6	13.9	17.7	24.9	37.8	40.5	42.4	45.9	46.8
Sino-Soviet	.9	NA	3.3	5.3	7.8	8.3	8.8	9.3	10.5
Total World	10.5	14.2	21.0	30.2	45.6	48.8	51.2	55.2	57.3

[1] Less than 100,000 barrels per day.

Source: FEA, final task force report, "Project Independence," Washington, D.C., November, 1974. B.P. Statistical Review of the World Oil Industry 1974, London, 1975.

On a global scale the advantages of oil over other sources of energy are in its availability—at least in the short and medium time scale—in the physical and economic sense, and the fact that oil serves as a ready substitute in case of shortfalls of other energy sources. The main limiting factors—again in the short and medium time scale—are availability of capital to explore for and develop oil resources and the policies of some governments related to drilling, production and export rates.

TABLE 40.—FORECASTS OF NON-COMMUNIST WORLD DEMAND FOR OIL

[In millions of barrels per day oil equivalent]

	1977	1980	1985
Chase Manhattan:			
Spring, 1975 forecast:			
3.5 percent annual growth rate		54.5	64.7
2.5 percent based on 1974 output		51.4	58.2
FEA (April, 1975)		60.1	
BP (Maximum, 1975)			68.4
Exxon	52.00–54.00	56.00–60.00	64.00–70.00
DOI (February 1975) 2.4 percent	47.1	50.7	57.0
OECD ($9 case for OECD plus nonoil exporting LDC's)	NA	51.2	60.8
This study	50.0–50.9	55.5–58.4	62.1–68.2

Source: OECD: "Energy Prospects to 1985," vol. II, Paris, 1974, p. 114. U.S. Department of the Interior. "Energy Perspectives", p. 8. The Chase Manhattan Bank, "Business In Brief," No. 122, June 1975.

The four studies project that worldwide oil demand in 1980 will range between about 51 and 60 million b/d. and by 1985 between approximately 60 and 70 million b/d. The low demand would indicate a combination of slower economic growth rates and successful energy conservation measures, whereas the high demand case reflects expectations for more rapid economic growth and/or less successful conservation measures, or slower-than-anticipated development of alternative fuels. Increasing environmentalist resistance to nuclear power in Europe and Japan could force oil demand upward.

On the basis of these demand projections, the following production scenario has been derived.

TABLE 41.—DEMAND BALANCED SCENARIO OF WORLD OIL PRODUCTION, 1977–85, BY REGION, EXCLUDING COMMUNIST COUNTRIES

[In millions of barrels per day]

	1977	1980	1985
Total demand	50.0–50.9	55.5–58.4	62.1–68.2
Non-OPEC supply	17.0	22.5	28.0
OPEC supply	33.0–34.0	33.0–35.9	34.1–40.2
Middle East and North-Africa, OPEC and non-OPEC	(26.2–27.1)	(25.3–28.2)	(27.1–33.2)

By 1977, world-wide demand for oil has been estimated at between 50.0 and 50.9 million b/d, and demand for OPEC oil at between 32.5 and 33.4 million b/d, or slightly above the 1974 average daily production level. With Saudi Arabian production capacity alone expected to rise to about 11.0 million b/d by the end of this year, additional world 50.0 and 50.9 million b/d, and demand for OPFC oil at between 32.5 and 33.4 million b/d, or slightly above the 1974 average daily production level. With Saudi Arabian production capacity expected to rise to about 11.0 million b/d by the end of this year, additional world demand can be met without adding additional production capacity in the Middle East. Assuming high o.l demand growth rates, OPEC countries would need to add to production capacity to meet 1980 and 1985 demand. Iran is expected to add add tional production capacity in the next few years, and Iraq is planning to double production by the early 1980s. Kuwait, the United Arab Emirates, Qatar, Algeria and Libya, on the other hand, are not likely to expand production, and some of these countries may even reduce output below the 1974 level.

Saudi Arabia will undoubtedly remain the major "swing factor" in the international oil market. In order to meet world-wide oil demand in the foreseeable future, Saudi Arabia would have to produce more oil, and consequently receive more revenue from oil exports than the nation's domestic economy can possibly absorb within the next ten years. This is also true, but to a lesser extent, for other Arab nations with low populations and limited capital absorptive capacity such as the United Arab Emirates.

It is impossible to forecast under what conditions the oil producing States of the Middle East, North Africa and other OPEC countries in general, and the OPEC countries with limited capital absorptive capacity in particular, will continue to play the role of "swing" countries, filling the gap between demand and domestic supply in the industrialized world (see also section on Middle East and North Africa). If, however, some of the key countries such as Saudi Arabia would no longer be willing to meet world oil demand, the consequences would be disastrous for the entire world.

Some of the many uncertainties inherent in any demand and supply forecast are described below:

1. It is assumed that recent major discoveries in Mexico will result in a production of 2.0 million b/d in 1980 and 3.0 million b/d in 1985. These figures seem reasonable on the basis of the available information, but by no means certain. (See subsection on Mexico).

2. This analysis does not take into account the possibility of major oil imports by the Soviet bloc in 1980/85. Various sources have estimated that the Soviet bloc may need to import a few million barrels per day by the early 1980's. This would lead to additional competition for available supplies.

3. Some Middle Eastern nations with low population and limited capital absorptive capacity will probably be willing to produce significantly more oil than domestic needs would require at current prices. Hence, the consuming nations would have to create a favorable investment climate for surplus petrodollars. One major oil company has projected that if Saudi Arabia decided to produce no more than an average of slightly more than 7 million b/d of oil between 1976 and 1985, Saudi Arabia would have achieved a "European" consumption level in 1985 and have invested $10,000 capital stock per capita. The country would have a net cumulative surplus of the balance of payment of $153 million in 1980 and $342 billion [78] in 1985. Our projected Saudi Arabian oil production of up to 11 million b/d by 1985—a figure mentioned as a possibility by a Saudi Cabinet Member—would leave vast cumulative balance of payment surpluses in 1985, which would have to be invested in elsewhere in the world. A peaceful solution in the Arab-Israeli conflict could have a significant

[78] Information received from a major U.S. oil company.

effect on the willingness of producing nations with low populations and limited capital absorptive capacity, to produce up to western industrialized states demand rather than their own limited absorptive capacity.

4. This forecast does not take into account major changes in the real 1974 price of crude oil, which could alter the scenario significantly. Major increases in the price of oil could have a considerable negative impact on worldwide demand, as well as on the production level required to meet domestic needs in the oil producing nations of the region.

5. The possibility, which seems remote to us at this time, of major new discoveries elsewhere onshore or offshore in shallow waters, which could be developed within the period covered in our study, or at least until the early 1980s, has not been taken into account.

6. Finally, the possibility of a "technological fix" in the energy industry that could either lead to higher production of crude oil or to more rapid transition to alternative sources of energy, has not been taken into account.

7. Uncertainties in outlook for nuclear and coal capacity and utilization.

8. Uncertainties in outlook for world economic growth.

Comparison of OPEC Projections for 1980 and 1985

Several estimates on OPEC production of crude oil have been published recently. Most studies do not go beyond 1990, and in terms of projected supply our estimates tend to be in line with the higher estimates.

TABLE 42.—FORECASTS OF OPEC OIL PRODUCTION, 1980–85

[In millions of barrels per day]

	1980	1985
Exxon Corp	31–36	34–40
This study	33.0–35.9	34.1–40.2
Chase Manhattan Bank	30.6–33.7	32.4–38.9
Levy	31.5	
Citibank	31.0	
Morgan Guarantee	29.0	
Enders	25.0	
Irving Trust	24.7	
C.I.A	29.0	

OPEC local oil consumption was estimated at 1.4 million b/d in 1974, and we estimate that local consumption will rise to about 2 million b/d in 1980 and 4 million b/d by 1985. This would leave about 31.0–33.9 million b/d for the export market in 1980, and 28.4 to 34.9 million b/d in 1985.

Regional Supply and Demand of Oil: Western Europe, Japan and the United States

Table 43 shows that Western Europe and Japan are much more dependent on foreign oil imports than the United States. While the United States will continue to be less dependent on foreign oil than the other two major industrial regions in the free world, it is expected that relative to the 1974 degree of dependence on foreign sources of oil of the three regions, United States dependence on foreign oil will grow most rapidly. Western European production of North Sea oil is likely to offset expansion of demand by 1980, but by 1985, growing European consumption may once again further increase dependence on outside supplies.

Japan may stabilize its imports from OPEC at current levels by 1980 by increased imports of crude from China, but even under optimistic conditions, the country is likely to import considerably more OPEC oil in 1985 than in 1974.

United States imports of foreign crude from the Western hemisphere and Eastern hemisphere other than the Middle East and North Africa, are projected to remain at about the 1974 level in 1980, and could rise somewhat by 1985. A more disturbing trend is the growing dependence on the Middle East and North Africa, which according to many observers is difficult, if not impossible, to avoid in the short and medium term. This trend is disturbing because of the limited capital absorptive capacity of many of the most petroliferous countries in the region, the possibility of continuation of internal and external conflicts in part of the region, and the geographical location of the area.

TABLE 43.—1973: WORLD OIL CONSUMPTION AND PRODUCTION BY REGION

[In thousands of barrels per day]

	Consumption	Production	Net export	Net imports
United States	16,815	10,925		5,890
Canada	1,755	2,105	350	
Venezuela	225	3,366	3,141	
Other: Western Hemisphere	2,640	1,404		1,236
Western Europe	15,155	445		14,710
Japan	5,425	14		5,411
Indonesia	191	1,300	1,109	
Other: Southeast Asia	1,264	330		934
Middle East	1,230	21,070	19,840	
Algeria	58	1,070	912	
Libya	30	2,176	2,146	
Nigeria	51	2,048	1,997	
Other: Africa	846	741		105
Other: Eastern Hemisphere (Australia, New Zealand)	670	575		95
China	798	1,000		202
U.S.S.R.	6,485	8,478	1,993	
Eastern Europe (excluding U.S.S.R.)	1,492	395		1,097

Sources: De Golyer and MacNaughton, "Twentieth Century Petroleum Statistics," 1974, Dallas, Tex., September 1974, p. 2. "B.P. Statistical Review of the World Oil Industry," 1973, London, 1974, pp. 6 and 8.

REGIONAL ANALYSIS

WESTERN EUROPE

Western Europe's oil consumption in 1974 averaged 14.2 million b/d. Oil consumption had quadrupled during the 1950's, and in the 1960's consumption rose almost as fast. From 1970 onward, oil consumption grew at a slower pace until 1973, the year when daily consumption dropped again to slightly below the 1970 level. Demand decreased slightly from 14.3 in 1973 to 14.2 million b/d in 1974, and is projected to decrease further to 13.7 million b/d this year.

The quadrupling of the price of crude following the 1973 Arab oil embargo is likely to have a somewhat similar effect as in the U.S.; i.e., a slowdown of oil consumption growth rates and more rapid development of substitute sources of energy.

Many observers would agree that an average annual oil consumption growth rate of between 3.0 to 4.0 percent between 1975 and 1985 appears within reasonable limits. Such a growth rate would result in the following demand for oil:

TABLE 44.—FORECASTS: WESTERN EUROPE'S OIL CONSUMPTION 1974-85

[In millions of barrels per day]

	Annual oil consumption growth rate		
	3 percent	3 to 5 percent	4 percent
1974 (actual)	14.1	14.1	14.1
1975 (projected)	13.7	13.7	13.7
1977	14.5	14.7	14.8
1980	15.8	16.2	17.3
1985	18.4	19.2	21.0

Western European supply, mainly from the North Sea is projected at:

TABLE 45.—FORECASTS: WESTERN EUROPE'S OIL PRODUCTION, 1974-85

Year	B.P. North Sea volume (million barrels per day)	OECD (offshore and onshore)	This study (offshore and onshore)
1974 (actual)		0.445	0.445
1977	1.0	Not available	1.5
1980	3.23	4.4 (lowest) to 4.5	3.5
1985	6.35	5.6 (lowest) to 5.9	5.5

Under these production and consumption forecasts, Western European oil imports from OPEC and the Middle Eastern would continue to be below the 1974 level at least until 1980. Under a low oil consumption scenario, W. Europe could still be importing less OPEC oil in 1985 than it did in 1974, but at 4% growth of oil consumption, the continent would have to import 1.4 million b/d more from OPEC.

TABLE 46.—DEMAND BALANCED SCENARIO OF WESTERN EUROPEAN OIL IMPORTS, 1974-85

[In millions of barrels per day]

	At 3 percent annual growth rate of consumption	At 3.5 percent annual growth rate of consumption	4 percent annual growth rate
1974 (actual)	14.1	14.1	14.1
1977	13.0	13.2	13.3
1980	12.3	13.7	13.0
1985	12.9	13.7	15.5
1985	12.9	13.7	15.5

JAPAN

Japan's traditionally very high rates of economic growth are no longer expected to continue. The country's annual economic growth rate is likely to be significantly below the rates of the 1960's, but still higher than Western European and U.S. growth rates.

The Nation's major alternative to oil and gas imports within the next decade is nuclear power. The combination of conservation measures, projected lower economic growth rates and some substitution of oil by nuclear energy could very well bring annual oil demand down to between 4.0 and 5.0 percent per year.

TABLE 47.—FORECAST OF JAPAN'S OIL CONSUMPTION GROWTH RATES: 1974-85

[In millions of barrels per day]

	Annual oil consumption growth rate—		
	At 4 percent	At 4.5 percent	At 5 percent
1974 (actual)	5.3	5.3	5.3
1975 (projected)	5.2	5.2	5.2
1977	5.6	5.7	5.7
1980	6.4	6.5	6.6
1985	7.7	8.1	8.4

Japan's domestic oil production is negligible, and unless major new discoveries are made offshore, the country is likely to remain almost completely dependent on foreign sources of supply for the foreseeable future.

However, an interesting shift in Japan's sources of oil imports is taking place and is likely to gain more significance by the end of the decade and beyond. While Japan is expected to import between 130,000 and 200,000 b/d of oil from the People's Republic of China in 1975 (*Journal of Commerce*, August 1, 1975), the Nation may import between 250,000 and 500,000 b/d from China by the end of the decade. (See also Chapter subsection on the People's Republic.)

TABLE 48.—JAPAN'S OPEC OIL IMPORTS: 1974-85

[In millions of barrels per day]

	At 4 percent growth and 250,000 barrels per day imports from China	4 percent and 500,000 barrels per day from China	4.5 percent and 250,000 barrels per day from China	4.5 percent and 500,000 barrels per day from China	5 percent and 250,000 barrels per day from China	5 percent and 500,000 barrels per day from China
1974	5.3	5.3	5.3	5.3	5.3	5.3
1977						
1980	6.2	5.9	6.3	6.0	6.4	6.1
1985	7.5	7.2	7.9	7.6	8.2	7.9

Under these forecasts and provided that the People's Republic of China will be capable and willing to supply between 250,000 and 0.5 million b/d by 1980 and 1985, Japan's additional imports from OPEC countries (beyond 1974 level) could range from 0.7 to 1.1 million b/d in 1980, and from 1.9 to 2.9 million b/d by 1985.

WESTERN EUROPEAN AND JAPANESE IMPORTS

Given the assumptions in this study concerning oil production and consumption in Western Europe and Japan, and provided the People's Republic of China exports 250,000 to 0.5 million b/d oil to Japan in 1980, total additional oil imports of these two regions (beyond 1974 imports from OPEC) from OPEC nations would be no more than 0.8

million b/d and could actually be 1.2 million b/d less than 1974 imports under the most favorable circumstances. Under less favorable circumstances, Western Europe and Japan would have to purchase an extra 0.8 million b/d in 1980.

For 1985, additional Western European and Japanese demand for OPEC oil would range from a low of 0.7 million b/d to a high of 4.3 million b/d above 1974 imports.

Hence, under moderately optimistic supply and demand conditions, Western European and Japanese dependence on traditional OPEC suppliers could remain almost unchanged compared with the 1974 situation.

UNITED STATES

The United States was energy self-sufficient until the late 1940's Since then, production began to fall behind oil consumption. This happened in spite of the fact that domestic oil production almost doubled in the period from 1950 to 1974.

U.S. imports have gradually grown from approximately 13.0 percent of total supply in 1950 to approximately 37 percent in 1974. Moreover, in the early period, U.S. imports came primarily from "secure" Western Hemisphere sources, whereas today more than half of total imports are from the Eastern Hemisphere, some of which are not considered "secure" due to past experiences of trade interruption. Reliance on Middle Eastern and North African oil had been relatively small in the period prior to the early 70's, but it grew steadily thereafter. Thus in 1967 of about 10.2 percent of crude oil for petroleum products imported from that region, an estimated 19.1 percent was imported from the Middle East and North Africa in 1973. (See table 50.)

TABLE 49.—U.S. SUPPLY OF PETROLEUM LIQUIDS 1950–73

[In millions of barrels per day]

Year	Production	Imports	Total	Percent imports of total
1950	5.9	0.9	6.8	13.2
1955	7.6	1.2	8.8	14.1
1960	8.0	1.8	9.8	18.3
1965	9.0	2.5	11.5	21.1
1970	11.3	3.4	14.7	22.7
1971	11.2	3.9	15.1	26.0
1972	11.2	4.7	15.9	29.8
1973	11.1	6.2	17.3	35.9
1974	10.5	6.0	16.5	36.9

Source: Bureau of Mines.

United States dependence on imported oil is the result of recent disappointing petroleum discoveries and governmental policy. With the exception of the Alaskan North Slope discovery when nearly 10 billion barrels of oil were added to the Nation's reserves, there have been few years in the postwar era when annual additions to oil reserves surpassed that year's production. Until the Alaskan discovery in 1970, crude oil discoveries had fallen by 50 percent in the 1961–1969 period, but improvements in oil recovery technology had stabilized the amount of economically recoverable reserves in the U.S.[79] Between 1961 and

[79] William D. Witter, Inc., *A Basic Report on the World Crude Oil Outlook*, New York, March 1974, p. 5.

TABLE 50.—U.S. IMPORTS OF CRUDE OIL AND REFINED PRODUCTS BY SELECTED COUNTRIES, REGIONS OF ORIGIN, AND WORLD TOTAL, 1967–74 [1]

[In thousands of barrels per day]

Origin of imports	1967		1968		1969		1970		1971		1972		1973		1974	
	Barrels per day	Percent	Barrels per day	Percent	Barrels per day	Percent	Barrels per day	Percent	Barrels per day	Percent	Barrels per day	Percent	Barrels per day	Percent	Barrels per day	Percent
Canada	450	17.7	507	17.8	608	19.2	766	22.4	858	21.8	1,108	23.4	1,313	21.2	1,083	17.9
Venezuela	937	36.9	887	31.2	875	27.6	989	28.9	1,020	26.0	960	20.2	1,123	18.1	1,178	19.5
Ecuador											17	.4	48	.8	64	1.08
Bahamas			1	(3)			31	.9	150	3.8	173	3.6	171	2.8		
Dutch Antilles	359	14.2	394	13.9	449	14.2	479	14.0	432	11.0	424	8.9	573	9.2	505	8.37
Trinidad and Tobago	165	6.5	189	6.6	215	6.8	217	6.3	183	4.7	226	4.8	251	4.0	280	4.64
Virgin Islands	37	1.4	78	2.7	117	3.7	189	5.5	273	7.0	330	7.0	329	5.3		
Nigeria	5	.2	8	.3	49	1.5	50	1.5	102	2.6	251	5.3	459	7.4	701	11.62
Gabon	2	.1	1	(3)												
Indonesia	67	2.6	73	2.6	89	2.8	70	2.0	111	2.8	165	3.5	212	3.4	304	5.03
Iran	71	2.8	61	2.1	46	1.4	38	1.1	112	2.8	142	3.0	223	3.6	519	8.60
Algeria	5	.2	5	.2	2	.1	8	.2	15	.4	93	2.0	135	2.2	227	3.76
Bahrain	2	.1	4	.1	7	.2	5	.1	13	.3	15	.3	11	.2	12	.20
Egypt	4	.2	29	1.0	40	1.3	21	.6	19	.5	8	.2	15	.2	13	.22
Iraq	5	.2							11	.3	4	.1	4	.1		
Kuwait	23	.9	48	1.7	39	1.2	36	1.0	36	.9	45	.9	47	.8	1	.03
Libya	42	1.6	114	4.0	135	4.3	47	1.4	57	1.4	122	2.6	164	2.6	<1	<.1
Qatar					1	(3)					3	.1	7	.1	18	.3
Saudi Arabia	86	3.4	60	2.1	44	1.4	42	1.2	128	3.3	190	4.0	488	7.9	433	7.18
Tunisia									3	.1	8	.2	18	.3		

United Arab Emirates	5	.2	16	.6	14	.4	63	1.8	80	2.0	73	1.5	71	1.1	87	1.45
Other Middle East	17	.7	29	1.0	43	1.4			2	(2)	1	(2)	2	(2)		
Persian Gulf States [3]	209	8.2	218	7.7	194	6.1	184	5.4	382	9.7	473	10.0	853	13.8	1,070	
Arab Countries [4]	189	7.8	305	10.7	325	10.3	222	6.5	364	9.3	562	11.8	962	15.5	793	13.5
Middle East and North African States [5]	260	10.2	366	12.9	371	11.7	260	7.6	476	12.1	704	14.8	1,185	19.1	1,310	
Communist bloc countries [6]	1	(2)	1	(2)	6	.2	11	.3	5	.1	19	.4	33	.5		
Western Europe countries [7]	53	2.1	124	4.4	162	5.1	166	4.8	131	3.3	160	3.4	258	4.2		
OPEC countries [8]	1,213	47.8	1,211	42.6	1,206	38.1	1,257	36.8	1,636	41.7	2,003	42.2	2,934	47.3	3,534	58.5
U.S. total world imports [9]	2,537	100.0	2,840	100.0	3,166	100.0	3,419	100.0	3,926	100.0	4,741	100.0	6,202	100.0	6,036	100.0
Some comparative data:																
Imports of crude oil only	1,128		1,290		1,409		1,324		1,680		2,216		3,244			
Crude imports as percent of all oil imports	44.5		45.4		44.5		38.7		42.8		46.7		52.3			
Total petroleum consumption	12,560		13,393		14,137		14,697		15,213		16,367		17,254		16,489	
Percent of total U.S. oil consumption	20.2		21.2		22.4		23.3		25.8		29.0		35.9		37	
Dependence on Arab oil (percent)	1.5		2.3		2.3		1.5		2.4		2.4		5.6		8.2	
Dependence on OPEC oil (percent)	9.6		9.0		8.5		8.6		10.8		12.2		17.0		19.5	

[1] Oil shipments from all sources into the 50 States and the District of Columbia.

[2] Less than 1/10 of 1 percent

[3] Bahrain, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, the United Arab Emirates, and other Middle East (comprising Oman, the Yemens, and the Neutral Zone) are considered here the Middle East.

[4] Algeria, Bahrain, Egypt, Iraq, Kuwait, Libya, Qatar, Saudi Arabia, Tunisia, the United Arab Emirates, and other Middle East.

[5] Middle East (1) plus, Algeria, Egypt, Libya, and Tunisia.

[6] Romania and the Soviet Union.

[7] Scandinavia, the European Common Market, and Spain.

[8] Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia United Arab Emirates, and Venezuela (as of November 1974).

[9] Partially estimated.

Sources: 1967–73 data: From various publications of the Department of Interior, Bureau of Mines and the Office of Oil and Gas; the Bureau of Census; consultations with other agencies; CRS computations and reconciliation. Compiled and analysed by Dario Scuka analyst in international trade and finance, Nov. 27, 1974, 1974 data are based on FEA information.

1965 reserve additions equalled 65 percent of oil consumption, but in more recent years the industry has not been able to replace more than 40 percent of consumption.[80]

The disappointing oil discoveries were in part related to a liberal import policy inaugurated during the late 1960's. It had the effect of restraining domestic price increase said to be needed to encourage exploration.[81] More important was the regulation of natural gas which resulted in rapid growth in demand for natural gas (cheap in comparison to oil), which in turn discouraged development of other alternative sources of energy, including oil.

The effect of the rise in the price of old crude and the potential effect of decontrol of old crude on domestic output is not known, but it is expected to result in significant additional exploration activities and further development of advanced recovery technology.

Geopolitical Distribution of U.S. Petroleum Imports and Future Projections

While oil imports from Western Hemisphere nations have grown continuously in absolute volume until 1974, in terms of a percentage of total oil imports, Western Hemisphere supplies to the U.S. have declined since the middle 1960's. For example, Venezuela exported 937,000 b/d to the U.S. in 1967, or 36.9 percent of total U.S. imports in that year. In 1974, Venezuelan imports into the U.S. amounted to 1.2 million b/d, but the percentage of total oil imports declined to 19.5 percent (See table 50). In contrast, imports from the Middle East and North Africa grew from 10.2% in 1967 to more than 19.1% in 1973. (See table 50.)

This trend is likely to continue at an accelerated pace in the coming decade. Even prior to the Canadian decision to curb imports of oil and natural gas to the United States, a major oil study by the National Petroleum Council concluded:

> Besides the possible large increase in volume of imports, a shift in the source of imports through 1985 is indicated. The U.S. will become increasingly dependent on Eastern Hemisphere crude supplies. Projected Western Hemisphere petroleum supply/demand balances were developed. These indicate that not only would the export availability of potential oil and gas supplies from the Western Hemisphere outside the U.S. be limited, but that the Western Hemisphere itself would become more dependent on Eastern Hemisphere supplies.[82]

The study also projected that under certain conditions as much as ¾ of total imports might have to come from the Eastern Hemisphere by 1985.[83] Last year's import figures provide some indication that we may indeed be moving in this direction. In spite of the Arab oil embargo, U.S. oil imports from Eastern Hemisphere sources increased from 43 percent in 1973 to 53 percent in 1974.[84] The Director of the

---

[80] Ibid., p. 5.
[81] Ibid., p. 4.
[82] National Petroleum Council, *Energy Outlook*, op. cit.
[83] Ibid., p. 39.
[84] Petroleum Industry Research Foundation, *U.S. Oil Imports and Import Dependency, June–October 1974*, New York, December 1974, p. 4.

Petroleum Industry Research Foundation, Mr. Lichtblau, maintains that the principal reason for the relative stability in U.S. oil imports from Arab sources in 1974 has been Libya's unwillingness to sell oil to the U.S. in 1974. In the absence of this policy, according to Mr. Lichtblau, U.S. dependence on Arab oil would probably be several percentage points above the 1973 figure.[85]

And indeed, it seems that Mr. Lichtblau was proven right when figures on oil imports for the first quarter of this year became available.

Direct imports of Arab oil reached nearly 23 percent of total imports, up from 18 percent in the fourth quarter of 1974. Saudi Arabia moved decisively into the front rank of foreign suppliers to the U.S. on a direct-shipment basis. As a direct supplier, Saudi Arabia's 780,000 b/d to the U.S. in the first quarter of 1975 were only about 100,000 below Venezuela's 880,000 and Nigeria's 870,000, and narrowly outpaced Canada's exports of 760,000 b/d. While Saudi imports gained 110,000 b/d from the fourth quarter, Venezuela dropped 380,000 and Canada 160,000 b/d.[86]

TABLE 51.—U.S. CRUDE AND PRODUCTS IMPORTS BY SOURCE, FIRST-QUARTER 1975 AND FOURTH-QUARTER 1974

[In millions of barrels daily and percent of total imports]

	1st quarter 1975		4th quarter 1974	
	Volume [1]	Percent	Volume [1]	Percent
OPEC countries:				
Arab	1.3	22.9	1.1	17.9
Saudi Arabia	0.8	13.4	0.7	10.6
Algeria	.3	5.5	.3	4.3
United Arab Emirates	.1	1.9	.1	2.3
Libya	.1	1.6		
Qatar		.3		.6
Kuwait		.2		
Non-Arab	2.5	43.0	2.8	45.4
Venezuela	.9	15.0	1.3	20.2
Nigeria	.9	14.8	.8	12.8
Iran	.4	6.4	.4	6.9
Indonesia	.3	5.8	.3	4.9
Ecuador	.1	1.0		.7
Total OPEC	3.8	65.9	3.9	63.3
Non-OPEC countries:				
Canada	.8	13.2	.9	14.8
Trinidad	.2	3.7	.3	5.2
Bahamas	.2	3.0	.2	2.5
Other	.8	14.2	.9	14.3
Total non-OPEC	2.0	34.1	2.3	36.7
Total imports	5.8		6.2	

[1] Volume figures extrapolated from government totals and percentages. Volume excludes propane, butane, certain nonenergy oil imports and all movements to or from U.S. Virgin Islands.

Source: "Petroleum Intelligence Weekly," June 2, 1975, p. 3.

[85] Ibid., p. 7.
[86] *Petroleum Intelligence Weekly*, June 2, 1975, p. 3.

UNITED STATES OIL IMPORTS: PROJECTIONS FOR THE FUTURE

(See also chapter V, part I)

According to the analysis in part I, chapter V, unless "old" oil is decontrolled soon, oil production in the United States will continue to decline until late 1977, after which a rapidly expanding volume of Alaskan crude oil will be piped to Valdez (Alaska) and from there be shipped by tanker to the lower 48 States. This study also projected shortfalls in natural gas, coal, and nuclear energy production.

TABLE 52.—U.S. OIL CONSUMPTION AND IMPORTS

[In millions of barrels per day]

	1977	1980	1985
Total consumption:			
2.8 percent energy growth	19.0	21.0 [1]	21.0 [1]
3.1 percent energy growth	19.2	21.6	22.4
Imports at:			
2.8 percent energy growth	9.0	10.0	9.0
3.1 percent energy growth	9.2	10.6	10.4

[1] Volume of oil consumption equal for 1980 and 1985 under 2.8% energy growth is due to a different energy supply mix in 1985, when nuclear energy and coal are expected to replace some imported oil.

The 1974 imports were approximately 6.0 million b/d. Hence, with an energy growth rate of 3.1% per year (0.4% lower than the 20 year average prior to 1973, and 1.4 percent below 1965–73 energy growth rates) U.S. imports of oil could increase by about 90% in 1985. At a lower energy growth rate of 2.8 percent, imports could peak in 1980, if assumptions concerning larger contributions of natural gas, nuclear energy, coal and synthetics fuels to the total energy mix will prove correct.

Under the stated assumptions imports will grow under any circumstances at least until 1980, and foreign supplies will steadily shift away from Western to Eastern Hemisphere sources.

There is little doubt that unless our energy supply and demand situation for the next ten years can be altered considerably beyond what has been projected in this analysis, the United States will grow heavily dependent on Middle Eastern and North African oil.

No one can project with any degree of accuracy how much oil we will be importing from each potential source of supply, due to a number of physical, economic, and political variables.

United States oil import forecasts for 1977, 1980 and 1985 by source of supply are based in part on official projections (Canada in particular), production estimates based on actual and projected reserve estimates coupled with past and projected production and export policies of producing countries, and finally as in the case of Iraq, the U.A.E. and Saudi Arabia primarily on "guestimates".

TABLE 53.—DEMAND BALANCED SCENARIO OF UNITED STATES PETROLEUM IMPORTS, BY REGION AND COUNTRY

[In thousands of barrels per day]

	1974	1977	1980	1985
Western Hemisphere:				
(Group I):				
Canada (official projections)	1,083	400	140	0
Venezuela	1,178	1,100	1,000	1,000
Ecuador and Peru	69	160	200	200
Trinidad and Tobago	280	300	300	300
Other Caribbean (primarily Dutch Antilles) in part based on Middle East crude oil)	505	500	500	500
Mexico	11	200	500	700
Total Western Hemisphere oil imports	3,126	2,660	2,640	2,700
Canadian natural gas (under the most optimistic conditions)	450	450	450	450
Total Western Hemisphere oil and gas imports	3,576	3,110	3,090	3,150
Eastern Hemisphere:				
Africa, south of the Sahara (group II):				
Nigeria	701	800	1,000	1,000
Gabon and Zaire	34	60	125	175
Angola (Cabinda)	47	60	100	150
Southeast Asia (group III):				
Indonesia	304	400	500	600
Other (including Brunei)	16	30	60	100
Subtotal (groups I, II, III (incl. natural gas)	4,678	4,460	4,875	5,175
Total United States oil and gas imports at energy growth rates of 2.8 to 3.1 percent	[1] 5,972	9,000-9,200	10,000-10,600	9,000-10,400
Middle East and North Africa (group IV):				
Needed from Middle East and North Africa	1,294	4,540-4,740	5,125-5,725	3,825-5,225
Iran	519	800	1,000	900-1,000
Algeria	227	250	250	200
Tunisia	31	50	75	75
Kuwait	20	200	250	250
Qatar	18	25	25	25
Libya	150	250	300	300
Iraq	10	500	600	500
U.A.E.	87	650	700	500-700
Saudi Arabia	433	1,745-1,945	1,825-2,425	975-2,075
Other Arab		70	100	100
Total	1,495	4,540-4,740	5,125-5,725	3,825-5,225
(of which of Arab)	(976)	(3,740-3,940)	(4,125-4,725)	(2,925-4,225)

[1] Actual.

Middle East and North African Export Scenario

Under earlier assumptions of total worldwide and regional European and Japanese supply and demand conditions for the period 1975–85, meeting U.S. demand for Middle Eastern and North African oil could require some countries—and in particularly Saudi Arabia—to produce significantly more oil than they have projected. Other countries within the region may have little difficulty accommodating additional U.S. demands as projected here.

Iran may produce 7 million b/d in 1977 and peak at 8 million b/d in 1980. Exports to the US assume continuation of current trends. Algeria may not be able to increase its exports any further because of physical limitations related to its reserve situation. Export forecasts for Kuwait and Libya are based on projected total oil exports of these countries and assume that a significant portion of future exports in excess of current supplies will be available to the U.S.

Iraq is in the midst of a major agricultural and industrial development program, requiring increased exports of oil (now expected to double by the early 80's). In view of projected worldwide oil supply and demand and U.S. capability of supplying Iraq with much of the technology needed to meet that country's needs, our projection of rapid expansion of oil exports to the U.S. does not seem unrealistic.

The remainder would have to be imported from the two countries with respectively large and vast oil reserves: the UAE and Saudi Arabia. In view of the limited capital absorptive capacity of these two countries, and depending on total world oil demand, our import needs may be considerably in excess of their domestic economic requirements. Hence, if they were to produce a significantly higher volume of oil in 1977 than in 1974, and receive foreign exchange considerably in excess of domestic development needs, they would have to invest much of the proceeds of their oil sales in foreign countries. Arab countries are not projecting major direct foreign investments at this time.

On the other hand, both have an interest in economic stability in the Western world. Substantial shortages of energy in the United States and elsewhere would lead to economic stagnation and subsequently higher unemployment, and perhaps a depression that will be exported to the entire Western world.

The major oil producing nations of the Middle East are aware of the fact that they do not live in an economic vacuum, and that they will play a central role in providing the world with oil in the coming decades when the world prepares itself to move gradually away from oil and natural gas to other sources of energy.

Few observers would disagree that the availability of additional exports of Middle Eastern and North African oil—and particularly from the nations with low populations and limited capital absorptive capacity—is seriously at risk without a peaceful settlement of the Arab-Israeli conflict.

Chapter VIII

WORLD SUPPLY OF OIL: DESCRIPTIVE ANALYSIS OF MAJOR PRODUCING AREAS

There is little doubt that the projected cumulative world demand for the next decade can be produced physically from current worldwide reserves, even though the reserve/production ratio may further decline.

On the basis of existing worldwide oil reserves and the considerable lead-time to bring future discoveries to full production, we believe that oil marketed in 1980 will come almost exclusively from currently proved reserves (with some exceptions such as Mexico), and much of the oil produced in 1985 will also be from currently proved reserves.

We have projected United States imports to rise from the current six million b/d to between 9.0 and 9.2 million b/d in 1977, between 10.0 and 10.6 million b/d in 1980 and between 9.0 and 10.4 million b/d by 1985 (assumes energy growth rates of 2.8 to 3.1% per year). Will the United States be able to purchase all the oil it needs from abroad, and what are the likely sources of foreign supply?

Table 53 forecasts U.S. petroleum imports by source for 1980 and 1985. (See p. 69.)

Sources of supply were divided into major groups: the Western Hemisphere and Eastern Hemisphere; the latter was subdivided into three subgroups: Africa south of the Sahara, Southeast Asia, and the Middle East and North Africa. The Middle East and North Africa were combined in our analysis, because the major suppliers in North Africa are Arab nations whose oil policies frequently coincide with the policies of the Middle Eastern Arab nations.

Our projections for Canada and Venezuela, currently our major foreign suppliers of oil and oil products, and Mexico—a potential major source of supply in the western hemisphere—are analyzed below:

Canada

Until last year Canada was the major exporter of oil and petroleum products to the United States (excluding natural gas). In 1974 Venezuela replaced Canada as the number one exporter of oil to this country. Under Canada's current energy policy, that nation's exports of oil to the United States will gradually decline and be phased out completely by 1984. As Canadian exports of oil to the United States used to be in the vicinity of 20 percent of our imported oil for each of the five years preceding 1974, the loss of what once was considered our most secure source of supply will have very serious implications for the nation's future energy supply situation. The impact of the projected cutback in Canadian oil exports reaches far beyond energy policy, and it is therefore of great importance to understand the Canadian position.

Oil and Gas Reserves.—Canadian oil reserves grew from about 5.2 billion barrels in 1962 to 10.5 billion barrels in 1969 (or from 4.5 to 8.6 billion barrels excluding natural gas liquids) when reserves of liquid hydrocarbons reached a peak.[87] After 1969 reserves of crude oil and natural gas liquids continued to decline and reached a low of 8.8 billion barrels at the end of 1974.[88] At Canada's current rate of production of 2 million barrels per day, these reserves will last about 12 years. The natural gas situation is more favorable. Reserves grew from 31 TCF in 1962 to 56.7 TCF at the end of 1974.[89] This represents about 25 years of natural gas at the current rate of production including a substantial export to the United States which has averaged at about 950 billion cubic feet annually in recent years. Canada's undiscovered recoverable petroleum resources have been estimated at 120 billion barrels of oil and 725 TCF of natural gas. In addition, tar sands recoverable with the use of established open-pit mining and above-ground recovery techniques are estimated to be capable of producing more than 26 billion barrels of synthetic crude oil.[90] The best oil potential is said to be in the Mackenzie delta, the far north and beneath the Atlantic OCS.

Canadian Energy Policy in the 1960's.—Canada adopted an energy policy in 1960 designed to foster development of the domestic petroleum industry and to take advantage of low-cost foreign supplies. Oil produced in the western states was more expensive than Middle Eastern oil imported in the East, but by law, the cheap imported oil was prohibited from moving west of the Ottawa valley. Hence, Alberta's policy was geared towards promoting exports of western oil to the United States. In order to protect its domestic high-cost oil industry, the United States had adopted import restrictions for foreign oil. In spite of these restrictions, oil imports from Canada increased gradually from 250,000 b/d in 1960 to about 1.3 million b/d in 1973 (see table 53).

Canada's Policy for the 1970's.—Due to a particular set of domestic and foreign economic and geographical circumstances, Canada has for years been in the peculiar position of being simultaneously a major importer and exporter of oil. The western provinces exported much of their production to the United States, while the eastern provinces imported cheap Middle Eastern and Caribbean oil. In 1973, for example, Canada consumed 1,755,000 b/d of oil and produced 2,105,000 b/d: it exported 1,020,000 b/d and imported 670,000 b/d. As long as the price of imported oil was cheaper than that of western Canadian oil transported to the East, and as long as the sources of imports could be considered relatively secure, there was no need for major change in Canada's basic energy policy.

However, the world situation changed rapidly in 1973/1974. United States domestic oil production had peaked in 1970 and production began to decline at a time when domestic demand was growing at a

---

[87] Canadian Petroleum Association, A.P.I. and A.G.A., *Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada and United States Productive Capacity as of December 31, 1973*, Vol. 28, Washington, D.C., June 1974, p. 236.

[88] The British Petroleum Company Ltd., *BP Statistical Review of the World Oil Industry, 1974*, London, 1975, p. 4.

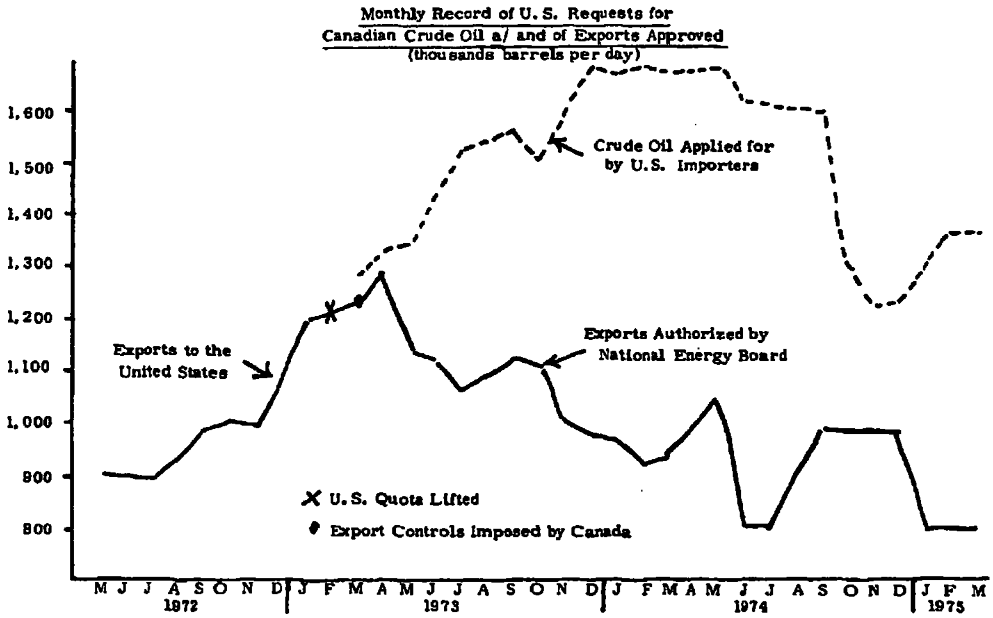
[89] American Gas Association, *News Release*, April 1, 1975, p. 3.

[90] U.S. House of Representatives. Committee of Foreign Affairs. Subcommittee on Inter-American Affairs. *The Energy Crisis: Impact of Canadian Policies*. Hearings, 93rd Congress. First Session, November 14 and 15, 1973. Washington, D.C., Government Printing Office, 1974, p. 94.

U.S. House of Representatives. Committee on Science and Astronautics. Subcommittee on Energy. *Energy From U.S. and Canadian Tar Sands: Technical, Environmental, Legislative, and Policy Aspects*. 93rd Congress, Second Session, Washington, D.C., Government Printing Office, December 1974, p. 11.

pace of about 4 percent annually. As a result of OPEC policy, the world crude oil price in early 1973 had reached a level at which protection of domestic oil in the U.S. was no longer needed. Hence, on February 15, 1973, President Nixon lifted import restriction on oil. This in turn led to a sharp rise in demand for Canadian oil which threatened to create shortages in Canada.[91] To ensure that Canadian refineries would get the oil they needed, Canada responded to the increased U.S. demand by imposing export restrictions (see figure 10). The Canadians were not in a position to increase total supplies, because at the time output was approaching its effective capacity limit of just over 2 million b/d.[92]

[Figure 10 follows:]



a/ Includes condensates, excludes LPGs.

Sources: Oilweek, November 5, 1973, p. 76; National Energy Board.

FIGURE 10

The Arab oil embargo during the fall and winter of 1973 (and continuing into 1974) and the quadrupling of the price of OPEC crude following the embargo, resulted in a re-assessment of Canadian energy policy.

Canadian oil consumption in 1974 was 1,850,000 b/d and has been rising at an average of 5 percent per annum in the period from 1969–1974.[93] At this rate of growth Canada will have reached its effective capacity limit of 2 million b/d at the end of 1976.

The Canadian government had the option to continue its policy of allowing exports of slightly more than half of its domestic oil production to the United States, while meeting the demands of the eastern states with imported oil, or to gradually reduce exports and imports by upgrading oil transportation facilities from the west to the eastern provinces. The government opted for an export reduction policy.

[91] Canadian-American Committee, *Keeping Options Open in Canada—US Oil and Natural Gas Trade* Washington, D.C., April 9, 1975, p. 7.
[92] Ibid., p. 7.
[93] The British Petroleum Corporation Ltd., *BP Statistical Review of the World Oil Industry 1974*, op. cit. p. 8.

This policy did not come as a complete surprise to insiders in the United States. In a report for the Subcommittee on Inter-American Affairs of the Committee of Foreign Affairs of the U.S. House of Representatives written in October 1972, Mr. George Doumani, specialist in earth science at the Congressional Research Service, wrote:

> Another point that casts doubt on the reliability of petroleum to be imported from Canada is the policy and practice prohibiting the provinces west of Ottawa to sell their products to the eastern provinces. This forces the western provinces to find their own markets, principally the United States, while the demand of the eastern provinces is satisfied by supplies imported from outside. In the event that these imported supplies are interrupted, for whatever reason, it is obvious that Canada will have to fall back on its western supplies, consequently halting their exports and depriving the United States of these supplies.[94]

Moreover, Canadian law requires that before exports can be licensed' the National Energy Board must "satisfy itself that the quantity of oil to be exported does not exceed the surplus remaining after due allowance has been made for the reasonable foreseeable requirements for use in Canada".[95] If as expected a cumulative 12 to 15 years reserve requirement is adopted as a condition for continued exports, little oil will be available for exports within the next few years.

Canada now aims at energy self-sufficiency by extending its pipeline from the western oil fields to Montreal. After an initial cut-back of exports in January 1975, Canada is expected to 'shut-in' extra oil production in the West to give the country a slightly longer period of self-sufficiency. Reportedly once the pipeline has been completed (projected for late 1975) Canada will boost its estimates of domestic demand by 250,000 b/d to cover the needs of the pipeline, and consequently exports to the United States will be decreased further according to the following scheme:[96]

Average	*Barrels per day*
1975	800,000
1976	560,000
1977	400,000
1978	290,000
1979	210,000
1980	140,000
1981	30,000
1982	5,000
1983	1,000
1984	0

Exports could be further reduced to 450,000 b/d or even less in 1976, in case production from tar sands falls considerably short of earlier projections. In any case, the demand/supply figures will be reviewed annually, and the available volume of oil for export abroad may be changed subject to currently unforeseen alterations in demand and supply.

The projected cut-backs have not been based upon anti-Americanism, but simply because Canada itself is faced with losing its self-sufficiency in domestic crude production within the next few years. If exports to the United States were to continue at the 1974 level, Canada might have become a net importer of oil by 1977 or 1978.[97] By cutting back exports to the United States, Canada will only

[94] *The Energy Crisis: Impact of Canadian Policies*, op. cit., p. 99. While the formula for reducing Canadian imports was accepted by Canada's Energy Minister, Donald MacDonald in November 1974, the National Energy Board had projected the reduction in a report in 1972. Ibid., p. 76.]

[95] *Keeping Options Open in Canada—US Oil and Natural Gas Trade*, op. cit. p. 35.

[96] Weekly Energy Report, vol. 2, No. 47, November 25, 1974, p. 1.

[97] *Weekly Energy Report*, vol. 2, No. 47, November 25, 1974, p. 6.

stretch its self-sufficiency by a few years. A National Energy Board report on oil supply and demand in the 1970's and 1980's has predicted that even if all exports are eliminated and even if Canada drops the planned extension of its crude pipeline into Eastern Ontario and Western Quebec, domestic demand for oil could exceed domestic supply by 1982.[98]

If the current downward trend of Canadian proved oil reserves

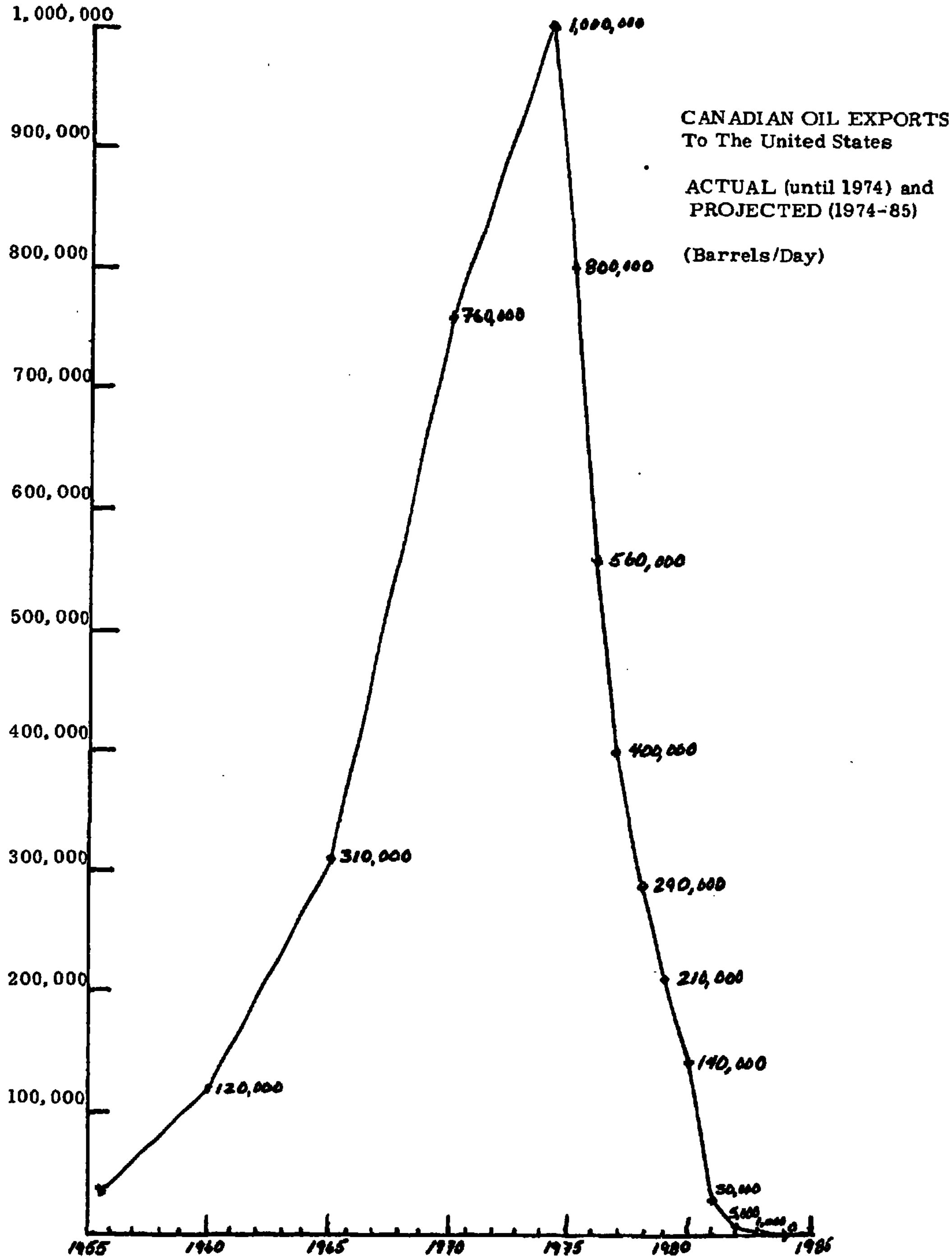


Figure 11

[98] Ibid., p. 6.

continues for some years, production is not likely to surpass the 2 million b/d level. Not only would the United States be faced with reduced imports from its northern neighbor, but Canada would probably also continue to compete with the U.S. and other countries for the gradually declining Venezuelan oil exports.

It cannot be excluded that the Canadian oil export policy may change once more in favor of larger oil exports to the United States, if and when large new additions to proved oil reserves are made. But, even if the Canadian reserve situation improves, Canada "is unlikely ever to have the potential to play a dominant role with regard to total North American needs" according to the Canadian ambassador to the United States, Mr. Marcel Cardieux.[99]

Canadian Natural Gas Exports.—Net production of natural gas was approximately 2.45 TCF in 1973, out of which approximately 0.96 TCF was exported to the United States and 1.5 TCF consumed at home. Exports of Canadian gas to the United States are not likely to increase in the near future. The country's policy has been to export only that gas which remains in surplus after making provision for Canadian requirements in an amount equal to 25 times the annual Canadian requirements at the fourth year from the date of consideration, plus the previously authorized export volumes, and the volumes being applied for.[100] It is also necessary generally to meet tests of future surplus and trends in reserve growth. In compliance with these requirements, the National Energy Board has turned down all applications for additional exports since 1970. It is an open question to what extent the policy of allowing only exportable surpluses abroad will permit significant new supplies to be licensed for export before the development of new gas reserves in frontier areas.

Most natural gas exports are committed by long-term contracts, but existing export commitments will begin to decline significantly in the second half of the 1980's. In fact, natural gas deliveries to the United States have declined during the past year because of a sharp reduction in production from British Columbia's gas fields, caused by water flooding problems, and a shortfall in Alberta's production destined for the Canadian market (exports declined from slightly over 1 TCF in 1973 to 959 billion cubic feet in 1974.)[101]

Until recently, the Federal Power Commission maintained that Canadian exports of natural gas would rise from the current level to 1.8 TCF in 1980 and 2.76 TCF by 1985. The American Gas Association was less optimistic, and estimated the natural gas imports from Canada would be no more than 1 TCF in 1980 and 1.2 TCF by 1985.[102]

In the meantime, however, the Canadian National Energy Board has completed its review of the national supply and demand conditions in Canada, and recommended export reductions in view of the NEB's findings which indicate that near-term gas supplies will be inadequate to meet both projected increases in Canadian gas demands and existing U.S. export obligations.[103] Speaking before the House of Commons in Ottawa on July 16, Energy Minister Donald S. MacDonald stated: "It is clear from the information presented that there will have to be some curtailment of our export contracts and that

[99] *The Energy Crisis: Impact of Canadian Policy*, op. cit., p. 74.
[100] Ibid., p. 99.
[101] Federal Power Commission, News Release, Washington, D.C.
[102] FPC and AGA estimates were obtained from officials of the two institutions in telephone conversations in May, 1975.
[103] *Energy Users Report*, Number 102, July 24, 1975, p. A-29.

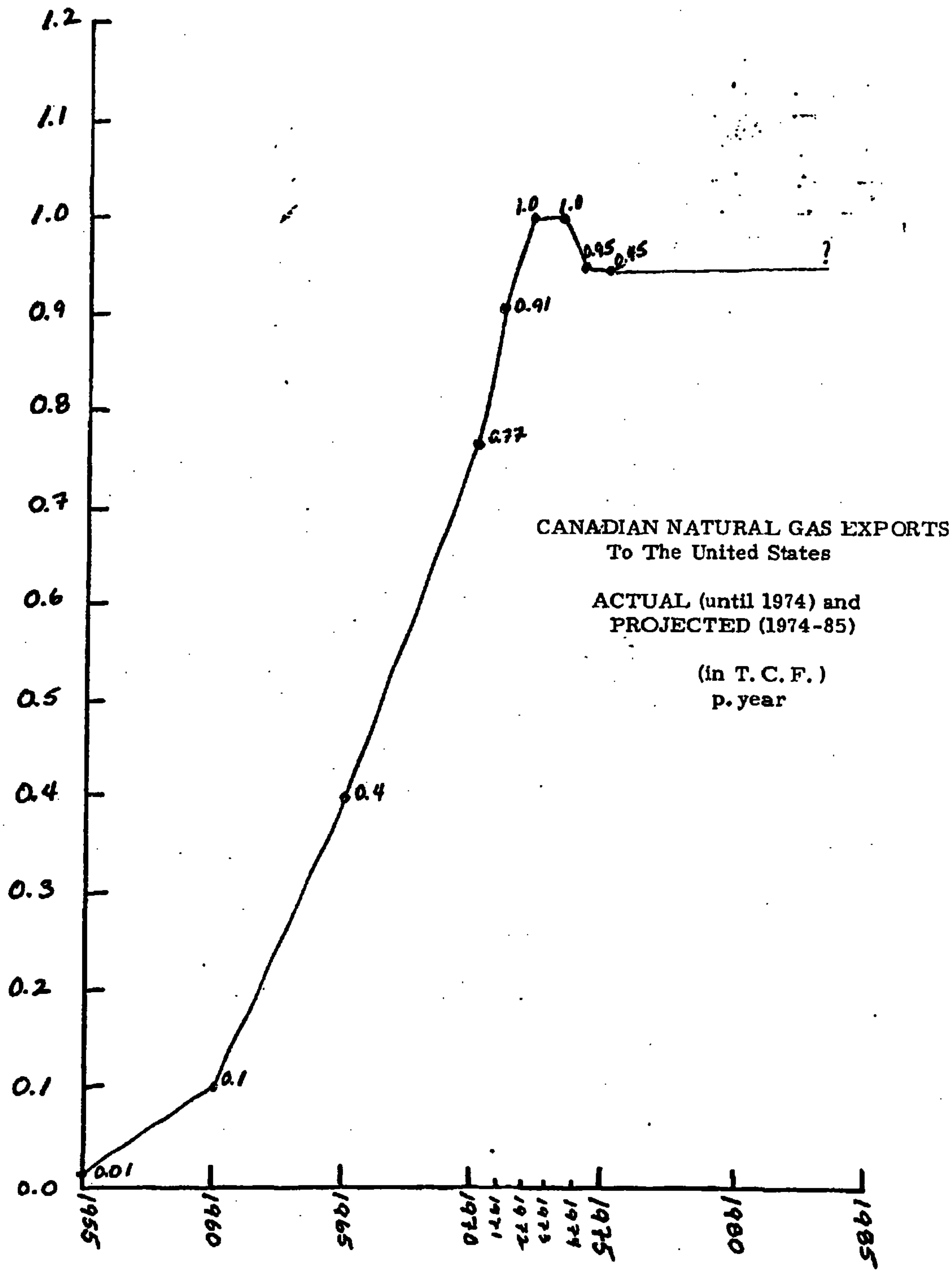


FIGURE 12

growth of demand in Canada will have to be restrained until frontier supplies of gas are available".[104] The NEB report reasserted that the Board will act to assure that all existing export licenses are conditioned on the requirements that Canadian needs are met before any gas leaves the country.

[104] Ibid., p. A-20.

The Canadian Government also noted that it will continue its policy of raising gas prices to bring them to par with the cost of alternative sources of energy. On November 1, 1975, the price of Canadian gas will rise to $1.60 per 1,000 cubic feet and is expected to rise even farther to about $2.00 per 1,000 cubic feet.[105]

With the gradual phasing out of Canadian oil exports and possibly further significant decline in natural as deliveries, the United States is about to lose its most secure source of imported energy.

OTHER WESTERN HEMISPHERE SOURCES OF OIL IMPORTS

MEXICO

Mexico was a major supplier of oil to the United States in the early 1920's. Exports of Mexican oil gradually declined during the late 1920's and varied between 1 and 13 million barrels per year between 1930 and the middle fifties. After another considerable dip in Mexican oil imports between 1958 and 1961, imports were stablized at between 2.5 and 3.6 million barrels per year until 1966, when exports of Mexican oil came to a complete stop. Domestic demand had surpassed production, and Mexico became a net importer of oil. Mexico produced 550,000 barrels per day in 1973 and consumed 610,000 barrels per day. However, with the recent discovery of the giant Reforma field in the southern part of the country, the chances of Mexico becoming once again a major oil exporter have grown.

The discovery of the Reforma field in the southern provinces of Chiapas and Tobasco will add substantially to Mexico's oil reserves which were estimated at 13.5 billion barrels in 1974.[106] While consumption increased to 645,000 b/d in 1974, production jumped to 625,000 b/d. The Reforma fields contributed as much as 250,000 b/d by the end of 1974.[107] As little as two years ago production from the Reforma fields was non-existent. Mexico's total oil production has been estimated to rise to over 800,000 b/d by the end of this year, and if the Reforma fields are indeed another "North Slope", production could rise to as much as two million barrels per day by the end of the decade.

It is difficult to estimate how much oil will be available for export. Mexico became self-sufficient in the fall of 1974 and began to export an estimated 50,000 b/d. Forecasts for 1975 exports range from 76,000 to 135,000 b/d, and more than half of the exports are destined for the United States. The official production plan calls for exports of 110,000 b/d for 1975. A representative of PEMEX, the Mexican national oil company, indicated in an interview last year that his country wants to avoid Venezuela's past policy of unrestrained exports in order to save her reserves for future generations.[108] Moreover, Mexico's domestic demand is expected to grow at a rapid pace, requiring a rate of consumption of 1.5 to 1.8 million b/d by 1980/1982.[109] This would be an increase of about 100 percent in crude oil consumption in a period of eight years.

In view of the limited information available on the size of the Reforma fields and the uncertainty of the country's oil export policy, we believe that oil exports to the U.S. of 500,000 to 700,000 b/d

[105] Ibid., p. A-30 and *Wall Street Journal*, March 19, 1975.
[106] *The Oil and Gas Journal*, October 21, 1974, p. 78.
[107] *The Oil and Gas Journal*, January 6, 1975, p. 37.
[108] *Energy Notes*, no. 62, October 17, 1974, p. A-25.
[109] *Journal of Commerce*, January 30, 1975; *The Oil and Gas Journal*, May 26, 1975, p. 25.

by early 1980's may be reasonable estimates. Some of the available Mexican oil by the end of the decade is likely to be in the form of petroleum productions rather than crude oil.

Venezuela

Venezuela has 80 percent of the proved recoverable oil reserves of South America and 52 percent of the natural gas reserves. The nation has traditionally been one of the oldest and largest exporters of oil to the United States. However, exports of oil from this secure source of supply have declined in 1974 and this recent trend is likely to continue into the future, because the nation's resource base is steadily declining. Moreover, the quadrupling of the price of oil in 1974 has enabled Venezuela to cut back production without a subsequent loss of revenues needed for the country's domestic development plans. In fact, the nation is running a considerable surplus on the balance of payments which leaves room for investments abroad.

Venezuela's policy of conserving a scarce resource is understandable if one takes into consideration the country's declining oil reserves. Reserves were at a high of 17.4 billion barrels in 1960 but dropped gradually to about 15 billion earlier this year. If this trend were to continue, Venezuela would run out of oil in about 12 years at the 1973 rate of production. Whether this decline will be checked is doubtful. The government has reported that 95 of the country's 250 oil fields are marginal producers (as defined before the recent price escalation), and that 227 reservoirs are already producing by secondary methods.[110] The country has vast resources of tar sands (estimated at 700 billion barrels), but technological and economic conditions do not yet permit the development of this potential resource.

Oil production peaked at 3,760,000 barrels per day in 1970 and declined gradually to 3,060,000 barrels per day in 1974. Output for the first four months of this year averaged only 2.5 million barrels per day, and the government has decided to cut production even further to 2.2 million barrels per day.[111] The Venezuelan Minister of Mines has stated that his country could reduce output to 1.7 million barrels per day and still meet its financial requirements.[112] At a production level of 2.2 million barrels per day existing reserves can be stretched from 12 to 18 years.

Venezuelan exports of crude oil and products has grown rapidly until it reached a peak of 1,178,000 barrels per day in 1974. In view of its declining reserves and conservation policy, the country's exports of oil to the United States are likely to decline both in absolute figures and as a percentage of total U.S. petroleum imports. Under these circumstances U.S. imports of oil from Venezuela in 1980 and 1985 are not likely to be more than 1 million barrels per day.

EASTERN HEMISPHERE

Western Europe

The possibility of significant new onshore finds is not encouraging in this part of the world. Aside from the giant Groningen fields no

[110] Neal A. Van Middlesworth, "Petroleum Developments in South America, Central America, and Caribbean Area in 1973: Venezuela". *The American Association of Petroleum Geologists Bulletin.* Vol. 58. no. 10. October 1974, p. 1927.
[111] *The Oil Daily*, May 19, 1975.
[112] *OGJ Newsletter*, March 3, 1975.

major petroleum provinces have been located osnhore in the past decade-and-a-half. More than 80 percent of the known reserves of natural gas are located in the North Sea or in areas bordering coastal areas of Western Europe.

Total Western European oil reserves were estimated at 25.8 billion barrels or less than 5 percent of the non-communist oil reserves. Of the 25.8 billion barrels some 23 billion have been estimated to be located beneath the British and Norwegian continental shelf.[113] There are additional prospects in the Northern Atlantic, the Celtic and Irish seas, and the Mediterranean region (all offshore), but Western Europe—with the exception of Great Britain and Norway—will continue to be a major net importer of oil. In 1974, the region produced 445,000 b/d and consumed 14,170,000 b/d. Net imports were running at about 13,725,000 b/d which was close to 30 percent of world oil consumption.

Evaluating the importance of the North Sea fields in terms of total European demand—which is now expected to rise at a rate of 3.1 to 3.5 percent per year between 1975 and 1985—we found that North Sea production is likely to offset increased demand by 1980 and possibly even in 1985 (see chapter 7, tables 44 and 46). North Sea production will probably satisfy about 25 percent of Western European demand for oil in 1980, and between 25 and 30 percent of the region's oil demand by 1985. Great Britain is likely to become completely independent from foreign imports of oil by the end of the decade, and Norway will become a major exporter. With the exception of one major find off Denmark, discoveries in the Dutch, Danish and German sectors of the North Sea have so far proved disappointing.

Any available surplus oil from Britain and most of the Norwegian oil would for economic reasons be exported to the European continent. The United States is not likely to become a major importer of North Sea oil.

TABLE 54.—ESTIMATED NORTH SEA OFFTAKES

[In thousands of barrels per day]

	1980	1981	1982	1983	1984	1985
United Kingdom:						
Current development	1,790	1,760	1,640	1,530	1,360	1,220
Probable development	570	1,060	1,310	1,360	1,240	1,100
Expected discovery	30	160	520	860	1,170	1,350
Subtotal	2,390	2,980	3,470	3,750	3,770	3,670
Others:						
Current developments	790	810	950	1,090	1,040	870
Expected discoveries	50	120	540	940	1,280	1,490
Subtotal	840	930	1,490	2,030	2,320	2,360
Grand total	3,230	3,910	4,960	5,780	6,090	6,030

Source: The British Petroleum Co., August 1975.

Asia

The continent of Asia can be subdivided for purposes of oil and gas demand and supply into five regions: the communist countries (China and the U.S.S.R.), Japan, South-East Asia, South Asia, and the Middle East. China and the Soviet Union will be discussed in more detail elsewhere in this paper.

Japan is consuming its little oil and gas reserves at a very rapid pace, and the country is more dependent on outside supplies of energy than any other major country in the industrialized world. There are

[113] *The Oil and Gas Journal*, December 30, 1974, p. 108.

some good prospects in the East China sea, but there are legal disputes about ownership of continental shelf resources around the Senkaku islands and about the extent of the Japanese part of the continental shelf west of Okinawa. The country consumed 5,310,000 b/d in 1974 and produced less than 15,000 b/d.

South Asia (India, Bangladesh, Pakistan and Burma) is also a petroleum deficient area. These countries produced close to 180,000 b/d in 1974 and consumed some 640,000 b/d. The offshore potential of each one of the countries is very good: India may become self-sufficient in oil within a few years, and Burma has been regarded by some geologists as one of the most promising offshore areas in that part of the world. However, for the forseeable future the area is not likely to become a net exporter of oil.

In South East Asia, Indonesia and Brunei are the only major producers and exporters of oil. As a region, South East Asia produces only slightly more than it consumes. In 1974, South East Asis produced approximately 1,700,000 b/d and consumed 1,585,000 b/d. The major exporter in the region was Indonesia. It produced close to 1.5 million b/d and exported the bulk of its output to Japan, the United States and Western Europe. Unless Indonesia makes significant new additions to reserves in the years ahead, production is not likely to increase by more than 500,000 b/d within the next decade. Indonesia, a country with a population of more than 130 million, can easily absorb the revenues expected from increased oil production. Hence, there is little doubt that Indonesia will continue its policy of maximizing oil production to meet growing domestic demand and to earn the necessary foreign exchange to meet domestic economic development plans. Thailand and in particular Malaysia have good offshore prospects, but domestic supply is not likely to surpass domestic demand by a sufficiently large volume to turn those countries into major exporters. The situation offshore Vietnam and Cambodia was nebulous prior to the change in government. It seems unlikely at this point that the area will become a major petroleum exporter prior to 1985.

Sub-Saharan Africa*

Most of the continent of Africa is geologically unfavorable for the accumulation of oil and natural gas. However, the regions that have accumulations are among the most abundant in the world. The North African nations of Algeria, Libya, Tunesia and the U.A.R. hold more than 60 percent of the continent's crude oil and more than two-thirds of its natural gas.

In recent years important new discoveries have been made off Nigeria, Gabon and Zaire. The Niger delta, Gabon and the Congo/Cabinda basin remain the only oil producing provinces in West Africa, but considerable exploratory efforts have been made off the coast of more than 20 countries in Africa.

The continent of Africa is of great significance as oil exporter to the United States. Imports from Nigeria have risen rapidly in recent years, making that nation the second biggest supplier of crude oil to the U.S. The continent as a whole is a major net exporter of oil. In 1974, total African production was 5,640,000 barrels per day and consumption only 965,000 b/d, leaving 4,675,000 b/d for exports.

* North Africa is primarily Arab and will be discussed as part of the chapter on the Middle East and North Africa.

Aside from Nigeria, Gabon, Zaire and Cabinda (part of Angola) are oil exporters. Out of an average of 2,750,000 b/d of Sub-Saharan oil exports in 1974, Nigeria supplied 2,330,000 b/d, or about 85 percent.

The Nigerian petroleum industry has expanded rapidly since its inception in 1958 to the present, and recent developments in the worldwide energy situation have boosted Nigeria to its current status as the seventh largest oil-producing country in the world. Recent discoveries and planned expansion indicate that this status is likely to be maintained. The country's proved reserves are estimated at 20 billion barrels of oil and 40 TCF of natural gas. Until recently natural gas associated with oil production was flared, but Nigeria is building an LNG plant to liquefy and export natural gas to—among others—the United States. On the basis of proved and probable oil reserves in the country several sources have indicated that a maximum production of 3 million b/d is feasible, and Nigeria's Permanent Secretary of Mines and Power has said that this figure could be achieved within five years, provided Nigeria continued to get a fair economic return.

The country is likely to follow a policy of maximizing production because of its high capital absorptive capacity and ambitious economic development plans. Nigeria's population of 80 million continues to grow at a rate well above two percent, and failure to promote the development of the petroleum industry would tend to limit the future revenue potential of the government. In 1973, petroleum exports provided 85 percent of all export revenues, and in 1974 the government take alone was substantially above the entire GDP of Nigeria in 1972. Petroleum taxes and royalties now provide more than 90 percent of the annual government revenues.

Under the circumstances it is very likely that the policy of the Gawon Government, i.e. expansion of exploration, processing and marketing of petroleum will continue under the new government.

The United States is importing slightly less than half of Nigeria's total oil output, and in our import analysis for 1980/85 we have quoted an equal percentage of the then higher production of approximately 3 million b/d.

COMMUNIST AREA OIL EXPORTS

Over the next ten years, the Communist nations are likely to play a much more active role in the world's energy supply and demand picture than today. At this time, Communist oil exports to the West are still marginal, but Chinese exports in particular are expected to grow rapidly within the next few years. The Soviet Union, the prime—and until recently almost sole—exporter of oil to Eastern Europe, is known to possess among the world's largest resources of oil and natural gas, but limitations on technology and capital may limit exports and, according to some sources, turn the Soviet Union into a net importer of OPEC oil in the near future. On balance, some sources indicate that Communist country oil exports could be in the vicinity of about 2 million b/d by 1985 (up from 1.1 million b/d in 1973); other—less optimistic analyses—would indicate a considerably lower export figure. Most of the additional oil exports will be of Chinese origin. If exports are to rise to as much as 2 million b/d, the United States is still not likely to be among the beneficiaries. Most of the exported Chinese oil will go to Japan and other Asian countries, and

Soviet oil exports will continue to go primarily to Eastern and Western Europe and Soviet allies elsewhere in the world. At the time this study went to press, negotiations were opened between the United States and the U.S.S.R. for the purchase of Soviet oil.

Soviet Demand and Supply

In 1974, the Soviet Union surpassed the United States as the world's leading oil producer. Soviet output averaged 9.16 million b/d, while U.S. production dropped to 8.6 million b/d in that year. The Soviet Union provides Eastern Europe with about 90 percent of that region's needs (Eastern Europe consumed approximately 1.5 million b/d in 1974), and some oil is also sold to Western Europe and Soviet allies outside Europe. The country produces about half as much natural gas as the U.S., but the rapid rise in output would suggest that Soviet production may surpass the United States in natural gas production in the early 1980's.

Proved reserves are estimated at 83.4 billion barrels of oil (more than twice the U.S. reserves) and 882.5 TCF of natural gas (more than 2½ times the U.S. reserves). One source maintains that with one-seventh of the surface of the earth and many prospective sedimentary basis only partly explored, the Soviets probably have the greatest petroleum potential of any single nation and should be self-sufficient well into the twentieth century.[114] Dr. A. A. Meyerhoff, a well-known American geologist, has estimated Soviet oil and natural gas potential at 860 billion barrels and 4,500 TCF respectively.[115] Meyerhoff maintains that Soviet petroleum resources are more than a third of the world ultimately recoverable oil resources and about 7/10th of world ultimately recoverable gas reserves. Russia's petroleum wealth is more than double that of the Middle East and North Africa combined.[116]

More than half of these resources are expected to be located in three petroleum basins in the vicinity of the Arctic circle. In terms of Btu value:

> One of these basins, the Western Siberian basin contains 20 to 50% more reserves than those of the entire Middle East. Thus, the West Siberian basin at this time appears to be the richest petroleum basin on the earth.[117]

Other sources on Soviet oil and gas resources in comparison with the rest of the world are somewhat less impressed, but several tend to agree with Meyerhoff's basic thesis that the Soviet Union contains within its borders some of the biggest—if not *in toto* the biggest—petroleum provinces in the world. The National Academy of Sciences estimated Siberian gas resources at 51,000 cubic meters out of a world total of 143,000 cubic meters, and Siberian oil resources at 53,000 out of 206,000 million tons.[118] The Survey of Energy Resources quotes a study by T. A. Hendricks of the USGS, who placed Soviet undiscovered recoverable oil resources at 244,900 million tons out of a world

---

[114] *The Oil and Gas Journal, April 16, 1975.*
[115] A.A. Meyerhoff, "Geopolitical Implications of Russian and Chinese Petroleum:, in: *Exploration and Economics of the Petroleum Industry*, New York, 1973, p. 79.
[116] Ibid., 79.
[117] A. A. Meyerhoff, "Soviet Arctic Oil & Gas, A Second Middle East", *Professional Engineer*, July 1975, p. 29.
[118] National Academy of Sciences, *Mineral Resources and the Environment*, Washington, D.C., February 1975, p. 110 and 112.

total of 840,710 million tons, and Soviet natural gas resources at 70,404 cubic kilometers out of a world total of 144,934 to 147,655 cubic kilometers.[119]

On the basis of these estimates of vast oil and gas resources, Meyerhoff estimates that the Soviet Union may be producing approximately 21 million b/d in 1985–90, and P.E. Kent and D.C. Ion are quoted by Meyerhoff as having estimated a Soviet oil production of 25 million b/d by 1990.[120] A recent study by the OECD maintains that Soviet oil exports to non-communist countries could increase to 1.5 to 2.0 million b/d in 1980–1985 if a proposed pipeline to Japan is in operation by mid-1976. Without it, exports mainly to Western Europe are likely to fall to 0.9 million b/d and remain at approximately this level through 1985.[121] Meyerhoff lists as major constraints on Soviet expansion of oil and gas production: (1) inadequate drilling equipment; (2) antiquated technology; (3) inefficiency in the bureaucratic system resulting in frequent incompentence; (4) shortages of capital equipment; and (5) much of the resources are in hostile environments.[122]

Another school of thought, we shall call it the pessimistic school, questions the size of the Soviet petroleum reserves and resources, and emphasizes the problems the Soviets face in developing their resources. Members of this school argue that in accordance with the State Secrecy Act of 1947, no official information on Soviet energy is made available outside the highest Government circles, and that hence all information on Soviet oil reserves in the West is speculative at best. One source states that the size of Soviet fuel reserves has been questioned even by the Soviets, on the grounds that their published data on proved reserves include a high percentage of "reserves" whose development is not economically justifiable in the foreseeable future.[123] Mrs. Marianne Slocum of the FEA maintains that non-commercial deposits were included in the official published data on proved reserves for a number of reasons, such as governmental incentives for the exploration and prospecting in the geologically less promising regions (located in energy-demand areas), and desire on the part of all concerned to fulfill the planned increment of proved fuel reserves (which was based on the so-called "gross value output"—i.e., the sum total of all new reserves irrespective of their commercial value).[124] The Soviet Union has rapidly developed its energy sources, but—according to the pessimistic school—the rate of growth of its output seems to have been consistently behind the rate of growth of the major energy-intensive industries.[124]

The two schools of thought do not necessarily exclude one another. It is very possible that the Soviet Union contains some of the largest undiscovered recoverable oil and natural gas resources in the world, possibly even larger than those of the Middle East. However, given constraints on capital and technology, and the severe environmental conditions in much of Siberia where these potential resources are

[119] The United States National Committee of World Energy Conference, *Survey of Energy Resources*, New York, 1974, pp. 102 and 104.
[120] A. A. Meyerhoff, "Geopolitical Implications of Russian and Chinese Petroleum", op. cit., p. 103.
[121] O.E.C.D., *Energy Prospects to 1985*, op. cit., p. 109.
[122] Ibid., pp. 113 and 114.
[123] Marianne Slocum, "Soviet Energy: An Internal Assessment", *Technology Review*, October/November 1974, p. 20.
[124] Ibid., p. 20.
[124] Ibid., p. 25.

probably located, most of these "resources" may not be turned into "reserves" for a long time to come. Assuming that the resources are indeed of vast proportions as described by Meyerhoff and others, technology and capital are likely to become available at some time in the future, depending on Soviet priorities and Western (including Japanese) cooperation in Siberian resources development. However, development of much of the Siberian resources may be many years away. The recent decision by Japan not to enter into a joint Siberian petroleum venture with the Soviet Union is one indication of the problems related to Soviet Asian oil development.

In the meantime, some sources argue, the Soviet Union seems to be experiencing serious regional energy shortages, in particular because energy output in the industrial belt of the European SSR and the Urals is falling short of demand, while resources in Asiatic Russia cannot be developed fast enough to meet demand elsewhere in the nation.

Moreover, the Soviet Union, which had been supplying Eastern Europe with 90 percent of that region's need at about $2.45 per barrel recently decided to raise the price to about $6.70 per barrel. The price increase will have a negative economic and political impact on the nations of Eastern Europe, and if "reserves" were as plentiful as suggested by the optimistic school on Soviet reserves, the price increase would be difficult to understand. The *Economist* of July 19, 1975, writes that Premier Kosygin had to promise Eastern Europe that oil shipments to their region would continue at a level that should satisfy at least two-thirds of Eastern Europe's oil needs.[125] It is also interesting to note that last year, despite the high prices at which oil was selling on the world market, the Soviet Union cut its exports to the West to 880,000 b/d from just over 1 million b/d in 1973.[126] Oil consumption in the region may be between 80 and 100 million tons per year, or between 1.6 and 2 million b/d. If the Soviet supply two-thirds and the region continues to produce about 0.3 million b/d, Eastern Europe would need to import between 200,000 and 400,000 b/d.

Some analysts of Soviet energy policy maintain that the U.S.S.R. may be importing about 29 million tons (about 580,000 b/d) per year by 1980, and one source puts Soviet imports from the Middle East by 1980 at 75 million tons per year, or about 1.5 million b/d.[127] The *Wall Street Journal* of August 14, 1975 quotes a recent CIA study indicating that the Soviet petroleum industry is faced with serious technical problems that may restrict or even stop production growth by the late 1970's. The paper also quotes a State Department official who said that "predictions that the Soviets may be net importers of oil by 1985 are not out of line".[128]

With the information available to date, it is difficult to endorse either the optimistic or the pessimistic version of Soviet oil and natural gas production between 1975 and 1980/85. If the optimists are correct, the Soviets will have ample oil and natural gas supplies for domestic use and for export to the Comecon nations, and a growing volume of petroleum would become available for export to other non-communist countries. If, however, the pessimistic school of thought on the

[125] *The Economist*, July 19, 1975, p. 61.
[126] *Wall Street Journal*, August 14, 1975.
[127] *Petroleum Economist*, March 1975, p. 89.
[128] *Wall Street Journal*, August 14, 1975.

Soviet energy situation proves to be correct, Soviet and Eastern European imports from the Middle East would further strengthen OPEC as the Soviets would be competing with the rest of the world for available supplies.

If the resource base is as vast as Meyerhoff and others have projected, it is likely that Siberian oil and gas will be developed at some point in the future. The Soviets can develop it alone but at a much slower pace than if Western technology and capital were available. The Soviet Union has long been interested in exchanging oil and gas (for future delivery) for technology and development capital. Some oil-for-equipment deals have reportedly been offered to Union Oil and Indiana Standard.[129] Many discussions are underway with Western oil companies, but no commitments have been made so far.

The People's Republic of China

At the Ninth World Petroleum Congress in Tokyo in May 1975, three American oil experts predicted that the lion's share of East Asia's untapped oil reserves will eventually be found in China.[130] They estimated China's *current reserves* at 19.44 billion barrels of oil, or 56.13 percent of Asia's oil reserves outside the Middle East. Undiscovered recoverable oil resources were estimated at 28.8 billion barrels.[131] Other geologists have estimated China's continental shelf potential at around 30 billion barrels, and the more optimistic National Council for United States-China Trade put the country's potential at between 43.8 and 73 billion barrels onshore, and 146 billion barrels offshore.[132] The First National City Bank of New York maintains that "China's oil reserves are large, possibly immense".[133] It is difficult to say whether or not China's potential will be of "Middle Eastern" dimensions as indicated by the estimates of the National Council for United States-China Trade, but most geologists would doubt the high figures until a great deal more information will become available.

Premier Chou En-Lai told a Japanese Trade Commission in early 1974 that Chinese production amounted to 1 million b/d.[134] The *Oil and Gas Journal* has estimated that Chinese production could rise from 1.2 million b/d in late 1974 to 1.54 million b/d in 1975, 2.4 million b/d in 1977, and possibly as much as 8 to 10 million b/d by the early 1980's.[135] Of the estimated 1.54 million b/d in 1975, about 10 percent of 150,000 b/d could be available for export, mainly to Japan, the Phillippines and a few other Asian countries. It is expected that with the growing Chinese production of oil, the nation is likely to rapidly increase consumption.

China will probably continue to expand oil exports to non-communist areas for at least two reasons: the need for hard currency to purchase Western technology, and the desire to prevent Japan from

---

[129] *The Oil and Gas Journal*, OGJ Newsletter, December 2, 1974.
[130] *Journal of Commerce*, May 16, 1975.
[131] Ibid.,
[132] *The Oil and Gas Journal*, January 6, 1975, p. 26.
[133] Ibid., p. 26.
[134] *New York Times*, May 12, 1975.
[135] The Oil and Gas Journal, January 6, 1975, p. 26. [In view of technological and capital constraints the figures for the early 1980's seem too optimistic.]

In a recent report for Congress, Bobby Williams quotes Japanese estimates of approximately 4.3 million b/d in 1980 and 9 million b/d by 1985.

Bobby A. Williams, "The Chinese Petroleum Industry: Growth and Prospect", in the U.S. Congress, Joint Economic Committee, China: A Reassessment of the Economy, Washington, D.C., July 10, 1975, p. 225.

making major investments in joint Soviet-Japanese energy ventures in Siberia. It seems that one of the major reasons behind the Japanese decision to hold off on a major Siberian oil project was related to the prospect of purchasing Chinese oil without the diplomatic and financial risks that might have been involved in the Siberian venture.[136] Exports to Japan could very well reach between 250,000 and 0.5 million b/d by 1980, but more optimistic estimates put exports to Japan at 0.5–1.0 million b/d by 1980. One source indicates that if China's domestic consumption of oil were to be cut down, the country could export more than 1 million b/d by 1980. Whether the People's Republic will export vast quantities of oil will depend on a number of factors, i.e.:

1. The overall foreign exchange situation;
2. Ability to produce sufficient capital goods to develop the oil fields and transportation facilities;
3. The political situation; domestic and foreign.

There is no sign that the People's Republic is interested in joint development of oil fields in cooperation with Japan or any other Western country.

Officials inside and outside the U.S. government do not expect any oil imports from China into the United States in the foreseeable future, but they do not rule out the possibility of some oil imports in the 1980's. However, Chinese exports to Japan and other Asian nations will take some pressure off world demand for OPEC oil.

Middle East and North Africa

The thirteen major oil producing nations of the Middle East and North Africa, with an estimated population of approximately 114 million (1972), hold about 443 billion barrels of oil and 933 TCF of natural gas. By contrast, the U.S., with a population of 208 million (1972) has proved reserves of oil about one-tenth, and natural gas reserves approximately 25 percent of the Middle Eastern and North African reserves.

In addition to proved reserves, the Middle East is likely to contain tens of billions of barrels of undiscovered recoverable oil and natural gas. Saudi Arabia's oil minister Yamani on several occasions told newsmen that Saudi Arabia's ultimate recoverable oil resources may be 100 billion barrels or more over and above its current proved and probable reserves (see section on Saudi Arabia). Iraqi oil resources may also be more than twice its current proved reserves. These and other middle Eastern nations are now in the process of evaluating their oil and natural gas potential, in order to be better prepared for future policy-making regarding production and conservation.

In the Persian Gulf area reserves of petroleum onshore are so large that there has not been great urgency to proceed with haste in developing the offshore. Development and production of offshore fields have so far proceeded rather systematically in response to market demands.[137]

Persian Gulf reserves are so large relative to all other areas, and the geology of the offshore producing fields there is so similar to the geology of the onland fields, that it must be classed as unique among the offshore producing areas. The likelihood of finding another Persian Gulf situation elsewhere in the offshore seems remote at this time,

[136] *New York Times*, May 12, 1975.
[137] Henry L. Berryhill, Jr., The Worldwide Search for Petroleum Offshore—A Status Report for the Quarter Century, 1947–72, U.S. Geological Survey Circular no. 694, Washington, 1974, p. 12.

although recent finds in the North Sea and North Slope have been spectacular.[138] The Middle East and North Africa produced an average of about 25 million b/d in 1974 (more than half of the free-world production), and although output is currently below the 1974 level due to the higher price of crude oil and to simultaneous recessions in the industrialized world, the area could produce as much as 50 million b/d by 1985.

TABLE 55.—MIDDLE EASTERN AND NORTH AFRICAN OIL AND NATURAL GAS

	Reserves of oil (X'000 barrels)	January 1, 1975 gas (trillion cubic feet per year)	Producing wells	Oil production estimate 1974 (thousands of barrels per day)
Middle East:				
Abu Dhabi	30,000,000	200,000	160	1,750.0
Bahrain	336,000	6,600	211	68.0
Dubai	2,420,000	1,500	45	232.0
Iran	66,000,000	330,000	369	6,128.0
Iraq	35,000,000	27,500	156	1,829.3
Israel	2,200	20	25	100.8
Jordan				
Kuwait	72,800,000	32,000	692	2,600.0
Lebanon				
Neutral zone	17,300,000	7,500	449	485.4
Oman	6,000,000	2,100	61	297.09
Qatar	6,000,000	8,000	81	546.0
Saudi Arabia	164,500,000	55,000	670	8,400.0
Sharjah	1,500,000	1,500	3	50.0
South Yemen (Aden)				
Syria	1,500,000	700	123	119.0
Turkey	500,000	250	313	65.3
Total Middle East	403,858,200	672,670	3,358	22,670.8
North Africa:				
Algeria	7,700,000	229,000	826	888.8
Egypt	3,700,000	3,500	437	118.3
Libya	26,600,000	26,500	979	1,700.0
Morocco	450	24	22	.9
Tunisia	1,100,000	1,500	55	85.0
Total Middle East and North Africa	442,958,450	933,194	5,677	25,463.8

Source: "The Oil and Gas Journal," Dec. 30, 1974, pp. 108, 109.

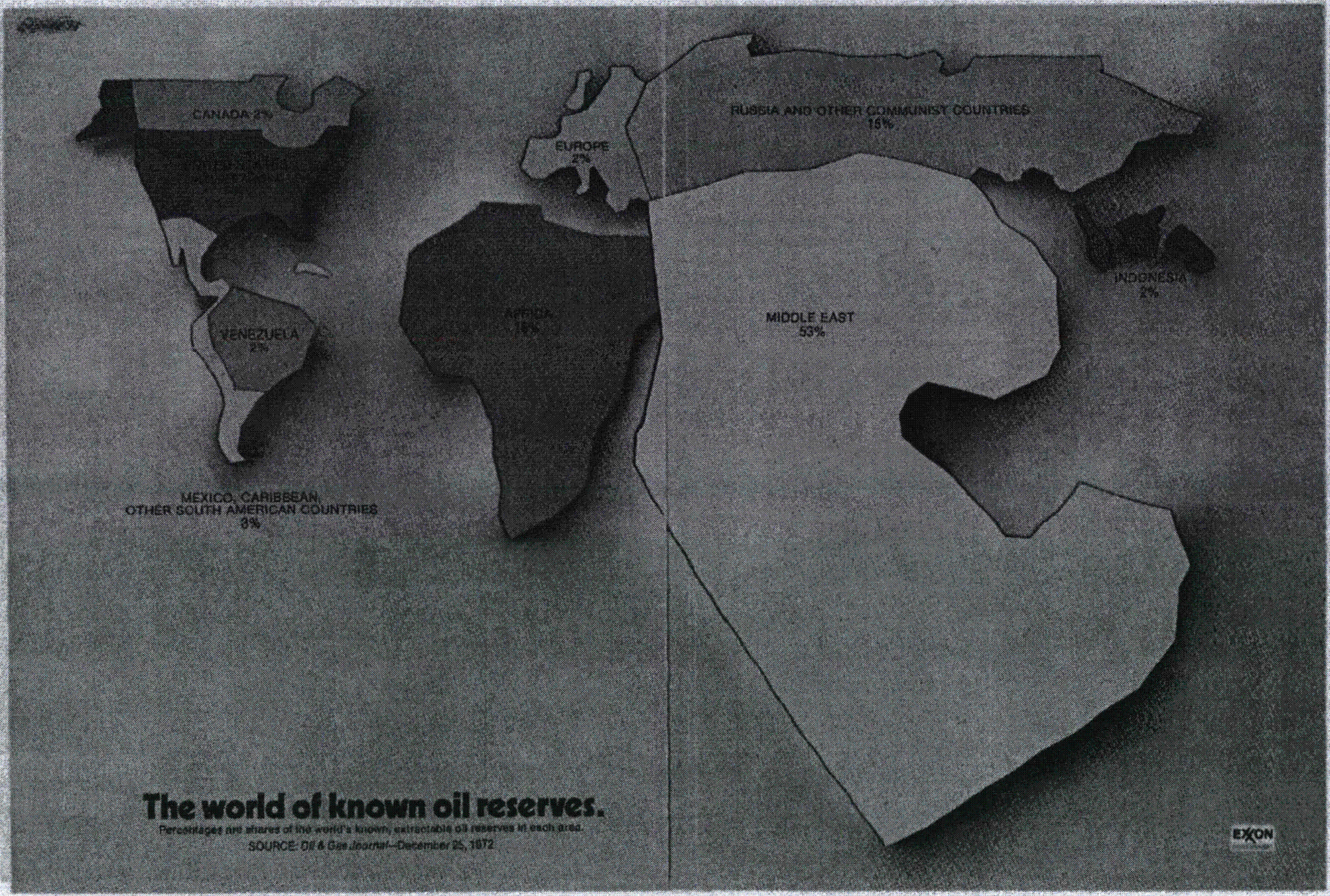
Of great significance for the industrialized world is the fact that in view of their small populations and limited domestic demand for oil, the nations of the Middle East consumed only about 2 percent of total world production, while producing approximately 37 percent, and controlling about 70 percent of the world export market of oil.

The importance of the Middle East and North Africa as a major supplier of energy to the industrial world can best be understood by comparing figures 13, 14, and 15, which depict world oil production, consumption and trade by region. Figure 13 shows how the world would look if measured on the basis of proved oil reserves, and figure 14 provides a clear picture of the world of the consuming nations. On the production map, the Middle East and North Africa are vast by comparison with the oil consuming nations of the west. In figure 14, on the other hand, the Middle East and North Africa are dwarfed by the United States, Western Europe and East Asia, the major oil consuming regions of the world. Finally, figure 15 projects a clear view of the world of consuming and producing nations, and of the significant movement of oil from the Middle East and North Africa to the industrial world.

[Figures 13, 14, and 15 follow:]

[138] Henry L. Berryhill, Jr., op. cit., p. 25.

Figure 13


CANADA 2%
EUROPE
2%
RUSSIA AND OTHER COMMUNIST COUNTRIES
15%
VENEZUELA
2%
MIDDLE EAST
53%
INDONESIA
2%
MEXICO, CARIBBEAN,
OTHER SOUTH AMERICAN COUNTRIES
3%
The world of known oil reserves.
Percentages are shares of the world's known, extractable oil reserves in each area.
SOURCE: Oil & Gas Journal—December 25, 1972
EXXON

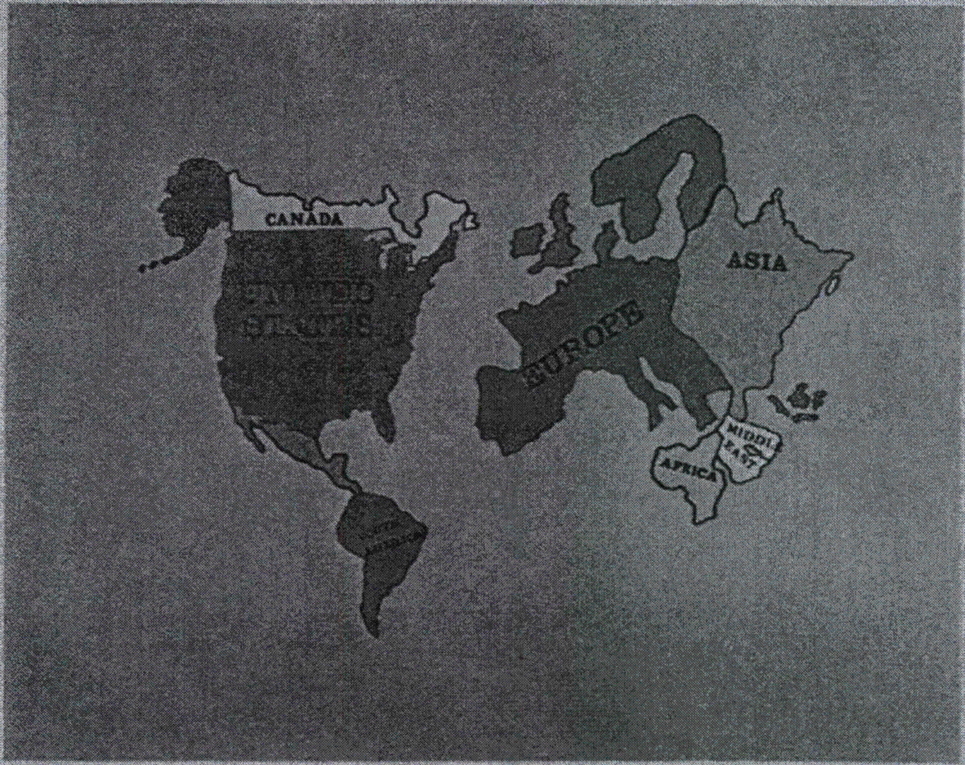


FIGURE 14


WORLD
OIL RESERVES
100%
75
50
25
Middle East
Total Reserves:
Source:
Oil & Gas Journal, year end 1974
Consumption
Production
Movements (by volume)
world oil consumption
and production
Day in and day out, tankers
crisscross the oceans, maintaining
a steady flow of oil from producing
regions to consuming areas.
This international traffic reflects the
circumstance that, in many cases,
the demand for oil is far from the
principal sources of supply. Major oil
consuming countries in Western
Europe as well as Japan, for instance
import from 70 to 95 percent of their
oil requirements from Africa and the
Middle East. These two producing
regions together account for more
than three-fifths of all crude oil
production and contain more than
three-fourths of the proven petroleum
reserves in the non-Communist world.
The United States currently imports
more than a third of its petroleum
requirements from the Middle East,
Africa, Canada and Latin America.
This dependence on imports
will continue until the country can
increase domestic oil and gas
production, chiefly from untapped
reserves offshore and in Alaska, and
develop alternative sources of energy.

FIGURE 15

The Middle East did not become a major source of oil supply until the early 1950's when the industrial countries of Western Europe and Japan gradually began to translate cheap oil into economic growth.[139] As a result, Europe and Japan have become increasingly dependent on Middle Eastern Oil, and the availability of cheap Middle Eastern oil until the early 1970's had an adverse impact on the development of alternative sources of energy.[140]

Middle Eastern oil production has grown 15 percent per year in the period from 1970 to 1973, or twice the rate of total oil demand, and the area supplied over half of the world's energy growth. By contrast, oil production outside the region contributed only 8 percent to world energy growth in the same time span. In the meantime, production in the United States, Canada, and Venezuela has peaked in the early 1970's, and little contribution to growth can be expected from these areas before production from major new reserves becomes available in the late 1970's (North Slope). North Sea production is also not likely to make a major contribution to oil needs in Europe until the end of the decade. Hence, the industrial world will continue to grow more dependent on the Middle East for at least several more years to come.

The availability of low-cost Middle Eastern oil has been a blessing for the industrial world, and in particular for Western Europe and Japan, which achieved rapid economic growth during the past two decades in part because of the switch from high cost domestic sources of energy to cheap Middle Eastern oil.

The availability of cheap Middle Eastern oil, however, has also increased the vulnerability of the industrial world. Large proved reserves of low-cost oil in the Middle East has limited the search for oil in other parts of the world. However, uncertainty of future supply, coupled with the quadrupling of the price of oil has led to feverish exploratory activities around the world. Results have been favorable. In 1974, industry discoveries totalled between 14 and 17 billion barrels of which 10 to 12 billion was found outside the Middle East. However, many petroleum experts will agree with the executive of a major US oil company who wrote:

> This level will be hard to sustain. Prospects of finding another region of giant size like the Middle East are virtually zero. This is based on careful judgment as to the degree to which principal sedimentary basins have been explored. Added together with other factors such as access to exploration acreage, negative attitudes on exploration by many governments, the geographic dispersion of targets and the trend of discoveries, it is questionable whether the trend discovery rate can be achieved.[141]

For the foreseeable future, the days of cheap energy are over, and the combination of high oil prices and limited alternative sources of supply are likely to result in increasing Western vulnerability to Arab oil production.

Middle Eastern countries' revenues increased rapidly from 1961 to 1970 due to the rising volume of oil exports at a constant per barrel revenue. Several Middle Eastern countires such as Saudi Arabia and

---

[139] Ronald Lewison, *A Basic Report on the World Crude Oil Outlook*, New York, March 25, 1974, p. 1.

[140] In some areas in the Middle East production costs are as low as 5 cents per barrel, whereas even the cheapest North Sea oil will cost about $3.00 a barrel to produce.

[141] Letter by an executive of a major oil company to the author, dated; May 9, 1975. See also Ronald Lewison, op. cit., pp. 12 and 25.

Kuwait soon reached comfortable surpluses of foreign exchange which resulted in a stronger bargaining position. A stable flow of oil revenue was no longer as critical to economic growth in the short run.

Countries with a small population and limited capital absorptive capacity, such as Saudi Arabia, Kuwait, Libya, the United Arab Emirates and Qatar know that surplus monetary reserves can see them through any production disruption (even though the UAE is suffering from a temporary shortfall of foreign exchange mainly due to a very generous foreign aid program). Iran, Iraq and Algeria, however, have a much larger capital absorptive capability. Algeria has probably already reached its peak production, and Iran's output will probably peak at about 8 million b/d (up from about 6 million b/d in 1974) by the late 1970's. Iraq's oil reserves will permit that nation to more than double production to about 4 million b/d by 1982.

In general, there is a distinct tendency in recent statements by Middle Eastern oil ministers to stress the need to tie oil production to domestic needs, including substantial foreign aid commitments. Few, if any, have recently expressed a desire to make major long-term investment in the industrial world, and in most Middle Eastern nations those elements calling for conservation of oil and stretching available resources are gaining ground.

Hence, the world will make efforts to reduce its dependence on Middle Eastern oil exports and these exports are not likely to grow as rapidly as in the past and almost certainly not to the physical limits possible on the basis of proved and probable reserves (see figure 16).

[Figure 16 follows:]

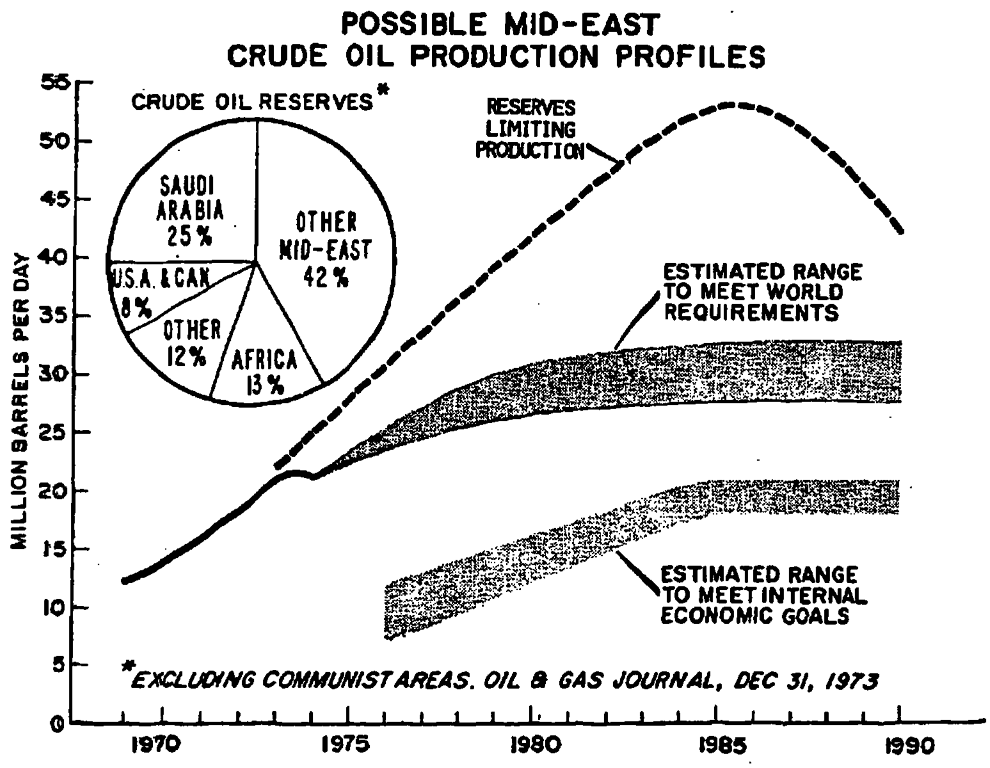


Figure 16

It was indeed before that expansion of production from OPEC countries outside the Middle East is not likely to grow substantially, due to physical supply limitation, and that with the exception of some new potential major sources like Mexico, the likelihood of the availability of other major sources of supply to the industrial nations prior to the early 1980's is not considered very high.

It was also noted that while Western Europe and Japan may not become more dependent on the Middle East (in terms of *volume* of oil imports) by 1980 than they are now, United States dependence on the region is likely to grow rapidly. Between 1980 and 1985, we projected that even under very favorable supply conditions, all three major industrial areas—the U.S., Western Europe, and Japan, are likely to be importing more oil from the Middle East in 1985 than in 1980. Moreover, several sources now show that there is a growing possibility that the Soviet bloc may become a net importer of oil, and that supplies will have to come primarily from the Middle East.

Under these supply and demand assumptions, the United States may have to compete with its allies and possibly even the Soviet Bloc for available Middle Eastern supplies.

A small number of Middle Eastern countries, and in particular Saudi Arabia which holds 21 percent of the world's oil reserves, are in the position of stabilizing worldwide supply and demand. While it may not necessarily be of economic and social benefit to these producing nations, it is difficult to disagree with one observer who wrote that should Saudi Arabia shun its critical role as stabilizer of worldwide supply and replace it with a rigid production rate, the aftermath would be chaotic market conditions and in the event of a significant shortage over time, reduce the level of world economic activity.[142]

TABLE 56.—*Estimated exports of crude oil and refined products of major middle eastern and North African nations in 1974*

	Thousands of b/d
Saudi Arabia:	
Exports to:	
United States	740
Japan	1, 380
Western Europe	4, 410
Other (including domestic consumption)	1, 680
Total	8, 210
Iran:	
Exports to:	
United States	710
Japan	1, 240
Western Europe	2, 180
Other (including domestic consumption)	1, 930
Total	6, 060
Kuwait:	
Exports to:	
United States	20
Japan	590
Western Europe	1, 090
Other	575
Total	2, 275

[142] Ronald Lewison, *op. cit.*, p. 12.

TABLE 56.—*Estimated exports of crude oil and refined products of major middle eastern and North African nations in 1974*—Continued

Iraq:	
Exports to:	
United States	10
Japan	50
Western Europe	880
Other	995
Total	1, 935
UAE:	
Exports to:	
United States	90
Japan	540
Western Europe	720
Other	65
Total	1, 415
Libya:	
Exports to:	
United States	150
Japan	70
Western Europe	1, 260
Other	45
Total	1, 525
Algeria:	
Exports to:	
United States	200
Japan	10
Western Europe	540
Other	290
Total	1, 040

MAJOR OIL PRODUCING COUNTRIES OF THE MIDDLE EAST AND NORTH AFRICA

IRAN

No generally agreed figure for Iranian reserves is available. Until NIOC has formed a more precise idea of the probable effects of secondary recovery projects, a reasonable working range for Iran's reserves is about 60–70 billion barrels, or about twice the United States reserves.

Taking into consideration natural gas reserves of the Khurestan fields, and new fields at Khangiran (Sarakhs) and Qeshm and recent discoveries both onshore and offshore, the United States Embassy in Teheran feels a *conservative* working figure for Iranian gas reserves to be 400 TCF. It must be emphasized, however, that while certain new discoveries are extraordinarily promising, more drilling is necessary to confirm their magnitude.

Iran, a nation with more than 30 million people in 1972 is engaged in an ambitious development and military build-up program. In order to meet its economic and military objectives, Iran is likely to continue to increase oil production from an average of 6.2 million b/d in 1974 to a maximum of about 8 million b/d by the early 1980's. We estimate that the U.S. share of Iranian oil imports could increase from about 0.5 million b/d in 1974 to a maximum of 1.0 million b/d in the early

80's, when both Iranian domestic production and exports to the U.S. are projected to level off.

In view of its vast reserves of natural gas, at 400 TCF by far the biggest in the Middle East/North Africa region, Iran is likely to increase its exports of natural gas to the industrialized world as well.

Exports of natural gas in 1974 were only 0.3 TCF (to the U.S.S.R. via the Iran Gas Trunkline). Total capacity of the pipeline (when completed) is said to be about 0.6 TCF per year. Another pipeline of similar capacity is planned to export natural gas through the U.S.S.R. to Western Germany. Another possible natural gas pipeline through Turkey and the Balkans to Western Europe is being discussed and several LNG projects are also being considered.

With total natural gas reserves of similar size (in terms of Btu's) as oil reserved, Iran's export potential continues to be very promising in all respects.

IRAQ

Iraq is a nation of 9.7 million inhabitants in 1971 with a capability to absorb significantly capital for its ambitious development programs. Official Iraqi petroleum reserves are estimated at 35 billion barrels and 27 TCF of natural gas. Probable reserves may be more than double this figure as in February 1975 the discovery of a huge oilfield west of Baghdad was reported. [143] This discovery, if confirmed, could raise the nation's proved reserves to about 75 billion barrels, making it the second richest Middle East country in oil reserves after Saudi Arabia.

Production rose from 731,300 b/d in 1958 to 2,018,000 b/d in 1973 and declined to 1.8 million b/d in 1974. Since 1972 when the Iraq Petroleum Company was nationalized, the major objective of the government has been to increase production continuously, partly to compensate for low growth rates in the past and partly to provide the revenues for an accelerated development process.

An earlier 1974 plan to increase production by 1980 to 5.6 or 6 million b/day was superseded by a much smaller planned volume of about 4 million b/d by 1980/81. Explaining the change of plan, a government spokesman said that the original decision to aim for a capacity of 325 million tons/yr. (6.5 million b/d) by 1980 was taken in 1972 when the price of crude oil was only $2.50 a barrel, and when the oil industry in Iraq had been stagnating for more than a decade prior to nationalization owing to the lack of investment by the oil companies. The situation changed with the price increases (1972–74), and consequently the production/revenue scheme had to be revised. A reassessment of the situation led to the new target figure of 4 million b/d by 1980. The government, however, will continually keep production plans under review in the light of market demand, financial needs and oil reserves position. It cannot be excluded that Iraq will produce more at the end of the decade and beyond. The nation's resources may be capable of supporting five to eight million b/d.

The volume that will actually be produced will depend on Iraq's own domestic and exports requirements plus an announced 30 million tons (0.6 million b/d) for increased assistance to Arab countries and some of the developing nations.[144]

[143] *The Washington Post*, February 9, 1975.
[144] "*Oil Exporation and Production in Iraq*", Arab Oil and Gas, July 16, 1975, p. 33.

Earlier higher production estimates of 6 million b/d by the end of the decade have been revised primarily because increased price of oil has deeply modified the financing prospects of development projects and the interest attached by the Iraqi leaders to the conservation of reserves.[145]

According to a well-informed source, Iraqi oil production has been and is likely to continue to be closely related to the national development plan. The Arab Oil and Gas Journal of July 16 of this year writes:

> While proposing to develop production as rapidly as possible, Iraq's present oil policy is closely tied to its agricultural and industrial development projects. Considering that the country's oil reserves, as large as they may be, are due to run out in a relatively near future, the Iraqi leaders are attaching particular importance to the development of other sectors likely to replace oil as a source of national income. With this policy, oil is no longer considered to be a source of foreign exchange only but also and mainly a means for obtaining the financial and technical assistance necessary for the development of the Iraqi economy. In this respect, Iraq is one of the very few Arab oil producing countries to have displayed the greatest efforts in the last few years to utilize its oil revenues for the financing of its economic development projects.[146]

Iraq has never been a major supplier of crude oil to the United States. However, it is very possible that this situation could change in the future for a number of reasons:

1. Iraq has one of the largest oil reserves in the world and is likely to double oil production by the end of the decade.
2. Iraq has an ambitious agricultural and industrial development program. There are some indications that the nation is rather dissatisfied with Soviet technical assistance and products. A shift in the direction of growing Western involvement in the development of Iraq would provide a major opportunity for the United States—the world's major agricultural exporter—to provide technical assistance and machinery necessary to meet Iraqi objectives.
3. Iraq has a significant foreign aid program, totalling about $800 million in 1974. Like so many Arab states, Iraq provides a much higher percentage of its GNP for foreign assistance than most industrial countries. Whether such a mutually beneficial exchange will be realized is to a large extent dependent on the outcome of current Arab-Israeli negotiations. If successive stages of agreement are reached, chances for growing U.S.-Iraqi trade might be termed excellent.

Kuwait

Kuwait is a small nation with a population of less than a million. Its proved reserves of petroleum—including its share of the Neutral Zone—has been estimated at 72.8 billion barrels of oil and 32 TCF of natural gas.

Oil production reached an average of 2.8 million b/d in 1974 and dropped to 1.9 million b/d during the past five months of this year. Maximum production capacity has been estimated at a conservative 3.3 to 3.5 million b/d. In view of the nation's current oil policy, it seems unlikely that that much oil will in fact be produced in the foreseeable future.

---

[145] Ibid., p. 33.
[146] Ibid., p. 20.

In a statement before the Kuwait National Assembly on July 12 of this year, Kuwaiti Minister of Oil, Mr. Al-Kazimi, outlined his nation's oil policy objectives. He mentioned that Kuwaiti oil output will be guided by the following goals: [147]

The conservation of oil resources by the use of the most up-to-date technical methods in producing the oilfields and by fixing the best production level consistent with the fields' special characteristics on the one hand and appropriate to the economic conditions and considerations affecting this level on the other. As Kuwait is determined to use natural gas associated with oil to meet the needs of the country's domestic energy requirements, the level of oil production will in part be related to domestic natural gas needs.

Kuwait, like Iraq, has also decided to let domestic economic and social development plans, as well as participation in financing development investments in Arab countries and friendly developing nations, play a major role in determining the rate of oil production. The Kuwaiti government has not decided on a specific annual production volume, but instead opted for a strategy of flexibility with regard to oil production levels based on the above-mentioned considerations.

Some Western sources have calculated that a maximum production level of 2.5 million b/d could meet Kuwait's domestic requirements and projected foreign assistance programs. There is some pressure in the Kuwaiti parliament to reduce total Kuwaiti oil production to 1.5 million b/d, which would be sufficient for national development and aid, and still leave a small surplus. [148]

Another aspect of Kuwaiti oil policy clarified in the July 12, 1975 statement of Mr. Al-Kazimi is related to Kuwait's plans to gradually turn away from exporting crude oil to refined products, LNG and numerous products of the petrochemical industry.[149] In view of the high value-added, industrial nations may prefer to turn to alternative sources of crude oil supply, if those will be available in sufficient quantity.

Kuwait is currently not a major source of U.S. oil imports, and if the former does not expand production significantly, the United States will have to compete for available supplies with Kuwait's traditional clients in Europe, Japan and elsewhere.

United Arab Emirates

The UAE is a confederation of the following sheikhdoms: Abu Dhabi, Ajman, Dubai, Fujairah, Ras Al Khaimah, Sharjah, and Umm Al Qaiwain. The seven city-states had a combined population of 197,000 in 1971 and controlled 32,000 square miles. Only Abu Dhabi, Dubai and Sharjah are known to have major petroleum reserves which are estimated at about 33.9 billion barrels of oil and over 200 TCF of natural gas. Current maximum production capacity has been estimated at 3.7 million b/d, but only about 1.9 million b/d were produced in 1974, and between January and May of this year production has averaged approximately 1.7 million b/d. The members of the confederation continue to be autonomous in many

[147] *Middle East Economic Survey*, July 18, 1975.
[148] *Petroleum Intelligence Weekly*, June 6, 1974, p. 3.
[149] Ibid., p. iii.

important respects such as the use of oil revenue and control over defense and internal security.

Domestic economic development, military requirements, and very generous foreign aid commitments to Arab and non-Arab Islamic States (which ran at 25 percent of UAW income) at a time when output has been forced down in view of lower demand have resulted in a shortage of foreign exchange. The UAE has asked the oil companies to increase production from the current low average of about 1.7 million b/d.

While some Western sources have put maximum production capacity at between 4 and 6.9 million b/d, it is questionable whether the UAE with its very small population would be willing to ever produce that much oil. In view of expected economic and social development, and continuation of a generous foreign assistance program, it seems likely that the UAE will eventually follow a flexible production policy primarily geared to meet domestic development needs. Under those circumstances, and assuming no significant downward shift in the price of oil, it would not be unreasonable to expect production to peak at between 2.5 and 3.0 million b/d.

UAE exports of oil to the U.S. have gradually grown from 5,000 b/d in 1967 to 87,000 b/d in 1974. If production continues to expand significantly, exports to the United States are likely to increase considerably.

Relations between the UAE and the United States are basically good, and the U.S. can supply advanced technology for the development of the UAE. It should be kept in mind, however, that much will depend on the future of Arab-Israeli relations. Abu Dhabi was the first nation to announce an oil embargo following a Congressional vote to supply $2.2 billion for Israel during the October 1973 war. The UAE are generally friendly towards the industrial world, but outbreak of further hostilities will certainly have a major effect on relations with the Western world.

Qatar

Qatar had a total population of about 100,000 in 1969. Its petroleum reserves are estimated at 6 billion barrels of oil and 8 TCF of natural gas. Qatar produces about 0.3 million b/d and could increase output to 0.5 million b/d. The United States imported about 18,000 b/d from this country in 1974.

In April 1975, the ruler of Qatar decided to reduce oil production, because oil revenues were in excess of the nation's financial needs, arguing that:

> the conservation of oil in the grounds yields a higher return than producing it, since its value is increasing several-fold above what may be realized from the investment of the oil revenue.[150]

Qatar is not likely to produce more than 0.5 million b/d, nor export much more than 25,000 b/d to the United States.

[150] *Petroleum Intelligence Weekly*, April 4, 1975, p. 6.

Algeria

Algeria had almost 15 million inhabitants in 1971. The country's oil reserves, estimated at 7.7 billion barrels, are not very large in Middle Eastern terms, but natural gas reserves, estimated at 229 TCF are among the world's largest. Unfortunately there are major delays in the construction of LNG facilities in Algeria and in the consuming nations likely to import Algerian gas. Hence, for some years to come, oil shipments will remain the only large area of energy exports.

Algeria has steadily increased shipments of oil to the United States, from 5,000 b/d in 1967 to 227,000 b/d in 1974. However, in view of its limited resources and technical production problems in several Algerian oil fields, oil output and exports to the United States are not likely to rise much. It seems reasonable at this time to assume that exports to the U.S. will stabilize somewhere in the vicinity of current shipments, but total energy exports to the United States may rise by the late 1970's, early 1980's, when Algerian natural gas will be shipped in special LNG tankers to the United States. Contracts with the U.S. call for initial shipment of 0.3 TCF per year.

Libya

The Libyan Arab Republic has a population of slightly more than two million in 1971. Petroleum reserves are estimated at 26.6 billion barrels of oil and 26.5 TCF of natural gas. Oil production averaged 1.5 million b/d in 1974 and 2.2 million b/d the year before. Currently production is running at an even lower level than in 1974, at 1.2 million b/d. Maximum production capacity on the basis of existing reserves has been estimated at 2.3 to 2.5 million b/d.

Libya favors a policy of oil conservation and according to oil minister Izz Al-Din-Al Nabruk, the ideal annual production figure for Libya would be around 1.7 million b/d.[151] Exports to the United States grew from 42,000 b/d in 1967 to 164,000 b/d in 1973. Because of the Arab oil embargo in 1973–74, exports to the U.S. dropped to a total of 478,942 in 1974. However, sales to the U.S. have resumed at the pre-war level, but in view of Libya's traditional clients—primarily Western Europe and Japan—and projected maximum output of only a few hundred thousand b/d beyond the 1973 production of 2.2 million b/d, it seems unlikely that exports to the U.S. will surpass a level of 200,000 to 250,000 b/d over the next five to ten years.

Saudi Arabia

Saudi Arabia, a nation with a population of 7.9 million in 1971 holds approximately 25 percent of the free world's oil reserves, or 172 billion barrels. The vast regions in the central, northern and western parts, which have not yet been explored could harbor major oil fields. A major exploration program is being planned for the new 5 year plan. Oil Minister Yamani believes that in addition to this country's vast reserves, another 100 billion barrels are likely to be found onshore and offshore Saudi Arabia.[152]

---

[151] *Middle East Economic Survey*, June 13, 1975, p. 5.
[152] *Middle East Economic Survey*, July 11, 1975, p. 5.

Saudi Arabia produced 8.3 million b/d in 1974, but reduced demand for oil in 1975 has lowered production to an average of 6.7 million b/d for the first five months of this year. Current optimum capacity has been estimated at between 9.8 and 11.2 million b/d, but some sources indicate that on the basis of its reserves, Saudi Arabia could physically produce more than 20 million b/d by 1985.

How much Saudi Arabia will actually produce in the next few years is very difficult to predict, but it is not likely to be anywhere near the country's ultimate physical capacity. The production ceiling (as an annual average) for Aramco since the termination of the Arab oil measures in March 1974 has been 8.5 million b/d, a figure which is higher than the average daily production in 1974. Within this framework Saudi policy is one of non-intervention and leaving production to find its own level in the light of prevailing market forces.[153]

Saudi Arabia is in the position to cut production significantly even below the current five month's average to—according to some sources—as little as 3-4 million b/d. Below that level domestic economic needs are likely to suffer. Hence, Saudi Arabia is the one country that could significantly reduce output in order to force prices upward, but the country has always implacably resisted all efforts by its OPEC partners to persuade it to join a program of coordinated output cutbacks for price maintenance purposes.[154]

In the spring of this year, Saudi Arabia launched a five-year, $142 billion development plan. The Saudi Arabia minister of State for Planning, Mr. Hisham Nazer revealed that the plan was based on oil production levels for 1975–76 of 5 million b/d, rising at the end of the plan 1979-80 to 7 million b/d.[155] It is likely that implementation of the plan would turn Saudi Arabia into a welfare state, along the lines of its neighbor Kuwait. Mr. Nazer has said that among the basic objectives of development under the plan would be the preservation of Muslim spiritual values and the Muslim ethic. "Family welfare, free education for all, and free medical care are all consistent with the teachings and precepts of Islam, according to the Minister.[156]

It is not at all certain at this point whether the plan will be implemented on the proposed scale. It has been reported that the vast size of the five-year plan was programmed in an attempt to utilize the huge oil revenues from pressures on Saudi Arabia to keep its oil production up to meet world demand, rather than the other way around. But, quite a few high Saudi officials are said to contend that their country should not produce more than 3 to 4 million barrels daily. This they feel would amply cover fiscal needs and avoid unnecessary depletion of oil reserves. They point out that if the country's oil reserves were stretched to last 100 years instead of say, 40, they would not be faced with the urgent need to create offsetting industries.[157]

On the other hand, Sheikh Yamani, Saudi Arabia's Oil Minister, has said that one of his country's policies is "to link the long-term sale of crude oil to industrializing Saudi Arabia.[158] And, Dr. Farouk

---

[153] *Middle East Economic Survey*, March 28, 1975, p. 2.
[154] Ibid., p. 2.
[155] *Middle Eastern Economic Review*, June 6, 1975.
[156] *Middle East Economic Survey*, July 18, 1975.
[157] *Petroleum Intelligence Weekly*, June 10, 1975, p. 1.
[158] *Petroleum Intelligence Weekly*, April 1975, p. 1.

Akhdar, the Chief of the Saudi Arabian Central Planning Organization has stated that from an economic point of view, his country would not cut production, but ". . . we'll go up to 12 million b/d production capacity and let demand decide production." [159]

United States direct imports of crude oil from Saudi Arabia had grown from 86,000 b/d in 1967 to 488,000 b/d in 1973. As a result of the Arab oil embargo and the subsequent quadrupling of the price of crude oil, average daily imports decreased in 1974 to 433,000 b/d.

With demand for foreign oil expected to increase significantly throughout the next ten years, the United States will become increasingly dependent upon the Middle East in general, and on Saudi Arabia in particular. Whether the country will be able to purchase a major portion of its additional requirements from Saudi Arabia will depend on the volume of oil Saudi Arabia is willing to produce.

While at some point prior to the 1973 Arab-Israeli war, Saudi Arabia had informally expressed an interest in major downstream investments in the United States in exchange for guaranteed crude oil supplies at a negotiated price (a plan rejected by the United States), Saudi Arabia is no longer interested in downstream activities abroad "such as refining in the U.S., nor, indeed, in real estate, company takeovers, bonds or other long-term investments that would limit its liquidity for development plans at home." [160]

If this policy persists, Saudi Arabian oil production in the future is likely to be linked primarily to economic and military development and foreign assistance programs. U.S. need for Saudi oil—even a few years prior to 1980—will be such that this oil producing nation may be asked to produce beyond its 1974 maximum output of 8.5 million b/d. Whether or not Saudi Arabia will be willing to supply the additional quantity of oil required to meet the U.S. energy deficit is not known, but if Saudi Arabia fails to continue its role of the prime "swing factor" in international oil trade, world-wide economic growth is likely to be adversely affected.

Conclusion

Prior energy outlooks have generally assumed that the massive oil reserves in the Middle East would be produced over the next decade and beyond at whatever rate is needed to balance world energy and oil demand. Our analysis of the major oil producing countries of the Middle East would tend to dispute this. We believe that in addition to considering the needs of the oil consuming nations of the world, one must also fully consider the socio-economic and political interest of the oil producing nations of the Middle East and North Africa.

Based on their reserves the nations of the Middle East and North Africa could perhaps produce as much as 50 million b/d in 1985 (or about twice as much as in 1974), but if they were to do so, production would peak in the middle 80's and decline thereafter due to resource limitations. In view of the current government policies in the countries analyzed, most Middle Eastern and North African oil producing nations see their interest better served by limiting production and extending the life of their reserves beyond this profile. Moreover, at

---

[159] *Petroleum Intelligence Weekly*, April 21, 1975, p. 8.
[160] *Petroleum Intelligence Weekly*, April 21, 1975, p. 8.

current prices, most of the governments of these nations can meet their internal goals at a much lower level of production than was estimated in studies undertaken prior to the 1973/74 quadrupling of the price of oil.

The Arab oil embargo and the subsequent increase of the price of oil rudely awakened the oil consuming nations. Major efforts are underway to curb demand by implementation of conservation efforts, and feverish oil exploration activities around the world are likely to result in significant discoveries outside the Middle East. The North Sea discoveries of recent years are but one example. But, even finds as vast as those of the North Sea and the Alaskan North Slope are not likely to diminish or even stabilize dependence of the free world on oil imports from the Middle East and North Africa over the next ten years.

The United States will join the ranks of the other major oil importing industrial countries and by 1977 the United States may be importing about one-half or more of our total oil and natural gas imports from the Middle East.

In view of the many uncertainties surrounding worldwide demand and supply of oil, it does not seem possible at this time to forecast whether sufficient oil will be available to meet projected demand. We can say with a fair degree of certainty that the Middle East in general, and a few nations with a low population and limited capital absorptive capacity, will continue to be called upon to balance supply with demand. The ultimate decision to bridge the potential gap between world demand and supply of oil will rest with them in the near term. In the longer term, reserves will be limiting on a worldwide basis, possibly as early as some time during the 1990's.

The consequences of growing U.S. dependence on imported oil will be discussed briefly in the concluding chapter.

Chapter IX

TOWARD PROJECT INTERDEPENDENCE

Energy in the Coming Decade

Analysis of energy supply and demand in the United States for the period 1975–1985, indicates that the country is moving rapidly toward greater dependence on foreign oil, and in particular oil from the Middle East and North Africa.

The oil industry estimates a continuation of the post 1970 trend of lower U.S. domestic oil output (decontrol would slow down this trend) until at least the fall of 1977 when the Alaskan pipeline is projected to be completed. Domestic oil production will then gradually rise again until it reaches a final peak sometime during the late 1980's or early 1990's.[161]

Natural gas output is also expected to continue to decline after peaking in 1973. It would take sustained annual additions to reserves of 22.5 trillion cubic feet TCF per year between 1975 and 1985—unprecedented in the history of natural gas exploration in America—to maintain the 1973 production level and still maintain a reserve/production ratio of about 10 to 1. Instead, the Federal Power Commission believes that additions to reserves are more likely to follow the experience of the past 6 to 15 years, and consequently production is likely to continue to drop for the forseeable future. This study projects growing dependence on foreign oil during the decade from 1975–1985, but assuming a commitment to increase domestic fossil fuel production (from conventional and nonconventional sources) and no significant cancellations of nuclear powerplants, foreign imports of oil may peak in the early 1980's.

While coal and nuclear energy are expected to make a significant contribution to the energy mix of 1985 (both are projected to rise from an oil equivalent of 6.8 million b/d in 1973 to a total of 15.0 million b/d in 1985), both sources of energy are no longer expected to contribute as greatly to the 1985 energy mix as projected earlier by government agencies such as the FEA (on coal and nuclear, see Blueprint) and the Department of the Interior (1972 Study on nuclear energy).

Other important sources of energy such as hydropower, geothermal energy, shale oil, syncrude and syngas are expected to make some contribution to the total energy package of 1985 but, with the exception of hydropower, the contribution of any one of these sources is likely to remain small until sometime after the mid 1980's.

Hence, conventional oil and natural gas from domestic and foreign sources will continue to be the dominant sources of energy in the United States, and will provide two-thirds or more of the nation's energy requirements by 1985.

What those requirements will be in 1977, 1980 and 1985, the years for which calculations were made in this study, is very difficult, if not

[161] Decontrol of the price of oil domestic crude may add as much as 0.5 million b/d to domestic supply within a few years after the fact.

impossible to forecast accurately. It is known that there is a proven historical connection between economic growth and energy demand, but it is not known whether current high prices of energy will at some point be able to decouple energy growth from economic growth rates. This study assumed some continuation of the past trends, but the most likely forecasts of total U.S. energy demand—projected to grow at between 2.8 and 3.1 percent per year between 1975 and 1985—take into account a combination of real economic growth rates of 3.0 to 3.5 per year, combined with successful conservation efforts. In view of the high price of energy, it does not seem likely that recent, pre-embargo, high-energy growth rates will continue. On the other hand, an energy growth rate of 2 percent would probably translate into very sluggish economic growth over the next decade.

Some observers maintain that very low economic growth rates will have beneficial side-effects in terms of energy savings and environmental quality; others, however, argue that domestic social problems and a depressed world economy which could result from sustained low economic growth rates in the U.S., may be too great a price to pay for gains in energy conservation and environmental quality.

Hence, in view of the assumption concerning economic growth rates in this study, energy growth rates are likely to average between 2.8 and 3.1 percent per year for the next decade. Actual growth rates will depend on the performance of the economy, the availability of domestic and foreign sources of energy, successful substitution of the scarcest sources of domestic energy (substitution of domestic natural gas for foreign oil), the long-term effects of higher energy cost, and the long-term effects of careful conservation efforts.

In view of the substantial lead-times for development of oil and gas in frontier areas (Alaska, the Atlantic and deepwater elsewhere), and for shifting from petroleum to coal and nuclear energy at a much more rapid pace than projected in this study, supply projections up to 1980 do not appear to be subject to very significant changes. Decontrol of the price of old domestic oil could add as much as 0.3 million b/d, and decontrol of oil and natural gas will probably spur further exploration activities. But, even under favorable circumstances, the lead-times between leasing and full production are such that the 1977 supply of petroleum is not likely to be affected by accelerated exploration programs, and the effect of 1980 production would probably be marginal. It is possible, however, that a combination of a favorable leasing policy and gradual decontrol of natural gas could result in higher natural gas and oil production by 1985 than projected in this study. However, other observers might argue that in view of recent pessimistic petroleum resources estimates, production is not likely to grow much beyond what has been projected in this study.

Hence, one may conclude that under the domestic supply and demand assumptions in this study which are considered "cautiously optimistic" the deficit between domestic energy supply and demand in the United States will grow at least until the early 1980's. Assuming the economy will recover rather rapidly in 1976 from the 1974 recession, and the natural gas shortage will continue as projected (estimated at 2.9 TCF between 1975 and March 1976 alone, which translated into 1.3 million b/d of oil), the total U.S. energy deficit will grow rapidly in the next few years.

Because oil is the only readily available substitute for shortfalls in domestic supply of all sources of energy, imports of oil are expected to rise sharply in the near future. This analysis assumes that the serious shortfall in natural gas production will continue at least for some years, and that wherever possible oil will be substituted for natural gas.

It is concluded that even with price decontrol and assuming moderate energy growth rates of 2.8 to 3.1 percent per year, oil and natural gas imports are likely to grow from an average of 6.4 million b/d in 1974 to between 9.0 and 9.2 million b/d in 1977, between 10.0 and 10.6 million b/d in 1980, and between 9.0 and 10.4 million b/d by 1985. A recent decision by Canada to phase out natural gas shipments starting in 1976 will add about 0.9 TCF of gas or the oil equivalent of about 450,000 b/d to oil imports by the time all natural gas shipment will have been entirely off.

Hence, while in the past we used to differentiate between "secure" (i.e. free from risk of loss, dependable) and "insecure" sources of foreign supply, the difference has become less distinct and appears to be related primarily to questions of timing and the rationale behind foreign cutbacks. Under this definition the only secure sources of energy supply are domestic supplies, because in the final analysis each and every country will act to protect its perceived self-interest.

Rather than dividing oil imports into secure and insecure sources of supply, one may differentiate instead between traditional long-term and more recent sources of supply. Throughout the 1950's and 1960's about two-thirds or more of all U.S. oil imports came from traditional Western Hemisphere sources, and as late as 1967 only about 10 percent of the imported oil came from the Middle East and North Africa. In 1974, the percentage of U.S. imported Western Hemisphere oil had declined to about 60 percent, and imports from the Middle East and North Africa had reached about 19 percent of total imports.

Canada's decision to phase out oil and gas exports to the U.S., and the fact that Venezuela's oil production peaked some years ago, will result in further substantial reduction of oil imports from traditional Western Hemisphere sources.

However, on the basis of available information of the recent Mexican oil discoveries, many observers now believe that Mexican oil exports to the United States will at least partially offset projected Canadian cutbacks by the end of the decade. While the region's oil exports (in terms of volume) are likely to decline slightly in the future, oil and gas imports from traditional Western Hemisphere suppliers will decline dramatically as a percentage of total U.S. petroleum imports.

Nigeria, Indonesia and a small number of South East Asian and West African states are projected to increase oil exports to the U.S. from about 1.1 million b/d in 1974 to about 2.0 million b/d in 1985.

Most of the remaining foreign oil needed to meet energy demand will have to be imported from the Middle East and North Africa. This study indicates that oil imports from this region will have to rise from about 1.3 million b/d in 1974 to between 4.5 and 4.7 million b/d in 1977; between 5.1 and 5.7 million b/d in 1980 and between 3.8 and 5.2 million b/d by 1985.

Many of the oil producing nations have already committed themselves to limited production in order to prolong existing reserves and to limit foreign exchange accumulations. Projections of U.S. oil imports from the Middle East and North Africa have taken into account current government oil policy in the producing countries, which have clarified their position in recent months.

Future petroleum policy of Saudi Arabia, with 25 percent of the world's oil reserves, and the United Arab Emirates, is less clear at this time. While both nations have relatively small populations and limited capital absorptive capacity in relation to optimum petroleum production capacity, both nations have so far shown considerable production flexibility. If U.S. demand for Middle East and North African oil reaches the high level this study forecast for 1977 and beyond, and these two nations should be called upon to produce significantly more oil than they are currently projecting, their oil revenues would be considerably higher than the domestic economies are likely to be able to absorb.

Assuming that the major industrial nations of the world will begin to recover from the current deep recession in the near future and that North Sea, Alaskan, Mexican and other significant recent oil discoveries will produce a substantial volume of oil by the late 1970's, or early 1980's, total world oil imports from the Middle East and North Africa are not likely to reach the high 1973–74 level again until sometime in the late 1970's. Under favorable demand and supply conditions, Western Europe's demand for oil from OPEC will remain stable at the 1973–74 level at least until the early 1980's, but Japan's dependence on oil imports from the Middle East and North Africa is likely to continue to grow, although the volume may be significantly less than Japan's total oil growth rate, due to the probability of significant Japanese oil imports from the People's Republic of China.

The dependence of the United States on Middle East and North African oil, which grew steadily to about 19 percent in 1974, has been projected to accelerate to approximately 50 percent in two years. Because a substantial volume of oil will be imported from non-Arab Iran, dependence on Arab oil imports in 1977 is likely to fall between 35 and 40 percent of total foreign oil imports.

It is beyond the scope of this study to analyze all of the consequences of rapidly growing dependence on foreign oil, but some of the more important consequences are summarized below:

1. The FEA has estimated on the basis of the 1973–74 Arab oil embargo that the annual loss in GNP of a shortfall of 1.0 million b/d of oil will be between $30–$40 billion. FEA's analysis also assumes that the economy can conserve 1 million b/d without adverse economic impacts.

Under these assumptions, an Arab oil embargo in 1977 could result in a GNP loss of between $78 to $112 billion, if the embargo were to last a year, and between $39 and $56 billion, if the embargo would last six months.[162] Additional unemployment could range from 1 to 1.5 million for an embargo of six months, and between 2 to 2.7 million for an embargo of a year (calculated on the basis of FEA findings for the 1973–74 embargo).

2. The volume of foreign oil to be carried in foreign tankers is likely to increase considerably with oil imports projected to increase by

[162] Federal Energy Administration, Project Independence, op. cit., p. 367.

almost 50 percent within the next two years. The carrying capacity of 247 U.S. oil tankers is currently about 19 percent (with oil imports at about 6.0 million b/d).

3. America's inability to switch quickly from its rising dependence on imported oil could lead to more significant world crude price increases as soon as much of the excess production capacity in the OPEC bloc has been utilized. Assuming a major recovery of the Western economies in 1976, this could very well happen in the latter part of 1977 or soon thereafter.

4. Once OPEC's spare capacity has been removed or diminished substantially, the United States may have to compete with Western Europe and Japan for available supplies, because it is not certain at this point how much oil low-population countries with limited capital absorptive capacity will produce over and beyond the level needed to meet domestic economic and other financial requirements. The possibility that such competition for resources could add to friction among the principal Western allies should not be taken lightly.

5. Rapid increase of oil imports in the United States raises questions about security of the supply lines. The role of our conventional naval forces in guaranteeing the security of the supply lines between the producer countries and the U.S. may need additional consideration.

6. Oil and gas imports ranging from 9.0 to 9.2 million b/d by 1977 raise questions about the ability to pay for these foreign imports. Assuming a 1974 constant price of $11.00 per barrel, foreign oil and gas imports (Canadian gas is likely to be priced at around $2.00 per 1,000 cubic feet) would cause a drain of between about $37 and $38 billion dollars (1974 dollars) on the balance of trade. Will the nation be able to offset such a drain by increasing agricultural commodity and industrial product exports (oil imports costs $24.6 billion in 1974 and $7.0 billion in 1973)?

7. A recent study by the National Academy of Sciences, entitled "Petroleum in the Marine Environment" has shown that marine transportation of oil, and in particular marine transportation in small tankers, contributes more to the total volume of oil spilled in the ocean than any other source, including offshore production.[163] Lack of deepwater ports in the United States will mean continuing reliance on small tankers to carry oil from the producing countries to the U.S., or from transshipment areas in the Caribbean where oil can be transshipped from very-large-crude-carriers to small oil tankers.

8. The effects of rising U.S. dependence on foreign oil is likely to reduce our ability to maneuver freely in the area of foreign policy. The scope of energy dependence forecast in our study is such that energy may become the Achilles heel of U.S. foreign policy in the same way as agricultural shortages have been for the Soviet system.

9. Producing countries are gradually moving toward integrated operations including their own transportation, refining and even marketing of oil. It is likely that gradually a larger part of oil exports to the industrial world will be shipped in tankers owned by the producing nations. Also, producing nations are likely to desire a larger share of the world oil product market when their domestic refinery capacity increases. Eventually, producing nations may want a share in

[163] National Academy of Sciences, *Petroleum in the Marine Environment*, Washington, D.C., 1975, p. 6.

marketing final products such as gasoline in the industrial nations as part of their efforts to develop truly integrated national oil companies. Not only will such policy of integrated oil companies increase the degree of consumer nation dependence on oil exporting nations, but it could provide additional incentives to the producing nations to cut exports of crude oil when net income rises sharply as a result of exporting significant volumes of oil products and petrochemicals with a high value added. Any additional shift from crude exports to oil products will add to the cost of imported oil and will consequently add to the foreign exchange problems of the importing nations.

10. On the basis of calculations by Lewis Weeks, John Moody and others, it has become clear that the age of abundance of cheap sources of conventional oil and natural gas is over. Continuation of oil growth rates of the 1950's and 1960's would require additions to reserves between 1970 and 1990 that are about 5 times total oil production between the early part of this century and 1973. Hence, rapid diversion to sources other than oil and gas is an absolute necessity if we consider it important to determine our own energy future once again. In this respect we need to keep in mind that the Soviet Union's energy resources are vast by comparison with ours, even though that nation may face short-term supply shortages due to outmoded technology and capital shortages.

In the short-run the world centers of energy supply are likely to continue to shift further away from the industrial nations (with the exception of the North Sea and the U.S.S.R.) in the direction of Asia and Africa. The foreign policy implications of the shift will be significant in terms of the establishment of new powerful regions and the development of new relationships between producer and consumer nations. Rather than continuing the myths of energy independence by 1985, governments would do better to plan for an ERA of energy dependence on foreign countries until the day comes when alternative domestic sources of supply can replace imported fossil fuels. Planning for such a future and recognizing the continuation of the present trend in the direction of a world of growing economic interdependence, is preferable to a policy of confrontation.

Recognition of Interdependence

In the preceding chapters it was mentioned on several occasions that it is close to impossible to limit the dependence of the oil consuming nations on OPEC within the forseeable future. Melvin Conant, Deputy Director of the FEA for International Relations, recently stated that even if major discoveries equivalent to the North Sea or North Slope were made now, we could not expect their coming into the world market on a scale of any importance for five years and maybe even ten.[164]

"And yet", Mr. Conant continued, "to make a significant dent in the role of the Middle East as a supplier, we would have to find this much perhaps every year. Over the past 35 years, however, if you except Nigeria and the discoveries in the Middle East and the Communist world, we have not even approached that figure in terms of

[164] *Forbes*, September 15, 1975, p. 51.

an annual average rate of discovery. Over that 35-year period, despite the North Sea and the North Slope, our rate of discovery is inadequate by perhaps 50 percent.[165]

Once governments of oil consuming nations publicly recognize that energy independence within the next ten years is next to impossible without causing serious dislocations in the economy, they can begin to prepare the public for an era of close-cooperation with energy producing nations, while simultaneously attempting to maximize most or all available energy supply options domestically.

Prior to the 1973–74 Arab oil embargo and the subsequent quadrupling of the price of crude oil, it was assumed by most oil consuming nations that the growing shortfalls in domestic energy production would continue to be met by importing more foreign, and in particular Middle Eastern oil. Demand for products and service from the industrial world were expected to keep pace with the rising exports of oil from the Middle East and other oil producing nations. At the post-embargo price of oil, however, a number of oil exporting OPEC nations with low populations and limited capital absorptive capacity, are faced with the serious dilemma of either producing sufficient oil to meet world demand (current and future) and in the process accumulate vast amounts of foreign exchange that can only be partially put to use at home, or limiting domestic production. Limiting production to the level required to meet domestic economic needs and foreign aid commitments would cause a rapidly growing gap between world-wide demand and supply for oil, which in turn would result in prolonged recessions in the industrial world and deepening poverty in the developing nations.

Production Optimization and Middle East Capital Absorptive Capacity

A recent study on capital absorptive capacity of the OPEC countries (for the complete text, see appendix) confirms the findings of this study that there is likely to be a significant relationship between the absorption rate of OPEC countries and their policies with respect to oil prices and production. The manner in which this relationship will evolve is highly uncertain at the present time. The Treasury report confirms that to date, the OPEC countries have been able to reconcile their respective revenue availabilities and requirements through selected changes in both prices and production.[166]

Of the 12 OPEC countries the Gulf States are least likely to be able to utilize their oil revenues domestically in a reasonably efficient way in the foreseeable future. Failure to utilize revenue in a productive way could prompt either lower prices or a cutback in production. In view of the political realities in the Middle East, one is inclined to believe that a cutback in production is more likely to occur than a price cut.

On the basis of the capital absorptive capacity of OPEC in the Treasury Department Study, and assuming a government take of $9.00 per barrel of oil produced (1974 dollars), the nations of the

[165] Ibid., pp 51 and 53.

[166] U.S. Treasury Department. Office of the Assistant Secretary of Trade, Energy, and Financial Resources. *The Absorptive Capacity of the OPEC Countries*. Office of Middle East Affairs. Washington, D.C. September 5, 1975, p. iv. OPEC countries are: Algeria, Equador, Indonesia, Iran, Iraq, Kuwait, Libya Nigeria, Qatar, Saudi Arabia, the United Abrab Emirates, and Venezuela (Gabon is an Associate Member).

Middle East and North Africa would need to produce the following volume by 1980:

TABLE 57.—RELATIONSHIP OF ABSORPTIVE CAPITAL CAPACITY AND OIL PRODUCTION

Country	1980 import projections per day (in 1974 dollars)	Oil production based on projected 1980 imports[1]	1974 actual average daily production
Saudia Arabia	20,500,000	2.3	8.4
Kuwait	9,300,000	1.04	2.8
United Arab Emirates	10,700,000	1.19	1.9
Qatar	1,600,000	.15	.5
Iraq	26,000,000	2.9	1.6
Libya	14,200,000	1.6	1.9
Algeria	17,800,000	2.0	1.1
Iran	66,900,000	7.4	6.2

[1] In millions of barrels per day.

The Treasury Department study suggests that Iran, Iraq and Algeria are likely to maximize production and attempt to get higher prices (in terms of real 1974 dollars) for their oil, while on the other hand several of the Gulf States are not in need of additional revenue at current production levels, and could in fact reduce output substantially without impairing national economic development plans.

Kuwait is among the OPEC nations favoring reduction of production. Kuwaiti economic and financial officials have on many occasions pointed out that their country's national interest is badly served by constantly increasing oil production, and they express concern for the industrial nations' prodigal waste of the world's limited petroleum reserves. They argue that the end of the age of fossil fuels will come within a few decades, and that at that time a country like Kuwait will be discarded "like an empty cigarette pack".[167] In the meantime, they feel that their national interest is well served by drawing added income from price increases and increased shares in companies, while slowing down the drain on their ultimately finite reserves. Kuwait's policy of conservation is being seriously considered in a number of oil producing countries, and even in Saudi Arabia and the United Arab Emirates—which have so far given no indication of a desire to cut back production—there is an ongoing internal debate on the desirability of limiting production below current maximum capacity.

The Treasury Department study suggests that Saudi Arabia, Kuwait, the UAE and Qatar could limit production to about 4.5 million b/d in 1980 and still meet all import requirements. A substantial foreign aid program might add another million b/d to production in order to meet both import and foreign aid requirements. In order to meet total world demand for oil in 1980, this study has earlier suggested that a production of between 12.5 and 14.5 million b/d from these four countries would probably be required.

Are the Persian Gulf States and a few other oil exporting countries with low population and limited capital absorptive capacity willing to produce significant volumes of oil beyond that required to meet national economic development and foreign aid requirements? If so, for

[167] U.S. Senate. Committee on Foreign Relations. Subcommittee on Near Eastern Affairs. *The Middle East Between War and Peace, November-December 1973.* A Staff Report. 93rd Congress. 2nd Session. Washington, D.C. March 5, 1974, p. 21.

how long a period of time are they willing to either increase production or keep output at high levels? Under what economic and political conditions would these countries be willing to meet growing demand for oil from their region? Unfortunately, nobody seems to have any ready answers to these questions. We must, however, continue to look for solutions to future petroleum supply problems, because for the next five to ten years the only alternative to continuation of high oil production levels in the Middle East and North Africa is likely to be a major worldwide shortfall in energy, which will have serious consequences for the economies of the industrial nations as well as the non-oil-producing developing countries.[168]

To maximize chances for uninterrupted Arab oil exports required to maintain acceptable economic growth rates in the oil consuming nations, a number of obstacles need to be removed. Some of the most obvious obstacles to maintain uninterrupted Arab oil exports to the consuming nations are discussed in the following pages.

THE ARAB-ISRAELI CONFLICT

One cannot discuss the availability of a steady supply of Middle Eastern oil to the oil consuming nations outside the framework of Middle Eastern politics. In the nineteenth century, relations between European nations had reached a degree of sophistication which allowed for continuation of civilian trade, even during times of war. The emergence of the concept of *Total Krieg* (total war) in the early part of this century signalled the beginning of trade embargoes, which caused a great deal of suffering among the civilian populations of warring nations. The use of the oil weapon should be seen in the context of modern methods of warfare. It was successfully used by the Arab nations during the 1973 Yom Kippur war, and it may be used again in some fashion or another in the future until the Arab-Israeli conflict has been settled to the satisfaction of the moderate elements in the Middle East.

The oil weapon was applied more extensively against the United States than against the rest of the industrial world (with the exception of the Netherlands), because Arab nations were convinced that only the United States was in a position to make Israel withdraw from occupied territories.[169] They were and are not satisfied with mere U.S. determination and sincerity to help solve the problems, but instead insist on performance.[170] The U.S. government believes that the conclusion of the recent Sinai agreement—in which the U.S. played a major role—is a step in the direction of achieving a settlement of the Arab-Israeli conflict. Many observers inside and outside government circles, however, maintain that Dr. Kissinger will have to deliver a great deal more (along the lines of U.N. Resolution 242) to satisfy the demands of the moderate Arab leadership.

Not all observers of the Middle East situation believe that in case of another Middle East war, oil supply interruptions of the scope of the 1973–74 embargo are likely to occur, or will even be necessary for

---

[168] See: U.S. Treasury Department. Office of the Assistant Secretary of Trade, Energy and Financial Resources. The Absorptive Capacity of the OPEC Countries, op. cit., p. iv.

[169] United States Senate, Committee on Foreign Relations. Subcommittee on Near Eastern Affairs. *The Middle East Between War and Peace. A Staff Report.* Washington, D.C., March 1974, p. 4,

[170] Ibid., p. 16.

the Arab nations to achieve their goal. Melvin Conant, Deputy Administrator of the FEA for International Energy Affairs maintains that the Arab nations have a more subtle weapon at their disposal. They can actually achieve some of their political objectives through what he calls "controlled shortages".[171]

Rather than a sharp cutback in production as during the Yom Kippur war, they can gradually reduce the volume of oil available to the industrial world. This can be done for reasons that have less to do with maintenance of price and more with political objectives.[172] As long as the industrial world remains as dependent on Middle East oil as it is today, Arab nations could successfully implement such a policy initially without impairing domestic economic development.

An early solution to the Arab-Israeli conflict is called for in view of the projected growing U.S. dependence on Arab oil. Failure to move closer to self-sufficiency in energy, major shortfalls in natural gas, Canada's planned oil export phase-out program, and rising demand for oil associated with projected economic recovery, all point in the direction of rising imports of oil, which can only come from the Middle East (and to a lesser extent from other OPEC nations). This study has projected that as early as 1977, U.S. dependence on Arab oil may reach 40 percent of total foreign petroleum imports. Even though the United States has not in the past subjected itself to foreign blackmail, it is very difficult to negate that such a degree of dependence will not have an effect on U.S. foreign-policy making concerning the Middle East. Testifying before House Foreign Affairs Committee, Robert F. Hunter, Senior Fellow at the Overseas Development Council stated that a major progress was needed in negotiating peace in the Middle East in order to reduce the likelihood that the United States will one day be forced to choose between Israel and oil.[173]

Hostage Capital

Peace in the Middle East is a necessary prerequisite for the creation of a favorable political climate, a first step in the direction of establishing a truly inter-dependent relationship between the oil consuming and oil producing nations. Without peace and without a truly inter-dependent relationship between consumer and producer nations, there may not be enough of an incentive for the latter to produce a volume of oil required to balance domestic supply shortfalls in the oil consumer nations. Arab as well as Western sources have indicated that the volume of oil exports from the Middle East required to balance consumer-nations' demand would result in vast accumulations of petro-funds, much of which out of necessity will have to be invested abroad.

In order to meet foreign oil demand of the consumer nations, this study has projected certain minimum levels of oil output for the Middle East nations On the basis of the Treasury Department study on OPEC capital absorptive capacity, and the oil output projections

[171] Forbes. September 15, p. 51.
[172] Ibid., p. 51.
[173] U.S. House of Representatives. Committee on Foreign Affairs. Subcommittee on Foreign Economic Policy. *Foreign Policy Implications of the Energy Crisis*. 92nd Congress. 2nd Session. September 21, 26, 27. Washington, D.C. October 3, 1972, pp. 169, 170.

in this study, the nations of the Middle East and North Africa would run the following current account surpluses and deficits on their balances of payments in 1980:

TABLE 58.—CURRENT ACCOUNT SURPLUSES AND DEFICITS OF MIDDLE EAST AND NORTH AFRICAN OIL PRODUCING NATIONS

Country	1980 oil production level (projected) [1]	1980 estimated current account	
		Surplus	Deficit (billions)
Saudi Arabia	7.0-9	15.5-22	
Kuwait	2.5	4.8	
United Arab Emirates	2.5	4.3	
Iraq	3.5	1.99	
Libya	1.7	.4	
Algeria	.75		$3.4
Iran	8.0	4.8	(2)

[1] In millions of barrels per day.
[2] At 7,000,000 barrels per day, Iran would run a deficit of $1,500,000,000.

Within a few years a huge economic entity would be created beyond the borders of Arab states. At some point those investments will have reached such vast proportions that the threat of an oil embargo would be offset by the counterthreat to confiscate Arab investments.[174] Many Arabs fear that they could get into a situation whereby large parts of their original oil resources will have been transferred beyond their effective control, and their investments will be held hostage for Arab cooperation in international affairs.[175] Yet, if they do not balance demand and supply of oil in the world by expanding output, oil consuming nations will at some point be faced with a severe shortage of oil which will have an upward effect on prices, reduce industrial activity and GNP, increase unemployment, create social unrest, and create additional friction among oil consuming nations competing for limited supplies.

With the exception of a temporary interruption of the supply of oil during the 1973/74 embargo, Arab states have met the energy supply deficit of the consumer nations, and all OPEC countries together ran cash surpluses of $66 billion in 1974.[176] Philip Bradley maintains that Arab nations may be producing about twice as much oil as they would if they were guided only by the considerations of present value.[177] Referring to the low rates of return on Arab short-term investments, Bradley writes:

> Entrepreneurial activity in the non-Arab world is not creating enough high-yield projects to attract more than a small percentage of Arab petro-funds, and the attractiveness of even these projects diminishes as latent confiscatory attitudes surface. As a consequence, the bulk of Arab petro-funds goes into short term deposits and into the governmental obligations of other nations. The average rate of return on

[174] Philip D. Bradley, "A Long Term Look at Petro-Dollars", *National Review*. May 23, 1975, p. 558. See also: Yusif A. Sayigh. "Arab Oil *Policies*: Self-Interest Versus International Responsibility", *Journal Palestine Studies*, No. 4. Spring 1975. pp. 59–73. Opinion on the size of OPEC balance of payment surpluses have differed greatly, and still do. For an excellent article by Alfred Reifman see appendix XI.
[175] Ibid., p. 558. Bradley calls these surplus funds "hostage capital", i.e. foreign capital at the mercy of a state which may at any time decide to confiscate it.
[176] First National City Bank, "Monthly Economic Letter", June 1975.
[177] Philip D. Bradley, "A Long-Term Look at Petro-Dollars", op. cit., p. 559.

> these investments, even without allowing for massive losses the Arabs have taken on stocks, is below the average rate of inflation in the nations where the investments are being made. In brief, the Arab states are using up their capital: the value of the assets they are acquiring is less than the value of the oil assets they are giving up.[178]

Moreover, recent actions by Saudi Arabia to keep OPEC prices from rising significantly above the rate of inflation of the industrial nations, is another indication of moderation and a desire to co-operate with the consumer nations. This study, as well as the Treasury study on the absorptive capacity of OPEC countries show that Saudi Arabia alone could have reduced current low output of less than 7 million b/d to about 3.5 million b/d without impairing domestic economic development.

Even if maximum efforts were already underway in the major industrial nations of the world to move away from imported OPEC oil to domestic sources of energy, it would take a decade or more to reduce dependence on OPEC, and the Middle East in particular, significantly below 1974 levels. Reduction of OPEC oil production to a volume sufficient to meet domestic economic development plans only, is certain to cause world-wide energy shortages during the coming decade, with serious effects on the economies of both developed and developing nations.

Most oil producing nations realize the situation the consumer nations are in, and they are not out to impair economic recovery in the consumer countries by holding back on oil exports. Oil producing states are aware that nations can no longer exist in "splendid isolation". The fate of the oil producing nations is closely tied to stability in the industrial world; which hold the key to their economic and technological development. The Shah of Iran expressed this view in an interview with the German magazine Der Spiegel. He said:

> At the end I would like you to know that in our case it is not to take vengeance on the West. As I said, we are going to be a member of your club. It is a question of readjusting the relation between the industrial world and the oil producing nations.[179]

The new relationship between oil producing and consuming nations referred to by the Shah, could include the following:

GUARANTEES OF INVESTMENT

In order to reduce Arab fears of accumulating "hostage capital", Phillip Bradley suggests that the importing nations could do much to help in creating new international arrangements designed to reduce politically inspired uncertainties.[180] Bradley proposes the following guidelines: nations participating in such arrangements might agree to grant to the foreign investor every right enjoyed by the domestic

---

[178] Ibid., p. 559.
[179] U.S. House of Representatives. Committee on Foreign Affairs. *Old Problems, New Relationships.* Report of a Study Mission to the Middle East and South Asia Persuant to House Res. 267, authorizing the Committee on Foreign Affairs to conduct thorough studies and investigations of all matter coming with the jurisdiction of the Committee. Washington, D.C., 1974, pp. 18 and 19.
[180] Philip D. Bradley, " A Long-Term Look at Petro-Dollars", op. cit., p. 575.

investor. Any industry not open to the foreign investor would be identified: otherwise the foreigner and the native would have equal rights of entry to any investment area. A foreign investor who found his investment threatened by confiscation in any form would have the right to take his case to a court presided over by judges drawn from the participating countries. The court would be given the economic power to enforce its decisions. Voluntary arrangements of this kind would not diminish any nation's sovereignty. Any nation that believed it had more to gain by leaving the agreement than by remaining within it would be free to leave; it might be permitted to re-enter whenever the court found it had satisfied its outstanding obligations to other participating countries.[181] Bradley believes that these arrangements would stimulate the international flow of capital, including petro-funds from the Arab world. The idea of guarantee of investment is not new to U.S. policy-makers. In fact, it has become a *conditio sine qua non* for U.S. acceptance of the economic zone concept at the Third Law of the Sea Conference.[182]

DOMESTIC EFFORTS BY THE INDUSTRIAL NATIONS

A firm commitment by the industrial nations is necessary to optimize all possible options in the direction of limiting dependence on imported oil. The higher price of oil following the Arab embargo of 1973/74 has encouraged world-wide drilling activities, but even if major discoveries will soon be made outside the Middle East, it will take between 5 and 10 years (or even longer) before significant volumes of new discoveries will come onstream. The United States needs to increase coal utilization and support research and development of synthetic fuels from shale and coal. All industrial nations have a nuclear option, but debates about the pros and cons of expanding nuclear power in most industrial nations, possible future shortages of uranium, and constraints on capital, have already lowered estimates on U.S. nuclear power availability by 1985, and may have similar effects elsewhere. There is, however, no other option but to go forward with nuclear power. The industrial nations will be in a better bargaining position vis-a-vis oil producing states if they were to implement serious plans towards reducing dependence on foreign oil. Several industrial nations have already indicated a desire to go slow in the development of certain energy sources within their borders because of potential adverse environmental and socio-economic impacts. The vast accumulation of wealth in the Middle East and North Africa—which is a direct result of the industrial nations' growing appetite for oil—is bound to have very significant socio-economic impacts. The industrial world's call for rising oil exports from Saudi Arabia and other oil producing nations with limited capital absorptive capacity, would be significantly strengthened if they could show substantial progress in the direction of limiting dependence on imported oil.

MODERNIZATION AND INDUSTRIALIZATION OF THE MIDDLE EAST

While investment of petro-funds outside many of the oil producing nations—especially the Gulf states—is likely to continue for the

---

181 Philip D. Bradley, "A Long Term Look at Petro-Dollars", op. cit., p. 575.
182 See article 27 of the U.S. draft articles for the economic zone and the continental shelf. United Nations, Third Law of the Sea Conference, doc. A/Conf. 62/C.2/L.47, p. 9.

foreseeable future (assuming current or rising volumes of oil will be exported), the oil producing countries aim at rapid industrialization and modernization of their agricultural sector. In addition to large capital goods imports, this policy will require modernization of the entire society, requiring massive transfers of technology from the industrial world. Gradually, oil producing states will refine a larger percentage of total oil output and export fuels, petro-chemicals, and other produces to the oil consuming nations. Availability of associated natural gas which is currently underutilized and mainly flared, could result in a rapid build-up of energy-intensive industries in the Middle East. The products of the new industries would—in part—be exported to other parts of the world. This, in turn, would strengthen the mutual dependence of the Middle Eastern countries and the industrial world. In a recent interview with *Forbes*, Melvin Conant, the Deputy Administrator of FEA for International Energy Affairs stated:

> . . . In the 19th century, the industrializing world developed certain institutional devices—imperialism, that is—for assuring access to a supply of raw materials. That system collapsed with World War II. What we are engaged in now, it seems to me, in oil as in other commodities, is the beginning of an earnest endeavor to find some new mechanism that will give the industrialized world the access that it used to have—but under terms acceptable to both sides. These terms are going to involve one very distinctive difference from the system we had earlier—the producers will have to be given access to the markets of the industrialized world. In oil, this means that more crude will be processed in its home territory. Similarly, in petrochemicals, those things we used to reserve to ourselves are indisputably going to be part of this new arrangement. So are steel and shipbuilding. The whole gamut of things that used to be reserved for our side of the table is somehow going to be worked into this new understanding. What we have to do is develop a mutuality of interest in keeping the system reliable, durable, reasonable, as seen from both sides.[183]

Facing growing dependence on imported oil for at least one more decade, the industrial nations cannot afford a policy of confrontation with the producing nations. Instead, they should maintain as harmonious relationships as possible with the oil producing states and work to limit external disturbances which could threaten the security of oil supplies of the industrial world. The producers, on the other hand, should also understand that they too have a stake in the peaceful and orderly development of the oil industry and in the maintenance of a viable economy in the consumer nations. Consumers and producers of oil can no longer afford to go separate ways. All nations need to work together to resolve problems which affect all countries in an era of growing global inter-dependence.

---

[183] *Forbes*, September 15, 1975, p. 51.

APPENDIX I

SELECTED GLOSSARY OF TERMS RELATING TO THE PETROLEUM INDUSTRY

BARREL.—Abbreviated bbl. A liquid measure of oil, usually crude oil: equal to 42 American gallons, or between 280–380 lbs. depending upon API gravity, and equal to 35 Imperial (British) gallons.

BARRELS PER DAY.—A customary unit of measurement of rates of output of oil fields, and throughput of pipe lines, refineries and marketing facilities. Reference ordinarily is to the average number of barrels per calendar day over a specified period, usually a year. Abbreviated BPD or B/D.

BTU.—Abbreviation for British thermal unit. A measure of energy. The amount of heat needed to raise the temperature of one pound of water by 1 degree fahrenheit when the water is at or near 39.2 F.

COAL GASIFICATION.—A process, not yet commercially viable in the United States, which produces petroleum gas from coal.

COAL LIQUEFACTION.—A process not yet commercially viable in the United States, which produces liquid petroleum from coal.

CONCESSION.—Any substantive right to explore for and develop petroleum fields, whether or not it be called a concession, lease, contractor's agreement, etc.

CONSERVATION.—The idea of foregoing present benefits to reserve them for the future. Oil producing states have instituted conservation programs to save their oil and the revenues derived from oil for their future use.

CONDENSATE.—Hydrocarbons that are in the gaseous state under reservoir conditions at high pressures, but becomes liquid at the surface or when reservoir pressures are significantly reduced.

CONTINENTAL SHELF.—The extension of the continental land mass into the oceans, under relatively shallow seas, as opposed to the deeper ocean basins.

CRUDE.—Oil in its natural state, before refining or processing.

DISSOLVED GAS.—Natural gas that is in solution with crude oil in the reservoir, the way carbon dioxide is dissolved in soda water.

DOWNSTREAM.—Oil is said to flow downstream from well head to gas pump. Refining and marketing are generally considered to be downstream activities.

DRY HOLE.—An oil well that does not produce oil; usually an exploratory well. Only one out of ten "wildcat" exploratory wells strikes oil—the rest are dry holes. One out of four wells drilled in a proven deposit is a dry hole. (See "Wells, Classification of.")

EMBARGO.—A prohibition against trading a product or many products with one or more countries. For example, Saudi Arabia has embargoed oil shipments to the United States and the Netherlands.

EXPLOITATION.—Extracting and utilizing oil from a proven deposit.

EXPLORATION.—Searching for oil; geologic surveys, drilling exploratory wells or bore holes, conducting soil tests, to see if oil or gas exists in economically exploitable quantities.

EXPLORATORY WELL.—Any well not surrounded by producing wells, ranging from wildcats, which are miles from production, to stepouts, which are adjacent to production. See "Wells, Classification of.")

FIELD.—An aggregate of overlapping, contiguous, or superimposed pools located on the same geological structure. All fields are not created equal; in the United States, for example, 200-odd fields out of 10,000 account for more than half of total reserves. (See "Wells, Classification of" and "Reservoirs, Classification of.")

FLARE GAS.—Unutilized natural gas burned in flares at an oil field: waste gas.

LNG.—Abbreviation for liquefied natural gas. Natural gas converted to a liquid under cryogenic conditions by cooling to −260F. LNG occupies 1/600 of its gaseous volume at normal atmospheric pressure.

LPG.—Liquefied petroleum gas: propane, butane, or a mixture of the two, kept in a liquid state by pressure or refrigeration for ease of handling.

MAJORS.—In international oil circles, the majors are the seven largest companies which control most of the free world's oil, Exxon, British Petroleum, Royal Dutch, Shell, Texaco, Gulf, Mobil, and Standard of California. In the United States, the term "majors" usually applies to the 20 largest integrated companies.

MAXIMUM EFFICIENT RATE (MER).—The producing rate consistent with maximum recovery of reserves (about 1/15 of proven reserves per year in the case of domestic oil fields, and 1/15 to 1/20 of proven reserves per year for domestic natural gas). The M.E.R. for any given field may, however, be significantly greater or less than this approximation. Production at a rate in excess of the M.E.R. for the field concerned may result in such depressurization or other reservoir drainage that very large amounts of crude become unrecoverable.

NATURAL GAS.—A naturally occurring mixture of hydrocarbons and varying quantities of nonhydrocarbons that exist either in the gaseous phase or in solution with crude oil in undergound reservoirs; primarily methane and ethane.

NATURAL GAS LIQUIDS.—Those portions of reservoir gas that are liquefied at the surface in separators or gas-processing plants; primarily propane, butane, and pentane.

Naval Petroleum Reserves.—Since 1910 certain of the public lands of the United States have been set aside from those available for sale or lease for purposes of oil production. Since 1928 these have been under the jurisdiction of the Department of the Navy.

There are four Naval Petroleum Reserves: Reserve Number One is at Elk Hills, California and contains at least 1.3 billion barrels of proved reserves. It may hold nearly 3 billion barrels of crude. This reserve is in a high state of readiness for production, and could begin to produce at a rate of 250,000 barrels per day within 6–12 months.

Naval Petroleum Reserve Number Two is located at Buena Vista Hills, California, just south of the Elk Hills Reserve. Because of the pattern of ownership in the area, it is not feasible to keep this reserve shut-in, and it is therefore presently producing at its maximum efficient rate. The proven reserves of this area are about 50 million barrels.

Reserve Number Three is at Teapot Dome, Wyoming. This reserve is shut in except for some minor drilling to prevent seepage. Reserves are estimated at 50 million barrels.

Naval Petroleum Reserve Number Four is on the North Slope of Alaska, just west of the lands to be served by the Alyeska pipeline. Estimated recoverable reserves in this area are 50 billion barrels of crude oil and 80 trillion cubic feet of natural gas. This does not include the offshore areas.

OAPEC.—The Organization of Arab Petroleum Exporting Countries, founded in 1968 by Saudi Arabia, Libya. and Kuwait for cooperation in economic and petroleum affairs. In 1970, Abu Dhabi, Algeria, Bahrain, Dubai, and Qatar joined. Egypt, Syria, and Iraq joined in 1972. Dubai withdrew in 1973.

Offshore.—The area from the high water mark seaward to the edge of the continental shelf.

Oil-In-Place.—Deposits of oil whose existence has been discovered through exploration. (*Compare* "Proved Reserves".)

Oil Shale.—A sedimentary rock containing organic material called Kerogen; yields oil when heated. Large areas of the United States are known to contain oil shale deposits, but those areas in Colorado, Utah, and Wyoming that contain the organic-rich sedimentary rocks of the Green River Formation hold the greatest promise for oil production in the immediate future. The known deposits of this formation include high-grade shales that contain about 600 billion barrels of oil. An additional 1,200 billion barrels are present in lower grade shales.

On Stream.—When a refinery or petrochemical plant becomes operational it is said to go "on stream".

OPEC.—Organization of Petroleum Exporting Countries. Founded in 1960 to unify and coordinate petroleum policies of the members. The members and dates of membership are: Abu Dhabi (1967); Algeria (1969); Ecuador (1973); Indonesia (1962); Iran (1960); Iraq (1960); Kuwait (1960); Libya (1962); Nigera (1971); Qatar (1961); Saudi Arabia (1960); and Venezuela (1960). OPEC headquarters is in Vienna, Austria.

PRIMARY RECOVERY.—Initial production of oil or gas, usually by natural reservoir energy.

PRODUCT.—One of the products produced from crude oil by the refining process, such as kerosene, tar, or gasoline.

RESERVE/PRODUCTION RATIO.—In the petroleum trade, a standard measurement is the ratio of proved reserves to annual production expressed in years supply. Again, a word of caution: the amount of crude oil "proved" and produced is an amount solely determined by investment and production policies. For the United States, the R/P ratio has slowly declined for many years, from 16.3 years (in 1920), 15.1 (1930), 14.1 (1940), 12.8 (1950). 12.3 (1960), 8.9 (1970). The oil strike on the North Slope of Alaska, however, has temporarily checked this downward trend. Last year (1972), the R/P ratio for the U.S. was 9 years.

Note. As in the past, the United States is drawing on its petroleum resources at a much faster rate than other countries. Over a hundred years of active production, since the discovery of oil in 1859 in the foothills of northwestern Pennsylvania, has resulted in the so-called "Lower 48" being the most drilled up piece of real estate in the world. Although the distinction will inevitably pass before the 1970's are out, the U.S. has from the beginning been the world's largest oil producer. In fact, production in the U.S. averaged more than half of world output up to the time of the Korean War. It was American oil, after all, on which Allied Forces "floated to victory" in World War I. and by 1924, as one contemporary author wrote, output had reached "the undreamed-of total of 2,000,000 barrels a day." In 1939, the U.S. produced nearly 3½ million b/d out of a world production of 5.7 million b/d.

Today, the U.S. has achieved a crude production level of 9 million b/d—equal to the world level after World War II. The U.S. has over 525,000 operating wells, in comparison to the 5,780 wells found in the Middle East and North Africa.

A comparison of the global distribution of reserves with crude production reveals a far from uniform pattern. The Organization of Petroleum Exporting Countries, which accounts for some 90 percent of international petroleum trade, had a percentage of world production below their percentage of world reserves, whereas the reverse was true for the non-OPEC producing group. In 1972, the United States produced about 22 percent of the world's crude but held only 5.5 percent of the world's crude reserves. Conversely, Saudi Arabia, which possessed over 30 percent of the world's reserves, produced only 11.4 percent of the world's crude. OPEC, however, is developing rapidly, and their reserves, as well as their annual share of the world's crude production, are certain to increase in the near future.

RESERVOIR.—A single, separate, natural underground accumulation of petroleum in the pores of sedimentary rock. It is a single natural pressure system; production of petroleum from part of the pool affects reservoir pressure throughout its extent. It is effectively separated (by rock, water, or other impermeable barriers) from any other pools which may be present in the same region or on the same geological structure.

RIG.—Oil well drilling structure; platform, pumps, drilling engines, tower, cables, winches, etc., are parts of the rig.

SECONDARY RECOVERY.—Enhancing the production of oil left in a reservoir by conventional methods, including water or gas injection, water-flooding, heat, or nuclear.

TAR SANDS.—Sand deposits that contain recoverable hydrocarbons. The most extensive known deposits are the Athabascan tar sands near Ft. McMurray, Alberta, Canada.

TERTIARY RECOVERY.—The process of flooding an oil reservoir with chemicals to recover reserves remaining after secondary recovery.

TON (SHORT TON, LONG TON, METRIC TON).—Short ton=2,000 lbs. Long ton=2,240 lbs. Metric ton=2,204.62 lbs.

A metric ton is the common foreign measure of quantity of petroleum. Because the common American measure is the barrel (a unit of volume not of weight), no single conversion factor applies to all crude oils: heavier crudes weigh more per barrel than light crudes. The normal range is 6.5 to 8.5 barrels per metric ton. At API gravity of 30, one long ton of crude equals 7.31 barrels. For convenience, a conversion factor of 7.3 barrels per metric ton is frequently used. At this rate, 1 million metric tons per year equals 20,000 barrels per day; or metric tons per year equals 50×barrels per day.

WELL.—An oil well may best be described as a pipe line reaching from the top of the ground to the oil-producing formation. It is through this pipe line that oil is brought to the surface. This pipe line is a series of joints of a special kind of pipe (casing) screwed together to form a continuous tube or string for the oil and gas to flow through.

A second protective string may be used. This casing is called the intermediate string or "salt string" because it generally is run to a depth sufficient to case off salt and anhydrite formations. Such a string may be set at depth of 5,000 ft. or more.

The final string of casing, called the oil string, will usually extend from the surface through the surface and intermediate pipe, to the top of and sometimes through the producing zone at total depths of 20,000 ft. or more. Because both strings of casing are subjected to large pressures and forces, it is necessary that the casing string be carefully designed and properly run into the well.

WELL HEAD.—The valving at the top of the well, the point at which production is counted and production cost is computed.

WILDCAT.—A well drilled in an area which has not produced gas or oil previously; usually exploratory, and often without geophysical investigation. On an average, one out of nine or ten wildcats strikes oil or gas. (See "Classification of Wells.")

APPENDIX II

OIL AND NATURAL GAS RESERVES AND RESOURCES

For any discussion concerning current supply and projected availability of oil and natural gas in the future, it is important to distinguish between reserves and resources.

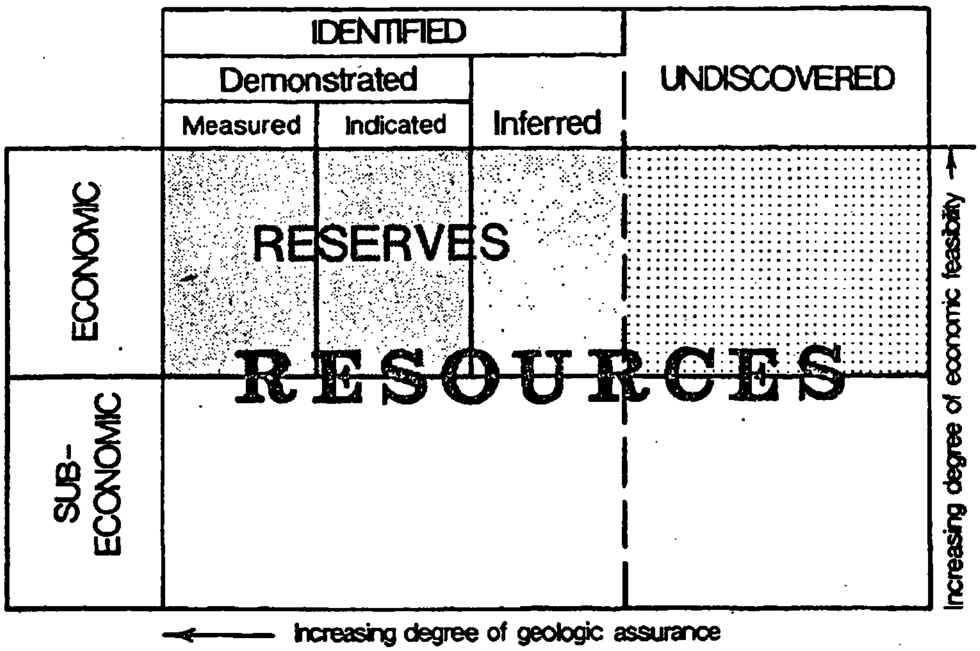


FIGURE 6.—Diagrammatic representation of petroleum resource classification by the U.S. Geological Survey of the U.S. Bureau of Mines (modified from McKelvey, 1973).

Source: U.S.G.S. *Geological Estimates of Undiscovered Recoverable Oil and Gas Resources in the United States*, Geological Survey Circular 725, Washington, D.C. 1975, p. 8.

Resources and reserves of oil and natural gas can be subdivided according to the degree of geologic assurance and economic feasibility of mining. The U.S.G.S. has subdivided resources and reserves in the following way:

RESERVES AND RESOURCES (DEFINITIONS)

Resources: Concentrations of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Economic Resources: Those resources, both identified and undiscovered, which are estimated to be economically recoverable.

Subeconomic Resources: Identified and undiscovered resources that are not presently recoverable because of technological and economic factors but which may be recoverable in the future.

Identified Resources: Specific accumulations of economic resources whose location, quantity and quality are estimated from geologic evidence supported in part by engineering measurements.

Identified Subeconomic Resources: Known resources that may become recoverable as a result of changes in technological and economic conditions.

Undiscovered Resources: Quantities of a resource estimated to exist outside of known fields on the basis of broad geological knowledge and theory.

Undiscovered Recovered Recoverable Resources: Those economic resources, yet undiscovered, which are estimated to exist in favorable geologic settings.

Reserves: That portion of identified resources that can be economically extracted.

Measured Reserves: That part of the identified resource that can be economically extracted using existing technology, and whose amount is estimated from geologic evidence supported directly by engineering measurements.

Indicated Reserves: Reserves that include additional recoveries in known reservoirs which engineering knowledge and judgement indicate will be economically available by application of fluid injection, whether or not such a program is currently installed.

Demonstrated Reserves: A collective term for the sum of measured and indicated reserves.

Inferred Reserves: Reserves in addition to demonstrated reserves eventually to be added to known fields through extensions, revisions, and new pays.

APPENDIX III

WORLDWIDE OIL AT A GLANCE

Country	Reserves, July 1, 1975 — Oil (thousand b/d)	Reserves, July 1, 1975 — Gas (billions cubic feet)	Producing wells July 1, 1974	Oil production — Estimate 1974 (thousand b/d)	Oil production — Percent change 1973
Asia-Pacific:					
Afghanistan	85,000	3,530	15	0.2	
Australia	2,300,000	38,000	373	370.6	0.7
Bangladesh		10,000			
Brunei-Malaysia	2,500,000	22,000	519	327.0	.6
Burma	65,000	150	595	23.0	
China Republic (Taiwan)	15,000	1,000	60	3.3	
Guam					
India	834,000	2,500	1,500	149.0	.7
Indonesia	15,000,000	15,000	2,710	1,457.0	10.0
Japan	30,000	1,700	1,044	12.3	
Khmer Republic					
Korea, South					
New Zealand	75,000	5,000	4	3.8	−5.0
Okinawa (R.I.)					
Pakistan	28,700	16,000	16	7.1	−16.5
Philippines					
Singapore					
Sri Lanka					
Thailand	115,000	1,000	25	.2	
Vietnam, South†					
Total, Asia-Pacific	21,047,700	115,880	6,861	2,353.5	4.3
Europe:					
Austria	182,000	953	1,271	47.0	−6.0
Belgium					
Cyprus					
Denmark	247,000	500	6	4.0	
Finland					
France	142,000	5,800	295	20.2	−19.2
Germany, West	550,000	11,473	2,699	125.4	−6.9
Greece†					
Ireland†					
Italy-Sicily	750,000	12,000	111	18.3	−9.4
Netherlands	250,000	94,800	347	27.4	−2.1
Norway	7,300,000	24,700	6	30.0	200.0
Poland					
Portugal					
Romania					
Spain	293,000	600	24	38.0	90.0
Sweden					
Switzerland					
United Kingdom	15,700,000	50,000	57	1.9	22.6
Yugoslavia	400,000	2,000	1,100	69.0	−2.8
Total, Europe	25,814,000	202,826	5,916	381.2	3.0
Middle East:					
Abu Dhabi	30,000,000	200,000	160	1,750.0	34.5
Bahrain	336,000	6,600	211	68.0	
Dubai	2,420,000	1,500	45	232.0	28.9
Iran	66,000,000	330,000	369	6,128.0	.6
Iraq	35,000,000	27,500	156	1,829.3	2.0
Israel	2,200	20	25	[1] 100.8	−11.8
Jordan					
Kuwait	72,800,000	32,000	692	2,600.0	−7.4
Lebanon					
Neutral Zone	17,300,000	7,500	449	485.4	−4.3
Oman	6,000,000	2,100	61	297.0	−.7
Qatar	6,000,000	8,000	81	546.0	5.4
Saudi Arabia	164,500,000	55,000	670	8,400.0	11.7
Sharjah	1,500,000	1,500	3	50.0	100.0
South Yemen (Aden)					
Syria	1,500,000	700	123	119.0	7.2
Turkey	500,000	250	313	65.3	.5
Total, Middle East	403,858,200	672,670	3,358	22,670.8	7.0

WORLDWIDE OIL AT A GLANCE—Continued

Country	Reserves, July 1, 1975: Oil (thousand b/d)	Reserves, July 1, 1975: Gas (billions cubic feet)	Producing wells July 1, 1974	Oil production: Estimate 1974 (thousand b/d)	Oil production: Percent change 1973
Africa:					
Algeria	7,700,000	229,000	826	888.8	−19.2
Angola-Cabinda	1,175,000	1,400	181	161.5	6.9
Congo Republic	4,874,000	1,000	52	51.2	12.0
Dahomey [2]					
Egypt [1]	3,700,000	3,500	437	118.3	−42.8
Ethiopia [2]					
Gabon	1,750,000	7,000	137	182.0	20.1
Ghana [3]					
Ivory Coast					
Kenya					
Liberia					
Libya	26,600,000	26,500	979	1,700.0	−21.6
Malagasay					
Morocco	450	24	22	0.9	
Mozambique [2]					
Nigeria	20,900,000	45,000	1,088	2,300.0	15.0
Rhodesia					
Senegal					
Sierra Leone					
Sudan					
Tanzania					
Tunisia	1,100,000	1,500	55	85.0	3.5
Union of South Africa [2]					
Zaire [3]	500,000	50			
Zambia					
Total, Africa	68,299,450	314,974	3,777	5,487.7	−7.2
Western Hemisphere:					
Antigua					
Argentina	2,346,000	7,500	4,095	422.0	
Bahamas					
Barbados	25,000		8	0.3	100.0
Bolivia	250,000	11,000	281	47.5	−5.0
Brazil	775,000	914	1,247	172.2	1.2
Chile	200,000	2,800	316	28.6	−15.9
Colombia	900,000	4,000	2,078	169.7	−16.0
Costa Rica [2]					
Cuba					
Dominican Republic					
Ecuador	[4] 2,500,000	5,000	843	232.0	12.5
El Salvador					
Guatemala [2]					
Honduras					
Jamaica					
Martinique					
Mexico	13,582,000	15,000	3,301	513.5	17.1
Netherlands Antilles					
Nicaragua					
Panama					
Paraguay					
Peru	2,500,000	5,000	2,422	69.7	−1.3
Puerto Rico					
Trinidad and Tobago	2,500,000	6,000	3,020	181.3	9.9
Uruguay					
Venezuela	[5] 15,000,000	43,000	12,450	3,025.0	−10.0
Virgin Islands					
United States	35,299,839	250,000	504,000	8,945.0	−2.9
Canada	9,400,000	[6] 52,500	21,202	1,682.0	−6.5
Total, Western Hemisphere	85,277,839	402,714	555,263	15,488.8	−1.7
Total, non-Communist	604,297,189	1,709,064	575,175	46,382.0	2.0
Communist world	[7] 111,400,000	[8] 846,000		10,390.0	7.5
Total, world	715,697,189	2,555,064		56,722.0	3.0

[1] Includes captured Sinai.
[2] Oil or gas discovered, but not developed.
[3] To go on production in 1976 at 25,000 barrels per day.
[4] Revised.
[5] Does not include Orinoco heavy oil belt's estimated 700,000,000,000 barrels.
[6] Does not include Artic gas.
[7] Including Russia 83.4 billion, Mainland China 25 billion, others 3 billion.
[8] Including Russia 812 trillion, Mainland China 25 trillion, Hungary 3 trillion, others 6 trillion.

Source: "The Oil and Gas Journal," Dec. 30, 1974, pp. 108, 109.

APPENDIX IV

WORLD OIL PRODUCTION, 1964–74

[In thousand barrels daily]

Country/Area	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Yearly change [1] (percent) 1974 over 1964	1974 over 1969
North America:													
United States:													
Crude oil	7,615	7,805	8,295	8,810	9,095	9,240	9,635	9,465	9,440	9,210	8,795	+1.4	−1.0
Natural gas liquids	1,155	1,210	1,285	1,410	1,505	1,590	1,660	1,695	1,745	1,740	1,690	+3.7	+1.2
	8,770	9,015	9,580	10,220	10,600	10,830	11,295	11,160	11,185	10,950	10,485	+1.7	−.7
Canada	850	935	1,015	1,100	1,195	1,310	1,475	1,585	1,830	2,115	2,000	+9.0	+9.2
Mexico	355	360	370	410	440	460	485	485	505	550	625	+5.7	+6.0
Total, North America	9,975	10,310	10,965	11,740	12,235	12,600	13,255	13,230	13,520	13,615	13,110	+2.7	+.8
Caribbean:													
Venezuela	3,395	3,505	3,405	3,580	3,645	3,630	3,760	3,620	3,305	3,460	3,060	−1.1	−3.5
Colombia	170	200	195	190	175	210	220	215	195	185	170	----------	−4.2
Trinidad	135	135	150	180	185	160	140	130	140	165	180	+2.8	+2.8
Total, Caribbean	3,700	3,840	3,750	3,950	4,005	4,000	4,120	3,965	3,640	3,810	3,410	−.9	−3.2
South America:													
Argentina	275	270	285	315	345	355	390	425	435	420	415	+4.2	+3.1
Brazil	90	95	115	145	165	175	165	170	165	165	175	+6.7	----------
Other South America	115	115	120	150	165	150	135	135	230	380	325	+10.8	+16.6
Total, South America	480	480	520	610	675	680	690	730	830	965	915	+6.5	+5.9
Total, Western Hemisphere	14,155	14,630	15,235	16,300	16,915	17,280	18,065	17,925	17,990	18,390	17,435	+2.0	+.1

Western Europe:													
France	55	60	60	55	55	50	45	35	30	25	20	−9.2	−15.4
West Germany	150	165	155	155	155	155	150	145	140	130	120	−2.1	−4.7
Austria	50	55	55	55	55	55	55	50	50	50	45	−1.7	−4.1
Turkey	20	30	40	55	60	70	70	70	65	70	65	+13.6	−1.7
Other, Western Europe	140	135	125	125	125	130	130	125	150	170	195	+2.7	+7.8
Total, Western Europe	415	435	435	445	450	460	450	425	435	445	445	+.4	−.7
Middle East:													
Iran	1,710	1,910	2,110	2,600	2,840	3,375	3,845	4,565	5,050	5,895	6,060	+13.4	+12.4
Iraq	1,255	1,315	1,390	1,230	1,505	1,525	1,565	1,700	1,465	2,020	1,935	+4.4	+4.8
Kuwait	2,115	2,170	2,275	2,290	2,420	2,575	2,735	2,925	3,000	2,755	2,275	+.7	−2.4
Neutral Zone	360	370	420	415	405	420	505	545	565	535	545	+4.1	+5.3
Qatar	215	235	290	325	340	355	370	430	485	570	520	+9.3	+7.9
Saudi Arabia	1,730	2,025	2,395	2,600	2,830	2,995	3,550	4,500	5,730	7,345	8,210	+16.8	+22.4
Abu Dhabi	185	280	360	380	495	600	695	935	1,050	1,305	1,415	+22.4	+18.7
Oman				55	240	330	330	285	280	295	295	([2])	−2.1
Other Middle East	50	60	65	75	105	185	245	320	345	390	465	+25.1	+19.7
Total, Middle East	7,620	8,365	9,305	9,970	11,180	12,360	13,840	16,205	17,970	21,110	21,720	+11.0	+11.9
Africa:													
Algeria	565	575	730	835	915	955	1,040	780	1,070	1,095	1,040	+6.2	+1.7
Libya	860	1,225	1,505	1,745	2,605	3,110	3,320	2,765	2,240	2,180	1,525	+5.9	−13.3
Other North Africa	130	130	140	170	290	420	555	505	435	335	325	+9.4	−5.2
Nigeria	120	275	420	320	145	540	1,085	1,530	1,820	2,055	2,330	+34.2	+33.9
Other West Africa	50	40	45	85	120	155	215	230	270	350	420	+24.0	+22.9
Total, Africa	1,725	2,245	2,840	3,155	4,075	5,180	6,215	5,810	5,835	6,015	5,640	+12.6	+1.8
Southeast Asia:													
Indonesia	470	485	475	510	600	750	855	890	1,080	1,335	1,395	+11.5	+13.2
Other Southeast Asia	75	80	95	110	125	140	160	220	250	325	305	+15.2	+17.1
Total, Southeast Asia	545	565	570	620	725	890	1,015	1,110	1,330	1,660	1,700	+12.0	+13.8
U.S.S.R.	4,485	4,885	5,335	5,795	6,190	6,595	7,090	7,470	7,890	8,455	9,055	+7.3	+6.6
Eastern Europe	300	305	315	325	330	325	325	340	345	345	350	+1.4	+1.5
China [3]	190	215	265	240	280	315	430	540	630	845	1,050	+18.9	+27.3
Other, Eastern Hemisphere	85	105	140	175	195	210	360	500	555	580	575	+20.8	+22.1
Total, Eastern Hemisphere	15,365	17,120	19,205	20,725	23,425	26,335	29,725	32,400	34,990	39,455	40,535	+10.1	+9.0
World (excluding U.S.S.R., Eastern Europe, and China)	24,545	26,345	28,525	30,665	33,540	36,380	39,945	41,975	44,115	48,200	47,515	+6.7	+5.5
World	29,520	31,750	34,440	37,025	40,340	43,615	47,790	50,325	52,980	57,845	57,970	+6.9	+5.9

[1] Based on weight.
[2] Greater than 300 percent.
[3] Includes Albania.

Source: The British Petroleum Co., BP Statistical Review of the World Oil Industry, 1974 London, 1975, p. 19.

APPENDIX V

WORLD OIL PRODUCTION, 1964–74

[In thousand barrels daily]

Country/Area	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Yearly change [1] (percent) 1974 over 1964	Yearly change [1] (percent) 1974 over 1969
CONSUMPTION													
United States [2]	10,815	11,300	11,850	12,280	13,085	13,815	14,350	14,845	15,990	16,870	16,220	+4.1	+3.3
Canada	1,070	1,145	1,210	1,285	1,375	1,440	1,525	1,585	1,655	1,755	1,850	+5.5	+5.0
Other Western Hemisphere	1,935	2,040	2,195	2,270	2,440	2,610	2,820	3,035	3,275	3,515	3,705	+6.6	+7.1
Total, Western Hemisphere	13,820	14,485	15,255	15,835	16,900	17,865	18,695	19,465	20,920	22,140	21,775	+4.6	+4.0
Benelux	740	835	890	940	1,030	1,150	1,290	1,290	1,425	1,470	1,275	+5.4	+1.6
France	970	1,100	1,190	1,360	1,470	1,705	1,920	2,090	2,315	2,585	2,435	+9.7	+7.7
West Germany	1,400	1,620	1,830	1,895	2,135	2,420	2,655	2,745	2,885	3,070	2,785	+6.9	+2.8
Italy	930	1,030	1,135	1,260	1,385	1,530	1,740	1,875	1,970	2,070	2,010	+7.8	+5.4
United Kingdom	1,360	1,495	1,610	1,690	1,830	1,950	2,060	2,080	2,210	2,300	2,150	+4.6	+2.0
Scandinavia	615	690	785	790	880	1,005	1,130	1,095	1,125	1,120	1,020	+5.2	+.1
Spain	195	230	270	325	365	425	490	570	605	735	765	+15.0	+13.0
Other Western Europe	715	820	900	1,000	1,100	1,225	1,375	1,510	1,620	1,810	1,730	+9.2	+7.1
Total, Western Europe	6,925	7,820	8,610	9,260	10,195	11,410	12,660	13,255	14,155	15,160	14,170	+7.3	+4.4
Japan	1,495	1,750	2,005	2,465	2,850	3,390	4,000	4,435	4,735	5,450	5,310	+13.3	+9.1
Australasia	380	430	450	485	530	560	600	625	640	685	710	+6.3	+4.5
U.S.S.R.	3,435	3,645	3,900	4,250	4,545	4,875	5,290	5,540	5,970	6,425	6,910	+7.3	+7.2
Eastern Europe	540	610	695	770	865	995	1,090	1,200	1,325	1,510	1,585	+11.1	+9.7
China [3]	205	240	285	260	305	340	460	560	645	845	985	+16.6	+23.5
Other Eastern Hemisphere	2,035	2,120	2,345	2,695	2,950	3,315	3,535	3,760	4,080	4,395	4,545	+8.3	+6.6
Total, Eastern Hemisphere	15,015	16,615	18,290	20,185	22,240	24,885	27,635	29,375	31,550	34,470	34,215	+8.5	+6.5
World	28,835	31,100	33,545	36,020	39,140	42,750	46,330	48,840	52,470	56,610	55,990	+6.8	+5.5

MAIN PRODUCT DEMAND (INCLUDING BUNKERS)

United States:												
Gasolines	4,910	5,110	5,365	5,560	5,915	6,125	6,330	6,580	6,960	7,260	7,095	+3.7	+3.0
Middle distillates	2,620	2,725	2,855	3,035	3,280	3,435	3,520	3,660	3,940	4,135	3,895	+4.0	+2.6
Fuel oil	1,405	1,505	1,615	1,675	1,710	1,860	2,090	2,190	2,420	2,700	2,530	+6.0	+6.4
Total	8,935	9,340	9,835	10,270	10,905	11,420	11,940	12,430	13,320	14,095	13,520	+4.3	+3.5
Western Europe:													
Gasolines	1,320	1,500	1,720	1,930	2,070	2,260	2,410	2,640	2,895	3,090	2,875	+8.1	+5.0
Middle distillates	2,040	2,335	2,585	2,815	3,195	3,650	4,170	4,425	4,755	5,130	4,610	+8.5	+4.8
Fuel oil	2,545	2,885	3,070	3,250	3,505	3,890	4,340	4,440	4,680	4,955	4,675	+6.2	+3.7
Total	5,905	6,720	7,375	7,995	8,770	9,800	10,920	11,505	12,330	13,175	12,160	+7.4	+4.4
EXPORTS													
United States	200	190	200	310	200	230	260	220	225	230	220	+.9	
Caribbean	3,160	3,210	3,100	3,200	3,250	3,440	3,300	3,630	3,535	3,685	3,245	+.2	−1.4
Other Western Hemisphere	360	330	390	610	620	660	780	860	1,215	1,540	1,290	+14.4	+16.0
Middle East	6,930	7,690	8,570	9,140	10,440	11,520	12,930	15,250	16,945	19,990	20,050	+11.2	+11.7
North Africa	1,440	1,720	2,240	2,460	3,620	4,230	4,690	3,880	3,480	3,400	2,625	+5.8	−9.2
Southeast Asia	370	340	350	410	440	830	800	930	1,125	1,370	1,400	+14.0	+10.3
U.S.S.R., Eastern Europe, and China	800	900	1,030	1,090	1,100	1,130	1,160	1,270	1,300	1,370	1,400	+5.7	+4.7
Other Eastern Hemisphere	360	610	670	690	730	1,130	1,680	2,100	2,380	2,600	3,100	+25.2	+19.9
World	13,620	14,990	16,550	17,910	20,400	23,170	25,600	28,140	30,205	34,185	33,330	+9.2	+7.4
IMPORTS													
United States	2,260	2,470	2,570	2,540	2,810	3,170	3,420	3,930	4,740	6,255	6,125	+10.4	+14.1
Western Europe	6,900	7,600	8,580	9,250	10,480	11,430	12,940	13,620	14,065	15,405	14,840	+7.8	+5.5
Japan	1,470	1,720	2,000	2,400	3,060	3,590	4,280	4,720	4,815	5,480	5,430	+13.6	+8.1
Rest of world	2,990	3,200	3,400	3,720	4,050	4,980	4,960	5,970	6,585	7,045	6,935	+8.6	+6.1
World	13,620	14,990	16,550	17,910	20,400	23,170	25,600	28,140	30,205	34,185	33,330	+9.2	+7.4

[1] Based on weight.
[2] U.S. processing gain has been deducted from local domestic product demand.
[3] Includes Albania, North Korea, and North Vietnam.

Source: The British Petroleum Co., "BP Statistical Review of the World Oil Industry, 1974," London, 1975, p. 21.

APPENDIX VI

WORLD OIL CONSUMPTION, 1974 AND 1973

Country/area	Million tons 1974	Million tons 1973	Percentage: 1974 share of total	Percentage: Change: 1974 over 1973	Percentage: Change: Annual average 1969–74	Thousand barrels daily 1974	Thousand barrels daily 1973
United States	785.4	818.0	28.6	−4.0	+3.3	[1] 16,220	[1] 16,670
Canada	88.1	83.7	3.2	+5.3	+5.0	1,850	1,755
Mexico	31.1	29.6	1.1	+5.0	+7.6	645	610
Caribbean	70.4	66.7	2.6	+5.5	+7.9	1,455	1,380
South America	77.4	73.6	2.8	+5.1	+6.2	1,605	1,525
Total, Western Hemisphere	1,052.4	1,071.6	38.3	−1.8	+4.0	21,775	22,140
Belgium and Luxembourg	27.5	31.5	1.0	−12.7	+1.8	555	635
Netherlands	35.4	41.3	1.3	−14.3	+1.5	720	835
France	120.1	127.3	4.4	−5.7	+7.7	2,435	2,585
West Germany	134.4	149.7	4.9	−10.2	+2.8	2,785	3,070
Italy	100.7	103.6	3.7	−2.7	+5.4	2,010	2,070
United Kingdom	105.8	113.4	3.9	−6.7	+2.0	2,150	2,300
Scandinavia	51.1	55.9	1.9	−8.6	+.1	1,020	1,120
Spain	38.2	36.3	1.4	+5.3	+13.0	765	735
Other Western Europe	86.0	90.0	3.1	−4.5	+7.1	1,730	1,810
Total, Western Europe	699.2	749.0	25.6	−6.6	+4.4	14,170	15,160

Middle East	69.7	64.6	2.5	+7.9	+8.1	1,355	1,255
Africa	47.0	47.5	1.7	−1.0	+3.8	965	975
South Asia	31.5	33.2	1.1	−5.0	+3.1	640	675
Southeast Asia	79.2	74.7	2.9	+6.1	+8.8	1,585	1,490
Japan	261.1	268.3	9.5	−2.7	+9.1	5,310	5,450
Australia	33.9	32.8	1.2	+3.2	+4.5	710	685
U.S.S.R.	341.8	317.7	12.5	+7.6	+7.2	6,910	6,425
Eastern Europe	78.3	74.8	2.9	+4.7	+9.7	1,585	1,510
China [2]	48.8	41.7	1.8	+17.0	+23.5	985	845
Total, Eastern Hemisphere	1,690.5	1,704.3	61.7	−.8	+6.5	34,215	34,470
World (excluding U.S.S.R., Eastern Europe and China)	2,274.0	2,341.7	82.8	−2.9	+4.9	46,510	47,830
World	2,742.9	2,775.9	100.0	−1.2	+5.5	55,990	56,610

[1] U.S. processing gain has been deducted from total domestic product demand.
[2] Includes Albania, North Korea, and North Vietnam.

Note: Differences between production and consumption are accounted for by stock changes and unknown military liftings.

Source: The British Petroleum Co., "BP Statistical Review of the World Oil Industry, 1974," London, 1975, p. 8.

APPENDIX VII

CRUDE PRODUCTION IN UNITED STATES, WESTERN HEMISPHERE, AND WORLD

[In thousands of barrels]

Year	U.S. annual total [1]	U.S. daily average	Western Hemisphere annual total	Western Hemisphere daily average	World annual total	World daily average
1918	355, 928	975	426, 416	1, 168	503, 515	1, 379
1919	378, 367	1, 037	471, 966	1, 293	555, 875	1, 523
1920	442, 929	1, 210	607, 262	1, 659	688, 884	1, 882
1921	472, 183	1, 294	675, 418	1, 850	766, 002	2, 099
1922	557, 531	1, 527	753, 197	2, 064	858, 898	2, 353
1923	732, 407	2, 007	899, 025	2, 463	1, 015, 736	2, 783
1924	713, 940	1, 951	880, 441	2, 406	1, 014, 318	2, 771
1925	763, 743	2, 092	920, 399	2, 522	1, 068, 933	2, 929
1926	770, 874	2, 112	928, 812	2, 545	1, 096, 823	3, 005
1927	901, 129	2, 469	1, 068, 549	2, 928	1, 262, 582	3, 459
1928	901, 474	2, 463	1, 107, 739	3, 027	1, 324, 774	3, 620
1929	1, 007, 323	2, 760	1, 243, 895	3, 408	1, 485, 867	4, 071
1930	898, 011	2, 460	1, 128, 557	3, 092	1, 410, 037	3, 863
1931	851, 081	2, 332	1, 053, 842	2, 887	1, 372, 532	3, 760
1932	785, 159	2, 145	986, 768	2, 696	1, 309, 677	3, 578
1933	905, 656	2, 481	1, 109, 944	3, 041	1, 442, 146	3, 951
1934	908, 065	2, 488	1, 144, 154	3, 135	1, 522, 288	4, 171
1935	996, 596	2, 730	1, 249, 114	3, 422	1, 654, 495	4, 533
1936	1, 099, 687	3, 005	1, 364, 162	3, 727	1, 791, 540	4, 895
1937	1, 279, 160	3, 505	1, 587, 471	4, 349	2, 039, 231	5, 587
1938	1, 214, 355	3, 327	1, 522, 785	4, 172	1, 988, 041	5, 447
1939	1, 264, 962	3, 466	1, 610, 055	4, 411	2, 086, 160	5, 715
1940	1, 353, 214	3, 697	1, 674, 747	4, 576	2, 149, 821	5, 874
1941	1, 402, 228	3, 842	1, 763, 800	4, 832	2, 220, 657	6, 084
1942	1, 386, 645	3, 799	1, 652, 161	4, 526	2, 093, 100	5, 734

1943	1,505,613	4,125	1,808,279	4,954	2,256,637	6,183
1944	1,677,904	4,584	2,069,750	5,655	2,592,289	7,083
1945	1,713,655	4,695	2,172,284	5,951	2,594,697	7,109
1946	1,733,939	4,750	2,257,692	6,185	2,745,430	7,522
1947	1,856,987	5,088	2,438,849	6,682	3,022,139	8,280
1948	2,020,185	5,520	2,666,031	7,284	3,433,225	9,380
1949	1,841,940	5,046	2,497,805	6,843	3,404,142	9,326
1950	1,973,574	5,407	2,719,273	7,450	3,802,995	10,419
1951	2,247,711	6,158	3,099,480	8,492	4,282,730	11,733
1952	2,289,836	6,256	3,194,595	8,728	4,504,708	12,308
1953	2,357,082	6,458	3,266,773	8,950	4,798,055	13,145
1954	2,314,988	6,342	3,304,471	9,053	5,016,843	13,745
1955	2,484,428	6,807	3,614,299	9,902	5,625,883	15,413
1956	2,617,283	7,151	3,917,189	10,703	6,124,676	16,734
1957	2,616,901	7,170	4,056,058	11,112	6,438,444	17,640
1958	2,448,987	6,710	3,829,032	10,490	6,607,750	18,103
1959	2,574,590	7,054	4,060,290	11,124	7,133,238	19,543
1960	2,574,933	7,035	4,130,061	11,284	7,674,460	20,968
1961	2,621,758	7,183	4,268,037	11,693	8,186,213	22,428
1962	2,676,189	7,332	4,470,817	12,249	8,881,858	24,334
1963	2,752,723	7,542	4,593,471	12,585	9,538,346	26,132
1964	2,786,822	7,614	4,706,615	12,860	10,309,644	28,168
1965	2,848,514	7,804	4,827,447	13,226	11,062,515	30,308
1966	3,027,763	8,295	5,018,545	13,749	12,021,786	32,936
1967	3,215,742	8,809	5,350,760	14,660	12,914,340	35,382
1968	3,329,042	9,096	5,600,002	15,300	14,146,318	38,651
1969	3,371,751	9,238	5,647,813	15,473	15,222,511	41,706
1970	3,517,450	9,637	5,894,815	16,150	16,718,708	45,805
1971	3,453,914	9,463	5,812,551	15,925	17,662,793	48,391
1972	3,455,368	9,441	5,804,018	15,858	18,600,501	50,821
1973	3,353,370	9,187	5,896,433	16,155	20,322,140	55,677

[1] Includes field condensate.

Source: DeGolyer and MacNaughton, "Twentieth Century Petroleum Statistics, 1974", Dallas, Tex., September 1974, p. 13. Authority: U.S. Bureau of Mines.

APPENDIX VIII

WORLD CRUDE PRODUCTION

[In thousands of barrels]

Year	Middle East												Total Middle East
	Bahrain Island	Iran	Iraq	Israel	Kuwait	Neutral zone	Oman	Qatar	Saudi Arabia	Syria	Trucial States [1]	Turkey	
1918		8,623											8,623
1919		10,139											10,139
1920		12,230											10,230
1921		16,673											16,673
1922		22,247											22,247
1923		25,230											25,230
1924		32,373											32,373
1925		34,038											35,038
1926		35,842											35,842
1927		39,688	388										40,076
1928		43,461	713										44,174
1929		32,145	798										42,943
1930		45,833	913										46,746
1931		44,376	830										45,206
1932	1	49,471	836										50,308
1933	31	54,392	917										55,340
1934	285	57,851	7,689										65,825
1935	1,265	57,283	27,408										85,946
1936	4,645	62,718	30,406						20				97,789
1937	7,762	77,804	31,836						65				117,467
1938	8,298	78,372	32,643						495				119,808
1939	7,589	78,151	30,791						3,934				120,465

1940	7,704	66,317	24,225						5,075				102,691
1941	6,794	50,777	12,650						4,310				74,531
1942	6,241	72,256	19,726						4,530				102,753
1943	6,572	74,612	24,948						4,868				110,900
1944	6,714	102,045	30,045						7,794				147,496
1945	7,309	130,526	35,112						21,311				194,258
1946	8,010	146,819	35,665		5,931				59,944				256,369
1947	9,411	154,998	35,834		16,225				89,852				306,320
1948	10,915	190,384	26,115		46,500				142,853			13	416,780
1949	10,985	204,712	30,957		90,000			750	174,008			95	511,507
1950	11,016	242,475	49,726		125,722			12,268	199,547			108	640,862
1951	10,994	123,512	65,122		204,910			18,009	277,963			133	700,643
1952	11,004	7,800	141,100		273,433			25,255	301,861			146	760,599
1953	10,978	9,400	210,268		314,592			31,025	308,294			179	884,736
1954	10,992	21,500	228,432		347,319	5,995		36,450	347,845			399	998,932
1955	10,982	120,562	251,206		398,493	8,848		41,983	352,240			1,205	1,185,509
1956	11,015	197,148	232,307	146	399,874	11,684		45,300	360,923			2,213	1,260,610
1957	11,691	263,134	163,498	394	416,045	23,259		50,798	362,121			2,159	1,293,099
1958	14,823	301,361	266,125	642	509,654	29,469		63,412	370,486			2,379	1,558,351
1959	16,473	344,800	311,193	925	504,855	42,438		61,431	399,821			2,700	1,684,636
1960	16,500	385,748	353,833	932	594,278	49,829		63,088	456,453			2,624	1,923,285
1961	16,444	431,653	365,594	1,133	600,226	65,153		64,386	508,269			3,075	2,055,933
1962	16,446	481,939	366,832	1,126	669,284	89,224		67,911	555,056		5,976	4,157	2,227,951
1963	16,503	538,121	423,140	1,091	705,471	114,535		70,123	594,592		17,571	5,201	2,486,348
1964	18,000	618,731	461,961	1,435	774,815	131,425		77,885	628,095		67,465	6,397	2,786,199
1965	20,788	688,215	482,461	1,469	791,903	132,181		84,215	739,078		102,804	10,827	3,053,941
1966	22,522	771,234	505,428	1,359	830,537	153,432		105,945	873,349		131,279	13,277	3,408,361
1967	25,370	947,706	448,239	8,687	836,719	151,461	23,030	118,428	948,110		140,117	19,526	3,667,393
1968	27,598	1,039,367	548,705	14,689	886,125	156,721	87,854	124,266	1,035,773	9,955	181,756	22,235	4,135,044
1969	27,774	1,231,826	555,241	18,042	940,041	163,149	119,710	129,746	1,092,322	16,771	222,598	25,774	4,542,994
1970	27,973	1,397,460	568,547	31,798	998,110	183,859	121,210	132,456	1,295,335	29,356	283,500	24,776	5,094,380
1971	27,346	1,661,901	624,312	44,618	1,067,795	199,068	107,430	156,882	1,641,615	36,462	386,655	25,031	5,979,115
1972	25,508	1,838,625	529,419	43,920	1,097,719	207,254	103,131	176,545	2,098,422	45,209	440,132	24,416	6,630,500
1973	24,948	2,139,269	716,751	32,193	1,004,781	191,175	106,926	208,014	2,677,146	38,170	554,332	24,273	7,717,978

[1] Includes Abu Dhabi and Dubai.

Source: DeGolyer and MacNaughton, "Twentieth Century Petroleum Statistics," 1974, p. 9.
Authority: U.S. Bureau of Mines.

APPENDIX IX

PERCENTAGE OF WORLD CRUDE OIL PRODUCTION BY COUNTRIES

Continent and country	1938	1950	1955	1960	1965	1970	1971	1972	1973
North America	63.38	54.56	48.06	37.24	29.47	24.86	23.35	22.59	20.63
Canada	.35	.76	2.30	2.46	2.64	2.76	2.79	3.01	3.19
Cuba			.01	0	0	0	0	0	0
Mexico	1.94	1.90	1.59	1.29	1.07	1.06	1.01	1.00	.94
United States	61.08	51.90	44.16	33.49	25.76	21.04	19.55	18.58	16.50
South America	13.22	16.94	16.18	16.47	14.15	10.40	9.56	8.61	8.38
Argentina	.86	.61	.54	.83	.89	.86	.87	.85	.76
Bolivia	.01	.02	.05	.04	.03	.05	.07	.09	.08
Brazil		.01	.03	.39	.31	.36	.36	.33	.31
Colombia	1.09	.90	.71	.73	.66	.48	.44	.38	.33
Ecuador	.11	.07	.06	.04	.03	.01	.01	.15	.37
Peru	.80	.39	.31	.25	.21	.16	.13	.13	.13
Trinidad	.89	.54	.44	.55	.44	.30	.27	.28	.30
Venezuela	9.46	14.38	14.00	13.55	11.46	8.10	7.33	6.34	6.04
Other South America		.02	.04	.09	.12	.08	.08	.06	.06
Europe	13.24	8.72	11.91	16.75	18.54	16.87	17.23	17.06	16.62
Austria	.02	.27	.44	.22	.18	.12	.10	.09	.09
France	.02	.02	.11	.18	.20	.10	.08	.06	.04
Germany, West	.19	.22	.40	.52	.51	.32	.30	.28	.24
Italy	.01		.03	.18	.14	.06	.05	.04	.03
Netherlands		.13	.13	.71	.15	.08	.07	.06	.05
Rumania	2.44	.84	1.40	1.11	.85	.61	.58	.57	.52
U.S.S.R.	10.31	7.00	9.06	14.04	16.15	15.25	15.73	15.57	15.23
United Kingdom		.01	.01	.01	0	0	.01	.01	.02
Yugoslavia		.02	.03	.09	.14	.13	.12	.13	.12
Other Europe	.25	.21	.30	.23	.22	.20	.19	.25	.28

Africa	.08	.44	.25	1.37	7.34	13.25	11.66	11.21	10.58
Algeria		.01	.02	.89	1.87	2.25	1.58	2.07	1.92
Angola				.01	.04	.24	.19	.28	.29
Egypt	.08	.43	.23	.31	.41	.71	.61	.45	.30
Gabon				.07	.08	.24	.24	.25	.27
Libya					4.03	7.23	5.70	4.41	3.91
Nigeria				.09	.90	2.37	3.16	3.58	3.68
Other Africa					.01	.21	.18	.17	.21
Asia, Middle East	10.08	19.34	23.60	28.17	30.48	34.23	37.56	39.88	43.08
Bahrain	.42	.29	.19	.22	.19	.17	.15	.14	.13
Brunei and Malaysia	.35	.82	.71	.44	.27	.34	.41	.54	.55
China		.02	.06	.52	.66	.87	.95	1.16	1.80
India	.13	.08	.08	.08	.24	.31	.29	.31	.27
Indonesia	2.88	1.27	1.55	1.99	1.61	1.86	1.84	2.13	2.40
Iran	3.94	6.38	2.14	5.02	6.22	8.36	9.41	9.88	10.63
Iraq	1.64	1.31	4.47	4.60	4.36	3.40	3.53	2.58	3.53
Kuwait		3.31	7.08	7.73	7.16	5.97	6.04	5.90	4.94
Neutral Zone			.16	.65	1.20	1.10	1.13	1.11	.94
Oman						.72	.61	.55	.53
Qatar		.32	.75	.82	.76	.79	.89	.95	1.02
Saudi Arabia	.02	5.25	6.26	5.94	6.68	7.75	9.29	11.28	13.17
Syria						.18	.21	.24	.19
Trucial States (Abu Dhabi and Dubai)					.93	1.70	2.19	2.37	2.73
Other Asia and Middle East	.70	.29	.15	.16	.20	.71	.62	.47	.35
Australia-New Zealand					.02	.39	.64	.65	.71
Total, world production	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: DeGolyer and MacNaughton, "Twentieth Century Petroleum Statistics, 1974," p. 3. Authority: U.S. Bureau of Mines.

APPENDIX X

OIL PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES—WORLDWIDE OIL AND GAS STATISTICS, BY COUNTRY

[Potential resources: See "Explanatory Notes" in text. Asterisk (*), estimated; ..., landlocked; Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add up to the totals where the onshore/offshore breakdown was not available]

Continent and country	1972 production						Cumulative production					
	Millions of 42-gal bbls			Millions of metric tons			Millions of 42-gal bbls			Millions of metric tons		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
North America:												
Bahamas	0	0	0	0	0	0	0	0	0	0	0	0
Barbados	Negl	0	Negl	Negl	0	Negl	Negl	0	Negl	Negl	0	Negl
Belize	0	0	0	0	0	0	0	0	0	0	0	0
Canada	560.7	0	560.7	75.8	0	75.8	5,761.0	0	5,761.0	776.0	0	776
Costa Rica	0	0	0	0	0	0	0	0	0	0	0	0
Cuba	1.2	0	1.2	.2	0	.2	13.2	0	13.2	6.6	0	6.6
Dominican Republic	0	0	0	0	0	0	0	0	0	0	0	0
El Salvador	0	0	0	0	0	0	0	0	0	0	0	0
Guatemala	0	0	0	0	0	0	0	0	0	0	0	0
Haiti	0	0	0	0	0	0	0	0	0	0	0	0
Honduras	0	0	0	0	0	0	0	0	0	0	0	0
Jamaica	0	0	0	0	0	0	0	0	Negl	Negl	1	0
Mexico	159.2	25.8	185.0	22.4	3.6	26	4,856.0	103.8	4,960.0	683.4	14.9	698.0
Nicaragua	0	0	0	0	0	0	0	0	0	0	0	0
Panama	0	0	0	0	0	0	0	0	0	0	0	0
United States	2,982.7	472.3	3,455.0	403.1	53.8	466.9	* 104,210.0	* 5,046.0	* 109,256.0	* 14,049.0	* 681	* 14,730.0
Total	3,703.8	498.1	4,201.9	501.5	67.4	568.9	114,840.2	5,149.8	119,990.2	15,515.0	696.9	16,210.6

South America:												
Argentina	158.4	0	158.4	22.7	0	22.7	2,055.7	0	2,055.7	313.7	0	313.7
Bolivia	16.0	-----	16.0	1.9	-----	1.9	144.0	-----	144.0	18.0	-----	18.0
Brazil	57.6	3.5	61.1	7.9	.5	8.4	660.6	5.5	666.1	90.3	.8	91.1
Chile	12.5	0	12.5	1.6	0	1.6	184.5	0	184.5	23.6	0	23.6
Columbia	71.7	0	71.7	10.2	0	10.2	1,722.0	0	1,722.0	244.0	0	244.0
Ecuador	28.6	0	28.6	3.8	0	3.8	134.6	0	134.6	17.6	0	17.6
Guyana	0	0	0	0	0	0	0	0	0	0	0	0
Paraguay	0	-----	0	0	-----	0	0	-----	0	0	-----	0
Peru	13.5	10.1	23.6	1.8	1.3	3.1	808.5	59.1	867.6	107.8	7.3	115.1
Trinidad and Tobago	41.5	9.7	51.2	6	1.3	7.3	1,054.5	290.7	1,345.2	151.0	41.3	192.3
Uruguay	0	0	0	0	0	0	0	0	0	0	0	0
Venezuela	1,178.0	0	1,178.0	168.3	0	168.3	28,808.0	0	28,808.0	4,112.0	0	4,112.0
Total	1,574.2	23.3	2,024.2	224.2	3.1	227.3	35,572.4	355.3	35,927.7	5,078.0	49.4	5,127.4
Africa:												
Algeria	400.0	0	400.0	52	0	52.0	3,318.0	0	3,318.0	430.0	0	430.0
Angola	4.9	46.5	51.4	.7	6.4	7.1	56.7	124.5	181.4	8	17.0	25.0
Botswana	0	-----	0	0	-----	0	0	-----	0	0	-----	0
Burundi	0	-----	0	0	-----	0	0	-----	0	0	-----	0
Cameroon	0	0	0	0	0	0	0	0	0	0	0	0
Central African Republic	0	-----	0	0	-----	0	0	-----	0	0	-----	0
Chad	0	-----	0	0	-----	0	0	-----	0	0	-----	0
Congo	.7	1.8	2.5	.1	.2	.3	5.9	1.8	7.7	.8	.2	1.0
Dahomey	0	0	0	0	0	0	0	0	0	0	0	0
Egypt	NA	>58.4	79.0	NA	>8.4	11.4	NA	>530.4	1,015.0	NA	>76.4	146.4
Equatorial Guinea	0	0	0	0	0	0	0	0	0	0	0	0
Ethiopia	0	0	0	0	0	0	0	0	0	0	0	0
Gabon	25.8	19.9	45.7	3.6	2.7	6.3	216.0	67.0	28.3	29.6	9.7	39.3
Gambia	0	0	0	0	0	0	0	0	0	0	0	0
Ghana	0	0	0	0	0	0	0	0	0	0	0	0
Guinea	0	0	0	0	0	0	0	0	0	0	0	0
Ivory Coast	0	0	0	0	0	0	0	0	0	0	0	0
Kenya	0	0	0	0	0	0	0	0	0	0	0	0
Lesotho	0	-----	0	0	-----	0	0	-----	0	0	-----	0
Liberia	0	0	0	0	0	0	0	0	0	0	0	0
Libyan Arab Republic	819.6	0	819.6	107.8	0	107.8	7,314.6	0	7,314.0	961.0	0	961.0
Malagasy Republic	0	0	0	0	0	0	0	0	0	0	0	0
Malawi	0	-----	0	0	-----	0	0	-----	0	0	-----	0
Mali	0	-----	0	0	-----	0	0	-----	0	0	-----	0
Mauritania	0	0	0	0	0	0	0	0	0	0	0	0
Mauritius	0	0	0	0	0	0	0	0	0	0	0	0
Morocco	.2	0	.2	Negl	0	Negl	15.0	0	15.0	2.0	0	2.0
Mozambique	0	0	0	0	0	0	0	0	0	0	0	0
Niger	0	-----	0	0	-----	0	0	-----	0	0	-----	0
Nigeria	482.5	182.8	665.3	65.1	24.7	89.8	1,798.0	563.3	2,362.0	243.0	76.0	318.5
Portuguese Guinea	0	0	0	0	0	0	0	0	0	0	0	0
Rwanda	0	-----	0	0	-----	0	0	-----	0	0	-----	0

APPENDIX X—Continued

OIL PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES—WORLDWIDE OIL AND GAS STATISTICS, BY COUNTRY—Continued

[Potential resources: See "Explanatory Notes" in text. Asterisk (*), estimated; ---, landlocked; Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add up to the totals where the onshore/offshore breakdown was not available.]

Continent and country	1972 production						Cumulative production					
	Millions of 42-gal bbls			Millions of metric tons			Millions of 42-gal bbls			Millions of metric tons		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
Senegal	0	0	0	0	0	0	0	0	0	0	0	0
Sierra Leone	0	0	0	0	0	0	0	0	0	0	0	0
Somalia	0	0	0	0	0	0	0	0	0	0	0	0
South Africa	0	0	0	0	0	0	0	0	0	0	0	0
Southwest Africa	0	0	0	0	0	0	0	0	0	0	0	0
Sudan	0	0	0	0	0	0	0	0	0	0	0	0
Swaziland	0	---	0	0	---	0	0	---	0	0	---	0
Tanzania	0	0	0	0	0	0	0	0	0	0	0	0
Togo	0	0	0	0	0	0	0	0	0	0	0	0
Tunisia	31.6	0	31.6	4.1	0	4.1	173.0	0	173.0	22.0	0	22.0
Uganda	0	---	0	0	---	0	0	---	0	0	---	
Upper Volta	0	---	0	0	---	0	0	---	0	0	---	0
Zaire	0	0	0	0	0	0	0	0	0	0	0	0
Zambia	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,765.3	309.4	2,095.3	233.4	42.4	253.7	12,897.2	1,287.5	14,415.0	1,696.4	179.3	1,945.2
Europe:												
Albania	15.0	0	15.0	2.2	0	2.2	96.0	0	97.0	14.2	0	14.2
Austria	17.3	---	17.3	2.5	---	2.5	502.0	---	502.0	73.0	---	73.0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	1.8	0	1.8	.2	0	.2	>66.0	0	>66.0	>9.2	0	>9.2
Czechoslovakia	1.4	---	1.4	.2	---	.2	*28.4	---	*28.4	*4.2	---	*4.2
Denmark	0	.6	.6	0	Negl	Negl	0	.6	.6	0	Negl	Negl
Finland	0	0	0	0	0	0	0	0	0	0	0	0
France	16.8	0	16.8	2.3	0	2.3	315.0	0	315.0	43.0	0	43.0
German Democratic Republic	1.8	0	1.8	.2	0	.2	NA	0	NA	NA	0	NA
Germany, Federal Republic of	51.3	0	51.3	7.1	0	7.1	994.0	0	994.0	138.0	0	138.0
Greece	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	15.2	---	15.2	2.0	---	2.0	283.0	---	283.0	37.0	---	37.0
Iceland	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0
Italy	7.3	.7	8.0	1.2	Negl	1.2	122.0	63.0	185.0	18.0	9.0	27.0

Lichtenstein	0	----	0	0	----	0	0	----	0	0	----	0
Luxembourg	0	----	0	0	----	0	0	----	0	0	----	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	10.9	0	10.9	1.6	0	1.6	271.0	0	271.0	39.0	0	39.
Norway	0	12.1	12.1	0	1.6	1.6	0	14.0	14.0	0	1.9	1.9
Poland	2.6	0	2.6	.3	0	.3	324.6	0	324.6	43.0	0	43.0
Portugal	0	0	0	0	0	0	0	0	0	0	0	0
Romania	105.0	0	105.0	14.2	0	14.2	3,037.0	0	3,037.0	407.0	0	407.0
San Marino	0	----	0	0	----	0	0	----	0	0	----	0
Spain	1.0	0	1.0	.1	0	.1	7.0	0	7.0	1.0	0	1.0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0
Switzerland	0	----	0	0	----	0	0	----	0	0	----	0
United Kingdom	.6	0	.6	Negl	0	Negl	19.0	0	19.0	3.0	0	3.0
Yugoslavia	23.7	0	23.7	3.2	0	3.2	228.7	0	228.7	31.2	0	31.2
Total	271.7	13.4	285.1	37.3	1.6	38.9	6,293.7	77.6	6,372.3	860.8	10.9	871.7
Europe and Asia: Union of Soviet Socialist Republics	2,895.9	0	2,895.9	394.0	0	394.0	37,138.0	0	37,183.0	059.0	0	5,059.0
Asia:												
Afghanistan	Negl	----	Negl	Negl	----	Negl	Negl	----	Negl	Negl	----	Negl
Bahrain	25.5	0	25.5	3.5	0	3.5	532.0	0	532.0	>3.0	0	73.0
Bangladesh	0	0	0	0	----	0	0	0	0	0	0	0
Bhutan	0	----	0	0	----	0	0	----	0	0	----	0
Brunei	21:8	45.2	67.0	3.0	6.2	9.2	>809.2	190.8	>1,000.0	>110.8	26.1	>136.9
Burma	7.5	0	7.5	1.0	0	1.0	421.5	0	421.5	56.0	0	56.0
China:												
People's Republic of China	192.0	Negl	192.0	26.0	Negl	26.0	<1,163	Negl	1,163	<159.0	Negl	159.0
Republic of China (Taiwan)	.9	0	.9	.1	0	.1	4.5	0	4.5	.6	0	.6
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0
India	57.0	0	57.0	7.7	0	7.7	433.0	0	433.0	59.0	0	59.0
Indonesia	374.0	21.0	395.0	51.0	3.2	54.1	5,043.0	24.0	5,067.0	686.0	3.2	690.1
Iran	1,580.0	258.0	1,838.0	214.4	35.0	249.4	NA	NA	15,809.0	NA	NA	2,145.0
Iraq	529.0	0	529.0	71.2	0	71.2	8,658.0	0	8,658.0	T.164.0	0	1,164.0
Israel	43.9	0	43.9	6.0	0	6.0	170.0	0	170.0	24.0	0	24.0
Japan	4.8	.4	5.2	.6	.1	.7	158.0	9.4	167.0	22.0	1.0	23.0
Jordan	0	----	0	0	----	0	0	----	0	0	----	0
Khmer Republic	0	0	0	0	0	0	0	0	0	0	0	0
Korea, Democratic People's Republic of	0	0	0	0	0	0	0	0	0	0	0	0
Korea, Republic of	0	0	0	0	0	0	0	0	0	0	0	0
Kuwait	1,126.3	75.0	1,201.3	155.5	11.0	166.5	<14,902.0	505.0	15,407.0	<2,052.0	>70.0	2,122.0
Laos	0	----	0	0	----	0	0	----	0	0	----	0
Lebanon	0	0	0	0	0	0	0	0	0	0	0	0
Malaysia	0	33.6	33.6	0	4.4	4.4	4.0	69.2	73.2	.6	8.9	9.5
Maldives	0	0	0	0	0	0	0	0	0	0	0	0
Mongolia	0	----	0	0	----	0	0	----	0	0	----	0
Nepal	0	----	0	0	----	0	0	0	0	0	0	0

APPENDIX X—Continued

OIL PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES—WORLDWIDE OIL AND GAS STATISTICS, BY COUNTRY—Continued

[Potential resources: See "Explanatory Notes" in text. Asterisk (*), estimated; ___, landlocked; Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add up to the totals where the onshore/offshore breakdown was not available]

Continent and country	1972 production						Cumulative production					
	Millions of 42-gal bbls			Millions of metric tons			Millions of 42-gal bbls			Millions of metric tons		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
Oman	102.8	0	102.8	14.1	0	14.1	560.0	0	560.0	76.0	0	76.0
Pakistan	3.4	0	3.4	.5	0	.5	76 0	0	76.0	1.0	0	11.0
Philippines	0	0	0	0	0	0	0	0	0	0	0	0
Qatar	88.8	87.8	176.5	11.5	11.4	22.9	782.0	288.0	1,070.0	172.0	57.0	229.0
Saudi Arabia	1,595.0	757.0	2,352.0	216.0	103.0	319.0	13,292.0	3,985.0	17,277.0	1,810	543.0	2,353.0
Singapore	0	0	0	0	0	0	0	0	0	0	0	0
Sri Lanka	0	0	0	0	0	0	0	0	0	0	0	0
Syrian Arab Republic	43.5	___	43.5	6.3	___	6.3	NA	___	NA	NA	___	NA
Thailand	Negl	0	Negl	Negl	0	Negl	.6	0	.6	.1	0	.1
Turkey	36.2	0	24.2	3.4	0	3.4	198.0	0	198.0	27.0	0	27.0
United Arab Emirates	259.6	173.3	432.9	34.6	23.1	57.7	*1,178.0	*790.0	*1,974.0	157.0	105.0	262.0
Viet-Nam Democratic Republic of	0	0	0	0	0	0	0	0	0	0	0	0
Viet-Nam, Republic of	0	0	0	0	0	0	0	0	0	0	0	0
Yemen Arab Republic (San'a)	0	0	0	0	0	0	0	0	0	0	0	0
Yemen People's Republic of (Aden)	0	0	0	0	0	0	0	0	0	0	0	0
Total	6,080.0	1,451.2	7,531.2	826.4	197.4	1,023.7	48,384.8	5,867.4	70,060.8	6,660.1	814.2	9,620.0
Oceania:												
Austrailia	29.0	114.0	143.0	3.6	14.8	18.4	108.6	257.2	365.8	14.1	33.5	47.6
Fiji	0	0	0	0	0	0	0	0	0	0	0	
Naura	0	0	0	0	0	0	0	0	0	0	0	0
New Zealand	1.1	0	1.1	.1	0	.1	5.5	0	5.5	.3	0	.3
Tonga	0	0	0	0	0	0	0	0	0	0	0	0
Western Samoa	0	0	0	0	0	0	0	0	0	0	0	0
Total	30.1	114.0	144.1	3.7	14.8	18.5	114.1	257.2	371.3	14.4	33.5	47.9
151 country total	16,321.0	2,409.4	19,177.7	2,220.5	326.7	2,525.0	266,769.6	12,994.8	284,320.3	34,883.7	1,784.2	38,882.0

Continent and country	Proved recoverable reserves: Millions of 42-gal bbls: Onshore	Offshore	Total	Millions of metric tons: Onshore	Offshore	Total	Potential resources (Ultimate recoverable resources): Onshore	Offshore	Total
North America:									
Bahamas	0	0	0	0	0	0	VI	VI	VI
Barbados	1.0	0	1.0	.1	0	.1	V	V	IV
Belize	0	0	0	0	0	0	V	V	V
Canada	10,200.0	NA	10,200.0	1,378.0	NA	1,378.0	III	III	III
Costa Rica	0	0	0	0	0	0	VI	V	V
Cuba	9	0	9	1.3	0	1.3	V	V	V
Dominican Republic	0	0	0	0	0	0	V	V	V
El Salvador	0	0	0	0	0	0	0	V	V
Guatemala	0	0	0	0	0	0	IV	V	IV
Haiti	0	0	0	0	0	0	V	V	V
Honduras	0	0	0	0	0	0	V	IV	IV
Jamaica	0	0	0	0	0	0	V	IV	IV
Mexico	NA	>1,934.0	5,388.0	NA	>272.4	758.8	III	II	II
Nicaragua	0	0	0	0	0	0	V	IV	IV
Panama	0	0	0	0	0	0	V	IV	IV
United States	30,398.0	*7,661.0	38,062.0	*4,107.0	*1,035.0	5,143.0	II	II	II
Total	40,598.0	9,598.0	53,660.0	5,486.4	1,307.4	7,281.2	...	...	...
South America:									
Argentina	>2,500.0	NA	>2,500.0	>357.7	NA	>357.7	III	III	III
Bolivia	200.0	...	200.0	24.0	...	24.0	III	...	III
Brazil	778.1	19.6	797.7	106.3	2.7	103.0	IV	IV	IV
Chile	100.6	0	100.6	12.9	0	12.9	IV	IV	IV
Columbia	1,590.0	0	1,590.0	227.0	0	227.0	III	IV	III
Ecuador	5,750.0	0	5,750.0	758.0	0	758.0	III	IV	III
Guyana	0	0	0	0	0	0	IV	V	IV
Paraguay	0	...	0	0	...	0	IV	...	IV
Peru	NA	NA	500.0	NA	NA	66.6	III	IV	III
Trinidad and Tobago	275.0	1,300.0	1,575.0	39.4	1,862.0	225.6	IV	IV	IV
Uruguay	0	0	0	0	0	0	V	V	IV
Venezuela	<13,800.0	NA	13,800.0	<1,971.0	NA	1,971.0	III	III	II
Total	24,993.7	1,319.6	26,813.3	3,496.3	1,864.7	3,751.8	...	...	...

APPENDIX X—Continued

OIL PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES—WORLDWIDE OIL AND GAS STATISTICS, BY COUNTRY—Continued

[Potential resources: See "Explanatory Notes" in text. Asterisk (*), estimated; ---, landlocked; Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add up to the totals where the onshore/offshore breakdown was not available.]

Continent and country	Proved recoverable reserves						Potential resources (Ultimate recoverable resources)		
	Millions of 42-gal bbls			Millions of metric tons					
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
Africa:									
Algeria	11,800.0	0	11,800.0	1,532.5	0	1,532.5	II	0	II
Angola	NA	NA	1,200.0	NA	NA	166.7	IV	IV	IV
Botswana	0	---	0	0	---	0	IV	---	VI
Burundi	0	---	0	0	---	0	0	---	0
Cameroon	0	0	0	0	0	0	V	V	IV
Central African Republic	0	---	0	0	---	0	V	---	V
Chad	0	---	0	0	---	0	IV	---	V
Congo	<4,270.0	>730.0	5,000.0	<571.0	>98.0	669.0	IV	V	IV
Dahomey	0	0	0	0	0	0	V	V	V
Egypt	NA	NA	3,800.0	NA	NA	550.7	IV	III	III
Equatorial Guinea	0	0	0	0	0	0	V	V	V
Ethiopia	0	0	0	0	0	0	V	V	V
Gabon	275.3	652.0	927.3	38.0	90.0	128.0	IV	IV	III
Gambia	0	0	0	0	0	0	V	V	V
Ghana	0	0	0	0	0	0	V	IV	VI
Guinea	0	0	0	0	0	0	V	V	V
Ivory Coast	0	0	0	0	0	0	V	IV	IV
Kenya	0	0	0	0	0	0	IV	V	IV
Lesotho	0	---	0	0	---	0	VI	---	VI
Liberia	0	0	0	0	0	0	0	V	V
Libyan Arab Republic	30,400	NA	>30,400.0	4,000.0	NA	>4,000.0	II	II	II
Malagasy Republic	0	0	0	0	0	0	IV	IV	IV
Malawi	0	---	0	0	---	0	0	---	0
Mali	0	---	0	0	---	0	IV	---	IV
Mauritania	0	0	0	0	0	0	IV	IV	IV
Mauritius	0	0	0	0	0	0	0	0	0
Morocco	1.2	0	1.2	.2	0	.2	IV	IV	IV
Mozambique	0	0	0	0	0	0	IV	IV	IV
Niger	0	---	0	0	---	0	IV	---	IV
Nigeria	9,200.0	3,400.0	12,600.0	1,243.0	459.0	1,702.0	III	III	III
Portuguese Guinea	0	0	0	0	0	0	V	V	V
Rwanda	0	---	0	0	---	0	0	---	0
Senegal	0	0	0	0	0	0	IV	IV	IV

Sierra Leone	0	0	0	0	0	0	V	V	V
Somalia	0	0	0	0	0	0	IV	V	IV
South Africa	NA	NA	NA	NA	NA	NA	VI	V	V
Southwest Africa	0	0	0	0	0	0	V	V	V
Sudan	0	0	0	0	0	0	V	V	V
Swaziland	0		0	0		0	VI		VI
Tanzania	0	0	0	0	0	0	IV	V	IV
Togo	0	0	0	0	0	0	V	V	V
Tunisia	NA	NA	1,000.0	NA	NA	130.0	IV	IV	IV
Uganda	0		0	0		0	0		0
Upper Volta	0		0	0		0	0		0
Zaire	0	0	0	0	0	0	V	V	V
Zambia	0	0	0	0	0	0	0	0	0
Total	55,946.5	4,782.0	66,728.5	7,384.7	647.0	8,879.1			
Europe:									
Albania	90.0	0	90.0	13.6	0	13.6	III	IV	III
Austria	184.5		184.5	26.7		26.7	IV		IV
Belgium	0	0	0	0	0	0	V	IV	IV
Bulgaria	278.0	0	278.0	38.0	0	38.0	IV	IV	IV
Czechoslovakia	12.0		12.0	2.0		2.0	IV		IV
Denmark	0	250.0	250.0	0	34.0	34.0	IV	IV	IV
Finland	0	0	0	0	0	0	0	V	V
France	94.2	0	94.2	13.0	0	13.0	IV	IV	IV
German Democratic Republic	11.0	0	11.0	1.5	0	1.5	IV	V	IV
Germany, Federal Republic of	545.0	0	545.0	76.0	0	76.0	IV	IV	IV
Greece	0	0	0	0	0	0	V	IV	IV
Hungary	210.0		210.0	27.6		27.6	I		IV
Iceland	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	V	V	V
Italy	NA	NA	320.0	NA	NA	32.0	IV	IV	IV
Lichtenstein	0		0	0		0	0		0
Luxembourg	0		0	0		0	0		0
Malta	0	0	0	0	0	0	IV	IV	IV
Netherlands	269.0	0	269.0	39.0	0	39.0	IV	IV	III
Norway	0	7,000.0	7,000.0	0	960.0	960.0	0	III	III
Poland	60.0	0	60.0	8.0	0	8.0	IV	V	IV
Portugal	0	0	0	0	0	0	IV	V	V
Romania	NA	NA	1,480.0	NA	NA	41.9	IV	IV	IV
San Marino	0		0	0		0	0		0
Spain	300.0	NA	>300.0	41.7	NA	>41.7	IV	IV	IV
Sweden	0	0	0	0	0	0	VI	V	V
Switzerland	0		0	0		0	V		V
United Kingdom	NA	5,000.0	>5,000.0	NA	694.0	>694.0	V	III	III
Yugoslavia	356.0	0	356.0	48.0	0	48.0	IV	V	IV
Total	2,409.7	12,250.0	16,559.7	335.1	1,688.0	2,097.0			

APPENDIX X—Continued

OIL PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES—WORLDWIDE OIL AND GAS STATISTICS, BY COUNTRY—Continued

[Potential resources: See "Explanatory Notes" in text. Asterisk (*), estimated; ----, landlocked; Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add up to the totals where the onshore/offshore breakdown was not available]

Continent and country	Proved recoverable reserves: Millions of 42-gal bbls			Proved recoverable reserves: Millions of metric tons			Potential resources (Ultimate recoverable resources)		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
Europe and Asia: Union of Soviet Socialist Republics	75,000.0	NA	75,000.0	10,273.0	NA	10,279.0	II	II	II
Asia:									
Afghanistan	90.0	----	90.0	12.0	----	12.0	IV	----	IV
Bahrain	514.0	0	514.0	70.4	0	70.4	IV	IV	IV
Bangladesh	NA	NA	NA	NA	NA	NA	IV	IV	IV
Bhutan	0	----	0	0	----	0	0	----	0
Brunei	NA	2,413.0	>2,413.0	NA	330.0	>330.0	V	IV	IV
Burma	40.0	0	40.0	5.4	0	5.4	III	IV	III
China:									
People's Republic of China	<20,000.0	NA	20,000.0	<2,700.0	NA	2,700.0	III	IV	III
Republic of China (Taiwan)	18.7	0	18.7	2.5	0	2.5	V	IV	IV
Cyprus	0	0	0	0	0	0	V	IV	IV
India	834.0	0	834.0	112.0	0	112.0	III	III	III
Indonesia	10,300.0	400.0	10,700.0	1,410.0	55.0	1,465.0	III	III	III
Iran	60,000.0	5,000.0	65,000.0	8,141.0	678.0	8,819.0	II	III	II
Iraq	33,000.0	0	33,000.0	4,400.0	0	4,400.0	III	IV	III
Israel	9.0	0	9.0	1.2	0	1.2	IV	IV	IV
Japan	8.0	15.0	23.0	1.0	2.0	3.0	IV	IV	IV
Jordan	0	----	0	0	----	0	IV	----	IV
Khmer Republic	0	0	0	0	0	0	IV	IV	IV
Korea, Democratic People's Republic of	0	0	0	0	0	0	0	IV	IV
Korea, Republic of	0	0	0	0	0	0	0	III	III

Kuwait	NA	NA	77,041.0	NA	NA	10,750.0	II	III	II
Laos	0	...	0	0	...	0	IV	...	IV
Lebanon	0	0	0	0	0	0	V	IV	IV
Malaysia	NA	NA	1,500.0	NA	NA	205.0	III	III	III
Maldives	0	0	0	0	0	0	VI	VI	VI
Mongolia	0	...	0	0	...	0	IV	...	IV
Nepal	0	...	0	0	...	0	V	...	V
Oman	NA	NA	5,000.0	NA	NA	684.9	III	IV	III
Pakistan	35.0	0	35.0	5.0	0	5.0	III	IV	III
Philippines	0	0	0	0	0	0	IV	IV	IV
Qatar	NA	NA	7,000.0	NA	NA	909.0	III	III	III
Saudi Arabia	83,905.0	57,338.0	141,248.0	11,500.0	7,879.0	19,373.0	II	II	II
Singapore	0	0	0	0	0	0	0	V	V
Sri Lanku	0	0	0	0	0	0	0	V	V
Syrian Arab Republic	7,250.0	...	7,250.0	1,044.0	...	1,044.0	IV	...	IV
Thailand	.5	0	.5	.1	0	.1	IV	IV	IV
Turkey	550.0	0	550.0	77.5	0	77.5	IV	IV	IV
United Arab Emirates	NA	NA	20,209.0	NA	NA	2,695.0	III	III	III
Viet-Nam, Democratic Republic of	0	0	0	0	0	0	V	V	V
Viet-Nam, Republic of	0	0	0	0	0	0	IV	IV	IV
Yemen Arab Republic (San'a)	0	0	0	0	0	0	VI	IV	VI
Yemen People's Republic of (Aden)	0	0	0	0	0	0	V	IV	IV
Total	216,554.2	65,166.0	392,475.2	29,482.1	8,944.0	53,664.0			
Oceania:									
Australia	NA	NA	2,082.0	NA	NA	268.0	III	III	III
Fiji	0	0	0	0	0	0	V	V	V
Nauru	0	0	0	0	0	0	IV	IV	IV
New Zealand	NA	NA	250.0	NA	NA	31.3	V	V	V
Tonga	0	0	0	0	0	0	IV	IV	IV
Western Samoa	0	0	0	0	0	0	IV	IV	IV
Total	NA	NA	2,332.0	NA	NA	299.3			
151 country total	415,502.1	93,115.6	633,568.7	56,457.6	14,451.1	86,251.4			

Source: USGS, Washington, D.C., 1973—Summary, 1972 oil and gas statistics, onshore and offshore areas, 151 countries, pp. 157–159.

APPENDIX X—Continued

NATURAL GAS PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES

[Potential resources: See "Explanatory Notes" in text. Asterisk (*), estimated; ---, landlocked; Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add up to the totals where the onshore/offshore breakdown was not available.]

Continent and country	1972 production						Cumulative production					
	Billions of cubic feet			Billions of cubic meters			Billions of cubic feet			Billions of cubic meters		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
North America:												
Bahamas	0	0	0	0 0	0	0	0	0	0	0	0	0
Barbados	.1	0	.1	Negl	0	Negl	.5	0	.5	Negl	0	Negl
Belize	0	0	0	0	0	0	0	0	0	0	0	0
Canada	2,913.0	0	2,913.0	82.5	0	82.5	38,824.0	0	38,824.0	1,099.0	0	1,099.0
Costa Rica	0	0	0	0	0	0	0	0	0	0	0	0
Cuba	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA
Dominican Republic	0	0	0	0	0	0	0	0	0	0	0	0
El Salvador	0	0	0	0	0	0	0	0	0	0	0	0
Guatemala	0	0	0	0	0	0	0	0	0	0	0	0
Haiti	0	0	0	0	0	0	0	0	0	0	0	0
Honduras	0	0	0	0	0	0	0	0	0	0	0	0
Jamaica	0	0	0	0	0	0	0	0	0	0	0	0
Mexico	NA	NA	660.2	NA	NA	18.7	NA	NA	9,200.0	NA	NA	261.0
Nicaragua	0	0	0	0	0	0	0	0	0	0	0	0
Panama	0	0	0	0	0	0	0	0	0	0	0	0
United States	20,654.0	3,325.0	23,979.0	585.0	94.2	679.3	*415,342.0	*23,931.0	*439,273.0	*11,761.0	*678.0	*12,439.0
Total	23,567.1	3,325.0	27,552.2	667.5	94.2	780.5	454,166.0	23,931.0	487,297.5	12,860.0	678.0	13,799.0
South America:												
Argentina	268.7	0	268.7	7.6	0	7.6	2,835.4	0	2,835.4	83.6	0	83.6
Bolivia	121.0	---	121.0	3.4	---	3.4	293.6	---	293.8	8.3	---	8.3
Brazil	43.8	Negl	43.8	1.2	Negl	1.2	384.8	Negl	384.8	11.2	Negl	11.2
Chile	284.9	0	284.9	8.1	0	8.1	3,018.0	0	3,018.0	100.6	0	100.6
Columbia	115.6	0	115.6	3.3	0	3.3	2,699.0	0	2,699.0	76.0	0	7.0
Ecuador	5.3	0	5.3	.2	0	.2	208.0	0	208.0	6.0	0	6.0
Guyana	0	0	0	0	0	0	0	0	0	0	0	0
Paraguay	0	---	0	0	---	0	0	---	0	0	---	0
Peru	41.2	23.2	64.4	1.2	.7	1.9	1,585.0	116.0	1,701.0	44.2	3.7	47.9
Trinidad and Tobago	69.9	34.4	104.3	2.0	.9	2.9	1,011.0	504.0	1,515.0	29.0	14.0	43.0
Uruguay	0	0	0	0	0	0	0	0	0	0	0	0
Venezuela	1,667.0	0	1,667.0	47.2	0	47.2	27,504.0	0	27,504.0	479.2	0	479.2
Total	2,617.4	57.6	2,675.0	74.2	1.6	75.8	39,538.8	620.0	40,158.8	838.1	17.7	855.8

Africa:												
Algeria	107.8	0	107.8	3.1	0	3.1	>1,708.0	0	>1,708.0	>48.0	0	>48.0
Angola	NA	40.3	>40.3	NA	1.1	>1.1	NA	>00.0	>40.3	NA	>1.1	>1.1
Botswana	0	---	0	0	---	0	0	---	0	0	---	0
Burundi	0	---	0	0	---	0	0	---	0	0	---	0
Cameroon	0	0	0	0	0	0	0	0	0	0	0	0
Central African Republic	0	---	0	0	---	0	0	---	0	0	---	0
Chad	0	---	0	0	---	0	0	---	0	0	---	0
Congo	NA	NA	.6	NA	NA	Negl	NA	NA	1.7	NA	NA	Negl
Dahomey	0	0	0	0	0	0	0	0	0	0	0	0
Egypt	NA	NA	160.8	NA	NA	4.6	NA	NA	459.0	NA	NA	131.0
Equatorial Guinea	0	0	0	0	0	0	0	0	0	0	0	0
Ethiopia	0	0	0	0	0	0	0	0	0	0	0	0
Gabon	NA	NA	31.8	NA	NA	.9	NA	NA	168.0	NA	NA	5.0
Gambia	0	0	0	0	0	0	0	0	0	0	0	0
Ghana	0	0	0	0	0	0	0	0	0	0	0	0
Guinea	0	0	0	0	0	0	0	0	0	0	0	0
Ivory Coast	0	0	0	0	0	0	0	0	0	0	0	0
Kenya	0	0	0	0	0	0	0	0	0	0	0	0
Lesotho	0	---	0	0	---	0	0	---	0	0	---	0
Liberia	0	0	0	0	0	0	0	0	0	0	0	0
Libyan Arab Republic	496.0	0	496.0	14.0	0	14.0	4,260.0	0	4,360.0	123.0	0	123.0
Malagasy Republic	0	0	0	0	0	0	0	---	0	0	---	0
Malawi	0	---	0	0	---	0	0	---	0	0	---	0
Mali	0	---	0	0	---	0	0	0	0	0	0	0
Mauritania	0	0	0	0	0	0	0	0	0	0	0	0
Mauritius	0	0	0	0	0	0	0	0	0	0	0	0
Morocco	2.2	0	2.2	Negl	0	Negl	10.2	0	10.2	.3	0	.3
Mozambique	0	0	0	0		0	0	0	0	0	0	0
Niger	0	---	0	0	---	0	0	---	0	0	---	0
Nigeria	438.7	165.9	604.6	12.4	4.7	17.1	*1,338.0	*566.0	1,907.0	*3.0	*16.0	54.0
Portuguese Guinea	0	0	0	0	0	0	0	0	0	0	0	0
Rwanda	0	---	0	0	---	0	0	---	0	0	---	0
Senegal	0	0	0	0	0	0	0	0	0	0	0	0
Sierra Leone	0	0	0	0	0	0	0	0	0	0	0	0
Somalia	0	0	0	0	0	0	0	0	0	0	0	0
South Africa	0	0	0	0	0	0	0	0	0	0	0	0
Southwest Africa	0		0	0	0	0	0	0	0	0	0	0
Sudan	0	0	0	0	0	0	0	0	0	0	0	0
Swaziland	0	---	0	0	---	0	0	---	0	0	---	0
Tanzania	0	0	0	0	0	0	0	0	0	0	0	0
Togo	0	0	0	0	0	0	0	0	0	0	0	0
Tunisia	60	0	60.0	1.7	0	1.7	61.0	0	61.0	0.7	0	1.7
Uganda	0	---	0	0	---	0	0	---	0	0	---	0
Upper Volta	0	---	0	0	---	0	0	---	0	0	---	0
Zaire	0	0	0	0	0	0	0	0	0	0	0	0
Zambia	0	---	0	0	---	0	0	---	0	0	---	0
Total	1,104.7	206.2	1,504.1	31.2	5.8	42.5	7,477.2	606.3	8,715.2	21.0	17.1	364.1

APPENDIX X—Continued

NATURAL GAS PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES—Continued

[Potential resources: See "Explanatory Notes" in text. Asterisk (*), estimated; ----, landlocked Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add up to the totals where the onshore/offshore breakdown was not available.]

Continent and country	1972 production: Billions of cubic feet: Onshore	Offshore	Total	1972 production: Billions of cubic meters: Onshore	Offshore	Total	Cumulative production: Billions of cubic feet: Onshore	Offshore	Total	Cumulative production: Billions of cubic meters: Onshore	Offshore	Total
Europe:												
Albania	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA
Austria	70.6	----	70.6	2.0	----	2.0	1,105.0	----	1,105.0	3.0	----	31.0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	14.9	0	14.9	.4	0	.4	93.9	0	93.9	.4	0	2.4
Czechoslovakia	42.4	----	42.4	1.2	----	1 2.	550.0	----	550.0	1.0	----	15.0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0
France	385.8	0	385.8	10.9	0	10.9	3,708.0	0	3,708.0	10.0	0	105.0
German Democratic Republic	190	0	190.0	5.4	0	5.4	NA	0	NA	NA	0	NA
Germany, Federal Republic of	624.8	0	624.8	17.7	0	17.7	2,477.0	0	2,477.0	7.0	0	70.0
Greece	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	144.0	0	144.0	4.0	0	4	975.0	0	975.0	2.0	0	28.0
Iceland	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	----	0
Italy	261.2	240.00	501.0	7.4	6.8	14.2	5,281.0	377.0	5,713.0	29.0	8.8	159.0
Lichtenstein	0	----	0	0	----	0	0	----	0	0	----	0
Luxembourg	0	----	0	0	----	0	0	----	0	0	----	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	2,043.0	Negl	2,043.0	57.9	Negl	57.9	6,889.0	Negl	6,889.0	19.0	Negl	195.0
Norway	0	18,659.0	18.659.0	0	528.6	528.6	0	18,659.0	18,659.0	----	528.6	528.6
Poland	200.0	0	200.0	5.7	0	5.7	*1,773.0	0	*1,773.0	*5.0	0	*51.0
Portugal	0	0	0	0	0	0	0	0	0	0	0	0
Romania	1,169.0	0	1,169.0	33.1	0	33.1	8,553.0	0	8,553.0	24.0	0	240.0
San Marino	0	----	0	0	----	0	0	----	0	0	----	0
Spain	.1	0	.1	Negl	0	Negl	.4	0	.4	Negl	0	Negl
Sweden	0	0	0	0	0	0	0	0	0	0	0	0
Switzerland	0	----	0	0	----	0	0	----	0	0	----	0
United Kingdom	3.6	919.8	923.4	.1	26.0	26.1	>9.6	>2,238.0	>2,248.0	>3	>63.3	>63.6
Yugoslavia	43.8	0	43.8	1.2	0	1.2	1,844.0	0	1,844.0	5.0	0	51.0
Total	5,193.2	19,818.8	25,011.8	147.0	561.4	708.4	33,258.9	21,274.0	54.588.3	1,080.7	600.7	1,539.6
Europe and Asia: Union of Soviet Socialist Republic	7,912.0	0.	7,912.0	224.0	0	224.0	69,866.0	0	69,866.0	1,979.0	0	1,979.0
Asia:												
Afghanistan	91.3	----	91.3	2.6	----	2.6	428.0	----	428.0	12.0	----	12.0
Bahrain	64.9	0	64.9	1.8	0	1.8	350.0	0	350.0	9.8	0	9.8
Bangladesh	17.0	0	17.0	.5	0	.5	>68.6	0	>68.6	>2.0	0	>2.0
Bhutan	0	----	0	0	----	0	0	----	0	0	----	0
Brunei	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Burma	4.2	0	4.2	.1	0	.1	368.2	0	368.2	10.1	0	10.1

China:

China:												
People's Republic of China	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Republic of China (Taiwan)	34.7	0	34.7	.1	0	.1	255.0	0	265.0	6.0	0	6.0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0
India	56.3	0	56.3	1.6	0	1.6	393.0	0	393.0	12.0	0	12.0
Indonesia	137.4	Negl	137.4	3.9	Negl	3.9	3,960.0	Negl	390.0	112.0	Negl	112.0
Iran	NA	NA	1,470.0	NA	NA	42.4	NA	NA	12,335.0	NA	NA	350.0
Iraq	3.4	0	3.4	Negl	0	Negl	NA	0	NA	NA	0	NA
Israel	4.4	0	4.4	.1	0	.1	45.0	0	135.0	1.0	0	1.0
Japan	NA	NA	87.4	NA	NA	2.5	<935.0	NA	135.0	<27.0	NA	27.0
Jordan	0	------------	0	0	------------	0	0	------------	0	0	------------	0
Khmer Republic	0	0	0	0	0	0	0	0	0	0	0	0
Korea, Democratic People's Republic of	0	0	0	0	0	0	0	0	0	0	0	0
Korea, Republic of	0	0	0	0	0	0	0	0	0	0	0	0
Kuwait	608.0	37.2	645.2	17.2	1	18.2	11,048.0	252.0	11,300.0	313.0	7.0	320.0
Laos	0	------------	0	0	------------	0	0	------------	0	0	------------	0
Lebanon	0	0	0	0	0	0	0	0	0	0	0	0
Malaysia	0	0	0	0	0	0	0	0	0	0	0	0
Maldives	0	0	0	0	0	0	0	0	0	0	0	0
Mongolia	0	------------	0	0	------------	0	0	------------	0	0	------------	0
Nepal	0	------------	0	0	------------	0	0	------------	0	0	------------	0
Oman	54.7	0	54.7	1.5	0	1.5	397.5	0	397.5	12.7	0	12.7
Pakistan	124.5	0	124.5	3.5	0	3.5	1,246.0	0	1,246.0	36.0	0	36.0
Phillippines	0	0	0	0	0	0	0	0	0	0	0	0
Qatar	44.3	44.4	88.7	1.2	1.3	2.5	737.0	244.0	982.0	21.0	6.0	28.0
Saudia Arabia	416.0	727.0	1,143.0	11.7	20.6	32.3	9,189.0	3,148.0	12,337.0	260.0	90.0	349.0
Singapore	0	0	0	0	0	0	0	0	0	0	0	0
Sri Lanka	0	0	0	0	0	0	0	0	0	0	0	0
Syrian Arab Republic	NA	------------	NA	NA	------------	NA	NA	------------	NA	NA	------------	NA
Thailand	0	0	0	0	0	0	Negl	0	Negl	Negl	0	Negl
Turkey	NA	0	NA	NA	0	NA	>79.0	0	>79.0	>2.0	0	>2.0
United Arab Emirates	NA	NA	NA	NA	NA	NA	>859.0	>446.0	>1,352.0	>25.0	>13.0	>38.0
Viet Nam, Democratic Republic of	0	0	0	0	0	0	0	0	0	0	0	0
Viet Nam, Republic of	0	0	0	0	0	0	0	0	0	0	0	0
Yemen, Arab Republic (San'a)	0	0	0	0	0	0	0	0	0	0	0	0
Yeman, People's Republic of (Aden)	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,661.1	808.6	4,027.1	45.8	22.9	113.6	30,358.3	4,090.0	46,831.3	861.6	116.0	1,327.0
Oceania:												
Australia	68.2	31.4	99.6	1.9	.9	2.8	147.7	93.8	241.5	4.2	2.6	6.8
Fiji	0	0	0	0	0	0	0	0	0	0	0	0
Nauru	0	0	0	0	0	0	0	0	0	0	0	0
New Zealand	14.6	0	14.6	.4	0	.4	>29.0	0	>29.0	>.8	0	>.8
Tonga	0	0	0	0	0	0	0	0	0	0	0	0
Western Samoa	0	0	0	0	0	0	0	0	0	0	0	0
Total	82.8	31.4	114.2	2.3	.9	3.2	176.7	93.8	270.5	5.0	2.6	7.6
151 country total	42,138.3	24,247.6	68,796.4	1,192.0	686.8	1,948.0	634,841.9	50,615.1	707,727.6	19,122.4	1,432.1	19,872.7

APPENDIX X—Continued

NATURAL GAS PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES—Continued

[Potential resources: See "Explanatory Notes" in text. Asterisk (*), estimated; ---, landlocked Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add up to the totals where the onshore/offshore breakdown was not available.]

Continent and country	Proved recoverable reserves: Billions of cubic feet			Proved recoverable reserves: Billions of cubic meters			Potential resources (ultimate recoverable resources)		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
North America:									
Bahamas	0	0	0	0	0	0	VI	VI	VI
Barbados	NA	0	NA	NA	0	NA	V	V	IV
Belize	0	0	0	0	0	0	V	V	V
Canada	55,462.0	NA	>55,462.0	1,570.0	NA	>1,570.0	II	III	II
Costa Rica	0	0	0	0	0	0	VI	VI	IV
Cuba	NA	0	NA	NA	0	NA	V	VI	V
Dominican Republic	0	0	0	0	0	0	V	V	V
El Salvador	0	0	0	0	0	0	0	V	V
Guatemala	0	0	0	0	0	0	IV	IV	IV
Haiti	0	0	0	0	0	0	V	V	V
Honduras	0	0	0	0	0	0	V	IV	IV
Jamaica	0	0	0	0	0	0	V	IV	IV
Mexico	NA	NA	11,500.0	NA	NA	326.0	II	III	II
Nicaragua	0	0	0	0	0	0	V	IV	IV
Panama	0	0	0	0	0	0	V	IV	IV
United States	NA	NA	266,085.0	NA	NA	7,537.0	I	I	I
Total	55,462.0	0	333,047.0	1,570.0	NA	9,433.0	---	---	---
South America:									
Argentina	6,700.0	NA	6,700.0	190.0	NA	190.0	III	III	III
Bolivia	4,800.0	---	4,800.0	135.9	---	135.9	II	---	II
Brazil	741.5	176.5	918.0	21.0	5.0	26.0	II	III	II
Chile	1,775.0	0	1,775.0	50.0	0	50.0	IV	III	III
Colombia	2,500.0	0	2,500.0	70.0	0	70.0	III	III	III
Ecuador	6,000.0	0	6,000.0	170.0	0	170.0	III	III	III
Guyana	0	0	0	0	0	0	IV	V	IV
Paraguay	0	---	0	0	---	0	IV	---	IV
Peru	NA	NA	500.0	NA	NA	67.0	III	IV	III
Trinidad and Tobago	900.0	4,000.0	4,900.0	25.8	113.0	138.8	IV	IV	IV
Uruguay	0	0	0	0	0	0	IV	IV	IV
Venezuela	<36,000.0	NA	36,000.0	<1,020.0	NA	1,020.0	IV	IV	IV
Total	59,416.5	4,176.5	64,093.0	1,682.7	118.0	1,867.7	---	---	---

Africa:									
Algeria	105,900.0	0	105,900.0	3,000.0	0	3,000.0	II	0	II
Angola	NA	NA	1,400.0	NA	NA	39.7	III	III	III
Botswana	0	---	0	0	---	0	III	---	III
Burundi	0	---	0	0	---	0	0	---	0
Cameroon	0	0	0	0	0	0	IV	IV	IV
Central African Republic	0	---	0	0	---	0	V	---	V
Chad	0	---	0	0	---	0	IV	---	IV
Congo	NA	NA	>5.0	NA	NA	Negl	III	V	III
Dahomey	0	0	0	0	0	0	V	V	V
Egypt	NA	NA	7,500.0	NA	NA	213.0	II	III	II
Equatorial Guinea	0	0	0	0	0	0	V	V	V
Ethiopia	0	0	0	0	0	0	III	IV	III
Gabon	NA	NA	6,532.0	NA	NA	181.0	III	III	III
Gambia	0	0	0	0	0	0	V	V	V
Ghana	0	NA	NA	0	NA	NA	IV	IV	IV
Guinea	0	0	0	0	0	0	IV	IV	IV
Ivory Coast	0	0	0	0	0	0	V	IV	IV
Kenya	0	0	0	0	0	0	III	V	III
Lesotho	0	---	0	0	---	0	VI	---	VI
Liberia	0	0	0	0	0	0	0	V	V
Libyan Arab Republic	27,500.0	NA	>27,500.0	779.0	NA	>779.0	II	II	II
Malagasy Republic	0	0	0	0	0	0	IV	IV	IV
Malawi	0	---	0	0	---	0	0	---	0
Mali	0	---	0	0	---	0	IV	---	IV
Mauritania	0	0	0	0	0	0	IV	IV	IV
Mauritius	0	0	0	0	0	0	0	0	0
Morocco	17.0	0	17.0	.4	0	.4	IV	IV	IV
Mozambique	0	0	0	0	0	0	III	III	III
Niger	0	---	0	0	---	0	IV	---	IV
Nigeria	*30,000.0	*10,000.0	40,000.0	*848.0	*280.0	1,120.0	III	III	III
Portuguese Guinea	0	0	0	0	0	0	V	V	V
Rwanda	0	---	0	0	---	0	0	---	0
Senegal	0	0	0	0	0	0	IV	IV	IV
Sierra Leone	0	0	0	0	0	0	V	V	V
Somalia	0	0	0	0	0	0	V	V	V
South Africa	0	0	0	0	0	0	III	IV	III
Southwest Africa	0	0	0	0	0	0	V	V	V
Sudan	0	0	0	0	0	0	V	V	V
Swaziland	0	---	0	0	---	0	VI	---	VI
Tanzania	0	0	0	0	0	0	IV	IV	IV
Togo	0	0	0	0	0	0	V	V	V
Tunisia	1,505.0	NA	>1,505.0	43.0	NA	>43.0	IV	IV	IV
Uganda	0	---	0	0	---	0	0	---	0
Upper Volta	0	---	0	0	---	0	0	---	0
Zaire	0	0	0	0	0	0	III	IV	III
Zambia	0	---	0	0	---	0	0	---	0
Total	164,922.0	10,000.0	190,359.0	4,662.4	280.0	5,376.1	---	---	---

APPENDIX X—Continued

NATURAL GAS PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES—Continued

[Potential resources: See "Explanatory Notes" in text. Asterisk (*), estimated; ---, landlocked; Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add up to the totals where the onshore/offshore breakdown was not available.]

Continent and country	Proved recoverable reserves: Billions of cubic feet			Billions of cubic meters			Potential resources (ultimate recoverable resources)		
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
Europe:									
Albania	300.0	0	300.0	8.4	0	8.4	IV	IV	IV
Austria	550.0	---	550.0	15.0	---	15.0	IV	---	IV
Belgium	0	0	0	0	0	0	V	IV	IV
Bulgaria	1,000.0	0	1,000.0	28.0	0	28.0	IV	IV	IV
Czechoslovakia	500.0	---	500.0	15.0	---	15.0	IV	---	IV
Denmark	0	500.0	500.0	0	14.0	14.0	IV	IV	IV
Finland	0	0	0	0	0	0	0	V	V
France	6,600.0	0	6,600.0	187.0	0	187.0	III	IV	
German Democratic Republic	500.0	0	500.0	14.2	0	14.2	II	IV	III
Germany, Federal Republic of	12,400.0	0	12,400.0	351.0	0	351.0	III	IV	III
Greece	0	0	0	0	0	0	V	IV	IV
Hungary	4,200.0	0	4,200.0	119.0	0	119.0	IV	---	IV
Iceland	0	0	0	0	0	0	0	0	0
Ireland	0	NA	NA	0	NA	NA	IV	IV	III
Italy	NA	NA	6,000.0	NA	NA	169.9	IV	III	II
Lichtenstein	0	---	0	0	---	0	0	---	0
Luxembourg	0	---	0	0	---	0	0	---	0
Malta	0	0	0	0	0	0	VI	IV	IV
Netherlands	88,000.0	NA	88,000.0	2,493.0	NA	2,493.0	II	III	II
Norway	0	50,000.0	50,000.0	0	1,420.0	1,420.0	0	III	III
Poland	5,000.0	0	5,000.0	140.0	0	140.0	IV	V	IV
Portugal	0	0	0	0	0	0	V	V	V
Romania	NA	NA	10,000.0	NA	NA	283.3	III	IV	III
San Marino	0	---	0	0	---	0	0	---	0
Spain	NA	NA	500.0	NA	NA	15.0	IV	V	IV
Sweden	0	0	0	0	0	0	VI	V	V
Switzerland	0	---	0	0	---	0	V	---	V
United Kingdom	NA	45,000.0	>45,000.0	NA	1,275.0	>1,275.0	V	III	III
Yugoslavia	1,700.0	0	1,700.0	48.2	0	48.2	IV	IV	IV
Total	120,750.0	95,500.0	232,750.0	3,418.8	2,709.0	6,596.0	---	---	---

Europe and Asia: Union of Soviet Socialist Republic	<706,000.0	NA	706,000.0	<20,000.0	NA	20,000.0	II	II	II
Asia:									
Afghanistan	5,000.0	----	5,000.0	142.0	----	142.0	III	----	III
Bahrain	840.0	0	840.0	23.8	0	23.8	III	IV	III
Bangladesh	9,250.0	0	9,250.0	262.0	0	362.0	III	III	III
Bhutan	0	----	0	0	----	0	0	----	0
Brunei	NA	NA	15,000.0	NA	NA	425.0	IV	V	IV
Burma	100.0	0	100.0	2.8	0	2.8	III	III	III
China:									
People's Republic of China	NA	NA	4,000.0	NA	NA	133.3	II	III	II
Republic of China (Taiwan)	500.0	0	500.0	14.0	0	14.0	IV	IV	IV
Cyprus	0	0	0	0	0	0	V	IV	IV
India	1,500.0	0	1,500.0	42.0	0	42.0	III	III	III
Indonesia	NA	NA	5,500.0	NA	NA	156.0	II	III	II
Iran	NA	NA	200,000.0	NA	NA	57,000.0	II	II	II
Iraq	20,000.0	0	20,000.0	566.6	0	566.6	III	IV	III
Israel	50.0	0	50.0	1.5	0	1.5	IV	IV	IV
Japan	<400.0	NA	400.0	<11.0	NA	11.0	III	IV	IV
Jordan	0	----	0	0	----	0	IV	----	IV
Khmer Republic	0	0	0	0	0	0	IV	IV	IV
Korea, Democratic People's Republic of	0	0	0	0	0	0	0	IV	IV
Korea, Republic of	0	0	0	0	0	0	0	III	III
Kuwait	NA	NA	42,000.0	NA	NA	1,190.0	III	IV	III
Laos	0	----	0	0	----	0	IV	----	IV
Lebanon	0	0	C	0	0	0	V	IV	IV
Malaysia	NA	NA	10,000.0	NA	NA	284.0	III	III	III
Maldives	0	0	0	0	0	0	VI	VI	VI
Mongolia	0	----	0	0	----	0	III	----	III
Nepal	0	----	0	0	----	0	V	----	V
Oman	NA	NA	189.5	NA	NA	53.7	III	IV	III
Pakistan	19,500.0	0	19,500.0	550.0	0	550.0	III	IV	III
Phillippines	0	0	0	0	0	0	IV	III	III
Qatar	NA	NA	8,000.0	NA	NA	266.6	III	III	III
Saudi Arabia	NA	NA	54,400.0	NA	NA	1,541.0	II	II	II
Singapore	0	0	0	0	0	0	0	V	V
Sri Lanka	0	0	0	0	0	0	0	V	V
Syrian Arab Republic	700.0	0	700.0	19.8	----	19.8	IV	----	IV
Thailand	Negl	0	Negl	Negl	0	Negl	IV	IV	IV
Turkey	170.0	0	170.0	5.0	0	5.0	IV	IV	IV
United Arab Emirates	NA	NA	11,800.0	NA	NA	33.2	III	III	III
Viet Nam, Democratic Republic of	0	0	0	0	0	0	V	V	V
Viet Nam, Republic of	0	0	0	0	0	0	VI	VI	VI
Yemen, Arab Republic (Sania)	0	0	0	0	0	0	VI	IV	VI
Yemen, People's Republic of (Aden)	0	0	0	0	0	0	V	IV	IV
Total	58,010.0	NA	408,899.5	1,640.5	NA	62,723.3	----	----	----

APPENDIX X—Continued

NATURAL GAS PRODUCTION, PROVED RESERVES, AND POTENTIAL RESOURCES—Continued

[Potential resources: See "Explanatory Notes" in text. Asterisk(*), estimated; ...., landlocked; Negl, negligible; NA, information not available; >, greater than; <, less than. The onshore and offshore production and reserves may not add to the totals where the onshore/offshore breakdown was not available.]

Continent and country	Proved recoverable reserves						Potential resources (ultimate recoverable resources)		
	Billions of cubic feet			Billions of cubic meters					
	Onshore	Offshore	Total	Onshore	Offshore	Total	Onshore	Offshore	Total
Oceania:									
Australia	NA	NA	37,700.0	NA	NA	1,068.0	II	II	I
Fiji	0	0	0	0	0	0	V	V	V
Naurn	0	0	0	0	0	0	IV	IV	IV
New Zealand	NA	NA	>6,000.0	NA	NA	>6,000.0	IV	III	III
Tonga	0	0	0	0	0	0	IV	IV	IV
Western Samoa	0	0	0	0	0	0	IV	IV	IV
Total	NA	NA	43,700.0	NA	NA	7,068.0			
151 country total	1,164,560.5	109,676.5	1,978,848.5	32,974.4	3,107	113,064.1			

Source: USGS, Washington, D.C., Summary, 1972 oil and gas statistics, onshore and offshore areas, 151 countries, pp. 160–162.

APPENDIX XI

U.S. ENERGY POLICY: MAJOR ISSUES AND OPTIONS

BY ALFRED REIFMAN

Senior Specialist in International Economics,
CONGRESSIONAL RESEARCH SERVICE

JULY 24, 1975

Table of Contents

U.S. ENERGY POLICY: A PERSPECTIVE ON MAJOR IMMEDIATE ISSUES

Summary

The Arab oil embargo of 1973 and the quintupling of oil prices has dramatized a long-term trend -- the end of cheap and reliable sources of energy for the United States.

The immediate problem, and the primary subject of this paper, arises from the control of a significant portion of the U.S. energy supply by members of the Organisation of Petroleum Exporting Countries (OPEC). Two basic problems are posed by OPEC for the United States:

1. How to deal with a potential embargo.

2. How to deal with higher prices.

These are different problems and can be met by different policies.

An embargo can best be met by:

-- the international oil sharing program already agreed to by the 18-country International Energy Agency; and,

-- a major oil storage program coupled with a stand-by allocation system which could keep the U.S. economy going through an Arab oil embargo of 6 to 12 months.

High oil prices present economic problems and costs to the United States. The problems are manageable and the costs, bearable. They are not a serious threat to the nation's security or independence.

Moreover, there are reasons why the world price of oil may break by the end of the decade. Such a conclusion flows from three major considerations:

-- an expected rise in non-OPEC output of energy.

-- an estimated slow-down in the growth of demand for oil in general and OPEC oil in particular.

-- projected balance-of-payments deficits of an increasing number of OPEC countries coupled with large, unutilized capacity to increase their output of oil.

These estimates are made by several reputable economists and institutions. Yet, they are open to two serious criticisms:

-- First, the degree of uncertainty about the estimates is very large.

-- Second, and more important, the reaction of the OPEC countries, particularly Saudi Arabia, if the new estimates are being realized, is the key to what happens to the price of oil.

While some OPEC countries (Algeria, Indonesia, Ecuador, Libya and Venezuela) will be running balance-of-payments deficits in the next year or two, and might insist on maintaining or expanding their oil production, cut-backs by Saudi Arabia alone would be sufficient to maintain the price. Indeed, it seems probable that reductions in OPEC output could lead to further increases in price and total OPEC earnings in the short-run -- the next five years or so. And OPEC countries may take a short-run view of their situation.

Thus, the heralded break in the price of oil, justified by conventional economic analysis and verified by the experience of previous cartels, may be long delayed.

In this situation it is difficult to formulate U.S. policy to avoid heavier "taxes" being levied by OPEC. Certain general principles, however, seem sensible and prudent:

1. Self sufficiency to meet the threat of a possible embargo is exceedingly expensive; an insurance program consisting of international oil sharing and stockpiles could meet the probable risk more cheaply. Self-sufficiency to meet the cost of higher prices is absurd. It would cost at least as much, and probably more, than the higher prices imposed by OPEC.

2. The major cost to the United States and the other industrial countries is not the level of OPEC prices but the abruptness of the increase which deepened the present recession. As the world economy adjusts to the shock of the rapid increase in oil prices, the continuing cost of the high price is manageable, and not a cause for draconian measures.

3. a) Since the cost of higher oil prices is low compared to the cost of unemployment, any measures taken to avoid the first problem should be devised so that they do not threaten the prospects of economic recovery.

b) More specifically, large increases in energy costs -- whether due to deregulation of prices as proposed by the Administration, government taxes, import duties or quotas, or price hikes by OPEC or U.S. private industry -- have to be offset by government policy if their adverse impact on employment and economic recovery is to be attenuated.

The import tax on oil and current proposals to decontrol the price will slow if not stop the current economic recovery and raise unemployment, if not offset by expansionary fiscal and monetary measures.

4. Morever, in the short-run, price changes are not very effective in achieving the necessary adjustments. It takes considerable time for an increase in price to yield increased output or significant reductions in the consumption of energy. Indeed, the proposed 30-month decontrol of "old" oil prices could have a perverse effect on output -- it would be much more profitable to delay oil production for 30 months and reap a gain of some 150 percent in price than to continue production.

5. Over the longer term, controls could be eased so that price can play its traditional role as an inducement to produce and conserve energy.

6. Measures to conserve on the use of energy, or increase the efficiency with which it is used, seem prudent. Policies to increase output are important, but conservation gets results more quickly and costs less in economic and environmental terms. Since gasoline accounts for one-quarter of total U.S. energy consumption, it deserves special attention in any long-run energy program.

7. Early measures to permit and encourage the exploitation of the Outer Continental Shelf, the Naval Petroleum Reserves and greater use of coal within acceptable environmental restraints could make a substantial contribution to the supply of domestically-produced energy by the end of the decade.

8. A cooperative, rather than an adversary, approach to OPEC may help to limit untenable price rises and, consequently, the costs to the United States and the world as a whole. This does not mean the country should compromise its foreign policy or avoid measures to reduce its dependence on imported oil. Moreover, cooperation may well be more a matter of style than of substance.

Finally, except for the "most seriously affected" developing countries, the international payments problem created by the phenomenal increase in oil prices has proven to be quite manageable and should become easier over time.

U.S. ENERGY POLICY: A PERSPECTIVE ON MAJOR IMMEDIATE ISSUES

I. The Major Problems -- Embargo and High Prices

The immediate energy problems facing the United States fall into two broad categories. How to deal with a possible embargo. How to deal with high energy prices. These are different problems. It is helpful to keep them separate:

-- They arise from different forces -- an embargo is a political act; increased prices are economic.

-- They have different durations -- an embargo is a short-term phenomenon; increased prices can be persistent.

-- The problems have different costs for a nation's economy.

-- And, the problems can be countered by different policies. Indeed, while some policies can help meet both problems, most policies to deal with one exacerbate the other.

Keeping the economic problem (price) separate from the political problem (embargo) can also help in an understanding of the more persistent problem by making it a less emotional subject. The economic problem (price) is one of cost, not of "sovereignty" or "independence."

The economic problem raises another political question. Does the United States approach the Organisation of Petroleum Exporting Countries (OPEC) in the spirit of confrontation, in an attempt to break the cartel, or in a spirit of cooperation, an attempt to live with OPEC on mutually-acceptable terms?

II. Policies to Meet Potential Embargo

Since an embargo is a political act, arising from a specific set of political circumstances, not all oil exporters may participate and the embargo may not be imposed on all importers. In 1973-74, only the United States and the Netherlands were hit with the embargo, and this was imposed not by OPEC but by Arab oil-exporting countries, and not all of them.

The embargo was costly to the United States. But its cost was limited by the duration of the embargo (October 1973 through March 1974), the availability of oil from non-Arab exporters, and informal cooperation of the importing countries and multinational corporations. A future embargo could be more costly if more of the oil exporters participate and if the United States becomes more dependent on imported oil.

There are three basic ways which can be used, singly or in combination, to meet an oil embargo:

-- First, is international agreement among consumers to share available supplies of oil.

-- Second, is a national system of stockpiles, shut-in production capacity, and an emergency allocation mechanism.

-- Finally, there can be various degrees of self-sufficiency.

Even though an embargo is a hostile act, a military response is not considered in this paper.

A. International Sharing

If a future embargo is similar to the one imposed in 1973-74, only a few countries will be denied oil. Obviously, the impact on them can be reduced if the cut-back is shared by other consuming countries.

The International Energy Agency (IEA),[a/] established as part of the Organisation for Economic Cooperation and Development (OECD), has an agreement for such sharing.

The agreement provides that each country reduce its consumption during an emergency by a common percentage. The basic principle of the allocation mechanism is that when a shortfall of oil supplies reaches a pre-agreed threshold -- 7 percent or more -- all countries will restrain demand by a common rate, draw from emergency supplies, and share available oil. (Only under extreme circumstances would the United States be obligated to share its domestic production.)

The agreement is extraordinary since it is triggered automatically. A meeting of government officials is not required. A meeting might take place after the sharing mechanism is in effect to consider deactivating it.

In order to comply with the Agreement on the International Energy Program (IEP), each country is expected to have an emergency allocation system to deal with a possible crisis.

The oil-sharing provisions of the IEP Agreement clearly spreads the burden of an embargo, and, thereby, reduces the likelihood that one will be imposed, and shortens the duration of one if it were imposed.

Moreover, because the oil exporters recognize the existence of the Agreement, a future embargo is likely to differ from the last one. The oil exporters may well use their power not by imposing a selective embargo but by cutting back sharply on their overall volume of oil exports to all consumers. This possibility makes more urgent the development of additional measures to counter an embargo and a sharp cut-back in oil availabilities. The most important of these measures is stockpiling of oil.

---

a/ The IEA members are Belgium, Canada, Denmark, West Germany, Ireland, Italy, Japan, Luxembourg, the Netherlands, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States, Australia and New Zealand, with Norway as an associate member.

B. Stockpiling and Shut-in Capacity

The International Energy Program (IEP) requires each of the 18 participating countries to maintain petroleum stocks or shut-in capacity equal to 60 days of net imports. The goal is to raise this target to 90 days within 3 to 4 years.

This option -- of maintaining adequate stockpiles and shut-in capacity a/ -- is singularly well-designed to deal with an embargo. Presumably, it would be of limited duration and, during such a period, a nation could live off its stocks while limiting "non-essential" consumption through its emergency allocation system. Thus, stockpiles plus shut-in oil wells are an effective device for meeting the threat of an embargo.

The question of cost -- how large a stockpile, what kind of a stockpile and how much shut-in capacity -- depends on the estimated likelihood of an interruption of supply and the quantity of supply which would be affected. Assuming that an embargo would by imposed only by Arab countries, as before, the United States would lose 1.4 million barrels a day at the 1973 rate; much more if the growth of imports from Arab countries continues as forecast -- between a "mid-point" estimate of 1.8 million and a "high" of 8 million barrels a day by 1985. b/ Six months supply -- which could be stretched to last perhaps twice as long through emergency conservation and increased domestic output -- might require the U. S. to store 324 million to 1,440 million barrels of oil.

Storage can be achieved in salt domes (or other natural or man-made caverns) or in steel tanks. Salt domes are the least costly but not as available. Steel tanks would have to supplement the salt domes.

According to Bohi and Russell, c/ if oil cost $10.00 a barrel, the annual storage cost -- principal and interest -- in steel tanks would be $2.29 a barrel. (A different price of oil would have only a small effect on the annual cost of storage.) Thus, to store 6 months oil supplied from Arab countries would cost the United States $0.7 to $3.8 billion a year. Other estimates vary between $0.6 and $1.0 billion per year. d/ This, of course, is much less than the cost of embargo.

a/ They could also meet other sudden interruptions of supply which, for example, might come from a civil war in an important exporting country.

b/ U. S. Energy Policy: Alternatives for Security, Douglas Bohi and Milton Russell, Resources for the Future, 1975, p. 22.

c/ Op. cit., p. 94.

d/ "The Project Independence Report" of the Federal Energy Administration, November 1974, estimates that storage sufficient to offset a cut-off of one million barrels a day for one year would cost $0.6 billion a year, close to the "mid-point" estimate of Bohi and Russell. The MIT study ("Energy Self-Sufficiency: An Economic Evaluation," 1974) estimates that a stockpile of 2 million barrels a day for one year would cost $990 million per year (or 26 cents a barrel or two-thirds of a cent per gallon).

Project Independence (page 10) estimates that a cut-off of one million barrels a day for one year would cost the U.S. economy $30-$40 billion.

Shut-in capacity is an alternative. But, since most oil fields can produce only one-tenth of their reservoir per year, shut-in capacity would involve tying up ten times as much oil as needed in an emergency. Thus, if as little as 1.8 million barrels a day were needed for 6 months, reserves equal to 6.6 billion barrels would have to be shut-in, compared to some 34 billion barrels of proved U.S. reserves today. Despite the many advantages of shut-in capacity, the immobilization of such a large fraction of U.S. reserves -- or, better, the discovery of 20 percent more reserves -- makes shut-in capacity not more than an adjunct to storage. Bohi and Russell suggest that a combination of storage and standby capacity be used.

The problems of a large stockpile are its cost, as noted earlier, the time required to order and build storage and ancillary facilities and, perhaps of most immediate concern, the impact on the price of oil of a substantial increase in demand at a time when rising economic activity is also raising demand. Nevertheless, these costs are an insurance policy against possible catastrophe later.

In short, stockpiling is an essential part of a long-term energy program though the speed of build-up and the size of the reserve is open to further consideration. The Administration's proposed Energy Independence Act of 1975 provides for a strategic oil reserve of a maximum of 1.3 billion barrels.

III. The Economic Impact of OPEC

A. The Problems of High Oil Prices

While an embargo hangs over our heads like the sword of Damocles, higher prices have taken their toll and continue to do so. Indeed, the price increases of 1973-74 have probably had a more convulsive effect on the world economy than any other event taking place in the same brief period of time in recorded history.

Higher prices present a persistent set of economic problems -- inflation, temporary recession and unemployment, balance-of-payments deficits, and permanent cuts in real income.

1. Inflation, already a serious problem in 1973-74, was boosted by a phenomenal 4 percentage points a/ as the result of the fourfold increase in the price of imported oil.

---

a/ Arthur Okun, Testimony before Subcommittee on Multinational Corporations of Senate Committee on Foreign Relations, February 5, 1975.

This was a one-shot affair, linked to the increase in oil prices, rather than their level, and its impact is reduced as the ripples subside, and the economy adjusts.

2. Unemployment and recession were deepened and, perhaps, triggered by the increased price of oil. For the United States the resultant cut in output was over 3 percentage points and the rise in unemployment, over one percentage point in 1974. a/

The increased price paid to foreigners is analagous to an excise tax, reducing domestic purchasing power, with only part of the "tax" returning to the income stream as OPEC countries increase their purchases of goods and services.

This, too, can be a one-shot affair. The impact of the higher price on unemployment and output b/ can be offset by expansionary domestic policies and by increased exports to the oil producers.

3. Balance-of-payments problems are posed for almost all the oil importing countries. OPEC countries ran cash surpluses of roughly $66 billion in 1974, c/ compared to $6 billion in 1973. This phenomenal increase implies equivalent deficits in the rest of the world and serious problems for a number of countries.

These problems are being met in part by market forces, international cooperation and increased aid by OPEC countries. Nevertheless, the balance-of-payments problem remains critical for many developing countries and unless more effective action is taken, the World Bank foresees "virtually no increase in per capita income levels of the poorest countries...over the remainder of the decade." d/

For the developed countries as a group, the balance-of-payments problem is self liquidating and, consequently, relatively unimportant. The OPEC countries have only two choices of what to do with their increased earnings.

---

a/ George Perry, "The Petroleum Crisis and the U. S. Economy," Brookings Institution, November 1974.

b/ But not on real income which is reduced by the higher oil price, as shown in section 4, below.

c/ First National City Bank, "Monthly Economic Letter," June 1975. The surplus for 1975 is estimated at $36 billion.

d/ "Prospects for the Developing Countries," Report No. 477, July 8, 1974, International Bank for Reconstruction and Development, p. 60.

They can be used to buy goods and services or they can be left as investments, short-term or long-term, in the oil-importing countries, primarily the industrial countries. There is no alternative. Thus, for the industrial countries as a group there is no balance-of-payments problem.

A balance-of-payments problem for an oil-importing country arises when its oil deficit is not offset by increased receipts from the oil exporters. But, for each such overall deficit, there must be a corresponding surplus in another industrial country (or group of countries). These deficits can be and, indeed, are being largely offset by movements of funds among the industrial countries in response to changed monetary conditions, investment opportunities or cooperative action by governments and central banks.

4. Redistribution of world income. Perhaps the most persistent impact of the increase in world oil prices is that it is redistributing income from oil consumers to producers. The price increases of 1973-74 are causing a transfer of 2 percent of the current gross national product of the industrial countries to the oil exporters. a/

This is a very large sum, approached in modern times only by early Marshall Plan aid to Europe in the immediate period following World War II.

The redistribution of income is not necessarily "bad." Outside of the Persian Gulf countries -- whose per capita incomes are now astronomical -- the other oil exporters have incomes which are quite low. Indeed, on the average, by 1980 per capita incomes of all OPEC countries will be roughly $600 per year, compared to over $5000 for the industrial (or OECD) countries. Thus, discounting from the unprecedented shock (and cost) to the world economy of the abrupt rise in energy prices, and the excessive increase in income of the Persian Gulf, the shift of income from the industrial countries to the OPEC countries as a group cannot be condemned out of hand. However, a good part of the redistribution of income is at the expense of the poorest people of the world -- the one billion people of South Asia, Tropical Africa and Central America who have per capita incomes averaging $200 or less per year.

---

a/ Hollis Chenery, "Restructuring the World Economy," Foreign Affairs, January 1975, p. 254. If the price of oil rises no faster than the general level of prices, the percent of world income being transferred will decline as gross national products rise.

5. Reduction in U.S. and world income. The rise in oil prices is not only transferring income to OPEC countries from the rest of the world, it is also reducing the total level of world income. This reduction is the result of not using low-cost Middle East oil but making large-scale investments for the production and conservation of energy in the U.S. and elsewhere. These are real costs to these countries and, indeed, the world at large.

The OECD estimates these costs at over one percent of 1980 GNP, a/ not an insignificant amount. Project Independence (page 320) suggests a similar cost.

There are two points to be made about these estimates. First, they are exceedingly rough. Second, over the long-term, as the world's oil reserves are depleted, a good part of these costs would have to be incurred anyway so that the total additional cost over time may not be very significant.

6. The changed balance of power. If the present price of oil (relative to other prices) persists, the share of the OPEC nations in world GNP may rise from 2 percent in 1973 to 4 percent in 1980. By itself, this does not suggest any dramatic change in the balance of economic power. The United States will remain the only economic superpower with over one-fourth of world GNP. b/

But, the rapid accumulation of large sums of liquid assets by a few OPEC countries has raised the fear that these sums can be used for mischievous purposes. While the estimates vary considerably, and recently have been sharply reduced, the important fact is that the amounts available to a number of Persian Gulf countries are now huge, growing and likely to be significant through the end of the decade. What are these fears and are they justified?

-- Can these funds create havoc in or disrupt the world financial markets? The motivation for disruptive acts seems small. Moreover, the International Monetary Fund plus cooperation of national central banks are strong defenses against such disruptions.

-- Can the funds be used to buy up and control corporations in the United States and elsewhere? Fears about foreign investment seem exaggerated. Such investment would add

---

a/ "Energy Prospects to 1985," OECD, Paris, 1974, p. 14.

b/ See "U.S. Policy in a Changing World Economy: Foreign Economic Policies for the Second Half of the Seventies," by Alfred Reifman Library of Congress, Congressional Research Service, November 11, 1974.

to the real capital America and its workers have at their disposal. Fear of foreign domination of the economy normally overlooks a number of practical realities. Foreign companies are subject to U.S. laws, U.S. antitrust policy, U.S. taxes; they must bargain with American labor; their properties can be nationalized or controlled. And even if a very high estimate of possible OPEC investments in the U.S. is assumed, it would amount to 3.6 percent of U.S. financial assets by 1980, and probably much less. a/

-- Could the available funds be used to support "other OPEC's," cartels in other commodities? This is certainly a possibility, given the growing political cohesion of the Third World. However, the feasibility of "other OPEC's" seems small.

7. Summary of costs of high oil prices. The increase in oil prices in particular and energy prices in general has been costly. Not only has it accelerated inflation, but it has probably been the immediate cause of the current recession. However, timely, countercyclical government policies could have offset much of the cost in unemployment.

For the industrial countries, the other economic costs have been minor. The transfer of real income to the oil exporters is just beginning as their imports rise. This imposes a small though manageable burden on the developed countries. The balance-of-payments deficits, though of unprecedented size, have not resulted in any serious problems. Real problems, however, have been raised for most of the poorest developing countries.

The problems are due less to the level of energy prices -- in real terms they are now about the same as they were in 1950 b/ -- but almost entirely to the abruptness of their increase. It was this which triggered the recession and contributed to inflation. Had the cost of energy risen gradually (at the same pace or even at a moderately faster rate than other prices,) the U. S. and the world economy would have adjusted easily to the current level of oil prices; there would be no energy "crisis" today. c/

---

a/ "The Oil Transfer Problem and International Economic Stability," Thomas Willett, Department of the Treasury, p. 15.

b/ Edward J. Mitchell, "The Energy Dilemma: Which Way Out?" American Enterprise Institute, Washington, D. C., June 1975, p. 2.

c/ Aside from the political threat of embargo.

B. The Outlook for World Oil Prices and the Financial Position of OPEC.

In May 1975, the Shah of Iran and a high U.S. Treasury official predicted a further increase in the world price of oil before the year is out. The forces making for another price increase are strong. The world will be recovering from a recession, current high oil prices have yet to have their full effect on energy output and demand in oil-importing countries, and production of the oil-exporters has been cut, and can continue to be restrained well below capacity rates.

But, over time, it is reasonable to expect that normal economic forces will keep oil prices from rising and may actually bring them down (in real terms, i.e., compared to the general level of prices). Indeed, this is the forecast (or implication) of much recent research. a/

Each of these estimates depends on a variety of assumptions on the reaction of consumers to higher prices, the growth of non-OPEC oil supplies, the speed and degree of the shift to coal and nuclear energy, the reaction of OPEC countries. The assumptions differ, as do the methods used. But much of the results are in the same general direction and reflected in the title of Citibank's article on the subject: "Why OPEC's Rocket Will Lose Its Thrust."

The bulk of the estimates project:

-- a steady increase in non-OPEC production of oil;

-- a slow rise in the world demand for oil;

-- consequently, an even slower rise in the demand for oil from OPEC sources and, in the early 1980's, a stable or declining demand for OPEC oil;

-- increased balance-of-payments deficits for OPEC countries to pay for ambitious economic programs.

As a result of these factors, some observers conclude that there will be increased pressure to expand OPEC oil production with a consequent fall in the price. Some date the decline at 1977, others in the 1980's.

---

a/ 1. First National City Bank, Monthly Economic Letter, "Why OPEC's Rocket Will Lose Its Thrust," June 1975.
2. Irving Trust Co., "Outlook for World Oil: Prices and Petrodollars," by Arnold E. Safer and Anne Parket Mills, New York, March 20, 1975.
3. Morgan Guaranty Bank, "World Financial Markets," January 21, 1975.
4. Edward Fried in Chapter 13 and 14 of Energy and U.S. Foreign Policy, edited by Joseph Yager and Eleanor Steinberg (Ballinger Publishing Co., Cambridge, Mass.), 1974.
5. The OECD, "Energy Prospects to 1985," Paris, 1974.
6. Bohi and Russell, Op. cit.

These new forecasts,[a/] contested notably by Walter J. Levy,[b/] an oil economist, is in marked contrast to the catastrophic forecasts made by many of the same authors a year or less earlier. The present optimism has come from the drop in OPEC oil exports in 1975 (due to the mild winter, the world economic downturn, and, to an unknown extent, the high price) and the unexpectedly sharp increase in OPEC imports. Let us briefly survey the forecasts.

1. Production of oil from non-OPEC sources: In 1974 and 1975 oil production in non-Communist countries outside of OPEC averaged 15 million barrels per day (b/d). This is expected to rise by some 6 million b/d before 1980. In addition, another one million barrels or more per day are expected to be exported from Communist China to Japan, for a total increase in availability of 7 million b/d from non-OPEC sources.

The declining trend in U. S. production is expected to be somewhat more than offset by the start of deliveries of Alaskan oil in 1977 or 1978. By then the North Sea is expected to be producing about 2 million b/d. Elsewhere, increased exploration -- worldwide drilling was up by 30 to 40 percent in 1974 -- has resulted in promising discoveries in Mexico and other parts of Latin America as well as Asia and Africa.

After 1980, large amounts of oil are expected to be forthcoming from the U. S. Outer Continental Shelf and Naval Petroleum Reserve No. 4 in Alaska.

Non-OPEC countries will probably charge OPEC prices for their oil. Some may even join OPEC formally. Nevertheless, increased supplies from non-OPEC sources will slow the growth of demand for OPEC oil and, as a result, put increased pressure on the cartel and the price.

2. World demand for oil: Estimates of the world demand for oil vary greatly. Many variables are involved. First, there is the question of the world demand for energy from all sources. Second, there is the question of how much coal and other sources of energy which can be substituted for oil will be produced. Third, there is the increased conservation and more efficient use of oil forced on consumers by the high price. Finally, the world demand for oil will be affected by direct measures taken by governments, particularly the United States government.

---

a/ The term "forecast" is used even though many authors make clear that they are not forecasting. The numbers they use are either "projections" of what would take place under assumed conditions, "targets" for what government policy ought to aim at and what is feasible or "assumptions" as to what seems possible and reasonable.

b/ "Future OPEC Accumulation of Oil Money: A New Look at a Critical Problem," Walter J. Levy Consultants Corp., New York, June 1975.

Obviously, the question is complex. Only a few of the forecasts noted earlier have made the necessary analysis of the total world supply and demand for all sources of energy; instead, they have concentrated on oil.

The demand for oil is closely related to the growth in economic activity. In recent years, the demand for oil has increased much faster than economic activity. In technical terms, the GNP elasticity of demand for oil has been about 1.5. According to a recent Central Intelligence Agency estimate, a/ it might fall as low as 1.0 as the result of higher prices and a shift to coal for many uses. Even before the rise in oil prices, the National Petroleum Council had forecast a sharp decline in the growth of oil consumption in Europe and Japan for the 1970s. Thus, the CIA minimum figure may not be out of line.

Even this, however, would yield a rate of growth in demand for oil of something like 6 percent per year for the next year or two as the world economy recovers from its present slump and expands at above normal growth rates. After 1977, with normal economic growth in the major industrial powers, the demand for oil and other forms of energy should moderate. A recent OECD study b/ estimates that oil at the end-1974 price would cut energy demand to 3.8 percent per year and, within this lower overall figure, shift demand from oil to other energy sources. Thus, the growth of demand for oil could be limited to between 3 and 4 percent per year between now and the end of the decade, though positive conservation measures, in addition to the high price, will undoubtedly be needed for such a forecast to materialize. Walter J. Levy assumes that the demand for oil will rise by 3.6 percent per year from 1973 to 1980.

The above judgments suggest that the world demand for oil could rise from some 45 million barrels in 1975 to roughly 50 million barrels a day in 1977.

The major question is not only one of estimating demand, but determining whether a slower growth in the use of oil will limit economic expansion. Various bits of data c/ suggest that economic growth will not be slowed, but that there will be a change in the composition of output -- a shift to more investment in the production of energy and energy-efficient goods and away from other sectors of the economy.

---

a/ "Projected World Oil Demand and OPEC Current Accounts, 1975-77," March 1975, Central Intelligence Agency.

b/ "Energy Prospects to 1985," OECD, Paris, 1974, Volume 1, p. 8.

c/ For example, Sweden, with roughly the same GNP per capita as the United States and a colder climate uses only half the amount of energy.

3. Demand for oil from OPEC: The rise in non-OPEC production and the slower increase in total world demand for oil is expected by many observers to limit exports from OPEC sources to less than the quantities of 1973. In 1973, OPEC produced 31 million b/d. This has dropped to between 26 and 28 million b/d in 1975, largely as a result of the economic recession and the mild winter. By 1977, most estimates place the demand for OPEC oil between 28 and 31 million b/d. Estimates for 1980 vary more widely, with the upper end of the range put at 31 million b/d by the First National City Bank and Walter J. Levy; others, including Thomas O. Enders, Assistant Secretary of State, a/ estimate that demand for OPEC oil will be below that achieved in 1977.

4. Balance-of-payments position of OPEC countries: Most observers expect that many, if not most, OPEC countries will run into balance-of-payments problems before 1980. b/ Enders expects deficits in Algeria and Indonesia in 1975, Ecuador in 1976, Venezuela in 1977. The First National City Bank differs only slightly on these countries and would add others as follows: Libya and Iran in 1976, Iraq in 1977, and Saudi Arabia (sic) and Kuwait in 1980.

In 1974 the World Bank c/ forecast that in 1980, and in the prices of that year, the cumulative balance-of-payments surplus (or total foreign assets) of OPEC countries would be about $650 billion; recently, this forecast has been reduced to between $110 and $400 billion. Other recent forecasts range from a possibility of zero (one Irving Trust scenario), to less than $200 billion (Citibank and Morgan Guaranty), and $450 billion (Walter J. Levy). In general, the new forecasts are markedly below those of a year ago.

The revised view is based on a reappraisal of the volume and price of OPEC oil exports and, more importantly, on the volume and price of OPEC imports. OPEC balance-of-payments deficits are expected to result in large part from a continued strong increase in their imports. The OPEC countries, especially those in the Middle East, are committing themselves to long-term and huge investment projects at home. Work on these projects is starting and, once started, so the argument goes, they develop a momentum which is hard to stop.

---

a/ Thomas O. Enders, "OPEC and the Industrial Countries: The Next Ten Years," Foreign Affairs, June 1975.

b/ See previous mentioned sources plus World Bank "Capital Requirements of Developing Countries," April 28, 1975, pages 17-19. These are summarized in the appendix table.

c/ Op. cit., July 8, 1974.

Imports of OPEC rose by an amazing 90 percent in value from 1973 to 1974 and by 40 to 45 percent in volume. a/ The World Bank balance-of-payments projections are based on the assumption that such a rate of increase cannot be maintained, and that the average growth in import volume from 1973 to 1980 will be 15.7 percent per year. Other forecasts use country plans to make up annual import estimates. The balance-of-payments forecasts also include an allowance for earnings of interest and dividends. These are summarized in the appendix table.

5. Critique of Estimates: There are two basic problems with the above estimates:

a) First, they are all subject to a wide degree of uncertainty.

For example, the U.S. Geological Survey has recently cut its estimate of the amount of oil available in the Atlantic Outer Continental Shelf by 80 percent, and has cut in half its estimate of the amount of U.S. domestic oil and gas resources.

The estimates of the growth of imports by OPEC differ partly because there is no agreement on what OPEC actually imported last year. Clearly, if the past is uncertain, the future cannot be seen very clearly, if at all.

The various estimates differ for a variety of other reasons, primarily differences about the growth in the volume and price of OPEC oil exports -- more basically, about what happens to the production of and demand for all sources of energy in non-OPEC countries -- and differences about the increase in the volume and price of OPEC imports. Over several years, seemingly small differences on price -- of OPEC exports and imports -- and on the rate of change in volume yield a large difference in the end result. In short, a variety of reasonable assumptions about OPEC imports and exports can yield huge differences in estimates of OPEC financial strength between now and the end of the decade.

b) Second, and more important, is the reaction of the OPEC countries to their developing situation.

Clearly, if they are running balance-of-payments deficits and eating up their financial reserves, as the New York banks expect, the OPEC countries can stretch out their plans. Indeed, the clogging of ports and internal transportation systems in a number of countries may well force this to happen soon. And, there is reason to doubt that the recent large imports of military equipment will continue.

---

a/ World Bank, Op. cit., April 19, 1975, p. 19.

Moreover, if the New York forecasts are being realized, the OPEC countries could raise the price of oil. This would require a cut-back in oil production, but it would yield an increase in their total earnings from oil.

This situation will persist as long as the demand for OPEC oil is inelastic with respect to price, and this will hold as long as the world depends heavily on OPEC oil for its energy.

An attempt to raise the price by further cut-backs in output would probably raise the question of how the cutbacks are to be shared among the various countries. Some countries would resist cutting back, attempting to maximize their earnings under the umbrella of restraints exercised by others. There would be a temptation to cheat on any quota agreement. The result would be increased oil exports and a fall in price.

This is the usual path for the decline and fall of a cartel. However, such a development may be long delayed in the case of oil. So far, no agreement on production cutbacks have been needed. Each member seems to recognize its interest in keeping output within limits. Moreover, Saudi Arabia's oil output is so large, actually and potentially, and the needs of its sparse population so limited, that it alone could absorb the cuts needed to maintain, if not increase, the price of oil. The real question is whether Saudi Arabia would have the will to do so.

Early in 1975, production in Saudi Arabia was roughly 6 million b/d, a little over half of its capacity. This output could be cut back further. But, economic and political reasons may inhibit the willingness of the Saudis to do so:

> -- Since oil in the ground a decade hence may well be worth less than if it were sold today, and the proceeds invested at home or abroad, a cutback would not merely defer income, it could mean a permanent loss.
>
> -- If the Saudis hold the price of oil up they would be aiding radical governments in Libya and Iraq which they may be unwilling to do at the expense of the United States and their own long-term economic position.

In short, the basic problem is less the accuracy of the economic forecasts discussed above, and more the political will and desire of Saudi Arabia.

III. The Major Policy Options

In this situation of uncertainty, it is difficult to formulate policy. However, certain general principles and major options seem clear.

A. General:

1.) The high price of oil, and energy, is not the major problem. Indeed, as noted earlier, the American consumer is paying no more for energy, after account is taken of general inflation, than he did in 1950.

The major economic threat inherent in the OPEC cartel (outside of that of embargo, discussed earlier) is the possibility of an abrupt price increase. This could be costly. But the level of prices -- certainly the current level -- poses no difficult obstacle to U.S. economic growth and affluence.

If the price increases of 1973 -74 had come about gradually, adjustments would have been made gradually, and the country would not be concerned with an energy crisis today.

Nevertheless, since OPEC still has considerable power to disrupt our economy and, in effect, to levy taxes on the country, measures to conserve energy and increase its supply in reliable areas are in order. These measures may be necessary. But, to repeat, as the world economy adjusts to the shock of the rapid increase in oil prices, the continuing cost of the high price is manageable, and not a cause for draconian measures.

2.) The immediate danger to be guarded against is that the policies devised by the U.S. government to deal with the problem of OPEC and high energy prices may impose a greater cost on the economy than OPEC actions are causing or threatening to cause. This problem is considered in B, below.

3.) There are three basic approaches to deal with the high price of energy: a/

-- First, let market forces (price) act to reduce consumption and increase production.

---

a/ This division of policy options follows the one set out in "Setting National Priorities, The 1976 Budget", by Barry M. Blechman, Edward M. Gramlich, and Robert W. Hartman, Brookings, 1975.

-- Second, take direct government action. Some of these, such as the imposition of excise taxes or import duties would work through the market; others would be direct controls such as rationing, and specific instructions to industry on the use of energy.

-- Third, take measures to alter the structure of the petroleum industry.

B. <u>The Use of Market Forces</u>

Conventional economists (and the Administration) argue that the cure for high prices is high prices. As the price of a commodity rises, consumption is reduced and production stimulated.

In the case of energy, a number of studies confirm that this would indeed be the case. More specifically, a recent OECD study a/ says:

> "If there is no substantial change in the real prices of imported crude oil from their end-1974 level, then:
> -- the overall energy consumption would grow at an annual rate of 3-1/2 - 4 percent up to 1985 compared to the 5 percent expected prior to the recent large increase in oil price;
> -- the OECD area would produce almost 80 percent of its energy requirements by 1985; this proportion was previously expected to decline to 55 percent (from 65 percent in 1972);
> -- the share of oil in total energy consumption would fall from 55 percent to around or below 45 percent by 1985;
> -- as a result of reduced growth in overall energy consumption and higher indigenous production of oil and other forms of energy, OECD oil imports would be considerably below present levels, particularly after 1980."

This analysis is based on the assumption that governments do nothing directly to affect the production and use of energy but let the price rise to the late 1974 level.

The policy of the Administration is based heavily on such conventional economic wisdom. The Administration has levied a $2 import fee on each barrel of oil imported, has recommended the decontrol of the price regulation of domestic "old" oil and natural gas. In addition, OPEC nations may well increase the price of imported oil further in October. All of these increases in the cost

---

a/ "Energy Prospects to 1985," December 1974, Paris, p. 3.

of natural gas and oil, imported as well as domestic, would be reflected in increased cost of other energy resources, though at a slower rate partly because of long-term contracts.

The use of the market has a number of advantages and disadvantages. The advantages are suggested by the OECD forecast. The disadvantages are equally clear. The increased price, whether imposed by OPEC or domestic measures of decontrol and taxation, would slow economic recovery, stop the expected decline in unemployment, perhaps increase it, and contribute to inflation. Yet, despite these heavy costs the reduction in energy consumption and the increase in output would materialize only slowly with time.

1. Reduced economic growth and increased unemployment.

Increased prices of "old" oil by itself would tend to raise the price of intrastate sales of natural gas and coal, which are substitutes for oil. Further increases would take place if the price of OPEC oil were raised and controls on the price of natural gas sold in interstate commerce relaxed. The result would be a reduction in economic growth and an increase in unemployment beyond what otherwise would have occurred if government policies do not offset the deflationary impact of the price rises.

The deflationary impact comes from three sources. First, the increase in OPEC prices would transfer purchasing power from the United States to OPEC countries. Second, the increase in U. S. taxes, import fees, and prices of domestic fuel would yield higher tax revenues for the government. If this does not result in an immediate increase in government expenditures, the result would be a net reduction in purchasing power and a deflationary impact on the economy. Similarly, the third impact comes in the transfer of purchasing power from the consumer to the companies producing energy in the United States. To the extent that they do not use their funds for increased investment, the result is an additional reduction in total purchasing power.

A number of recent estimates have been made of the impact of higher fuel prices on the U. S. economy. They cannot be compared directly because their assumptions differ. Yet the general trend is the same:

a.) The Congressional Budget Office a/ (CBO) assumes continuation of the $2 per barrel duty on imported crude oil, decontrol of "old" oil over a two-year period, and a $2.25 rise in the OPEC price. It estimates that these factors would cost the American consumer about $40 billion, almost twice as much as the increase provided by the recent tax cut. The result would be a depressing effect

a/ "Inflation and Unemployment, A Report on the Economy, June 30, 1975, pp. 69-73.

equal to the 1973 embargo and an increase in unemployment of one-half percentage point by the end of 1976.

b.) Using similar assumptions, the Joint Economic Committee in its report of July 10, 1974, gets similar results in terms of the cut in purchasing power and the rise in unemployment. It estimates that by the end of 1976 the growth of real GNP would be cut by roughly 2 percentage points. and unemployment increased by less than one-half percentage point.

c.) The Congressional Research Service[a/] (CRS) with similar assumptions estimates that the cut in the real rate of economic growth would be higher -- 4 percentage points, and unemployment would rise by more than one-half percentage point by the end of 1976.

d.) Brookings[b/] using somewhat different assumptions, notably a marked increase in the price of natural gas, concludes that some $30 billion would be drained from consumer purchasing power.

2. Renewed inflation.

All of the forecasts conclude that there would be a significant rise in prices as a result of the deregulation of "old" old and a modest rise in the cost of OPEC oil.

The impact would be both direct and indirect. First, an increase in the price of oil would be passed on, sooner or later, to other energy products which can be substituted for oil. Second, these prices enter into the cost of other commodities and the various price indexes. Finally, many wage contracts are tied to these price indexes so that an increase in the price of energy will eventually be translated into an increase in wages and another inflationary round.

In its report, the CBO notes that the rule of thumb is that for each $1 increase in the domestic price of oil, the GNP deflator -- the overall price index for the entire economy -- will rise by one-half of one percentage point. Thus, if oil rises by $5.50 a barrel, the GNP deflator would rise by 2.75 percentage points. The same general results come from the three other studies as well.

---

a/ "The Impact of Crude Oil Prices on the U.S. Economy," by Warren E. Farb and Lawrence Kumins, July 10, 1975.

b/ "Setting National Priorities, The 1976 Budget," by Barry M. Blechman, Edward M. Gramlich, Robert W. Hartman, 1975. p. 156.

3.) Impact on supply and consumption of oil.

Despite the depressant effect which a rapid decontrol of old oil prices and a modest rise in OPEC prices would have on the U.S. economy, the positive results would be slow in coming.

Finding oil and bringing it and other sources of energy into commercial production takes several years:

-- It takes 4 to 5 years to open new coal fields, 1 to 4 years to bring a new oil field into production, and 8 to 10 years to plan and build a nuclear energy plant.

-- Current prices have already given such a large impetus to oil exploration and production that the bottlenecks are less price and more shortages of equipment and manpower.

-- Finally, price controls are not as restrictive as they may seem. While controls hold the price of "old" oil at $5.25 a barrel, and "new" oil is roughly $13 a barrel, for each barrel of new oil one of old oil is released from price control. Thus, the marginal return to a U.S. producer of a barrel of new oil is over $20 a barrel -- the $13 market price plus the difference between it and the controlled price for old oil.

Similarly, the impact of a higher price on consumption of energy takes time to have a major effect. Substitutes must be found and life-styles altered. Since the price increases being considered would not be applied selectively to those areas where consumption can most readily be cut, a significant reduction in overall consumption will be long in coming.

The argument for removing price controls over "old" oil is straightforward. A higher price is needed because costs of production -- for secondary and tertiary recovery of oil from existing wells -- rise with time. Moreover, increased oil prices would act to depress consumption.

Recognizing that it will take considerable time before the increased price of old oil will yield results in terms of increased production, the Administration also favors a windfall profits tax (which would decline over time) to prevent the higher price from resulting in profits which yield little or no increase in investment. To the extent that these profits are plowed back into investment in the industry, they would not be taxed.

Serious questions can be raised about the Administration's decontrol program:

Should the decontrol of old oil take place over a 2-1/2 year period, as proposed by the Administration on July 15, 1975? In addition to the adverse impact on the economy, discussed earlier, a 2-1/2 year price decontrol program could have a perverse effect on U.S. oil production. It would result in a price increase averaging 43 percent per year. Such a rapid price increase would make it exceedingly profitable for companies to slow down production of old oil, borrow, if necessary, to cover any expenses they may have, and yet earn a gross rate of return of 43 percent on the old oil not produced in each year.

Clearly, if old oil is to be decontrolled gradually, the increase in price per year ought to be less than the returns on alternate investments, or the costs of borrowing. Otherwise, there will be a real inducement for producers not to produce oil which will be much more profitable in the near future than in the present.

Should there be a ploughback provision? The ploughback provision -- reducing taxes by the amount of investment made by the oil companies -- is a "tax expenditure." The country as a whole would be financing oil investment. An economist might argue against this because the full cost ought to be borne by the users of the investment and its product, encouraging non-wasteful use, and current energy prices are high enough to attract an adequate amount of investment.

4.) Alternative use of price mechanism.

The clear adverse effect on the overall economy of using the market mechanism to meet our current energy problem and the meagerness of the immediate results suggests two alternatives:

First, the adverse impact of the increase in prices (including taxes) on purchasing power be offset by government action reducing the general level of taxation, increasing federal expenditures or easing monetary conditions.

Second, increases in prices (or taxes) be introduced slowly. This would avoid sharp adverse repercussions on the economy. And, it would not inhibit the production of oil from existing facilities, investment in new productive facilities, and shifts required to reduce the demand for energy.

It takes consumers and producers considerable time to adjust to changes in the price of energy. Their expectations about future prices are more important than the level of current prices. Thus, a slow, but clearly defined, price decontrol program would probably yield virtually the same beneficial results in terms of consumption and production as rapid decontrol, and the several depressing effects could be avoided or more easily absorbed.

A combination of the two alternatives might be appropriate -- some immediate price rises coupled with expansionary fiscal policy, and an announced program of future price increases to take place over a period of years.

C. Other Government Measures -- Direct Controls, Taxes, Import Duties and Quotas

A number of specific government measures to conserve fuel and to increase supply are being considered.

Reducing energy consumption has as much impact on the world price of oil as an equivalent increase in energy output. Moreover, conservation has a number of advantages over increased output:

-- A reduction in consumption can be achieved more quickly than an equal increase in output. As noted earlier, a number of years are required to open new coal fields, to bring a new oil field into production, and to build a nuclear energy plant. A limited, though significant, cut in energy consumption can be achieved more quickly than an equal expansion in output.

-- Conservation prolongs the lifetime of available energy resources; production has the opposite effect.

-- Conservation has positive environmental effects in contrast to increased production. Indeed, serious questions have been raised about the environmental threats of exploiting the Outer Continental Shelf and sharply increasing the output of nuclear power.

-- Conservation, up to a point, costs less than the cost of producing an equal amount of energy.

These reasons argue for putting major emphasis on the conservation of energy.

There are a number of bills in the Congress designed to conserve energy. Increased use of electricity generated by coal and nuclear power would conserve oil. This would require changes in laws protecting the environment. There are other proposals as well. But, probably most important, are measures to reduce the consumption of gasoline in the United States.

The rise in the cost of oil is likely to induce significant savings in its use by industry. It can economize on the use of all energy and shift to fuels other than oil. But, the ability to switch out of gasoline as the prime source of energy into coal, natural gas or nuclear fuels is extremely limited in the transportation sector in marked contrast to industry. Gasoline accounts for one-quarter of U.S. consumption of all energy. If, there is to be significant savings in the use of energy without adversely affecting economic output, gasoline consumption will undoubtedly have to be cut.

These reasons lay behind the original proposals in the Ways and Means bill (H. R. 6860) to impose a tax on gasoline and to tax automobiles which do not meet standards for gasoline consumption. However, these proposals pose three major problems:

-- one, each one cent tax would increase revenues by one billion dollars and, thereby, act as an additional drag on a country in a business recession; for this reason the original Ways and Means bill would return most of the tax to consumers;

-- two, the major impact of the proposals would be felt only slowly, as the stock of automobiles changes to include more cars with gasoline-efficient engines, as more public transport becomes available and U.S. life-styles change; partly for these reasons the Ways and Means bill provided for a gradual increase in taxes on gasoline and gasoline-inefficient automobiles.

-- three, adequate conservation might be achieved if the consumer price rose to reflect more fully the cost of oil with the proposed reduction in price controls over "old" oil.

In addition to taxes on gasoline and gas-inefficient automobiles, government standards and regulations can achieve economies. In late 1974 the Administration got the agreement of the major domestic automobile producers for a 40 percent increase in fuel efficiency by 1980. Several bills before the Congress would impose higher standards on automobiles as well as provide tax incentives for other means of saving fuel.

Cutting down on oil imports, either by a tariff or a quota, would limit supplies available at home, raise all energy prices, and, thereby, stimulate energy production and retard the growth of energy consumption.

The basic difference between tariffs and quotas is simple -- with tariffs one can be certain of the effect on price and less certain of the effect on imports; with quotas the certainties are reversed, i.e., one can be fairly sure of the amount which will be imported and uncertain as to its impact on price. But, both affect the quantity imported and the price. Tariffs, however, leave more flexibility for imports to expand to meet the needs of an expanding economy.

There are a number of questions about cutting down on imports directly:

1. Is it necessary, given the current high price of energy and higher prospective prices?

2. Is it necessary, if there are other government policies to restrain total demand?

3. Will it be effective in increasing output, given the current high prices for energy or will an import tariff or quota merely raise windfall profits for U.S. energy producers, domestic producers of oil, coal and natural gas sold in intrastate commerce?

4. Is it necessary because multinational oil companies may prefer to import from abroad, liquidating their insecure investments rather than use their secure sources at home? Will the multinationals prefer to import even though the marginal return of new production at home yields some $20 per barrel, as noted earlier?

5. Finally, is it too costly? A two dollar import charge -- or an import quota with the equivalent impact on price -- raises the domestic price of coal and natural gas sold in intrastate commerce as well as non-price-controlled oil. The cost on oil alone could reach $12 billion per year (rising to $18 to $20 billion, if all secondary effects were considered), with $4.6 billion going directly to the government as tariff revenue and the remainder going to profits. All would come out of the consumer and would be a major shock to, and drag on, an economy in the midst of the deepest recession since the Great Depression.

D. Changes in the structure of the oil industry

With advent of the oil embargo and the sharp increase in the price of OPEC oil, there have been a number of suggestions for changing institutional arrangements to undercut the cartel and bring down the price of oil.

One such proposal was made by Professor M. A. Adelman. He has proposed that the U.S. Government take over the importation of oil, assigning import quotas on the basis of sealed bids. The point would be to encourage OPEC exporters to undercut the price anonymously so that they could get a larger share of the American market.

Some observers have even gone farther than Adelman. They have suggested that the multinational oil firms be required to divest themselves either of their foreign or their domestic operations. Unless this were done, it is argued, the corporations would be ambivalent about searching for the lowest-cost supplier. A large multinational oil company not only has interest in its domestic operations but in maintaining its foreign operations as well. In order to protect their interest abroad, the multinationals may operate in a way which is detrimental to the U.S. interest in getting lower cost energy. Forcing a breakup of the large multinationals into domestic and foreign operations could increase competition.

Finally, it has been proposed that the U.S. government itself introduce competition into the energy industry by creating a public corporation to search for and produce oil. Britain has done this and the Tennessee Valley Authority in the United States has had a similar function in the production of hydropower.

However well motivated the above suggestions may be, they do little to affect the basic supply-demand relationships. Unless this happens, OPEC together, or Saudi Arabia alone, has considerable leeway to set production and, consequently, determine the price for oil.

There are a host of other proposals for government financed research and development and government price guarantees for the production of energy from new sources and processes. Such proposals need to be studied to meet the long-range problem. While such policies would do little to affect the supply and demand for energy in the next 5 to 10 years, if they are to be effective at all, progress on them will have to be made soon.

V. Policy Toward OPEC: Confrontation or Cooperation

What should be the U.S. attitude toward OPEC? This question was raised dramatically when the Undersecretary of State for Economic Affairs publicly contradicted his Assistant Secretary for stating that the U.S. objective was to break-up OPEC.

A break-up of OPEC, if perceived by the developing countries as engineered by the United States, whether correctly or not -- would not necessarily be in the U.S. interest. It would look as though the U.S. was using its power to thwart "legitimate" economic aspirations of the Third World. The result could be further disillusionment with U.S. leadership with no diminution in attempts to form other OPECs. Even if such attempts were unsuccessful, serious economic dislocations and disruptions could develop.

Moreover, U.S. objectives in the energy field do not require the break-up of OPEC, even if it were possible to do so. The United States wants an assured supply of petroleum at a reasonable and fairly stable price. While a reasonable price might be well below current levels, this is less important than that the price not be subject to the sharp increases of 1973-74.

Cooperation, on the other hand, does not mean a commodity agreement on oil. At the moment one would be difficult to negotiate and could probably be negotiated only at a high price which would be costly to the United States and other oil-importers.

Cooperation with OPEC is as much a matter of style as it is of substance. On substance we are cooperating. We are supplying goods, skilled manpower, technical services to OPEC countries. We are accepting their investments, both liquid and long-term.

We need to continue to do so. Indeed, if OPEC investments, at home and abroad, are sufficiently remunerative, OPEC countries may well decide that oil in the ground is less valuable than oil sold and the revenues invested. For this and the economic reasons mentioned earlier, it is in the U.S. interest to encourage OPEC investment.

Attempts to bargain with OPEC by organizing counter-cartels for exports of food, military equipment and capital equipment are doomed to fail because cooperation of the other industrial powers would be lacking and, if not, the Soviet Union would be able and willing to replace "Western" exports.

There may be specific help the U.S. Government could give the OPEC countries, but this is less important than the style we use in talking about our common problems or, more specifically, our love-hate attitude toward their potential investments in this country and our expressed feeling that OPEC may act to disrupt the world economy.

The major oil exporters -- especially Saudi Arabia -- have many interests in common with the United States. As conservative regimes they are anti-communist and want to preseve the existing political order. They also have similar economic objectives. They have no interest in disrupting the world economy. They do want access to our market, supplies and technology. They do need outlets for their surplus funds. And, they would like to tilt the economic order more to benefit the disadvantaged countries, an objective which the U.S. has always supported in principle if not always in action.

From all of this it would appear that the United States, which has many similar objectives, may not need to make many substantive changes to be able to work cooperatively with many of the major oil exporters. One change that would be necessary is in the style with which we defend our interests.

We have much to gain from cooperation. Specifically, in the short-run the demand for and supply of oil is inelastic with respect to price -- a rise in price would affect supply and demand only after a considerable time lag and at considerable cost in economic disruption and uneconomic investment. In an atmosphere of hostility, or confrontation, the oil exporters might well take a short-run view of their situation, and, to avoid the decline in oil revenues forecast by many, they might well raise oil prices and cut production rather than increase output. In the long-run they would be hurt as we made adjustments to do without their oil. But, it would be a Pyrrhic victory with heavy costs imposed on both the oil importers and exporters.

The major oil exporters -- especially Saudi Arabia -- have many interests in common with the United States. As conservative regimes they are anti-communist and want to preseve the existing political order. They also have similar economic objectives. They have no interest in disrupting the world economy. They do want access to our market, supplies and technology. They do need outlets for their surplus funds. And, they would like to tilt the economic order more to benefit the disadvantaged countries, an objective which the U.S. has always supported in principle if not always in action.

From all of this it would appear that the United States, which has many similar objectives, may not need to make many substantive changes to be able to work cooperatively with many of the major oil exporters. One change that would be necessary is in the style with which we defend our interests.

We have much to gain from cooperation. Specifically, in the short-run the demand for and supply of oil is inelastic with respect to price -- a rise in price would affect supply and demand only after a considerable time lag and at considerable cost in economic disruption and uneconomic investment. In an atmosphere of hostility, or confrontation, the oil exporters might well take a short-run view of their situation, and, to avoid the decline in oil revenues forecast by many, they might well raise oil prices and cut production rather than increase output. In the long-run they would be hurt as we made adjustments to do without their oil. But, it would be a Pyrrhic victory with heavy costs imposed on both the oil importers and exporters.

OPEC CURRENT ACCOUNT ESTIMATES
(Billions of Current US $)

	1974	1975	1976	1977	1978	1979	1980
OPEC oil exports (MMB/D)							
Enders		27.0		31.0			25.0
W. J. Levy	29.6	26.5	30.0	31.5	32.5	32.5	31.5
Morgan Guaranty a/	29.6						29.6
Irving Trust b/	30.5	28.6	27.3	24.7	24.7	24.7	24.7
Citibank	30.0	26.0	27.0	28.0	29.0	30.0	31.0
CIA	29.2	26.1	27.7	29.3			23.6
Per barrel revenues ($/B)							
W. J. Levy	9.72	10.00	11.20	12.00	12.80	13.70	14.65
Morgan Guaranty a/	9.72						13.25
Irving Trust c/							
- Prices rise	9.40	11.00	12.00	12.87	13.74	14.70	15.72
- Prices break	9.40	11.00	12.00	10.00	9.00	8.00	7.00
Citibank c/	11.40	11.30	11.80	11.20	10.70	9.90	9.10
CIA	10.68	10.89	11.73	12.35			
OPEC total oil revenues							
IBRD		105.1					185.1
Enders	d/	d/		148.8			
W. J. Levy	95.0	93.0	123.0	138.0	152.0	162.0	168.0
Morgan Guaranty	105.0	110.0	119.0	125.0	128.0	135.0	143.0
Irving Trust e/							
- Prices rise	108.0	119.0	120.0	116.0	124.0	132.0	141.0
- Prices break	108.0	119.0	120.0	90.0	81.0	72.0	63.0
Citibank	126.0	107.0	116.0	114.0	113.0	108.0	103.0
CIA	113.9	103.8	118.7	131.9			
Non-oil exports f/							
IBRD		6.1					21.0
W. J. Levy	7.0	8.0	10.0	12.0	14.0	16.0	19.0
Morgan Guaranty	7.0	8.0	10.0	12.0	14.0	16.0	19.0
Irving Trust	12.0	14.0	17.0	21.0	25.0	30.0	36.0
CIA	5.9	7.1	8.5	10.5	12.9		
Imports (Goods and Services)							
IBRD (Goods only)		58.4					160.6
W. J. Levy	45.0	58.0	71.0	88.0	108.0	133.0	164.0
Morgan Guaranty	50.0	65.0	83.0	108.0	138.0	177.0	227.0
Irving Trust g/	57.0	76.0	98.0	119.0	144.0	176.0	215.0
Citibank h/	65.0	79.0	92.0	105.0	118.0	131.0	146.0
CIA	48.9	70.8	89.5	108.7			
CIA (goods only)	35.5	54.0	68.7	84.4			

61-173 O - 75 - 14

	1974	1975	1976	1977	1978	1979	1980
nvestment Income							
W. J. Levy	3.0	7.0	11.0	16.0	21.0	26.0	30.0
Morgan Guaranty	3.0	8.0	13.0	16.0	19.0	19.0	16.0
Irving Trust							
- Prices rise	2.0	7.0	12.0	16.0	19.0	21.0	21.0
- Prices break	2.0	7.0	12.0	16.0	17.0	15.0	10.0
CIA	4.1	7.7	11.2	14.8			
rant Aid							
W. J. Levy	2.0	3.0	4.0	5.0	6.0	6.0	6.0
Morgan Guaranty	2.0	3.0	3.0	3.0	3.0	3.0	3.0
Citibank i/	4.0	6.0	5.0	3.0	3.0	3.0	3.0
CIA	4.2	2.7	2.2	2.1			
PEC Current Account (cash basis)							
IBRD		47.2					47.9
Enders		56.0	61.0	64.7			
W. J. Levy	58.0	47.0	69.0	73.0	73.0	65.0	47.0
Morgan Guaranty	63.0	57.0	54.0	40.0	17.0	-13.0	-56.0
Irving Trust							
- Prices rise	65.0	64.0	51.0	34.0	24.0	7.0	-17.0
- Prices break	65.0	64.0	51.0	8.0	-21.0	-59.0	-106.0
Citibank	66.0	36.0	37.0	30.0	19.0	8.0	- 7.0
CIA	56.8	45.1	46.7	46.3			
PEC Cumulative Surplus (end of period)							k/
IBRD j/	62.4	131.5					403
Enders							337.0
W. J. Levy	75.0	122.0	191.0	264.0	337.0	402.0	449.0
Morgan Guaranty	80.0	137.0	191.0	231.0	248.0	235.0	179.0
Irving Trust							
- Prices rise	85.0	149.0	200.0	234.0	258.0	265.0	248.0
- Prices break	85.0	149.0	200.0	208.0	187.0	128.0	22.0
Citibank j/	66.0	102.0	139.0	169.0	188.0	196.0	189.0
CIA	83.1						

›te: Citibank figures are for its "central scenario."

Morgan Guaranty export volumes and per-barrel revenues for 1975-1979 not available.

Irving Trust assumes same export volumes in their Case A (rising prices) and Case B (price break in 1977).

Data for Irving Trust and Citibank are prices rather than per-barrel government revenues.

Actual cash receipts. Assumes a payments lag of $10 billion in 1974 and a further $4 billion in 1975, with a payments lag of $14 billion remaining constant thereafter.

e/ Data for Irving Trust and Citibank are total value of oil exports rather than total government oil revenues.
f/ Data for non-oil exports and investment income are not shown separately in the Citibank scenario.
g/ For Irving Trust, imports are net merchandise imports plus net services excluding interest. Assumed to be the same for both Cases A and B.
h/ Citibank imports of goods and services include foreign oil-company profits.
i/ Citibank data are "transfers."
j/ Excludes pre-1974 accumulation.
k/ IBRD notes that minor changes in assumptions could change 1980 cumulative surplus from $400 billion to $200 billion.

Sources:
1) Morgan Guaranty — World Financial Markets, January 21, 1975.
2) Irving Trust — The Economic View from One Wall Street, March 20, 1975.
3) First National City Bank (Citibank) — Monthly Economic Letter, June 1975.
4) W. J. Levy Consultants Corp. — Future OPEC Accumulation of Oil Money: A New Look at a Critical Problem, June 1975. This report summarizes the estimates of the above three reports.
5) Enders —"OPEC and the Industrial Countries: The Next Ten Years," Foreign Affairs, July 1975.
6) CIA -- Project World Oil Demand and OPEC Current Accounts, 1975-77, March 1975, updated informally, June 1975.
7) IBRD -- Capital Requirements of Developing Countries, April 28, 1975, as revised informally in July 1975.

APPENDIX XII

The Absorptive Capacity of OPEC Countries

U.S. Treasury Department
Office of Assistant
Secretary for Trade, Energy
and Financial Resources
Policy Coordination:
Office of Middle East Affairs

September 5, 1975

Executive Summary

1. The sharp increases in the price of oil in late 1973 and early 1974 and the consequent jump in the revenues of the oil producing countries have generated considerable interest in the question of the absorptive capacity of these countries and the extent to which they will be able to utilize their oil revenues for domestic investment and consumption. The question is central to the issues of real resource transfer, recycling and to the impact of these issues on the domestic economic objectives of the consumer countries.

2. These issues have resulted in a number of efforts to gauge the size and structure of the evolving payments position of the OPEC countries. Little effort, however, has been devoted to analyzing the capacity of individual OPEC countries to utilize domestically (or absorb) oil revenues despite large differences in the economic structure of these countries. Most of the forecasts have been of aggregate imports for OPEC as a whole. A few have attempted to separate OPEC into two groups -- high absorbers and low absorbers and have projected imports for each of these groupings. This study investigates factors which will bear heavily on each country's import levels over the next decade.

3. During the past year and a half, oil revenues have trickled through broad segments of almost all of the OPEC economies, in consequence of sharply rising government expenditures. In most cases public outlays have increased more rapidly than imports and this pattern has been a major factor in intensifying domestic price pressures. There is considerably greater scope for further massive redistribution of oil revenues in OPEC countries, but an effort in this direction is not a prerequisite for sustained high levels of imports. The extent to which OPEC revenues will be redistributed, however, will affect the mix of OPEC imports.

4. The OPEC countries are beginning to face major problems in further expanding their import levels. These problems have become increasingly apparent in the aftermath of the sharp increase in OPEC imports since 1973 which has strained certain facilities in a number of countries to their limits. Most OPEC countries have recognized these constraints, however, and have in train policies and programs to mitigate or overcome them in the framework of their

domestic development plans. The most serious of these constraints are in transportation and manpower. Foreign exchange availabilities are already limiting the import capability of one OPEC country and several others are expected to experience a similar constraint within the next few years.

5. Infrastructure expenditures now have the highest priority in most of the OPEC countries, but many OPEC governments have plans for diversification into industrial activities and establishment of broader agricultural bases. The prospects for successful diversification are uneven and for some countries further development of the energy sector may be the most profitable avenue. Many of the OPEC countries have limited non-hydrocarbon resources and in addition small domestic markets will severely limit the possibility of achieving economies of scale without access to broader regional or world outlets. This access in turn will depend on comparative costs which have not yet been sorted out for many of the plans and projects under consideration. Duplication of effort in some areas which could lead to oversupply problems is also likely to occur. The completion of investment projects in industry and agriculture will frequently result in either increased exports or import substitution, so that the absorptive capacity of these countries will change. The direction of this change will vary from country to country.

6. The Gulf States are least likely to be able to utilize their oil revenues domestically during the next five years, in a reasonably efficient manner. But perhaps only Saudi Arabia and Kuwait will sustain large current account surpluses into the 1980's. On the whole we would expect to see aggregate OPEC imports grow from $37 billion in 1974 to $89 billion in 1980 and to $133 billion by 1985, (all in 1974 prices). This would mean a continuous decline in the annual increase in real OPEC imports from 45 percent in 1974 and 33 percent in 1975, to an average increase of 16 percent annually through the end of this decade, and then to an average increase of only 8 percent from 1980 to 1985. Employing the OECD's forecasts of the growth in OPEC's oil earnings, these import levels would imply an OPEC current account surplus of about $13 billion in 1980, and a cumulative surplus through 1980 of $195 billion, both in 1974 dollars.

7. In comparison, the aggregate OPEC investible surplus in 1974 is estimated at $59 billion which we anticipate will decline this year to a surplus of about $46 billion.

Saudi Arabia and Iran, which accounted for more than half of the aggregate OPEC surplus last year, will have an even more dominant position in 1975, despite extremely large increases in their import levels.

8. The issue of absorptive capacity -- through its determination of how rapidly the transfer of real resources from the consuming to the producing countries will proceed -- relates to several key goals which the industrial countries would seem to have in their relations with OPEC nations. In particular absorptive capacity raises questions with respect to the compatibility of the policies and objectives of the two groups of countries and efforts to ensure that current and prospective oil earnings have minimum disruptive effects on the Western economy and its growth prospects.

9. In the debate that has followed the large and abrupt change in oil prices, there appears to have emerged a preference in many industrial countries for a continued rapid increase in OPEC imports, i.e., a continued rapid transfer of real resources. The preference for present versus future transfers, however, involves a number of complex considerations which have not previously been adequately explored and some of the key arguments in favor of one option or the other fail to hold up under intensive scrunity. Some of the more widely discussed factors bearing on this issue include the effects on: the total level of transfers that would result; the capacity to service OPEC claims; the problem of recycling and cyclical conditions in the major consumer countries.

10. It is far from certain that delayed transfers of real resources will mean a larger total transfer over time. As long as general price movements are as large as pecuniary returns on OPEC investment then the size of the transfer will be unchanged. But recent history indicates a less than complete interest rate accommodation to the rate of inflation.

11. On the other hand, OPEC investment in the consuming countries will not necessarily permit a greater increase in their capacity to service OPEC claims, since export income not only also generates investment capital, but equally important, it increases the demand for such capital through fuller utilization of existing capacity.

12. It is probably impossible for either OPEC governments or OECD governments to develop a trading pattern which will always complement the domestic economic policies of the exporting country, nor would this appear to be necessary.

Export markets cannot predictably be turned on and off with ease and foreign trade has seldom been used successfully as a major counter-cyclical device. On the other hand domestic authorities are able to create or extinguish domestic demand with greater ease, particularly since policy shifts to change overall demand and supply conditions must be taken quickly. Finally, from a micro viewpoint it is not practical to assume that OPEC countries are ready or able to confine their purchases to the more severely depressed sectors of the economy during periods of economic slowdown.

13. Similarly it should not be assumed that the main solution to short-term adjustments in the international payments position of the major consuming countries, either individually or collectively would lie in a sharp acceleration of exports. The ability to increase exports depends upon the pace and manner of implementation of the highly diverse and uncertain plans of the OPEC countries. As a general proposition the high degree of mobility of capital makes short term adjustments through financial flows far more practical than through changes in current transactions. Previous fears that the market mechanism would be incapable of handling such large financial adjustments have proved to be largely unfounded.

14. There is likely to be a significant relationship between the absorption rate of the OPEC countries and their policies with respect to oil production and prices. But the manner in which these relationships will evolve is highly uncertain at the present time. To date the OPEC countries have been able to reconcile their respective revenue availabilities and requirements through selected changes in both prices and production. Whether countries which have excess revenues will be prepared to continue to make adjustments for the sake of countries facing revenue constraints remains to be seen. Similarly, it is not clear whether the success of the development efforts of OPEC governments which would graphically demonstrate the utility of their oil revenues, would encourage them to maintain high revenue levels through higher prices or higher production. Conversely, the failure to utilize OPEC revenues in a productive way could prompt either conservation efforts or lower prices.

15. Regardless of the preference that individual oil consuming countries may have with respect to the timing of real resource transfers to OPEC countries, a number of constraints will intervene which will make it difficult to carry out major policies designed to achieve the preferred result. In the first place, commercial exchanges of the oil

consuming countries are heavily dominated by the activities of private firms who cannot easily be convinced to undertake unproductive ventures, nor sacrifice productive undertakings against the interests of their shareholders and communities. Furthermore, policy decisions which would attempt to channel oil revenues in a particular way could lead to preferential trade and investment policies which would compromise the economic liberalization that has been so painstakingly established in the post-war period.

16. Governments must guard against a tendency toward a competitive race among them for OPEC markets and investment capital, through subsidies, guarantees or the like. Otherwise the total cost of their oil burden could easily increase. Moreover, they must recognize that countries which rely heavily on specific foreign markets are no less vulnerable to them than are countries which rely on specific sources of oil.

17. We would conclude that the appropriate policy framework in the OECD countries for the transfer of real resources to OPEC governments would be one which would maximize the play of market forces. Not only is this likely to prove necessary for practical reasons, but advantageous from the viewpoint of maximum efficiency and world income.

Introduction

The sharp increase in the price of internationally traded oil has posed complex problems to both producing and consuming countries which both are now beginning to sort out. The consuming countries are seeking to find ways of minimizing the adverse impact on their economies, while the producing countries are attempting to sustain high oil prices and to utilize their increased oil receipts in a productive manner.

The policy issues which have evolved from the sharp redistribution of world income to the oil producing countries have directed considerable attention to the absorptive capacity of these oil producing countries. It is central to the issue of real resource transfer and to the associated issues of recycling and consistency with the domestic economic objectives of the consumer countries. Finally, it is relevant to the industrialization efforts of the OPEC countries and consumer country response. These issues have prompted a number of analysts to investigate the evolving size and structure of OPEC revenues and expenditures in the years ahead.

The analysis behind most of the forecasts of the OPEC current account position which have appeared to date has focused mainly on the outlook for oil revenues. Far less effort has been devoted to an analysis of the capacity of each of the OPEC countries to utilize (or absorb) oil revenues despite their distinct differences. Some forecasts have applied a common growth rate in forecasting imports for the OPEC countries. Others have separated OPEC members into a high absorber group and a low absorber group, and have applied separate growth rates to each group.

As a step toward further refinement of forecasts of the OPEC payments position, this study investigates factors in each of the OPEC countries which will bear heavily on their respective import levels over the next decade. Rough estimates of each country's imports in 1980 and 1985 have been derived from these analyses. The study benefits from the considerable work that has been done in estimating oil revenues, to identify possible cases of revenue constraints.

It should be emphasized that significant problems and uncertainties remain in attempting to analyze OPEC's payments position. Most notable are a paucity of hard data and the somewhat related problem of a still less than perfect understanding in the industrial world of the evolving structure of each OPEC economy.

The Absorptive Capacity of the OPEC Countries

Although the absorptive capacity of the OPEC countries can be measured by the current level of their imports relative to their current oil revenues, this measurement is not indicative of future absorptive capability. Countries which will have mounted large current account surpluses in 1974-75 may nevertheless eventually be able to employ the bulk of their current oil earnings for domestic purposes. After a time most of them may be able to utilize even their accumulated wealth domestically, especially those countries with major infrastructure requirements and/or moderately large population bases.

In order to accelerate the utilization of their new wealth and to do so in the most efficient manner, OPEC countries have been relying heavily on foreign contractors and consultants in implementing their investment plans. Imports of consumer goods continue to be dominated by government imports, particularly of agricultural commodities and foodstuffs. Changes in this trend will depend upon the increase in disposable income in the hands of individuals which more than ever will depend upon the willingness and ability of OPEC governments to redistribute oil revenues, directly and/or indirectly. With respect to the "non-commercial" category of imports, several OPEC countries, particularly in the Middle East, have exhibited a strong desire to import military equipment. On the other hand, "prestige" expenditures have not been pronounced to date.

Developments in the aftermath of the abrupt and massive increases in petroleum prices have presented OPEC countries with problems as well as opportunities. In most cases they have been unable to absorb fully the resulting large infusions of foreign exchange. Oil revenues have trickled through broad segments of the economy both directly through government transfer programs and indirectly through the demand for services associated with government investment and consumption. Increases in government expenditures have generally exceeded increases in imports and domestic price pressures have intensified.

The effects of oil revenues on the private sectors in the OPEC countries and on their propensity to consume pose a complex situation which is not easily understood. Strengthening the private sector is not a goal in all of the OPEC countries. Nor is it clear to what extent income redistribution can be accomplished through traditional fiscal policies on the income and expenditure side. A major redistribution of oil revenues within OPEC economies, however, is not a prerequisite for sustained high levels of imports, but the extent to which this is accomplished will have an important bearing on the import mix. Direct government expenditures will mean continued emphasis on imports for infrastructure development, and other forms of investment, in addition to food and in some cases military imports. A major redistribution of income into private hands, will result in imports of a broader range of goods, particularly for consumption.

Most, but not all, OPEC countries have established development plans that provide a general framework for future development but their capacity to execute these plans differs. In some countries, but not all, the decision-making process is highly centralized and commitments can be taken expeditiously. As noted earlier, some countries rely heavily on foreign advisors and contractors to expedite development spending.

As the following country overview papers indicate, a major constraint in the development efforts of the OPEC countries is insufficient skilled manpower and managerial talent which is characteristic of both the public and private sectors in most of the OPEC countries. Inadequate ports and transport facilities are often a constraint to an immediate increase in imports (representing a source of import demand as well), but this problem is generally not insurmountable. Private sectors are typically small and financial and other institutions, rudimentary. Technology and entrepreneurial talent will have to be imported. In a few countries, there are political, social and/or cultural restraints that will have a significant effect on the pace and direction of government expenditure patterns.

Almost all OPEC countries have recognized the importance of emphasizing the building blocks of a modern economy, by concentrating on the development of modern and adequate infrastructure. Some have looked beyond and have already developed ambitious plans for wide-ranging development of industry and agriculture. The industrialization prospects of the OPEC countries, however, are uneven. In each case the extent to which comparative advantages can be identified and opportunities in these areas maximized will have important long-term policy implications both for the OPEC countries and the rest of the world. These relative cost considerations remain to be sorted out. Moreover, duplication of industrial projects in different OPEC countries is not unlikely, and can lead to serious oversupply problems in world or regional markets. The importance of early formulation of a sound development strategy should not be underestimated for the momentum of plans and projects is likely to prove very difficult to reverse.

Some countries, e.g., Indonesia and Nigeria, have important non-oil natural resources and large populations, potentially providing both ample labor and markets, and thus offer good prospects. In other cases, major industrial development will require larger markets than the national economies will provide. If successful, these efforts could have a significant effect on foreign exchange revenues and expenditures. An increase in production for export should increase imports of raw materials, and semi-finished products, while the increase in export earnings will expand import demand over a wider range of goods. Import policies may tighten, however, to protect infant industries, thus limiting absorptive capacity. The net effect will probably differ from country to country.

While diversification of their economies to lessen the dependence on oil exports is an important goal of most of the OPEC nations, in some of them the energy sector offers the best potential for development, if outside technical and managerial assistance is available. Development of Venezuela's tar sands, Algeria's LNG processing and transport facilities, and ambitious petrochemical projects in a number of countries are areas in which Western technology and services will be needed.

For some countries, like Indonesia, oil revenues may be a relatively minor factor in determining the course of development given its large population, its major development requirements, and low per capital income relative to potential oil earnings. Countries like Algeria, Iran and Nigeria will use oil and gas revenues in developing both the energy sector and in diversifying their economies.

A potentially large, albeit currently meagerly employed outlet for surplus OPEC funds is in the non-oil exporting developing world which can accommodate substantial aid and investment flows. OPEC bilateral aid commitments have been substantial--although concentrated geographically--but disbursements have been considerably more limited.

There are also small but growing flows of investment funds to LDC's from OPEC countries. Many projects in the primary sector may eventually be included in the OPEC investment portfolio, particularly as the more populated OPEC countries seek to secure long-term agricultural and raw material supplies. The importance of these flows to the less-developed countries will depend upon a complex of factors including the relative profitability of funds in the developed consuming countries and in OPEC domestic economies, the evolution of a greater willingness by OPEC financial managers to accept investment risks, the availability of technical services from the developed countries, and the emphasis OPEC countries place on aid as a political device.

Saudi Arabia, Kuwait, and Qatar would appear to be the OPEC countries with the least likelihood of being able to utilize "efficiently" at home the major portion of their accumulated oil earnings over the next decade or so, given their high per capita oil revenues, small labor force and domestic markets, limited natural resources, and problems of wealth concentration.

On the other hand, several OPEC countries will face revenue constraints some time during the next ten years, in the absence of dramatic changes in their export earnings. Algeria is already experiencing a significant current account deficit and a relatively large current account deficit is emerging in Indonesia. Moreover, these countries have not had the opportunity to build up sizeable assets abroad and consequently further rapid increases in their imports will depend upon their ability to obtain external financing. By the turn of the decade the net excess revenues of most of the remaining OPEC countries will probably have disappeared.

OPEC Imports In 1980 and 1985

The country analyses which follow provide estimates of import levels of each of the OPEC countries for 1980 and 1985. These should be viewed as indicative estimates which will become increasingly precise with the passage of time. The point estimates from this paper are presented in the following table together with forecasts by the World Bank and the OECD.

OPEC Imports f.o.b.
(billions of 1974 dollars)

	1974	1980	1985
Algeria	3.7	6.5	10.0
Ecuador	0.8	1.5	2.2
Indonesia	3.9	9.4	12.3
Iran	8.0	24.4	32.0
Iraq	3.5	9.5	14.0
Kuwait	1.5	3.4	6.4
Libya	3.0	5.2	6.5
Nigeria	2.5	8.5	12.6
Qatar	0.3	0.6	0.9
Saudi Arabia	3.5	7.5	17.4
United Arab Emirates	1.6	3.9	6.9
Venezuela	4.7	9.4	12.0
Total	37.0	89.8	133.2
IBRD c.i.f.	44	92.0	NA
OECD f.o.b.	32	78.5	114

The 1980 estimate of total imports of $90 billion would represent a real growth rate of 16 percent per annum from 1974. The estimate of $133 billion for 1985 imports represents a halving of the average growth rate to only about 8.0 percent in real terms, and corresponds closely to the growth in global imports from 1968 to 1973. The 1980 estimates are appreciably higher than those of the OECD and the IBRD (after adjustment for freight and insurance), both of which divided OPEC into high absorber and low absorber groups for the purpose of forecasting. The 1985 estimates are substantially higher than the OECD's forecasts in absolute terms, but the percentage changes for the period are quite similar.

The country analyses in this paper suggest that only Iran will have an average real rate of growth of imports of 20% or more in the period 1975-1980. Saudi Arabia, Algeria and Libya will have average real import growth rate of less than 10% a year from 1975 to 1980. During the period 1980-85 the real growth rate of imports will fall below 10 percent for all of the OPEC countries with the possible exception of Kuwait, Saudi Arabia, and the United Arab Emirates. Only in Saudi Arabia will imports accelerate sharply from the pace of the previous five years, while the growth rates for Kuwait and the Emirates remain relatively constant. Iran and Indonesia should experience a pronounced decline in import growth during this period.

In identifying possible cases of revenue constraints on imports, the country analyses have assumed small annual increases in real oil revenues over present levels for OPEC as a whole, generally in line with aggregate estimates by the OECD. Differential growth factors were applied to individual countries, within a relatively narrow range to take into account cases of new and depleting reserves. A significantly different pattern would affect the import estimates for some countries.

Employing the OECD's growth estimates for aggregate OPEC oil revenues, the import forecasts in the table above would imply a current account surplus for OPEC as a whole of $13 billion in 1980 (in 1974 dollars). The cumulative surplus over the period 1974-80 would total about $195 billion, also in 1974 dollars.

Iran

The Government of Iran contemplates that it will be able to utilize fully its annual oil earnings in the very near future, and some Iranian observers are predicting that by 1976 or 1977 Iran will become once again a net importer of capital.* This assessment has been greeted with skepticism by a number of analysts, particularly in light of Iran's impressive current account surpluses over the past year and a half. An assessment of Iran's evolving payments position, however, must take into account the sizeable outstanding Iranian commitments which even if not fully implemented will entail major expenditures abroad in the coming years, particularly for purposes of foreign assistance and domestic project development. This situation and a desire to sort out domestic priorities have prompted the recent Iranian reassessment of its spending plans.

The extent to which Iran's plans and commitments will be translated into actual imports will depend in part on the ability to alleviate bottlenecks which are becoming increasingly apparent in face of the dramatic surge in import levels since 1973. But revenue constraints might also arise. A major problem is an inadequate transportation system where demurrage can run up to 60 days and railroads and warehouses become periodically overburdened. Another problem is the lack of skilled labor and a growing shortage of semiskilled or unskilled labor, which the Iranians estimate could total 700,000 workers during the present plan period.

These two problems may not be as severe or as intractable as commonly believed. More effective utilization of port capacity in the past two years has enabled a 100% increase in the volume of cargo entering Iran's seaports. Moreover, expanded air freight and truck transportation has been used to alleviate the burden somewhat and use of these modes of transport should expand further in the coming years. More importantly, plans are underway to expand both port capacity and the domestic rail network. Port capacity should jump from 10 million to 18 million tons during Iran's current development plan period (ending March 1978), but continued expansion of the ports and domestic transport network will be required if Iran is to continue to expand its imports at a pace commensurate with the economy's growth potential.

---

* A recent small borrowing in the Eurodollar market by an Iranian bank should be viewed as a step toward familiarizing the international financial market with Iranian paper and potential Iranian borrowers.

Despite the projected labor gap, the plan indicates that the labor force will increase by 1.4 million workers, or by nearly 15%. This would appear to be a conservative estimate. In the fourth plan period, the labor force in industry and services alone rose by 1.5 million people. In addition an increase in the low participation rate (29%), increased vocational training to upgrade the skills of the indigenous population and recourse to foreign labor could fill any remaining gap.

Iran's current development plan (March 1973-March 1978) calls for expenditures of over $123 billion, with a foreign component of $95 billion. Foreign exchange receipts are estimated at $114 billion of which $102 billion would be derived from energy exports. The revenue projections may be somewhat high, particularly in the case of energy exports which at present prices and levels would be overstated by about 10%. On the other hand it is also unlikely that merchandise imports, which at the halfway mark totaled about $22-25 billion, will reach the $79 billion target. We would anticipate total merchandise imports of about $65-70 billion in current prices, assuming average annual import price increases of about 10% a year, with allowances for a reduction in transport costs as a result of the opening of the Suez Canal. This would imply a merchandise import level in 1977 of between $17 and $20 billion on an f.o.b. basis, in current prices or about $13 to $15 billion in 1974 dollars. The current account surplus would shrink to about $3 to $4 billion and could disappear the following year. These estimates would mean continued full utilization of port capacity.

Looking beyond, it is clear that the Iranian authorities are determined to proceed with the rapid development of the Iranian economy, with initial emphasis on infrastructure and energy and then on industrial and agricultural development. Many extremely large projects are planned and a number of major contracts have already been awarded. These include, for example, $500 million for modernization and expansion of the telephone network, rail contracts estimated at $1.5 billion, $250 million for a wood products complex, $550 million for expansion of the Tehran airport and about $2 billion for nuclear power plants. Other projects in the billion dollar range are under consideration, particularly in the energy area. In addition, Iran also expects to expand considerably its military establishment and import payments for military equipment could reach $5 billion annually toward the end of the decade. Agricultural imports are also likely to be extremely high over the next five years, perhaps exceeding $2 billion a year by 1980.

The extent to which Iran will be able to continue to increase imports at a rapid pace in the late 1970's will depend in large part upon its ability to increase export revenues. It is difficult to quantify the pace at which export capacity will increase as a result of Iran's industrialization efforts. The plan's estimate of $4.9 billion in non-oil exports over the five years ending March 1977, would imply a 10-15% annual increase during the second half of the plan period and does not appear to be unrealistic.

It is even more difficult to assess the extent to which Iran's natural gas exports will be expanded. In Iranian Year (IY) 74/75 these exports amounted to about $200 million. Completion of the proposed Kalingas LNG plant and the expansion of the Iranian Gas Truckline could raise gas export levels to $750 million or so by the end of the plan period. Large Iranian gas reserves could enable Iran to expand sharply this level in the 1980's, if arrangements can be made to construct costly LNG facilities.

In looking at Iranian import requirements over the next decade, we find that the experience in the 1960's demonstrates an especially close link between public and private investment and public consumption, on the one hand, and Iranian import levels, on the other. This relationship provides remarkably good estimates of the large increases in imports in IY 1973/74 and IY 74/75 and indicates that a 1% increase in the real value of these components will prompt a 1.2% increase in real imports. Using this relationship, based on plan targets, non-military imports in IY 77/78 would run about $11.5 billion in 1974 prices.

We would expect that the growth of Iran's GNP would continue to taper off toward a more mature level in the Sixth and Seventh Plan periods. The 16.5% real growth rates expected in 1976-77 could decline to a 6% level by the mid-1980's which would imply a non-military import level of about $28 to $30 billion (in 1974 prices). A higher growth rate is probably not obtainable within the limits of present plans for expanding port capacity and the internal transport network and even at this level any significant level of military imports might stretch physical capacity beyond its limits.

Saudi Arabia

During the past year the marked increase in the efficiency of the Saudi Arabian Government to respond bureaucratically and administratively to developmental needs bodes well for Saudi Arabia's ability to spend a substantially larger portion of oil revenues in the coming five years than had been previously thought. The extraordinary sum of $144 billion in expenditures has recently been announced for the 1975-80 Development Plan. Progress toward this developmental goal will require Saudi Arabia to increase the efficiency of its air and sea ports, to attract skilled and semi-skilled foreign labor, to expand an already strained construction industry, and to upgrade the quality of the Saudi civil service.

The economic development of Saudi Arabia will clearly be dependent on its ability to import. The Development Plan anticipates annual import levels rising by 30% a year. This is somewhat below the increases in Saudi Arabia's imports in 1974 and 1975, which are estimated at 57% and 43%, respectively. The present facilities in Saudi Arabia are not capable of handling the plan's target for import growth, but projects now either under active consideration or construction will gradually alleviate some of the more pressing bottlenecks to further rapid increases in imports.

There is little question but that Saudi Arabia's requirements are sufficient to accomodate sharply expanding import levels at least in the short-term. Expenditures for large and costly capital projects as well as for defense material could easily increase the still low absolute level of Saudi Arabia's imports by 20% to 30% a year if bottlenecks to delivery and implementation are reduced. There is some question, however, whether Saudi Arabia will take this course. The Government is clearly determined not to be stampeded into ill-conceived expenditures and is taking considerable pains both to set in place administrative machinery which can handle a sharp acceleration in investment activity and to assess carefully both the need and efficiency of the many (and occasionally conflicting) project ideas which have been proposed.

Instead, we would expect the trend in Saudi Arabia's imports to follow a somewhat different course than trends in most of the other OPEC countries. Over the next decade a number of the other oil exporting nations may experience a continuous tapering off of import growth levels from the rapid increases of 1974 and 1975. The growth curve for Saudi Arabia, however, may prove to be roughly N-shaped, with relatively small increases in the near term, followed by significant acceleration a few years from now, as plans and programs become sorted out and major bottlenecks are breached. Thus, the volume of Saudi Arabia's imports might increase by less than 10% on average until the turn of the decade, when the rate accelerates sharply to perhaps 18 to 20% a year during the period 1980-85. Service payments over the next ten years, however, may well increase more rapidly than merchandise imports.

Saudi Arabia's development plan earmarks almost $15 billion for the hydrocarbon industries, including a gas gathering system, five petrochemical complexes, three export refineries, an aluminum plant and a 3.5 million ton gas reduction steel plant. The $15 billion target does not include investment financed by the Saudi private sector or by foreign firms such as oil companies, which are expected to provide at least 30% of equity capital. These major industrial undertakings will be sited at Jubail, near the oil fields on the Arabian Gulf and at Yenho on the Red Sea. The implementation of these projects will rely on the ability of foreign joint-venture firms to develop their own supply lines and services and to recruit manpower first to construct these installations and then to operate them. The prospects are good that these projects will be on stream on schedule between 1978 and 1980.

The largest allocations in the development plan are for defense and education; $24 billion and $22 billion, respectively. About $10 billion has been allocated to school construction while planned military construction amounts to only $3 billion. By and large, more of the defense budget can be expected to be utilized than the education budget, given the nature of the expenditures involved and the substantially different capacities of the two sectors. The majority of defense expenditures will be for sophisticated, expensive and mobil hardware. In addition, the Defense establishment already has relatively sophisticated infrastructure, ready access to educated manpower and independent means of facilitating imports.

Other sectors on which the plan places heavy emphasis, also do not share the same capabilities of the defense establishment and will have greater difficulty in utilizing planned allocations. These have been set at $15 billion for urban development, $10 billion for water and desalination, $7 billion for health, $5 billion for social welfare, $5 billion for electricity, $2 billion for agriculture, and $1 billion for telecommunications.

The principal constaint on Saudi Arabia's absorptive capacity remains the small manpower base and an extreme shortage of persons with technical skills. Unofficial estimates set the Saudi labor force (including foreigners) at 1.5 Million men. Traditional restraints effectively prohibit women from entering the labor pool, but this situation can be expected to change and with it Saudi Arabia's absorptive capacity. In order to meet the manpower requirements of major projects scheduled to be on stream by 1980, the total labor force will have to increase by more than 500,000, according to the Plan. More than 150,000 Saudis will enter the labor force before 1980, with the balance of the plan's manpower requirements satisfield by an increased level of non-Saudi labor.

The port situation is also a major stumbling block. Large quantities of unclaimed and uncleared tonage clog transit sheds. Demmurage charges regularly range between 20-40%, as turn-around time hovers between 30-60 days. In 1974, about four million tons of general cargo valued at $3.5 billion were imported. Port development plans such as the addition of 20 new berths at Jidda and 16 at Dammam and the increasing mechanization of both ports are expected to raise Saudi Arabia's import capacity to 13 million tons a year by 1980. Contracts involving $1 billion for construction and equipment have already been awarded for the port expansion at Jidda and Dammam. The development of new ports, in addition to Jabail and Yenbo, is also being contemplated. Not all the solutions to port congestion are physical; improved port administration could make the ports more equal to the burden. A first step in this direction was taken by the Saudi Customs Service's recent decision to drastically cut-back the number of signatures required to clear goods from land, sea, and air ports.

The Saudi construction industry is heavilly overburdened. Last year's outlay of about $3 billion is projected to expand by 60% a year, a goal which is unattainable given present construction techniques in Saudi Arabia. But, the influx of more labor-saving, capital-intensive construction techniques can be expected to transform this sector into a responsive and productive industry during the next couple of years.

The long-term prospects for the development for Saudi Arabia also depend on the improvement and ungrading of the Saudi administrative machinery. The Saudi administrative infrastructure is sometimes frustratingly thin, despite the large number of Saudi graduates returning from Western, mainly American universities. It is not uncommon for the

Saudi private sector to attract talented young Saudi bureaucrats and administrators from their government positions. Aware of the problem, the Saudi Arabian Government is developing incentives to attract and to keep that talent to respond to the administrative needs of the rapidly expanding economy.

KUWAIT

Because of the high level of Kuwait's oil earnings and projected income on foreign investment, its ability to import will, for the foreseeable future, be constrained only by what it can physically and economically absorb, by government policies which impinge on consumption, investment and imports, and by the comparative costs and advantages of domestic vs foreign investment. Kuwait's oil earnings are expected to continue to be well above its import needs despite a pattern of production cuts which had by mid-1975 brought output down to about 55% of its pre-crisis level.

Kuwait's capacity to import is limited primarily by its small population (under 1 million) and land area and lack of non-hydrocarbon natural resources. The effect of these limitations is reinforced by various government policy decisions: restrictions on immigration to check the growth of the non-Kuwaiti population (now 55% of the total); unwillingness to facilitate investment projects of questionable economic efficiency or which would degrade the environment; and an unwillingness to lock itself into a higher rate of petroleum production that it will want to sell abroad.

The requirement for 51% Kuwaiti ownership of businesses tends to discourage foreign investment and associated imports. The government's policy of restricting imports on competing products to encourage development of new, small industries will also inhibit the growth of imports over the longer term as the output of these new industries increases. Thus, the more rapidly Kuwait's imports of capital equipment increase, the more likely will there be a shift away from imports of selected consumption and intermediate goods. Although the government is prepared to continue to utilize a portion of its oil earnings for domestic investment and consumption, pressures for substantial increases in expenditures are not significant, given Kuwait's present high standard of living, extensive welfare services and well-developed infrastructure which have been achieved through judicious use of oil revenues in the past decade.

The most important factor stimulating Kuwait's imports is the government's domestic current and investment expenditures. Earnings from petroleum production accrue directly to the government and contribute to disposable income in the private sector as they are spent by the government. The government's domestic spending has been directed toward transferring income to its citizens, toward providing a high level of public services and to a lesser extent, toward investment (16% of total domestic expenditures from FY 1971-74 1/).

Kuwait's FY 1975 budget called for total domestic expenditures of about $3 billion, up 70 percent from FY 1974. Domestic expenditures in the FY 1976 budget, reflecting a balancing of needs and problems associated with rapid growth, are only 13% above FY 1975 levels. This approximates the more traditional pattern in the period FY 1971-74 when expenditures rose by an annual average of 16%. Public consumption will continue to account for a major share of total budget outlays - about 60 percent. Although a new development program has not yet been formulated, the 114% projected increase in capital expenditures in FY 1975, while not fully realized, and the 62% increase projected for FY 1976 (to over $800 million) indicate that the government will be encouraging a much more extensive domestic development effort than it has in the past. Development is likely to be centered in hydro-carbon-based, high technology, non-labor-intensive industries and in light industries which are not labor-intensive. Some $3 billion or more is expected to be earmarked for industrial projects over the next five years, including a very large LPG plant, petrochemical plants and expansion of refineries, fertilizer plants and the oil tanker and general cargo fleets. Public sector plans include $1 billion in new public housing, expansion of power and water desalting facilities, improvement and expansion of education, medical, transportation and communication facilities. Because of the lack of domestic resources, the import component for these projects will be very high. The projected improvement in Kuwaiti military equipment and facilities, which is expected to cost at least $1.4 billion by 1980, will largely entail imports from abroad.

The rate of growth of Kuwait's imports in constant prices during the next ten years may be expected to range from 10% to 20% compared with an average annual increase of about 7% from 1968 to 1973 and estimated increases of 60% in 1974 and 40% in 1975 (in current prices). These estimates assume that the growth in the government's domestic expenditures in the near term will be closer to the FY 1976 budget target than the FY 75 surge which resulted from

1/ Fiscal years end March 31.

the abrupt jump in oil receipts. The lower end of the range (around 10%) would reflect a continuation of present fairly conservative policies with respect to immigration and development, and assumes that development expenditures will rise more rapidly than in the pre-1973 period. An average increase of 20 percent in imports would reflect a more dynamic government policy and a willingness to accept an increasing number of problems associated with sustained and fairly rapid development of the economy.

A growth rate nearer the lower end of the range is likely in any event in the earliest and latest years of the 1975-1985 period. In the early years, if the government attempts to implement an ambitious development program it will take time to import or develop the necessary managerial and technical skills and organization. In the later years, military spending should decline after the present modernization of the military forces is completed, and a portion of the greater industrial output resulting from the new development projects will be in import substitutes. Based on an estimated 1975 import level of $2 billion, these growth patterns would lead to an import level of about $3-4.5 billion in 1980 and of $5-7 billion in 1985.

Nigeria

Nigeria's imports have accelerated sharply over the past year, putting a great strain on ports and on available managerial and technical manpower. However, neither constraint is expected to continue for long, and balance of payments deficits are expected to develop by 1980, if not before.

The government has liberalized imports during the past year in order to help control inflation and this is resulting in a substantial increase in consumer goods imports. At the same time, development spending is expected to increase as a result of the government's policy of meeting its manpower needs by undertaking crash training programs to the maximum extent possible and of relying on private foreign investment as necessary to organize and implement many of the larger and more complex development projects. Major programs are also underway to recruit foreign experts to fill planning and technical positions throughout the public sector. The revenue side of Nigeria's international accounts may, therefore, prove to be the chief constraint on imports by the early 1980's.

With a large population (75-80 million), a low per capita income ($270), inadequate physical and social infrastructure, a need to improve the agricultural sector which provides income and employment for most of the population, and natural resources which include oil, gas, coal and tin, the scope for development and imports is great.

Nigeria's Third Five Year Plan, covering the period from 1975 to 1980 calls for expenditures of $45 billion, compared with actual expenditures of $7.9 billion under the Second Five Year Plan. Of the $45 billion to be spent under the current plan, $30 billion is to be financed by government revenues - mostly oil receipts - and the balance from the private sector. Major emphasis will be on development of infrastructure (roads, communications, airports, and housing), the agricultural and rural sectors, and large scale industry to produce steel, pulp and paper, fertilizers, petrochemicals and refined petroleum products.

The Nigerians will have to turn to foreign sources for much of the capital goods, consumer goods and services needed to fulfill the Plan. Imports under the Plan are projected to increase at an annual average rate of 20%, in real terms, to 95% of oil revenues by 1980. While experience under the Second Five-Year would seem to point to nonfulfillment of Plan goals, revenue constraints have been temporarily lifted and accelerated development outlays - perhaps peaking by 1980 - seem likely as plans which were to have been implemented earlier finally get underway toward the end of the decade.

The current plan envisions large accumulations of reserves during the early years which would be utilized to finance the deficits projected in the early 1980's. However, this goal is currently in jeopardy because the projected oil revenues for 1975, the first year of the plan, are running well below the target figure. At the same time, domestic inflation has continued to increase and may cause imports of consumer goods to increase more rapidly than projected. Furthermore, unless agricultural production is increased substantially, Nigeria, which has traditionally been a large exporter of agricultural commodities, may become a net importer as higher incomes are reflected in increased spending on foodstuffs. This shift is already occurring, causing more funds than projected to be spent on food imports.

As a result of these factors, Nigeria's surpluses in the early years may prove to be smaller than projected in the Five Year Plan, deficits may develop before 1980 and accumulated reserves may be inadequate to finance the projected deficits in the early 1980's. Under current Plan assumptions, Nigeria's imports would be close to $9 billion by 1980 and as much as $11 billion by 1985 (in 1974 prices). However, if recent trends persist and consumption is not restrained, import capacity could be as much as $3 billion higher in 1980 and Nigeria's ability to realize the import level projected for 1985 would depend on its ability to mobilize sufficient external aid.

The United Arab Emirates

The UAE's capacity to import is determined primarily by consumption and development activity stimulated by the domestic expenditures of the government of Abu Dhabi, which accounts for 85% of the oil receipts of the Emirates and finances most of the UAE budget as well as its own budget. The import level is also affected, to a lesser extent, by the general level of economic activity in the Persian Gulf region, since Dubai, the second most important of the Emirates serves as a large entrepôt center.

Abu Dhabi has projected a balanced budget (of about $3.3 billion) for 1975. The projected budget calls for a 50% increase in current expenditures over the 1974 level, a doubling of both Abu Dhabi's contribution to the UAE budget and its assistance to third countries, and a quadrupling of development spending. The balanced budget for 1975 is in marked contrast with Abu Dhabi's previous experience of governmental surpluses, when oil revenues outpaced expenditures. The disappearance of this budget surplus, which in 1974 was estimated to have been $1.5 billion dollars, together with drastic cutbacks in oil production in the earlier part of this year led to expressions of concern that Abu Dhabi was facing a financial squeeze. This concern has proven to be unfounded, as oil production once again picked up and actual foreign exchange disbursements lagged behind the expenditures committed in the 1975 budget.

The expenditure targets, especially for domestic development, are not likely to be realized in 1975 due to persistence of the constraints which impeded implementation of Abu Dhabi's development activities even before the fourfold increase in oil prices. The most important of these obstacles are the shortage of skilled and unskilled labor, slow implementation of economic plans by a governmental apparatus beset by organizational and institutional problems and restrictions on foreign ownership of businesses. The latter discourages foreigners from taking too active and direct a part in the economy of Abu Dhabi. However, the estimated 50% increase in development expenditures which was achieved in 1974 in real terms indicates that the government has made progress in overcoming these problems.

As a result of projects now under consideration (see below), government outlays are likely to reach the levels projected for 1975 within a year or two. It would appear that after 1977 further increases in budget expenditures for domestic development will have to be limited to the amount of any increased receipts from oil, gas, or investment, or to a reduction in actual disbursement of foreign aid commitments, unless the government is willing to engage in deficit financing, which the governments in the area have generally not been inclined, or pressed by their citizens, to do.

The 1975 budget, which includes new projects with a total estimated value of well over $600 million, continues Abu Dhabi's pre-1974 emphasis on the development of infrastructure services while embarking on an extensive industrialization program. Abu Dhabi's plans include the following infrastructure projects: a $300 million expansion of its port, $30 million extension of its international airport, construction of a road to the Qatari border expected to cost over $60 million, construction of general hospitals ($80 million) and over $100 million in power and water projects. In addition, Abu Dhabi's industrialization program includes: the Das Island LNG complex, expected to cost $1 billion, a $40 million oil refinery, a $20 million cement plant, a $20 million flour mill, and construction of new hotels worth more than $70 million. Abu Dhabi has also indicated preliminary interest in an aluminum smelter, a small steel mill, petrochemical plants, and a large civic and sports center, although the magnitude of expected outlays has not yet been determined.

Dubai has also embarked on a program to expand its trade and services capacities and to diversify its limited industrial base. Decision-making in Dubai is concentrated in the hands of Sheikh Rashid and a small group of advisors and, thus, decisions are made more expeditiously than in Abu Dhabi. Furthermore, Dubai encourages foreigners to help implement the economic decisions. Dubai has recently completed a $70 million deep water expansion of its port and has started construction of a $300 million dry dock. In addition it plans a $400 million LNG plant, a $125 million trade center, and a $70 million cement plant.

The UAE (Federal) budget also provides a source of development expenditures, primarily for infrastructure projects in the poorer, non-oil producing Emirates. In 1974, the Federal Government spent about $40 million on development and has earmarked about $244 million in 1975 for development projects. The major projects are in the sectors of housing, and hospital construction; roads (approximately $50 million), ports, electricity and water desalinization. The UAE Federal Government also plans to expand its military forces and military imports are expected to run $100-$200 million annually over the next five years.

In addition to expenditures by Abu Dhabi, Dubai and the Federal Government, the only other source of any major expenditure is the oil revenue accruing to the Emirate of Sharjah. Infrastructure projects totalling over $60 million as well as a $50 million expansion of its port facilities, extensive construction of hotels and a $25 million cement plant have been initiated there.

With little domestic agriculture and industrial production as yet, the UAE economy is almost wholly dependent on the import of goods for consumption as well as for investment. Import levels have followed the pattern of the domestic expenditures of the government of the UAE, Abu Dhabi and Dubai, and more than doubled from 1971 to 1973 and almost doubled again in 1974 to about $1.6 billion. Imports for 1975 are projected at about $2.4 billion or 47% over the 1974 level.

While substantial increases (perhaps 20-30%) may continue over the next couple of years, as the UAE's new wealth reflects itself in increased development and private consumption, budget constraints coupled with domestic production of import substitutes can be expected to result in smaller increases in subsequent years. As a result, imports from 1975 to 1980 should increase by an average of about 15% per year, leading to an import level in 1974 prices of almost $3.9 billion in 1980. After 1980, as basic infrastructure requirements are satisfied, expansion of the military is completed, and the disruptions caused by rapid industrialization and competing development in the individual emirates begin to be felt, the small size of the population (about 350,000, the majority of whom are foreigners) and the barren land will limit import growth to about 10% a year. If oil exploration in the other Emirates is successful, however, these states can be expected to pursue an independent development effort and imports will continue to grow rapidly. A range of imports of $6-8 billion (in 1974 prices) is therefore possible by 1985.

Iraq

Iraq's pattern of foreign trade during this decade will be fashioned from an ongoing balancing of objectives and performance of the country's development plans. The financing requirements of large prospective levels of imports appear to be within the level of foreign exchange receipts that the plan will provide over the span of several years, but the surplus is not likely to be so large as to encourage grossly inefficient expenditure, nor oil revenues so predictable as to preclude financial stringencies over short intervals of time. The first years of the development program should see the implementation of many infrastructure projects that will ease bottlenecks to further development and, being capable of multiple productive uses, should prove to be economically worthwhile. The subsequent stages of development, and their success cannot be as readily assessed.

The energy sector is being given high priority by the Iraqi authorities and further development of this sector is likely to result in a significant "recycling" of oil revenues into Iraq's energy development. Petroleum exports, currently about 2.4 million b/d is considerably less than can be realized with additional investment. Output is more or less restricted to current levels by the capacity of transit and terminal facilities. Heavy investment such as the Hoditha-Rumaila pipeline and new terminals on the Persian Gulf, due to be complete in the next year, should raise capacity significantly. Furthermore, there has been little exploration for oil in Iraq during the past decade, and it is believed that a $1.5 billion exploration program to be carried out during the next five years will substantially increase proven reserves. As part of a general pruning of its development plan, and in response to possible continued sluggish growth in the consumption of petroleum, Iraq recently lowered its targeted 1980 production capacity from 6.5 million b/d to around 4 million b/d, but this level could be exceeded since the change in target levels was not accompanied by corresponding changes in capacity expanding investment.

Under the influence of expanded budgets and development plans, imports which tripled between 1973 and 1974 should continue to increase rather rapidly. The development budget for 1976-1980 calls for expenditures of $34 billion, or triple the previous five-year plan, of which $10 billion is targeted for agricultural development.

Industrial projects involving production of fertilizer and farm machinery are important steps toward achieving the goal of agricultural self-sufficiency. The plan also provides $7 billion for education, communication and transport which will expand both import and export capacity substantially. In particular ports will be expanded from a capacity of 1 million tons in 1973 to 2.5 million tons by 1980, while overland connections to a free port that Iraq has arranged to use in Kuwait will be improved to relieve any potential port congestion that might arise before the completion of the port expansion program. Many of the individual projects that make up the plan are drawn from a backlog of projects that Iraq has studied for years, and,considering the large number contracted for on a turnkey basis, the large majority should be completed according to schedule, significantly improving an implementation rate that only reached 65% during the 1965/66 - 1969/70 development plan.

The course of economic development should affect the demand for imported goods in several ways. First, the demand for capital goods, most of which will have to come from abroad, should be sustained by that projected high level of capital investment. Second, to the extent that oil revenue is redistributed as disposable income to the private sector the demand for consumer goods, and consequently for imports of consumer goods will rise. We would expect, however, that government investment would continue to have a substantially greater impact on the demand for imports than funds transferred to the private sector, especially in light of the governments emphasis on import substitution for non-investment goods.

The government has influenced the level of private imports, both directly through its foreign exchange licensing procedures, and indirectly through the budget's influence on private disposable income, hence on the demand for goods. This influence was exercised forcefully during the period 1969/74 when, anticipating a fall in oil revenue, the growth in real private disposable income was completely stopped. In the future, the policy of promoting the production of import substitutes should restrict the level of imports without recourse to the traditional controls. The government has in fact begun to stimulate private demand by granting extensive tax cuts and expanding welfare programs. Since the current account is very close to being in balance, it is to be expected that temporary shortfalls in revenue will occur in the near future. Iraq's recent borrowing of $500 million from the Eurocurrency market suggests that it will meet such shortfalls by recourse to foreign capital rather than by disrupting the expansion of either private or public expenditure.

The expansion of various sectors of the economy should be sufficiently in tandem to avoid heavy reliance on external financing. Merchandise imports may be expected to reach, in constant 1974 prices, $9.5 billion in 1980, and $14 billion in 1985, while the current account balance which showed a small surplus in 1975 can be expected to gradually reach a surplus of about $4 billion in 1980 then to decline to a deficit of perhaps $1 billion in 1985 (both in current prices).. Balanced economic expansion will result from an expected high rate of implementation of the current development program and an expanded program for 1981/85, while attaining a petroleum production level of 4.5 million b/d by 1980, and maintaining it at that level through 1985. The goal of agricultural self-sufficiency may not be met, but the growth of agricultural imports should stop. On the other hand, imports of raw materials and capital goods should increase markedly as private income and capital expenditures under the development plan increase.

Algeria

The substantial current account deficit projected for 1975, despite continued restraints on consumption through strict controls on wages and nonessential imports, clearly demonstrates that the most significant constraint on Algeria's ability to import will be the availability of foreign exchange. As a result of a deterioration in the trade account and some prepayment of external debt, Algeria's net foreign reserves dropped by 75% from September 1974 through May 1975, to $428 million, or less than 2 months' imports at the projected 1975 rate. (A $350 million increase during June is attributable in large part to recent borrowings.) The crucial question is whether Algeria can obtain sufficient external financing during the next few years to enable it to implement its development program as scheduled and whether development of its gas reserves will proceed at a sufficiently rapid pace to eliminate the resource gap after 1980.

Algeria's economic development program is dominated by intensive efforts to industrialize as well as to meet the country's substantial needs for food,imports of which are projected at over $1 billion for 1975. Key areas of effort include continued rapid development of basic industries (hydrocarbon, steel, fertilizers), accelerated growth of the processing industries (metals and construction materials) and increased production of consumer goods.

The potential for absorption of imports in Algeria is significant given: 1) the need for infrastructure development as a result of the low priority which has been given to this sector in the past, 2) the large potential labor supply based on a large population, a rapidly increasing labor force and a high level of unemployment and underemployment which is estimated at 12 percent of the labor force, and 3) lack of additional land suitable for cultivation which means that a large volume of food imports will be required at least until 1980 as Algeria attempts to increase the productivity of land now under cultivation.

The Algerian Government has shown itself able to make decisions to commit funds for domestic development purposes. Actual expenditures under the 1970/73 Plan were 20% higher than projected although, as a result of delays and constraints in project preparation, adoption of new techniques, and unavailability of qualified manpower and basic raw materials, a backlog of projects remained at the end of the Plan period.

The 1974-77 Plan calls for public investments of $27 billion, triple the total expended under the previous plan, with an import component of about $10 billion. In 1977, the last year of the present plan period, imports of investment and consumer goods are expected to reach a level of $8 billion under the original plan estimates.

Difficulties in achieving these targets are likely, however, primarily because of an increasingly serious foreign exchange constraint. The 1977 target would imply a current account deficit of $4-5 billion, the full financing for which may not be readily available. Another major factor in Algeria's evolving payments position is repayment of principal and interest on its public external debt, which is already running in the neighborhood of $600 million on an outstanding debt level of almost $3.5 billion. In order to avoid adding to its debt burden in the near future, Algeria is seeking longer term credit to cover present current account deficits.

Inadequate infrastructure is emerging as another constraint. Unless greater emphasis is given to infrastructure - which is to account for only 14 percent of total expenditures in the present plan - severe bottlenecks will emerge with consequent implications for the efficiency of industrial undertakings and import levels. The government must also train and educate its labor force to operate an evolving industrial economy. At present the lack of skilled technical and managerial workers causes serious problems which may ultimately result in investment slippages.

Algeria's imports will probably be affected mainly by its ability to expand its gas exports and by the amount of external capital Algeria can obtain. If Algeria is successful in obtaining the external financing it needs, it should be able to maintain an 8 percent real growth in GNP - the 1974 rate - and based on present income propensities to import, the level of merchandise imports in 1974 prices would reach $6 to $8 billion by 1980 and $10.5 to $12.5 billion by 1985. We would expect imports to be in the lower end of these ranges because of foreign exchange constraints, and even these levels will not be achievable without a substantial increase in export earnings.

Qatar

Qatar's use of its oil revenue to further the country's economic development will be restricted by its small population and lack of skilled indigenous labor force. However, imports of consumer goods, as well as intermediates for domestic production of consumer goods, should grow substantially.

Capital investment is largely in the hands of the government, although the absence of comprehensive national income data precludes an accurate assessment of the size and the influence of private investment activity on imports. The major thrust of the development effort has been and will continue to be in the area of infrastructure facilities such as communications networks, power plants, and power transmission facilities. More recently, decisions have been made to undertake a number of industrial projects including an asbestos cement plant, gas-based petrochemical plants, worth over $200 million; a $200 million steel-rolling mill, and a $100 million natural gas liquefication and ancillary facility. These projects are not expected to come on stream before 1977, and some slippage in the time table can be expected.

The development budget which targets nearly $500 million of capital expenditures for 1975/76 should be difficult to implement. This would represent an increase of more than 200% over the previous year's budgeted capital expenditure, which in itself represented an increase of over 130% over the 1973/74 budget. These increases are difficult to administer as Qatar does not have a centralized planning authority, and the administrative machinery for planning and executing government projects is still in its formative stages. As a result, actual expenditures are usually but a fraction of budgeted expenditures (only 65% in 1972). Efficiency is also hindered by public policy which guarantees jobs to all nationals and requires that middle and upper management slots in many of the proposed heavy industries be reserved ultimately for Qatari citizens.

The industrial sector has grown substantially during the recent past. Annual cement production expanded by 21%, frozen shrimp, 15% and electricity generation, 13%. Moreover, new activities, such as the production of flour and desalinized water, have been introduced. There are indications, however, that further expansion will be limited. First, the shortage of labor in Qatar has resulted in the use of substantial imported labor, with the result that Qatari nationals constitute only a small portion of the economically active work force. But industrial development in the countries which are important sources for Qatar's labor (for example, Iran and Oman) has restricted the flow of labor to Qatar and substantially increased wage rates. This trend should continue and labor should become increasingly scarce and expensive. Moreover, there is major concern over further dilution of the national character of the labor force which will be a restraining influence. Second, some key sectors have been neglected. Agricultural production, after a decade of flourishing growth, began to decline in 1972 as agricultural labor left the land for more renumerative employment in construction. Also until recently, when the government began to invest in industrial plants, private investment was channelled into construction and trade rather than into industry, because of the higher short-term profits in these activities and the minimal requirements for capital and technical know-how.

In the past the public sector has redistributed a substantial part of its oil earnings through its current expenditures, and this policy should continue in the future. Public expenditures support a growing social welfare program in the areas of housing, education and health. These programs, as they supplement the income of the private sector, will stimulate the demand for consumption goods and, with limited domestic production, the demand for imported consumption goods. A rough indication of the magnitude of income redistribution is the level of annual current government expenditures which in the past has amounted to 50% of the previous year's oil revenue.

Last year, Qatar's balance of payments showed a current account surplus equivalent to 75% of its oil revenues, a historical high. This is a natural reflection of the difficulty of making prompt adjustments to the surge of oil revenues, but in the next few years the absorptive rate is expected to increase substantially. Qatar can be expected to increase its merchandise imports by 13% a year to about $600 million in 1980, and by 9% annually thereafter, reaching $900 million in 1985, (both in 1974 prices).

Venezuela

The growth in Venezuela's imports will be subjected to financial constraints by 1978, when the current account, having shown substantial surpluses in 1974 and 1975, again moves into deficit.

Oil revenues are expected to fall 12% between 1974 and 1975, and Venezuela planning authorities anticipate that they will continue to fall at a rate of 5% per year at least through 1980. These declines, resulting from a fall in oil production to a level that currently stands at 76% of capacity, are attributable in the short run to decreased demand for petroleum and perhaps to production rationing as well. The depletion of oil reserves, which has reduced productive capacity by 9% since 1973, will compel reduced levels of production in the long term unless new petroleum sources are developed.

The ambitious development plans of the Venezuelan Government will require large amounts of foreign exchange. Investment in transportation, communication and power infrastructure is well advanced. The new Government of President Carlos Andres Perez has greatly accelerated long-standing programs for the development of Venezuela's steel, petrochemical and aluminum industries. Venezuela has nationalized the iron mines and will do the same with the petroleum companies during 1975. The Government intends to move quickly into new industries, such as aircraft and shipbuilding, and has budgeted large in-increases in credit to be extended to the agricultural and industrial sectors. Large new investments will be necessary in the petroleum sector, particularly in the Orinoco tar sands, if Venezuela is to continue to be a major petroleum producer in the future. Notwithstanding such hopes, the National Planning Office is just completing a Fifth National Plan which, according to the press, projects a gradual decline in the output of petroleum, which is to be offset by a general increase in the other economic sectors.

Plans for capital intensive and highly sophisticated industries will require a level of managerial and technical skill that is very scarce, and substantial imports of capital goods. In light of the shortage of labor and apprehension over the disruption that sharp increases in demand can cause, a substantial part of the oil revenues in 1974 and 1975 will be held abroad to sterilize its impact on the domestic economy, but will be drawn down over time to finance the foreign exchange costs of the investment program.

For 1976, recent estimates by the Finance Ministry call for an "austerity program" in order to minimize the impact of an estimated $1 billion decline in government income from the petroleum industry resulting from declining output as well as anticipated effects in the post-Nationalization period.

The total ordinary budget for 1975 amounts to $6.6 billion, as compared to actual cash outlays of $5.1 billion in 1974 and $3.4 billion in 1973. Roughly 40 percent or $2 billion of the 1974 ordinary budget was devoted to domestic investment, but 47 percent or $3.8 billion is allocated to investment in the 1975 budget.

The major persistent obstacle to long-term development in Venezuela, is the economy's lack of diversification and a failure to mobilize domestic resources outside the petroleum sector. Agriculture accounts for less than 5 percent of GDP and is technologically backward by Latin American standards. The manufacturing sector is high cost and highly protected. Skilled labor and managerial and scientific talent are in short supply despite very large educational expenditures over the past decade. Income distribution is extremely skewed. On the other hand, transport, communications, and power infrastructure are well advanced, and the natural resource endowment is exceptionally rich.

Venezulan imports rose 65% in 1974 and should increase about 40% in 1975. But, as a result of an emerging foreign exchange constraint, the growth in imports should decline sharply, perhaps to 20% in 1976. The current account may go into deficit in 1977, and import growth may not exceed 10% a year through 1980.. The severe financial constraints that will become apparent by then, and the completion of the first stages of the development program may further reduce the growth in imports to 5% per year during the period 1980-85. At these rates imports (in 1974 prices) will amount to about $9.5 billion in 1980 and $12 billion in 1985.

Ecuador

Ecuador should have the capacity to absorb oil revenues over the next ten years under any reasonable scenario of production and prices. Public sector infrastructure is undeveloped and the country is starting from a low level of economic development. Increasing imports of industrial inputs are easily absorbing Ecuador's foreign exchange at the present time.

Ecuador's 1973-77 Development Plan presents a comprehensive strategy for maximizing the impact of petroleum revenues and achieving self-generating growth. The plan calls for: (a) expanding and improving the physical infrastructure by extending transportation, energy and other basic facilities into new potentially productive areas and improving such facilities as now exist, (b) expanding and improving the provision of services and technical inputs needed for raising productivity in agriculture, industry and supporting services and (c) expanding and improving the provision of education, training, health and other social services to upgrade the quality and raise the living standards of the labor force and the population generally.

In order to implement the Plan efficiently, the Planning Board has been considerably strengthened with personnel and financial resources. Serious efforts are also being made to strengthen and accelerate the process of project preparation in the Planning Board and public agencies. Government planners have just completed an inventory of projects, and a Pre-Investment fund for financing pre-feasibility and feasibility studies through final engineering design has been established. Complementing these efforts, the Government has segregated from the budget the additional revenues accruing to the Central Government from the increase in petroleum prices. These resources, accumulated in the National Development Fund, will finance investment projects as they become ready, over and above those already included in budgetary appropriations.

The Government plans to invest $1.7 billion during 1974-78, with emphasis on rural infrastructure projects and manpower development. Imports for the same period are expected to reach $3.8 billion of which close to $3 billion are expected to be producer goods--which should impact favorably on future growth rates.

The progress of the country's growth has emphasized industrial development. In 1973 industrial production increased by 8% and by 12% in 1974. Revenue increases from rising oil prices have enabled Ecuador to sustain real growth in manufacturing and agriculture. Availability of foreign exchange reserves has enabled Ecuador to decrease tariffs on imports of materials inputs and intermediate goods, encouraging domestic industrial growth. Imports of capital goods for industry increased 112% in 1974 over 1973's level. The principal item in this category of imports was industrial machinery which grew by about 120%.

Construction has been another growing sector with an average annual growth in output of 9% over 1972-1974. At present the capacity for producing inputs for construction is severely limited. Demand for capital goods and intermediate inputs for construction has been met by a substantial increase in imports, doubling from 1973 to 1974. Government policy has been to subsidize imports of construction materials, especially cement and iron, in order to increase national production in other sectors.

Total imports in 1974 increased by 72% over 1973. Although the annual rate of increase of imports should slacken in succeeding years, we anticipate no serious obstacles to utilization of Ecuador's oil revenues through the 1970's. Tariffs have been reduced and the Government is offering expanded credit facilities for imports. Ecuador should have no port capacity bottlenecks to slow import growth.

There are only two elements in Ecuador's development policy which signal a lower level of imports in 5 years time. The first of these factors is a conscious part of the GOE development goal.

Ecuador's industrial development is primarily based on import substitution in the consumer goods sector. The country is beginning to enter a period of substitution of imports of raw materials, intermediate products and small capital goods and as Ecuador's industrial sector expands it will require lower levels of imports of many of these items. Imports of larger and more sophisticated capital equipment, however, should continue to increase at a significant pace in the foreseeable future.

An associated second factor which will affect Ecuador's import trends over the next five or ten years results from emphasis on capital intensive and technologically led development. As a result of tariff and tax reductions benefitting capital inputs in industrial projects, industrial growth in recent years has been heavily labor saving. Employment has lagged behind the forecasts for the 1973-1977 Plan and underemployment is likely to remain a social problem in the coming years. Income will probably remain skewed in the absence of a major income redistribution effort. As a consequence, the growth in the internal market for consumer goods will be somewhat limited.

Thus the growth rate of imports should average about 10% to 15% per annum, toward the end of this decade, and decline perhaps to about 8% a year during the first half of the 1980's. If the Government continues its conservationist policy in petroleum production, it should be able to absorb revenues quite easily. But if oil production is greatly expanded in the next five to ten years, revenues will probably far exceed the country's import level in the next decade.

Indonesia

Indonesia's oil revenues are of relatively smaller magnitude than other OPEC members, comprising 18% of GNP ($19 billion in 1974). At the same time, with a per capita income of $150, the need for capital investment and the scope for growth is large. Accordingly, Indonesia should continue to have little difficulty in utilizing its oil revenues.

Instead Indonesia will probably continue to face financial constraints as it seeks to enhance domestic economic growth. The small current account surplus in 1974 is expected to disappear in 1975, and a growing deficit to appear thereafter. To avoid this development the government hopes to double petroleum output by 1980, develop LNG exports, and to encourage the production of important import substitutes such as rice. The financial constraint may not be felt for several years if external aid and private capital flows continue at their current levels.

The most important physical obstacle to import expansion is Indonesia's limited port capacity. Cargo handling capacities in almost all ports are relatively low. Equipment and navigational aids remain inadequate. Wide-ranging port projects which include the design and engineering of new quays and warehouses, construction, dredging and dockyard rehabilitation, are to be completed in the next two to five years and should offer considerable relief to the physical limitation of ports.

Administrative inefficiencies arising from poor organization and low levels of trained manpower have hindered the effective utilization of external assistance, and retarded the speed of development. In fact, Indonesia was unable to utilize fully available external aid in 1974, and the size of the year-end aid pipeline rose to an estimated $1.7 billion. Reforms involving Pertamina, Indonesia's state-owned oil company, will interrupt the schedule of investment spending in a broad range of activities, until the reorganization is complete.

Indonesia's inadequate infrastructure has hindered the growth of import substitutes. For example, fertilizer and insecticide distribution has been slowed by the irregular and expensive transportation system. The second five year plan has allocated 19% of its funds to the development of agriculture and irrigation, and 15% to communication and transport related activities, which may aid in the development of import substitutes.

In the last three years, Indonesia's imports have nearly tripled, soaring from $1.7 billion in 1972-73 to an estimated $4.5 billion in 1974-75. During the next decade the largest increase in import volume is expected to come from capital goods imports necessary to fulfill the country's ambitious development goals. The share of imported consumer goods should fall from 31.9% in 1973/74 to about 17% in 1980 and perhaps 10% in 1985. The share of intermediate goods and raw materials should rise somewhat from its 1973/74 level of 37% to about 50% in 1980 and beyond. Merchandise imports in 1974 prices could reach about $9.5 billion by 1980, and around $12.5 billion by 1985, if petroleum revenues can be doubled through expanded output. Even then Indonesia will probably be facing persistent current account deficits over the next decade which will require continued flows of foreign aid.

Libya

The recent increases in oil prices have radically increased Libya's national income to $4,600 per capita (in 1974). The maintenance of a high level of investment, to ensure that these income levels are sustained in the face of depleting oil reserves, has resulted in correspondingly high levels of imports. The future growth of imports, however, may be restricted if inadequate infrastructure facilities--especially port congestion--and shortages of skilled manpower cannot be overcome. Programs are now in train to deal with these problems but in the near term they will remain important constraints to absorption.

Gross capital formation has traditionally accounted for some 30% of GNP. This has been a major stimulant to imports as increases in capital goods imports have generally amounted to about 65% of increases in gross investment. Substantial capital formation has also engendered a rapid growth in the non-oil sector of the economy, which expanded from 33% to 50% of GNP between 1970 and 1973.

Libya is presently in the last year of its three year Development Plan (1973-1975). Expenditure targets of the plan were increased by over 120% to $8.5 billion in light of increased oil revenue. The plan continues the emphasis of previous plans on infrastructure development (1/3 of total outlays), with emphasis especially on port expansion, electrification, housing and public works. It also gives high priority (22% of total outlays) to increasing agricultural output in order to reduce Libya's reliance on food imports.

The Plan's allocation to industry, which comprises 13% of total outlays, seeks to maximize the use of the domestic resource base and produce goods for which there is a large domestic demand. Thus, most of the investments are being put into plants for construction materials and food industries. Complementing the import substitution goals of Libya's agricultural and industrial development plans is the emphasis that the Plan gives to the expansion of the export-oriented oil industry and ancillary facilities.

New projects either under way or proposed include: a $150 million desalination and electrical power complex in Tobruk--part of a $675 million plan to build similar complexes throughout the country; a $100 million oil refinery;

a $230 million petrochemical plant; construction and expansion of cement plants worth over $150 million; a $240 million expansion of Tripoli harbor; new housing projects worth over $200 million; and a $100 million prefabricated housing factory. In addition, an experimental nuclear power plant, new roads, bridges, as well as clinics, schools and universities are either under construction or being planned.

The revolutionary government has also included ambitious social goals in its development plan. It seeks to eradicate illiteracy by 1980 through increased outlays in education, especially in the construction of schools for children and illiterate adults, and universities. In addition, the government seeks to redistribute income to the low-income groups through increased taxation of the upper-income classes and increased government expenditures on health, education, housing and food subsidies. These programs are only in their initial stages and the problems they seek to alleviate are so large that Libya's consumption base will not be significantly widened in the next ten years in the absence of substantially larger expenditures than now contemplated.

Implementation of the Development Plan has been hampered by the continued intensification of manpower constraints arising in part out of the government's agricultural support program which discourages migration from the farm despite the increased demand for non-farm labor engendered by the Plan. Thus, 1973 development expenditures fell 27% short of plan targets and it can be expected that total actual expenditures will fall short of the Plan's targets.

Although Libya's small population of 2.3 million should encourage the use of capital intensive production, both skilled and unskilled labor are required at levels not presently available indigeneously. Only one quarter of the population is in the active labor force, due to both the age distribution of the population, the effects of the literacy campaign in delaying initial entry into the labor force and a very low (7%) participation rate for women. As a result, Libya has permitted substantial immigration, and the foreign component of its labor force has increased from 8% in 1971 to over 50% in 1975.

Libya's program to develop its infrastructure and train its manpower will not have an immediate impact and the implementation of capital projects should become increasingly difficult during the near term. Shortages of labor will also put pressure on wage rates. These constraints could discourage the maintenance of investment at the traditional proportion of 30% of GNP. If this proportion should fall, the decrease in the level of capital goods imports would probably not be entirely offset by increased levels of consumer imports. Moreover, this flagging growth in import levels could be reinforced by the falling growth rates of GNP that are bound to result from a projected leveling off of real oil earnings.

In addition to manpower and infrastructure problems and lack of resources other than oil, Libya faces a financial constraint on the revenue side in the absence of new oil discoveries. Although it had a $2.3 billion current account surplus in 1974--primarily due to the difficulty of making prompt adjustments to the surge of oil revenues, Libya's strict oil conservation policies will bring its current account balance to near equilibrium within a few years and make it a net importer of capital in the long-term. Libya's concern for its depleting oil resources, which accounts for 98% of its export earnings, is reflected in the heavy investment in oil exploration and in the emphasis in the development plan on import substitution and export diversification.

Since 1973, imports have increased in nominal terms at a rate of about 35% a year with imports in 1975 expected to reach about $4.1 billion. The concentration on developing improved infrastructure facilities and a wider industrial base should result in an annual growth rate of about 8% during the next few years to a level of $5.2 billion in 1980. Between 1980 and 1985, we can expect the annual growth rate of imports to fall to about 5% as domestic industrial production replaces imports and increased capital investment slackens off. Thus, in 1985 we can expect an import level of $6.5 billion. These levels would suggest a current account position that will be approximately in equilibrium in 1980, perhaps moving into a deficit of about $2 billion by 1985.

Policy Implications

Objectives

The consumer countries have several basic policy objectives in their relations with OPEC countries which would seem to include:

a) Encouraging establishment of an OPEC oil pricing policy which would simultaneously permit a more efficient allocation of world resources and allow the OPEC nations to obtain a reasonable return on their major resource.

b) Avoiding fruitless confrontation which would create greater instability in the Middle East, increase the friction between consumers and producers in general, and render the economic objectives of both the consumer countries and OPEC difficult to acheive, and

c) Ensuring that current and prospective OPEC oil earnings have minimum disruptive effects on the world economy and its growth prospects.

The rise in oil prices has increased OPEC claims on the consuming countries' goods and services without increasing OPEC provision of real goods and services. These claims may be exercised in two ways -- OPEC importation of goods and services, or purchase of financial assets, -- but each case will represent a loss in well being to the oil consuming countries. The first policy objective addresses itself to the attenuation of this burden.

The discussion of OPEC absorptive capacity touches largely on the last two policy objectives, through its determination of how rapidly the transfer of real resources from the consuming to the producing countries will proceed. It must be stressed that, in the face of continuing high oil earnings, satisfaction over the lower than anticipated OPEC current account surpluses which have been evolving indicates a preference for substantial OPEC imports over OPEC foreign investment -- that is for the rapid transfer of real resources.

This preference, however, involves a number of complex considerations which do not yet appear to have been adequately explored. A number of arguments have been posited in support of each option, but many of them fail to hold up under intensive scrutiny. A brief discussion will help sort through the various policy considerations that spring from the absorptive capacity issue. From this discussion the conclusion emerges that attempts to influence the timing of the flow of real resources to the OPEC countries should be discouraged and that this would best be left to market forces.

Level of Transfer of Real Resources

If the obligations that the consuming countries have incurred are to be honored, there will eventually be a transfer of real resources. The choice is to transfer now or to transfer over the future. The quantity and value of the resources transferred to the OPEC countries will naturally depend upon the nature of the claims they hold, the productivity of capital and the course and anticipation of future prices. That is to say that the real resources transferred will be the same at any two dates if the rise in export prices is sufficient to offset the pecuniary return on the obligations held by OPEC. Even though anticipated general price movements will be a determinant of pecuniary return, recent history suggests a divergence between general and export price increases, and indicates a less than complete interest rate accommodation to the rate of inflation. Accordingly, investment of OPEC revenues abroad could result in a lower total transfer of real resources to OPEC over time.

The oil producing countries, however, are not likely to be indifferent between transferring the same quantity of goods at two dates. First, goods transferred now could be put into productive use, and so generate more goods than if the transfer of real resources was deferred (these might come through additional trade with consuming countries). Second, the present valuation of future consumption is likely to be lower than that of current consumption.

Capacity to Transfer Real Resources

Deferred transfer would in some respects, give the consuming countries greater flexibility to determine the conditions upon which the transfer would take place. This flexibility however may not lead to formation of a greater productive base from which to produce goods for future transfer. Any change in the level of productive capacity from what it would have been in the absence of real resource transfers will depend not only upon the investment propensity of the consuming countries' private sectors, but also upon government policies of the consumer countries.

First, the availability of financial capital does not automatically ensure increased demand for investment goods. The rate of capital formation will be sensitive to the level of idle capacity and this in turn will depend upon government policy directed toward influencing the level of economic activity. It will also depend on the sources that private firms traditionally employ to finance capital expenditures, particularly for those firms which rely on internally generated funds.

Second, exports directly and through the multiplier effect also generate income that can finance investment activity. Moreover, exports represent additional effective demand that will result in increased capacity utilization which in turn will spur demand for investment capital.

Finally, there is a fundamental question of whether an expansion of capacity requires foreign capital or income generated from abroad. This might be as readily achieved by appropriate domestic economic policies to influence the size of the domestic capital stock and the uses to which it will be applied.

The Short Term Financial Problem

While OPEC investment in the industrial countries would help increase their capability to eventually redeem OPEC claims through increases in productive capacity, questions have been raised concerning the short-term adjustment to higher oil prices. Indeed, the desire in some quarters to see rapid utilization by OPEC of its oil revenues has stemmed at least in part from a fear that high oil prices would create major recycling problems. Specifically, this would have resulted from 1) the inability of Western financial institutions to perform their intermediation function because of the sudden surge of liquid funds from the OPEC countries and/or 2) an insufficient flow of such funds to Europe -- the major oil importing area of the world -- on reasonable terms, thus forcing severe domestic policy adjustments.

These fears have proved unfounded on the basis of experience to date, and indeed there should have been no presumption that the necessary recycling efforts would be more difficult to accomplish than a sharp sudden expansion of exports of a magnitude necessary to cover the potential deficit, nor that financial intermediaries should prove to be the weakest link in the chain of transfers of claims. There was in fact no alternative to recycling in the very short term given the abrupt and massive shifts brought about by the increase in the price of oil. To be sure the adjustments to higher oil prices have been imperfect, but it is highly improbable that export expansion to OPEC countries would more perfectly match the pattern of increased expenditures for imported petroleum in the short-term.

During the past year the OPEC countries have demonstrated portfolio management objectives similar to most other investors. In particular, they have recognized the desirability of risk spreading both among geographical areas and types of investment assets. Moreover, the intermediary function performed by financial institutions in the postwar period, through a well established institutional framework and open capital markets, has traditionally assured a high degree of mobility of capital and last year was no exception. As a general proposition financial adjustments have continued to be executed by the market's rearrangement of interest rates, reconciling differing preferences for financial instruments as well as adapting the capital structure of financial institutions to new needs of the market. The creation of the OECD Solidarity Fund together with other existing arrangements will, of course, serve as supplements to the private market mechanism as each country attempts to adjust financially to higher oil prices.

Transfers During Cyclically Slack Periods

It has also been suggested that increases in exports to the OPEC countries would clearly complement domestic policy in periods of economic slow-down, but the practical case for encouraging transfers of real resources during such cyclically slack periods is weak.

In the first place, the absorptive capacity of OPEC countries is the main determinant of the rate of the export response to any policy shifts in the consuming countries, and because of the uncertain knowledge of this structure, attempts to manipulate OPEC demand would probably be unsuccessful.

Second, it should not be forgotten that in many cases increasing slackness may reflect an attempt to bring inflation under control, so that this goal could be compromised were export demand to increase. But there are also problems even where this is not the case and where an expansion of foreign demand would complement domestic economic policies. As a general matter, the tempo of expansion of both foreign demand and domestic supply is extremely uncertain. Increased utilization of capacity, spurred by export orders, can be accomplished only after a lag. Above and beyond this is the fundamental question of whether export led growth is essential to economic recovery or whether domestic policy instruments are adequate to insure recovery without the need to transfer real resources abroad.

There are other major problems as well. At some point, an expansion of domestic and foreign demand can quickly outstrip improved supply conditions and the pressures to curtail dynamic export markets would begin to mount. A policy of turning on and turning off exports to OPEC through the course of cyclical swings is not a viable long-term proposition. Yet, if not curtailed these exports put added pressures on domestic economies in times of total excess demand. Moreover, the effects within an economy of a cyclical slowdown are uneven. OPEC nations cannot be expected, however, to confine their purchases to the most depressed sectors in a cyclically slack period. Indeed their demand for imports from these sectors may be minimal or nil.

If transfers are delayed, the resulting infusions of OPEC financial capital might alleviate some of the financial stringencies that firms suffer during contractionary periods. But the firms in greatest need are generally those with the weakest capital structure, or those who find the cost of borrowing high relative to the return on their enterprise. It is doubtful that investments in failing firms would prove to be a very attractive proposition to OPEC countries. It is also doubtful that substantial OPEC funds would be invested at lower than market rates of return. There is the general question, moreover, of whether marginal operations can be sustained through special and, perhaps, one-time arrangements with OPEC countries.

Absorption and Oil Price Policy

There is also likely to be a significant relationship between the absorption rate of OPEC countries and their policies with respect to oil production and oil prices.

In the case of countries with relatively low levels of oil reserves and revenues, successful implementation of domestic development plans and substantial utilization of oil revenues for domestic purposes are likely to result in a decision either to seek higher oil prices or to increase oil production. The choice will be influenced by 1) the ease with which either course of action can be taken, 2) assessments of the supply and demand elasticities for oil over the short and longer terms, and 3) the relative importance attached to protecting long-term interests by accepting short-term discomfort.

The experience to date has suggested that when faced with revenue constraints, individual OPEC countries are more likely to opt for efforts to maintain production. It is not clear, however, that this process can or will continue, particularly if such action would represent a clear break of OPEC solidarity. But it is also not clear to what extent those countries whose revenues substantially exceed domestic needs are prepared to reduce further their own level of production to sustain oil price levels for the benefit of the other OPEC countries.

In the case of countries with relatively high levels of oil reserves and revenues, their continued inabilty to utilize a substantial proportion of oil receipts for domestic development purposes, and the consequent recycling of substantial levels of funds for the use of the consuming countries, might also prompt them to reassess their policy. The options open in this situation are the reverse of the revenue constraint case. Oil production that results mainly in the build up of assets abroad may suggest to individual OPEC countries that either production should be reduced or that some price relief should be extended for the sake of the interests of the rest of the world. Experience to date, however, indicates that the latter trade-off has unfortunately not dominated the thinking of these few producers.

The present situation, of course, contains elements of both of the cases described above. Compatibility has been found in a combination of price and production cutbacks. The question, of course, is whether this pattern can or will be perpetuated if the disparities between revenues and need continue and/or accentuate, or whether different OPEC policy responses will evolve. The outcome will naturally depend upon a number of factors including the ability of the OPEC countries to use their oil revenues for domestic development.

Constraints on Policy Actions By Consumer Countries

Should consumer countries decide to emphasize either exports to OPEC countries or OPEC investment in the industrial world, the question becomes whether the consumers can influence this course of events, and, if so, how. There are obvious problems and pitfalls.

Many governments in one degree or another must operate in an environment of both significant private sector control of, and interest in commercial exchanges. Governments in their efforts to spur exports or investment inflows must recognize the limitations imposed by both of these facts. It is difficult to restrain or prevent firms' efforts to maximize commercial exchanges that will directly benefit their shareholders and communities. Conversely, it is difficult to persuade firms to commit themselves to unprofitable operations.

Policy decisions which would attempt to channel oil revenues in a particular direction risk preferential or exceptional approaches and a departure from basic policies. Development of OPEC industrial capacity will almost certainly enhance desires for preferential access to consumer country markets. We have already witnessed some pressure in this direction. Growing OPEC investment abroad, on the other hand, could lead to pressures to limit such investments in additional sectors and/or conversely may require special inducements. All of this would further distort the world's economic structure.

Another factor which the consumer countries must guard against is a possible tendency toward a competitive race among them for OPEC markets or investment capital. While such promotional efforts would not necessarily render long-term balance of payments adjustment within the consumer bloc more difficult if exchange rates remain flexible, the end result could be an even greater transfer of real resources to OPEC countries, since increased costs from exchange rate adjustments might not offset the savings to OPEC from subsidies, etc. Moreover, economies heavily reliant on specific foreign markets are no less vulnerable to them than are the countries heavily reliant on specific sources of oil.

<u>Conclusion</u>

There are, of course, factors other than those discussed above which bear on the real resource transfer problem, but most of the main economic considerations have been covered. These would suggest in varying degrees of force that a policy of permitting both merchandise and capital flows to be determined primarily by economic forces would be the most prudent course for the consumer countries. The emphasis individual OPEC members will place on domestic versus foreign investment will shift over time according to their investment plans. The diversity of such plans among the OPEC countries, and the highly uncertain manner in which they will be carried out, suggest that the most flexible economic institutions, to wit free markets, are best adapted to the orderly transfer of real and financial resources. A plethora of nonmarket arrangements in such a fluid situation is almost certain to hamper effective adjustments among the industrial countries.

Beyond this, emphasis on economic efficiency will help ensure producer country investment in areas where their comparative advantage will be the greatest. The same criterion would ensure a substantial flow of investment capital to the West, both directly and indirectly. World income would of course be maximized, and the burden which oil price increases have imposed on the consuming countries would probably be eased. Flexible policy instruments will also enable consuming countries to take maximum advantage of the return flow of OPEC capital.

Annex

Trends in the OPEC Current Account Position

Developments in 1974

The most recent available data indicate that the OPEC current account surplus in 1974 reached $59 billion, excluding government grants (when oil receipts are recorded on a payments basis). This is somewhat lower than a number of initial forecasts made last year which anticipated surpluses in the range of $65-70 billion. The initial forecasts did not fully anticipate the extent to which OPEC import demand would respond to the high level of oil earnings. It became apparent, however, over the course of 1974 and early 1975, that estimates of growth of imports were too low, and many projections were revised accordingly.

Comprehensive, accurate import data remain unavailable. The statistical reporting systems of some countries do not pick up all imports and the true current account position of the OPEC countries may never be known. Presently available data including export data for the major industrial countries suggest that the increase in OPEC imports last year was approximately 80%. Price increases on average accounted for somewhere around 25% of this increase.

OPEC's non-oil exports also rose sharply, by nearly 40% above the level of 1973. The major factor was the boom in commodity prices, although for Indonesia which accounts for 40% of all OPEC non-oil exports, volume increases were also large.

We would estimate that the deficit on services rose somewhat last year to $4.8 billion. Investment income increased sharply as a consequence of the build up of assets abroad, but this was more than offset by freight and insurance payments associated with the dramatic jump in OPEC imports, as well as an increase in workers remittances, particularly, in the Persian Gulf countries.

The balance of payments data for 1974 show striking contrasts between the OPEC members. Three countries, Saudi Arabia, Iran and Kuwait, account for almost two-thirds of the OPEC surplus. Of the remaining eight members only Nigeria, Venezuela and the UAE had significant surpluses. The dissimilar financial accumulations were primarily the result of different levels of oil production. Although imports increased markedly in all OPEC countries, there were significant differences among them. At the extreme the imports of Iraq and Iran increased nearly 200% and 125% respectively, while the imports of Libya and Nigeria rose less than 40% in nominal terms.

Outlook for 1975

The OPEC current account surplus for 1975 should be down sharply from last year. This should result from further large increases in imports, but much smaller increases in oil revenues due to cyclically depressed demand in the industrialized countries during the first half of 1975, stock drawdowns, a mild winter and some demand response to the oil price increases. Although the value of imports should increase by about half last year's rate, a sharp decline in import price increases to about 12% will mean that the reduction in real terms will not be as great.

We would also expect to see little change in the services deficit this year. Investment income will continue to mount, but so will freignt and insurance payments. Workers remittances, travel expenditures and payments on government debt will continue to be substantial and together will be nearly as large as either investment income or freight and insurance payments. A light reduction of about $300 million in the services deficit is projected.

The distribution of the surplus among the OPEC countries is likely to become even more skewed during 1975. We would expect the share of Saudi Arabia, Iran and Kuwait in the total surplus to grow at about 80%. Algeria should emerge as the first OPEC country to run a sizeable deficit, as it finances its expanded import program through international borrowing. Surpluses should disappear for Ecuador and Indonesia, and the current account of Iran and Libya are likely to approach near equilibrium positions.

OPEC Investible Surplus

1973
($ million)

	Oil Exports (Gov't Take)	Non-Oil Exports	Imports F.O.B.	Services and Private Transfers	Investible Surplus
Algeria	1000	360	-2060	-170	-870
Ecuador	100	310	-460	10	-40
Indonesia	1200	1610	-2410	-750	-350
Iran	4500	590	-3600	-400	1090
Iraq	1700	110	-1160	-180	470
Kuwait	1900	230	- 920	310	1520
Libya	2300	-	-2200	-700	-600
Nigeria	2400	620	-1780	-980	260
Qatar	400	10	-180	- 90	140
Saudi Arabia	5500	20	-1800	-600	3120
United Arab Emirates	1200	40	- 860	- 90	290
Venezuela	3000	375	-2820	-690	-135
Totals	25,200	4275	-20,250	-4330	4895

August 29, 1975

OPEC Investible Surplus

1974
($ million)

	Oil Exports (Gov't Take)	Non-Oil Exports	Imports F.O.B.	Services and Private Transfers	Investible Surplus
Algeria	3700	355	-3710	60	405
Ecuador	500	450	- 790	-50	110
Indonesia	3400	2200	-3890	-1480	230
Iran	18,700	800	-8000	-820	10,680
Iraq	5700	150	-3460	-420	1970
Kuwait	8000	390	-1480	425	7335
Libya	6200	40	-3000	-700	2540
Nigeria	7600	850	-2490	-740	5220
Qatar	1600	10	- 270	- 50	1290
Saudi Arabia	24,600	25	-3530	-295	20,800
United Arab Emirates	6000	20	-1600	- 60	4360
Venezuela	8900	375	-4660	-620	3995
OPEC Total	94,900	5665	-36,880	-4750	58,935

August 29, 1975

OPEC Investible Surplus

1975
($ million)

	Oil Exports (Gov't Take)	Non-Oil Exports	Imports F.O.B.	Services and Private Transfers	Investible Surplus
Algeria	3630	350	-5670	-300	-1990
Ecuador	375	550	-930	-90	-95
Indonesia	3675	2380	-4680	-1660	-285
Iran	19,875	1000	-10600	-660	9615
Iraq	7580	200	-6600	-670	510
Kuwait	7890	530	-2100	805	7125
Libya	5150	100	-4100	-500	650
Nigeria	6715	900	-5100	-610	1905
Qatar	1755	10	-380	-70	1315
Saudi Arabia	26,685	30	-5660	-100	20,055
United Arab Emirates	6475	10	-2200	-70	4215
Venezuela	8320	510	-6510	-550	1770
OPEC Total	98,125	6,570	-54,530	-4,475	45,690

August 29, 1975