DOE/IA-0002/01

Joint Egypt/United States Report on Egypt/United States Cooperative Energy Assessment

Volume 1 of 5 Vols.
Executive Summary, Main Report and Appendices

April 1979

U.S. Department of Energy
Assistant Secretary for
International Affairs

Available from:

National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

Price: Printed copy: $13.25
Microfiche: $3.00

DOE/IA-0002/01
Dist. Category UC-2, 13

Joint Egypt/United States Report on Egypt/United States Cooperative Energy Assessment

Volume 1 of 5 Vols.
Executive Summary, Main Report and Appendices

April 1979

Prepared collaboratively by representatives of the Government of Egypt and the United States Department of Energy with the assistance of the United States Department of State.

U.S. Department of Energy
Assistant Secretary for
International Affairs
Washington, D.C. 20585

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Stock Number 061-000-00323-1

FOREWORD

In Fiscal Year 1978, the United States in cooperation with the Government of Egypt conducted a comprehensive assessment of Egypt's energy resources, needs, and uses and developed several alternative energy strategies that utilize the available resources to meet their energy requirements. This work was performed during the pilot phase of the International Energy Development Program that was initiated by President Carter in September 1977. This assessment was a collaborative effort by a team of U.S. and Egyptian experts in energy resources and technologies, development economics, and energy systems planning and analysis. The Department of Energy managed the U.S. component of the assessment under the overall policy guidance of the Department of State.

This report on the assessment was jointly prepared by the U.S./Egyptian expert team. Volume I contains the executive summary, the main report, and seven appendices of information that directly support the integrated energy supply and demand analysis. Volumes II through V contain thirteen annexes which present the contributions of the participating technical specialists.

This report is being distributed to interested agencies within the Executive Branch of the United States Government and U.S. Congressional committees and staffs. In addition, copies have been provided to the Government of Egypt for their distribution and use and to institutions such as the World Bank and the United Nations. Additional copies of the report can be obtained from the Government Printing Office under the terms of the GPO price schedule set forth on the inside of the front cover of the report.

Any questions about the report should be directed to:

A Nelson Tardiff, Director
Developing Country Program Office
Office of International Affairs
U.S. Department of Energy, Stop 7F-031
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Egypt Country Report
Table of Contents

LIST OF TABLES

LIST OF FIGURES

STANDARD UNITS AND CONVERSION FACTORS USED IN THE ASSESSMENT

1. General Conversion Factors

(a) tonne = metric ton = 1000 kilograms = 2205 lbs.
(b) bbl = barrel (oil) = 42 U.S. gallons
(c) m^3 = cubic meters = 35.31 ft^3
(d) Energy Units:

1054	joules/Btu	9.486×10^{-4}	Btu/joule
3.60×10^6	joules/kw-hr	2.778×10^{-7}	kw-hr/joule
4186	joules/kilogram-calories	2.389×10^{-4}	kilogram-calories/joule
3413	Btu/kw-hr	2.928×10^{-4}	kw-hr/Btu
3.968	Btu/kilogram-calories	0.252	kilogram-calories/Btu
1.163×10^{-3}	kw-hr/kilogram-calories	859.9	kilogram-calories/kw-hr

QJ = quadrillion joules = 10^{15} joules

2. Egypt-Specific Conversion Factors

	Energy Content (joules/tonne)	
Fuel Oil (mazout)	4.071×10^{10}	
Gas Oil (sular)	4.463×10^{10}	
Kerosene	4.420×10^{10}	
Butagas	4.708×10^{10}	
Benzine	4.617×10^{10}	
Diesel Fuel	4.463×10^{10}	
Natural Gas	4.65×10^{10}	(3.744×10^7 joules/m^3)

Crude Oil:
Heat content: 130,000 Btu/gal = 5.75×10^9 joule/bbl=3.99×10^{10} joules/tonne
Density: 7.58 lbs/gal (6.93 bbls/tonne, 291.1 gals/tonne)

Natural gas:
Heat content: 1006 Btu/ft^3 = 37.44×10^6 joule/m^3 = 4.65×10^{10} joule/tonne
Density: 0.81 gms/liter (1242 m^3/tonne; 43,900 ft^3/tonne)

Coal:
Heat content: 12,650 Btu/lb = 2.94×10^{10} joule/tonne

3. International Energy Units
(Note: These were not used here and are for reference only)

	Tonnes of oil equivalent/tonne
Crude Oil	0.995
Residual Fuel Oil (mazout)	0.972
Sular	1.066
Kerosene	1.056
Butagas	1.125
Benzine	1.103
Diesel Fuel	1.066
Natural Gas	1.111
Coal	0.670

Note: 1 tonne of oil equivalent = 10^7 kilocalories = 4.186×10^{-5} QJ = 4.186 x 10J

EXECUTIVE SUMMARY

EGYPT/U.S. COOPERATIVE ENERGY ASSESSMENT

In a six month period during 1978, Egyptian and American officials and technical specialists have worked collaboratively to assess Egypt's energy resources needed to the year 2000 and the energy demand and supply options which are now or will be available to Egypt by that time. By presenting a comprehensive picture of Egypt's total energy demand and supply, the future plans and policies of Egypt can rest on a sounder information base and can consider various energy options and their potential effects upon the country's future.

The report on this cooperative assessment consists of this Executive Summary, a main report, seven appendices containing materials directly supportive of the integrated analysis which was conducted, and thirteen annexes containing contributions of the technical specialists to that analysis. This Executive Summary (1) presents the setting for an energy assessment in Egypt; (2) briefly explains what was done in this assessment; and (3) summarizes the principal insights which can be drawn from it.

1.0 THE CHALLENGE EGYPT FACES

Energy development will be an important element in the challenge Egypt faces over the next decades. That challenge is multifaceted and formidable.

Many of Egypt's requirements for the future stem from its spiraling population growth and the resultant stress this places on land use, urban growth and the need for industrial expansion to meet basic economic needs. The current population of about 40 million is expected to increase to 65-70 million by the year 2000. With about 50 percent of the people under 20 years of age, the momentum sustaining the current 2.5 percent yearly population growth rate will be difficult to slow for a number of years, even with early and effective family planning programs.

Egypt is a large country (1,000,200 square kilometers or 385,000 square miles), but over 90 percent of the land is uninhabited desert. Essentially the entire population lives in the rich lands of the Nile Valley, the Delta and the communities along the Suez Canal. About one-third of the population lives in the cities of Cairo and Alexandria, and continuing migration is expected to increase urban pressures.

Accordingly, a primary development objective of Egypt is to stabilize the growth of its existing urban centers and to accommodate most of the population increase in new cities and on new lands reclaimed from the desert. Unprecedented measures will be required to redistribute the population and to develop the facilities to support it. The social-cultural, technical, economic, infrastructure and energy supply challenges involved in achieving this goal are large and complex.

Egypt has a limited capability to expand its agricultural production. Therefore, a second primary development objective is to change its economy from one primarily based on agriculture to one which derives its economic expansion principally from increases in industrial and service activities.

The achievement of these two primary development objectives requires substantive improvement and expansion of Egypt's economic, transport, communications, energy and community infrastructures. At the same time, Egypt is attempting to make a number of significant societal and institutional changes relating to Egypt's economic system, management delegations and commodity prices.

Egypt's requirements for energy development should, therefore, be viewed in this broader context of national development objectives which involve major and fundamental changes from the past. The full impact of all these factors upon Egypt's future energy needs and supply capabilities is, at best, difficult to project with certainty. In this sense, the energy demand projection used for this assessment should not be viewed as representing official established Egyptian plans or policies.

2.0 THE COOPERATIVE ASSESSMENT PROCESS

The assessment was conducted by a collaborative Egyptian/U.S. team made up of Egyptian planning and energy officials and U.S. specialists representing a number of technical disciplines (e.g., energy technologies, energy resources, development economics and analytic methods). A Supreme Committee with representatives of a number of Egyptian Government Ministeries was established by the Egyptian Deputy Premier and Minister of Electricity and Energy to organize and manage the participation of Egypt's officials, energy planners and technologists. (The Supreme Committee membership and U.S. team roster are shown in Table 1). All information readily available on Egypt's energy consumption, production and future energy plans was made available to the collaborative team. A group of senior level Egyptian officials reviewed the analysis and assisted in the report preparation, and the joint report on the assessment was reviewed by the Supreme Committee.

The data and analyses presented in this report are based upon information and data available up to June 30, 1978. Developments subsequent to this date were not factored into this assessment.

In the assessment process, Egypt's economic development and energy resource base was analyzed, energy supply and demand options for the future were identified, and alternative energy supply and utilization strategies were prepared. An energy supply/demand network derived from an analytical model developed by the U.S. Brookhaven National Laboratory was used to represent energy production and consumption in 1975 and to project energy demand/supply balances for 1985 and 2000. Specialists from the U.S. Geological Survey assessed the prospective availability of energy resources and energy-related minerals. Other specialists were drawn from the U.S. Department of Energy and its contractors to examine the prospective application of existing and advanced energy supply and utilization technologies and the potential impacts of their use. An energy supply facilities model developed by the Bechtel Corporation and used previously for U.S. Department of Energy policy studies was applied to estimate the cost, manpower and materials of the energy supply facilities required for the various alternative strategies.

3.0 THE ASSESSMENT PRODUCT

The assessment is a technical analysis, it is not a policy study. In overview, the assessment provides: (1) a comprehensive picture of Egypt's projected energy demand through the year 2000; (2) an assessment of the basic fuels and energy resources potentially available to meet that demand with some indication of the extent of those resources; (3) alternative energy supply/demand balances for 1985 and 2000 which could be used to establish goals for Egypt's energy plans; (4) examination of alternative energy planning strategies; (5) aggregated estimates of the capital and operating costs, manpower and equipment that would be needed for energy supply facilities in each of the alternative balances; (6) identification of factors which should be considered in the evaluation of various options; and (7) suggestions regarding the next steps which Egypt should take to initiate selected courses of action and continue more comprehensive and systematic energy planning.

The assessment is not intended to be an energy plan, but it should provide an information base on which the Egyptian energy planning officials may formulate their energy plans. No optimization of the identified planning options is attempted nor are value judgments regarding those alternative courses of action provided. Through the cooperative assessment process, Egypt has been provided with the analytic tools, evaluation factors and data used in the assessment to facilitate their use in Egypt's continuing planning process.

4.0 ASSESSMENT INDICATIONS

Among the major observations which can be drawn from the assessment are the following:

1. Gaps and inconsistencies exist in Egypt's current energy and related planning which, if corrected, could not only significantly improve the accuracy of energy demand projections but also more definitively identify the corresponding requirements for new energy supplies. Subsequent planning should more fully address Egypt's economic development, population redistribution and other development goals. Detailed and consistently collected and aggregated data on energy consumption is not now available. Since the development of useful data will take several years, improved data collection efforts should be started promptly.

2. The energy demand projection provided by Egypt for this assessment implies a growth rate in the consumption of commercial energy of 6 percent per year over the next 20 plus years. This growth rate is generally consistent with Egypt's historic rate of growth of commercial energy demand and that implied in an earlier World Bank study. This energy demand projection does not represent established Egyptian policy, and concern exists whether the amount of energy which is projected to be needed would be sufficient to support the full achievement of Egypt's other broad-gauged development goals.

3. The projected growth in demand for electric energy (9.9 percent per year) is considerably greater than that for direct use of commercial fuels (5.3 percent per year). If these current projections proved valid, Egypt's consumption of electric energy in the year 2000 would be over 20 percent of its total consumption of commercial energy. This ratio is about twice the current ratio of industrialized countries such as France and the U.S. and is considerably higher than most other countries in a similar stage of development as is Egypt. In view of the high capital cost of providing energy in the form of electricity, a reduced dependence upon electric systems might be advantageous to Egypt. Examination of measures to achieve this appear to be warranted.

4. Egypt's plans for expansion of its industries warrant reexamination. Greater attention should be given to the types of new industry being proposed considering the cost of energy and the cost of transporting raw material and finished products to and from industrial plants and distribution centers. Improved transportation system planning needs to be conducted in close coordination with industry and energy supply planning and should fully address Egypt's demographic redistribution and new lands development objectives as well as the higher future cost of commercial fuels.

5. Egypt has limited proven indigenous energy resources; however, there remains extensive land areas which have not yet been explored. The current indications of energy resource availability in Egypt is summarized in Table 2. There is also the promise of significant energy resource finds in the Sinai and parts of the Gulf of Suez. This report, while touching briefly on resources of these two areas, made no specific assumptions with respect to discovery of new resources in either area. In view of the high costs, long lead times, and high risks involved in exploring for and developing new energy resources, Egypt should give priority attention to measures which can provide a better technical basis and improved incentives for exploration for fuels and energy-related commodities.

6. This assessment indicates that through the year 2000, Egypt's demands for commercial energy will, in large measure, need to be supplied by conventional fuels using existing technologies. These fuels in combination will provide over 88 percent of Egypt's energy needs throughout the period. Since Egypt's hydroelectric energy potential is almost fully exploited, its contribution, including consideration of low-head hydro systems, will remain essentially constant and will reduce as a percentage of total commercial energy supply from about 17 percent in 1975 to 11 percent in 1985 and 4 percent in the year 2000. Indigenous coal reserves are limited and for this assessment coal is assumed to be used primarily as a feedstock (coke) to the iron and steel industry which amounts to about 10 percent of

commercial energy demand in 2000. Use of imported coal for electricity generation was not analyzed. Even under favorable assumptions as to accelerated use of renewable resources (solar, wind, biomass and geothermal), oil, gas and uranium, in combination, are projected in this analysis to provide over 70 percent of Egypt's energy needs in 2000.

7. There are substantial uncertainties in Egypt's ability to attain its target goal of producing 1,000,000 barrels per day of oil by the mid-1980's. There are even greater uncertainties in assessing Egypt's ability to maintain that oil production level through the year 2000. To maintain such a production level would require finding new oil reserves of the order of 4 to 5 times Egypt's presently known oil reserves and much of these new reserves will probably have to be found in new geologic provinces.

8. There are favorable indications for increased reserves and production capability of natural gas. The prospects for significant production of associated gas cannot reasonably be predicted. Effective use of gas resources will depend in large measure upon Egypt's ability to bring into being economic gas processing, transport and distribution systems coincident with the finding and development of new gas reserves.

9. Egypt has the potential to continue to be a net energy fuels exporter through the year 2000 if:

- the targeted level of oil production can be attained and maintained;
- measures to use natural and associated gas can be effectively implemented;
- the favorable indications of economically recoverable uranium ore deposits can be confirmed and developed; and
- available and emerging solar energy technologies can be extensively applied to exploit the highly favorable solar, wind and biomass resources that exist in Egypt.

10. Egypt has limited alternatives for generation of its projected requirements for electric energy. Its hydroelectric potential is almost fully exploited. Egypt's indigenous coal resources and preliminary estimates of potential geothermal sources indicate that these possible sources should not be expected to provide significant quantities of electric energy. Egypt possesses highly favorable solar energy resources and aggressive programs to demonstrate and apply

solar energy systems in Egypt appear warranted. A comprehensive assessment was made of the extent to which these favorable resources could be effectively exploited. It indicates that even an accelerated application of solar electric systems could not fully offset the need for extensive capacity additions of other electric generation systems through the year 2000. Electricity generation is considered by Egypt to be a lower priority use of gas with industrial development and residential/commercial use being considered more attractive uses for available gas. Use of oil for electricity generation would (1) utilize a resource of uncertain reserve and production potential; and (2) decrease the role of oil exports in Egypt's international trade.

11. Accordingly, Egypt plans to initiate a nuclear power program which would supply a significant portion of its future electricity needs. The specifics of Egypt's plans for nuclear power are not yet finalized. If preliminary indications of the possible existence of economically recoverable uranium reserves prove valid, Egypt might be able to meet its own uranium fuel needs or export uranium as part of its international trade. However, extensive nuclear fuel enrichment, processing, and manufacturing services would still need to be acquired from foreign sources. In addition, use of nuclear power systems introduce new and stringent plant siting, construction, operational and maintenance requirements which will require a major upgrading of Egypt's current capabilities. Use of nuclear power will also involve higher capital costs for generation facilities, a large portion of which will require international financing.

12. If Egypt is able to attain and maintain the targeted oil production level of 1,000,000 barrels per day, it would appear that Egypt could meet its projected electric energy needs to the year 2000 without an extensive use of nuclear power systems. There is a significant risk as well as substantial costs associated with this increased dependence on oil. Also, beyond the year 2000, a rapid expansion in the use of nuclear or other advanced energy systems will be needed unless Egypt's oil and gas production can be significantly increased above current production targets.

13. Egypt's current management and technical capabilities are inadequate to carry out the major expansion of energy supply capabilities that appear to be needed between now and 2000. In strengthening these current capabilities, particular attention must be given to such areas as senior and middle management, engineering and craft skills, materials and equipment supply capabilities, operations and maintenance personnel, and financing. The prospective increased use of advanced technology nuclear and solar power systems introduces new and unique

requirements which emphasize this need. The projected high utilization of electricity (as compared with direct fuel use) and the high capital cost facilities which are thereby required, introduce major long-term financing requirements. Early commitments are needed to correct current deficiencies and begin development of an improved planning, management, engineering and project implementation capability.

14. Egypt should consider initiating steps to achieve improved energy planning. Improvements that are needed include: (1) a greater consideration of energy requirements and energy supply facility needs in the setting of Egypt's long-term development goals; (2) better coordination of energy supply with industrial and transport sector planning; (3) comprehensive energy supply planning which more fully accounts for the interaction of electricity use and direct fuels consumption; (4) greater attention to the infrastructure needed to support major increases of its energy supply capacity; (5) improved energy data collection and analysis; and (6) near-term institutional adjustments to help achieve the above.

5.0 SUMMARY

In summary, although solar and wind resources in Egypt are abundant, the contribution that such renewable sources can make toward meeting Egypt's increasing needs for commercial energy is judged to be quite limited through the year 2000. Therefore, conventional fuels will need to provide the bulk of Egypt's growing energy requirements during this period, in large measure, using existing energy conversion and delivery technologies. Decisions on preferable courses of action for this period are complicated by uncertainties in Egypt's oil, gas and uranium reserves, in the economic viability of imported oil or coal for energy use, and in foreign exchange and capital requirements. Inadequacies in Egypt's current plans compound this complexity in view of the need to also build during this period the basis for expanded economic development and the foundations with which Egypt will supply its energy needs after the year 2000.

Egypt's current ability to expand its energy supply capacity needs strengthening and the use of nuclear and other advanced technology energy systems will exacerbate this need. In this light, it would be prudent for Egypt to reassess all of the available energy options, both demand and supply. This reassessment should focus on Egypt's capability to effectively implement those options and the need for early commitment of resources to the selected courses of action. In any event, Egypt needs continuing assistance in establishing a comprehensive energy planning capability and in preparing to implement those plans effectively.

This report was prepared jointly by representatives of the Government of Egypt and the U.S. It does not represent a statement of either Egyptian or U.S. Government policy nor imply any commitment on either Government to concur with the conclusions or observations which are presented.

Table 1
U.S. COOPERATIVE ENERGY ASSESSMENT
U.S. DELEGATES

POSITION	NAME	ORGANIZATION
MANAGEMENT AND INTEGRATED ANALYSIS		
Team Leader	McFarren, Robert	Department of Energy
Supply Technology Team Leader	Cirillo, Richard	Argonne National Laboratory
Demand Option Team Leader	Anderson, B. Jennine	G.E. Tempo
Demand Projections Team Leader	Ezzati, Ali	Brookhaven National Laboratory
Electric System and Nuclear Power	Purvis, Edward	Department of Energy
Financial Evaluations	Cole, Henry	G. E. Tempo
Supply Facilities Cost	Gallagher, Michael	Bechtel Corporation
Executive Officer	King, Karla	Department of Energy
Administrative Support		
ANL Supervisor	Janson, Thomas	Argonne National Laboratory
Assistant to Team Leader	Hogan, Judith	Argonne National Laboratory
Editorial Control	Rohse, Bette	Argonne National Laboratory
Secretary	Hulit, Rebecca	Argonne National Laboratory
TECHNOLOGY SPECIALISTS		
Solar	Kaplan, George	Department of Energy
	Teagan, Peter	Arthur D. Little Corporation
Fossil Energy	Bliss, Charles	Mitre Corporation
	Watkins, Wade	Department of Energy
Nuclear	Purvis, Edward	Department of Energy
Hydro	Graham, William	Armstrong Associates
Environment	Cooper, Raymond	Department of Energy
	Zussman, Ronald	Argonne National Laboratory
Energy Systems	Palmedo, Philip	Brookhaven National Laboratory
	Ezzati, Ali	Brookhaven National Laboratory
	Lee, John	Brookhaven National Laboratory
	Davidoff, Jack	Brookhaven National Laboratory
Energy Facility Cost	Gallagher, Michael	Bechtel Corporation
Transmission and Distribution	Warchol, Edward	Bonneville Power Administration
Conservation-Industry	Moore, Christopher	Gordian Associates
	Kumar, Victor	Gordian Associatese
	Thorne, Paul	Gordian Associates
Conservation-Building and Community Systems	Berstell, Gerald	Resource Planning Associates
	Mead, Kirtland	Resource Planning Associates
	Kapus, Ted	Department of Energy
Conservation-Transportation	Tomazinis, Anthony	University of Pennsylvania
Development Specialist*	Cole, Henry	G. E. Tempo
Development Specialist	Walpole, Norman	G. E. Tempo
Manpower	Roman, Richard	Argonne National Laboratory

*Assistance was provided in Egypt by consultants from the American University in Cairo. These individuals were Dr. Donald Cole, Dr. Karima Korayem, Dr. Nazih Ayuki, Dr. Nazih Dief, and Saad Ibrahim.

Table 1 (Continued)

RESOURCE SPECIALISTS

Energy-Related Minerals	Tolbert, Eugene	U.S. Geological Survey
Petroleum Geologist	Maher, John	U.S. Geological Survey
Specialist for Geophysical Exploration for Petroleum, and Reservoir Analysis	Fouda, Ahmed	U.S. Geological Survey
Specialist for Electrical Geophysical Methods and Geothermal Energy	Zohdy, Adel	U.S. Geological Survey
Coal Geologist	Olive, Wilds	U.S. Geological Survey
Water Resources	Clarke, Frank	U.S. Geological Survey
Nuclear Materials	Page, Lincoln	U.S. Geological Survey

Table 1 (Continued)

SUPREME COMMITTEE EGYPT/U.S. COOPERATIVE ENERGY ASSESSMENT
EGYPTIAN DELEGATES

ENG. MOHAMED KAMEL HAMED, Chairman, Egyptian Electricity Authority

*DR. ABDEL RAHMAN, Counselor to the Prime Minister

MR. FOUAD HUSSEIN, Deputy Minister & Counselor to the Deputy Prime Minister for Economic Affair, Ministry of Economy

ENG. MAHER ABAZA, First Undersecretary, Ministry of Electricity and Energy

ENG. IBRAHIM SHARKASS, Deputy Chairman, General Organization for Industrialization (GOFI)

DR. MUSTAFA K. AYOUTY, Deputy Chairman, Egyptian General Petroleum Authority

DR. GALAL MOUSTAFA, Chairman, Egyptian Geological Survey and Mining Authority

DR. MOHAMED KAMEL, Chairman, National Research Center

DR. EL-WALID EL-SHAFIE, Principal, National Planning Institute

ENG. ADLY KAMEL YAKAN, Executive Chairman, Qattarra Depression Authority

ENG. HUSSEIN SIRRY, Chairman, Nuclear Power Authority

DR. SHAZLY MOHAMED EL SHAZLY, Chairman, Nuclear Materials Authority

DR. MAHMOUD EL-KOSHAIRY, President, Solar Energy Commission

DR. EMAD EL-SHARKAWI, Egyptian Electricity Authority (Principal Liaison Official)

DR. MOUSTAFA SWIDAN, Egyptian Electricity Authority (Liaison Official)

*Appointed by Deputy Prime Minister Sultan as head of the Egyptian Delegation to the United States

EXECUTIVE SUMMARY

Table 2

ENERGY RESOURCE AVAILABILITY IN EGYPT

Solar	Excellent: Sun energy incidence minimum 1.7 times U.S. best. High average wind velocities (12 to 18 miles per hour) in certain coastal areas. Technology, manufacturing and cost factors limit applications.
Biomass	High current noncommercial use. Urban waste is potential new source.
Geothermal	20 MWe maximum potential based on current information.
Hydro	Limited additional potential. Nile Annual Flow: 84 x 10^9 cubic meters (m^3) (highly variable). Aswan High Dam Electrical Generating Capacity: 2100 MWe; Low Dam: 220 MWe.
Oil	Production increasing: 1977 Reserves: 2.1 billion barrels Current Production: 150 million barrels/yr. Resource adequacy to maintain production goals to 2000 highly uncertain.
Natural Gas	1976 Reserves: 2.0 trillion ft^3 Projected 1978 Production: 675 million ft^3 Resource adequacy to maintain production goals uncertain but potentially favorable.
Coal	Limited economically recoverable reserves: 35.6 million tons in Sinai. Best potential use: Blend with imported coking coal
Uranium	None currently recoverable economically: Favorable potential.
Thorium	None currently recoverable economically: 3.7 x 10^5 tonne reserves (.062 percent content) in heavy sands but potential for economic recovery small.
Pumped	Adequate sites appear to be available. System needs for storage capacity are increasing but involves significant net consumption of high quality electric energy.

1.0 PURPOSE AND SCOPE OF ASSESSMENT

1.1 U.S. International Energy Development Program

1.1.1 Basis of program: In September 1977 President Carter approved the inception of a one-year pilot program which is known as the International Energy Development Program. The long-term program is aimed at cooperating with selected developing countries in overall energy and resource assessments and planning in order to assist these countries in meeting energy needs that are consistent with their development objectives. A systematic assessment of energy resources, applicable technologies, energy demand and supply projections, trained manpower availability and related environmental considerations was to be used to devise alternative strategies for energy development. These strategies could then be used by the national planning mechanisms of the participating countries to develop national energy plans and determine priorities for energy development.

The overall objectives of this program were to:

- reduce dependence upon imported oil and thus limit the impact of world energy prices on the social and economic development plans of many countries;
- encourage the use of indigenous energy resources;
- encourage the use of decentralized, renewable resource technologies, especially for rural applications; and
- avoid a premature commitment to a large nuclear power program.

The responsibility for overall guidance and coordination is vested in an Inter-Agency Group; policy responsibility has been given to the Department of State; and program management responsibility rests with the Office of International Affairs of the Department of Energy.

If the pilot effort proved successful, it was anticipated that the program would be expanded not only to include a greater number of interested countries, but also, where it was appropriate, to undertake cooperative, joint projects with these countries that would assist them in energy planning activities and priority follow-on steps.

1.1.2 Selection of Egypt: An explanation of the cooperative program was given to Egyptian officials by U.S. Government representatives in Cairo in January 1978. After a favorable initial reaction by the Egyptian officials, meetings of officials of Egypt and the United States were held in Cairo in mid-February 1978. In these meetings, the scope of the assessment that was being proposed by the U.S. was more fully explained and the willingness of the Egyptians to participate in a collaborative assessment activity was affirmed. The selection of Egypt as the first country to participate in the pilot year program was based on the following factors:

- the willingness of the Egyptian Government to enter into a full cooperative effort;
- the variety of energy demand and supply options available to Egypt;
- the presence in Egypt of a considerable breadth and depth of technical expertise in energy and economic planning so that full bilateral participation could be achieved; and
- the extent of prior planning and basic data on energy resources that are currently available for use in the assessment.

1.2 Scope of Cooperative Assessment

The assessment was conducted in a four-month period that extended from mid-March to mid-July. About one month was spent in Egypt gathering the necessary information on which to base the analysis. Accordingly, no new data was developed; and the assessment is based upon data that were readily available in Egypt, Egyptian planning studies and data available in the U.S.

The objective of the assessment was to: 1) identify energy demand and supply options for Egypt that are consistent with its indigenous energy resources; 2) assess Egypt's ability to effectively use those options; and 3) identify measures by which Egypt's energy planning activities could be improved.

This required the following:

- an assessment of Egypt's prospects for the exploration and economic utilization of its indigenous energy sources (this includes potential energy resources and those currently known);
- an examination of the technologies that are and can be employed in extracting, processing, converting, delivering and using available energy resources;
- an assessment of the applicability of the available fuels and resources and their conversion, delivery and end-use technologies for meeting the energy demands of Egypt. For example, this constituted a market penetration assessment of solar technologies in Egypt;
- an identification of some of the absorptive capacity factors (i.e., manpower availability, capital availability, etc.) that could be associated with the implementation of the available energy options;

- an identification of the steps that would be needed: (a) to further establish the availability of an identified option (e.g., geothermal source exploration, oil exploration, solar technology demonstration); (b) to improve the basis for well-founded energy planning (e.g., evaluation of transportation system alternatives or collection of better energy demand information); or (c) to provide an adequate basis for commitments to a selected course of action (e.g., engineering and cost evaluations of competing projects); and

- an identification both of gaps and inconsistencies in the existing energy planning activities and of the means to resolve them.

The assessment addressed all known and potential energy supply options, i.e., oil, gas, coal, oil shale, hydroelectric, nuclear power, geothermal, solar, wind and biomass. Energy demand options (for example, alternative industrial processes) were addressed in limited numbers on a selective basis, in order to keep the scope of the assessment manageable while still identifying those demand options which could materially affect the demand/supply balance.

A comprehensive framework that describes the entire energy supply and utilization process in Egypt has been applied in the analysis. This comprehensive framework, which is called the Reference Energy System (RES), displays the interactions that take place between demand changes and supply capacities and allows the analysis of: (1) energy demand reductions or changes in the type of energy required (i.e., fuel substitutions); and (2) changes in the utilization of alternative energy resources or resource conversion and delivery methods.

Using the Reference Energy System, two future energy supply/demand balances are constructed -- one for 1985 and one for 2000 -- and these are compared with a historical (1975) supply/demand balance. The period beyond 2000 is discussed only in the sense that the results include post-2000 supply facilities that are under construction before 2000.

This assessment is viewed as providing important insights to subsequent energy planning activities in Egypt. It is not an energy plan, as it carefully avoids those policy and priority decisions that the Government of Egypt would have to make in the preparation of an energy plan. In addition, the analysis required to determine optimal measures that will achieve stated objectives (e.g., lowest energy cost, maximized industrial growth, minimized international financing requirements, etc.) lies outside the scope of this stage of the assessment. However, it is expected that such work would be done in the future, as a natural outgrowth of the present activity.

For the purposes of this report, an energy strategy is defined as a grouping of energy options (e.g., hydro, oil, gas, coal, solar, wind, biomass, nuclear, etc.) in specified amounts that is directed at a stated objective, such as an "accelerated (use of) renewable resources".

The feasibility of each of the options is established in terms of the availability of the required resources and of the processing, conversion, transport and utilization technology. Other factors that should be considered in subsequent, more rigorous evaluations are identified; but they are not fully examined in this assessment.

1.3 U.S. Team - Egyptian Counterparts Concept

The assessment was conducted as a collaborative effort by a U.S. team of experts under the management of U.S. Department of Energy (DOE) working closely with Egyptian management and technical officials. The U.S. team had two principal components: (1) a management and integration group that conducted the integrated analysis of energy options and strategies and provided administrative support and liaison with Egyptian officials; and (2) specialists in various technical, economic, environmental and institutional areas who collected information in their assigned areas and provided this input to the management and integration group.

The specialists directed their attention to the following categories of information:

- o basic resources of energy fuels and energy-related commodities e.g., water, minerals, cement, etc.;
- o energy demand in the industrial, agricultural, residential/ commercial and transportation sectors;
- o energy production capabilities, including fuels production and processing, energy conversion (primarily to electrical energy), fuels and energy transport and delivery, and new renewable energy resources, i.e., solar, wind, biomass and geothermal;and
- o "crosscutting" development factors such as: 1) social/cultural, economic and institutional considerations; 2) financing requirements and capabilities; 3) supply facility costs, equipment and manpower requirements; 4) manpower capabilities; and 5) environmental considerations.

Integration team members and technical specialists were drawn from several sources, including DOE program organizations, the Argonne (ANL) and Brookhaven National Laboratories (BNL), private U.S. companies under contract to DOE, ANL, or BNL, and private consultants from both the U.S. and Egypt. (Appendix A lists the U.S. participants and their responsibilities.)

A fundamental principle of the operation of the U.S. team was to establish close working relationships with their Egyptian management and technical counterparts. The primary objectives of this close counterpart relationship were fourfold: (1) obtain better insight and quality information as to energy resource, production, planning and utilization capabilities in Egypt; (2) participate actively in the integrated analysis, the derivation of observations from that analysis and the preparation of a report on the assessment; (3) establish the functional means by which Egyptian officials may effectively apply the information collection, analysis, and evaluation methods used in the assessment to subsequent energy planning in Egypt; and (4) gain from the Egyptian counterparts better insight into energy analysis and planning factors that must be considered or emphasized in developing countries, vis a vis considerations that are more pertinent in developed countries.

1.4 Participation of Egyptian Officials

The need for active Egyptian participation in the cooperative assessment activities was strongly emphasized in the initial meetings. Egyptian officials expressed interest in active participation in both the information collection and the analysis activities of the assessment. A Supreme Committee was established under the authority of the Deputy Prime Minister of Egypt, A. Sultan. (Appendix B lists membership of the Supreme Committee and also identifies other significant interactions with Egyptian officials.) The Supreme Committee was responsible for scheduling all activities conducted in Egypt for the energy assessment. Egyptian officials named this bilateral program, the Egypt/U.S. Cooperative Energy Assessment.

The Committee met with the U.S. delegation periodically during the information collection phase of the assessment. Under the auspices of the Supreme Committee, extensive contacts were developed with a large number of Egyptian management and technical officials from March 18 through April 21, 1978. Significant quantities of energy supply and consumption information were collected through these contacts. Insight was also gained into the development objectives of the Government of Egypt and the role that the subsidiary planning objectives of various economic sectors (e.g., industry, agriculture, etc.) play in the achievement of their overall development objectives. A report on the information collection activities during this period was submitted to Deputy Prime Minister Sultan on May 9, 1978.

Arrangements were also made for direct Egyptian participation in the integration, analysis and review activities that were conducted in the U.S. following the fieldwork in Egypt. Two Egyptian engineering analysts attended a six-week training session at Brookhaven National Laboratory during the period May 2 to June 9, 1978, to become acquainted with the analytical methods that were applied in the assessment, and five executive-level Egyptian officials visited the U.S. from May 31 to June 9, 1978, to participate in a review of the preliminary results of the analysis.

Copies of a draft of the assessment report were provided to Egyptian officials in August of 1978. The Supreme Committee met on August 15, 1978 to organize review of this draft report. Extensive constructive comments were communicated to the U.S. team over the period September 17 to 24, 1978. In a meeting on September 25, 1978, the Supreme Committee approved finalization of the report on the assessment reserving the right to comment further at a later date upon the observations contained in the report.

1.5 Transfer of Methods and Data to Egypt

In addition to this report, a number of related analytical techniques and the supporting data are being provided to the Government of Egypt. These include:

- the energy system analysis structure that was utilized in the assessment and all of the pertinent data for each strategy that was examined;
- the estimates of energy supply facility cost, equipment and manpower requirements for each of the strategies, and the underlying model and data base that was used to prepare those estimates; and
- the individual specialist reports that supported the analysis.

This transfer should enable subsequent Egyptian planning activities to build more readily upon this first step assessment. The analysis of variations in the demand projections beyond those considered in this assessment and more rigorous analyses of specific energy demand or supply options are only two of the many areas in which further examination by the Egyptians could prove fruitful.

2.0 RESULTS OF ASSESSMENT

This section summarizes the Egyptian energy supply and demand assessment. Section 2.1 briefly describes the analytical procedure which was used. Section 2.2 discusses the energy demand projections that drive the analysis. Section 2.3 presents a summary of primary energy sources available to Egypt. Section 2.4 describes the Comparison Case* energy balance. Section 2.5 presents the cost, manpower and material requirements of the Comparison Case. A number of alternative energy options and strategies that are based on variations of the comparison case were developed. Discussion of these options and strategies are presented in Section 2.6.

2.1 The Analytical Procedure

2.1.1 The basic approach: The basic approach to the analysis is as follows. A view is constructed of the energy supply-demand situation

*In the early stages of the assessment the Comparison Case was referred to as the Reference Case.

that would exist in the future if the projection provided by the Egyptian Institute of National Planning (INP) were implemented. This is referred to as the Comparison Case energy supply demand balance, and its results are presented in some detail for 1985 and 2000. All forms of energy demand and supply are presented in common units. For this assessment the joule was the unit of energy. Due to the large amount of energy involved, a frequently used term is quadrillion joules or 10^{15} joules. This term is at times abbreviated to QJ. A table noting the conversion factors used in the assessment can be found on the page immediately following the table of contents. In addition, for each of the projected supply demand balances, an accounting is made of various key factors related to that balance such as: the energy resources consumed, the capital investment required, and, under certain assumptions regarding oil production, the implied imports or exports of petroleum. A set of alternative resource and technology options is then defined.

An option could be the development and use of a new resource (e.g., coal), the increased use of solar energy, or measures to increase the effectiveness of energy use in certain industrial activities. Each option is defined in terms of its economic, energy and resource characteristics, and its possible level of implementation (including the fuels or technologies for which it will substitute) in the years 1985 and 2000. Then, through adjustment of the energy supply-demand balance, one can estimate the effects of implementing the option on the energy supply requirements and capabilities. From these estimated effects, one can also estimate the related changes in supply facility costs, equipment or manpower requirements. The analysis thus results in a view of the energy implications of current policies and trends and an indication of the implications of alternative options and policies.

For the sake of presentation, several basic "strategies" have been defined which assemble a number of options. For example, an accelerated renewable resource strategy has been defined which combines accelerated solar electicity, solar hot water heating, wind energy, photosynthetic production of fuels and other, related options, with a commensurate reduction in the use of nuclear power. The other strategies examined are described in Section 2.6.

The analytical framework used for the analysis is based on three basic analysis processes. They are: (1) the Brookhaven National Laboratory (BNL) Reference Energy System* approach to represent the energy demand/supply network; (2) the Energy Supply Planning Model** for supply system costs, equipment and manpower requirements;

---

* The Reference Energy Systems approach as applied to the United States is described in M. Beller, Ed., Sourcebook for Energy Assessment BNL-50493, Dec. 1975, Brookhaven National Laboratory. Its application to developing countries is described in An Analytical Framework for the Assessment of Energy Resource and Technology Options for Developing Countries. BNL-50800, Feb. 1978.

** "The Energy Supply Planning Model, Volume I: Model Structure and Use. Volume II: User's Manual and Appendices." M. Carasso, J.M. Gallagher, K.J. Sharma, J.R. Gayle, R. Barany. NTIS No. PB-245382, PB-245383, August 1975.

and (3) special methods for analyzing the penetration of solar energy technologies. These methods were selected to meet the need for an integrated energy technology and resource assessment, which would be both manageable in the short time (three months) afforded for the analysis and flexible with respect to variations in the availability of data.

The Reference Energy System (RES) used in this assessment was derived from the reference energy system concept developed by Brookhaven National Laboratory and used to analyze alternative energy policies for the U.S. The RES is a framework that integrates a set of estimated energy demands, energy conversion technologies, fuel mixes and energy resources into an overall energy supply/demand balance. The RES format consists of a pictorial network diagram which indicates both energy flows and the associated conversion efficiencies of the technologies employed in various stages of the energy production, transmission, distribution and energy utilization systems. An RES network for the energy balance in Egypt in 1975 is shown in Figure 2.4-6a. Similar networks and supply/demand balances have been developed for the years 1985 (Figure 2.4-6b) and 2000 ((Figure 2.4-6c).

As illustrated in Figure 2.4-6a each path through the energy system diagram indicates a possible route for the flow of energy from an energy resource to a given demand category. Alternate paths and branches reflect the substitutability of various resources and technologies for one another. The energy flowing through each step or process is shown above the line representing the activity. The numbers in parentheses represent the efficiencies or relative effectiveness of the processes. Both commercial and noncommercial* fuel forms are normally dealt with in the RES.

Normally the construction of a supply/demand balance using this network starts with the projection of the underlying determinants of energy demand - for example, future industrial output (in terms of tons of steel produced), vehicle-kilometers to be traveled, etc. The energy processes to carry out those activities are then specified, along with the fuels used. Then, progressing to the left in the energy system diagram, the various energy conversion and transport technologies are specified with their associated efficiencies and costs. In choosing technologies and fuels for energy supply, consideration is given to the availability of various fuels and to any established capital construction plans. This process is judgmental, making use of any engineering, economic or resource information that is available. As employed in this assessment, the process does not include any computerized models or automatic optimization techniques. Such methods were not considered to be either necessary or effectively applied in this assessment given the

---

* Noncommercial fuels include wood, crop residues, animal waste and other traditional fuels. (It is also recognized that these fuels are traded, to some degree, in commercial markets.)

unavailability of sectoral and activity level data on energy demand and considering the variety of factors that influence the development of the energy supply system which could not be adequately represented in this analytic framework.

To elaborate, in order to be able to perform the analysis of options that affect very specific uses of energy (e.g., water heating), the demand portions of the energy balance must be developed in detail, a process requiring information at a level of detail that is not now available in Egypt. Moreover, the balance must also be projected to a time well into the future when very large uncertainties exist which must be attached to any projection regardless of the quality of the current data used.

It is important to emphasize that the projected energy balances for Egypt are not intended to be a prediction of Egypt's energy future. Rather, it is a mechanism for option analysis as a beginning step in the more detailed process of option evaluation and planning decisions. It was in this context that the energy demand projection used for this assessment was provided by the Government of Egypt. It should be clearly understood that that projection does not necessarily represent Egypt's plans or energy policies. For these reasons, the term "Comparison Case" is used for the base point supply demand balance.

2.1.2 Manpower, equipment and financial requirements estimates: The Energy Supply Planning Model (ESPM) was used to estimate the cost, equipment and manpower requirements for all facilities involved in the extraction, processing, conversion and delivery of energy fuels and electricity. Cost, manpower and equipment needs are estimated both for the financing and construction, and for the operation and maintenance, of energy supply facilities. The ESPM was originally developed for the National Science Foundation by the Bechtel Corporation to provide a quantitative tool for the analysis of energy options in the United States. This model and its included data base is useful in analyzing the requirements of prospective energy development programs. It is currently being used by the Department of Energy for energy policy and planning assessments.

The ESPM does not address facilities, systems or equipment which serve other purposes (e.g., industries, transportation systems and commercial facilities) and in the course of their operations are major consumers of energy. No ready means exist to develop comprehensive estimates for the costs and resource needs of those facilities and equipment. For example, cost requirements for the transportation sector would be based not only on estimated transport vehicle costs (e.g., trains, cars, buses, trucks, barges and airplanes), but also on estimated costs for the necessary railroads, roads, streets, waterways, terminals and transshipment facilities. As a result, the cost, equipment and manpower requirements provided in this assessment only cover energy supply facilities.

A central feature of the ESPM is the extensive engineering data base on all of the resources required to design, construct, start up, operate and maintain energy supply and energy transport facilities. This data base builds upon the extensive experience of a large architect engineer and construction management firm. Some 101 "typical" energy supply facilities are defined. Such "typical" facilities include oil fields, pipelines, refineries, coal mines, coal transport facilities, oil-fired steam power plants, combustion turbine power plants, nuclear power plants, electrical transmission and distribution systems, etc. For each facility, cost, equipment and manpower estimates are prepared both for the siting, construction and financing of the facility and for its subsequent operation and maintenance. More details on the operations and the assumptions embodied in the ESPM are set forth in Appendix E.

Although the estimates from the ESPM provide extensive detail as to various costs and types of equipment or manpower which are needed, they are not comparable in detail or accuracy with a detailed estimate based upon a well-specified facility for a selected site. Similarly, without detailed information on specified sites for the facilities, an estimate based on an ESPM "typical" facility cannot reasonably account for site-related costs and supporting infrastructure costs. Consequently, the estimates are best applied in an overall sense as they are in this assessment. Used in that way, the ESPM can both: (1) indicate the order of magnitude of costs, equipment and manpower associated with developing a broadly based energy supply system; and (2) estimate the general differences in the cost, equipment and manpower requirements of different energy supply strategies.

Energy supply facility requirements were derived by the ESPM directly from the energy supply/demand balances for 1975, 1985 and 2000. Supply facilities were scheduled for construction and operation as needed during the intervening years between these three balances assuming a smoothed growth in energy demand. The schedules for the major fossil fuel supply and processing facilities could be quite reasonably developed from the information provided by the EGPC and the assumption by the U.S. team. However, the preparation of construction schedules for the needed electric generation and transmission facilities posed a more difficult challenge. This results from: (1) the need to maintain a generating capacity reserve margin above estimated peak demand; and (2) the need to utilize a wide variety of electric generating facilities (e.g., oil-fired steam turbine, combustion turbine, nuclear, pumped storage and solar electric) each with significantly different operational and cost features and construction lead times.

In order to use the ESPM to estimate the costs, equipment and manpower requirements of Egyptian energy supply facilities, it was necessary to modify the model to reflect conditions that apply to Egypt (e.g., equipment, labor and material costs, and manpower productivity). During the U.S. team visit in Egypt, the data which were available as a basis for making such adjustments were collected. To ascertain the general validity of the adjustments which were then made to the ESPM data base, discussions were also held with experts familiar with Egyptian construction and power industry practice. As part of these adjustments, estimates were made of the amounts and types of equipment and labor that could be provided by Egypt's domestic, manufacturing, construction and service capabilities and those that would need to be obtained from other countries. Although the domestic supply capability can be expected to change significantly over the period to 2000, a single estimate that is generally consistent with the current situation was used in this assessment for each individual energy supply facility.

Appendix E provides further details on: (1) the assumptions applied in the use of the ESPM; (2) the adjustments made to the ESPM data base to make it more accurately reflect Egypt facility construction and operation conditions; (3) the preparation of the energy supply facility build schedules that were required for the ESPM; (4) the fuel and fuel cycle cost assumptions for fossil and nuclear electric generation facilities; and (5) the treatment of post-2000 facility needs upon the aggregate cost, manpower and materials estimates.

2.1.3 Solar penetration analysis: An additional process had to be employed to estimate the potential application of solar energy technologies (including solar, wind and biomass systems for electricity generation and solar water heating). An analysis of this type of advanced technology requires consideration of technology availability, economics, consumer acceptance, manufacturing capability and many other issues. In the time available it was not possible to develop a complete market analysis; however, a simplified evaluation based on several assumptions enabled some estimates of possible market penetrations to be made. The analysis considered: (1) the projected availability of solar heating and electric generation technologies; (2) the lead time to demonstrate those technologies in Egypt and bring into being a commercial supply, installation and maintenance capability; (3) the economic competiveness of solar systems including the role of governmental intervention in promoting advanced technologies through subsidies, building requirements, etc.; (4) the portion of the electric utility system that solar technologies should comprise without distorting system reliability; and (5) the availability of manpower and materials for manufacturing, installing, operating and maintaining solar systems. The details of the analysis are presented in Appendix F and in Annex 8-Potential Use of Renewable Resources.

2.2 Energy Demand Projections

In general, it is preferable to develop projections of energy demand from the lowest level (greatest detail) upward. That is, consumption estimates are made first at the level of the energy consuming process. These process estimates are then aggregated into projections for specific industries, and these, in turn, are aggregated to project the energy needed for all activities of the specific economic sector being addressed. Finally, the total energy demand of the national economy is obtained by summing the energy demands of the several sectors of the economy.

This type of detailed bottom up projection of energy demand permits the effects of fuel substitutions to be measured. However, it emerged at early meetings with the Egyptians that the information required to develop such detailed demand projections was not available. As a result, the following alternative approach to projecting sectoral energy demand was employed:

(a) Under the leadership of the Institute of National Planning (INP) and the Ministry of Planning, two major Egyptian ministries, projections of electricity and fuels demands for 1985 and 2000 for each of six major economic sectors were developed. These included industry, transportation, agriculture, residential, utilities and others. The Ministry of Energy and Electricity provided the electric demand projections. The Egyptian General Petroleum Corporation (EGPC) projected the demand for petroleum products and associated and natural gas. The Ministry of Transportation and the General Organization for Industrialization (GOFI) assisted in projecting energy demand for the transportation and industrial sectors respectively. It is important to note that the electricity and fuels projections provided for this assessment were individually prepared and were not necessarily based upon consistent assumptions of economic growth or other important factors. Accordingly, the demand projection used for this assessment does not represent approved Egyptian policies or plans. Additional detail on these demand projections is presented in Appendix C.

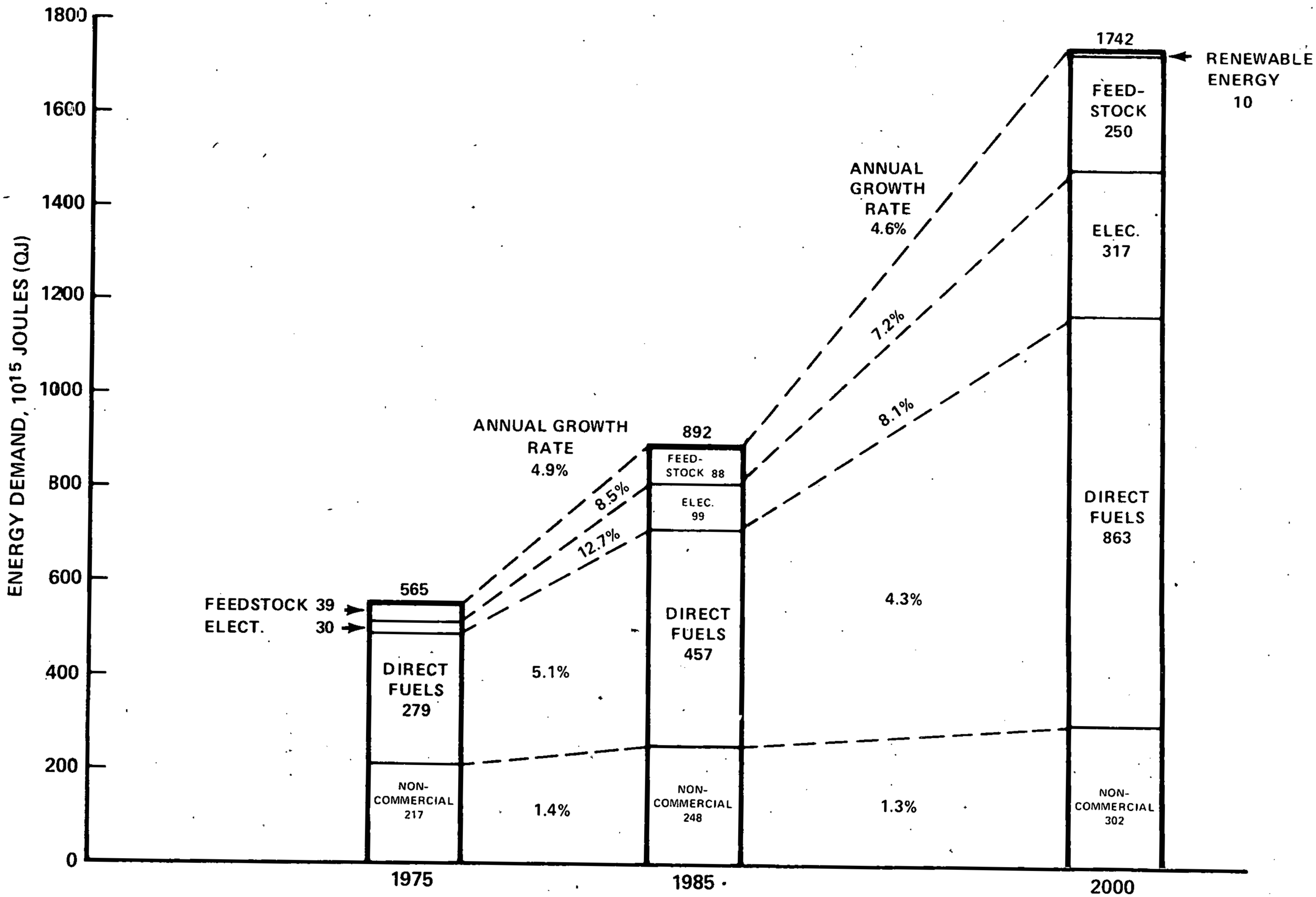
(b) The U.S. team developed a set of ratios* to disaggregate the electricity and commercial fuels demand projections provided through INP. These ratios were developed by a thorough examination of historic consumption patterns, penetration trends by various new end-use devices and processes, future fuel consumption and substitution patterns and transportation mode shifts, etc. These electricity and fuel apportionment ratios were reviewed by the Egyptian team members for their reasonableness.

Figure 2.2-1 illustrates the comparative demand for chemical feedstocks**, electricity, direct fuels and noncommercial fuels in Egypt in 1975, and as projected for 1985 and 2000. The pattern of commercial energy consumption shown is based upon projections for electric energy and fuels provided by INP; feedstock** and noncommercial fuel projections were estimated by the U.S. team.

---

* Specific disaggregation ratios are presented in Appendix C, Tables C.6 to C.9. The projected electric energy and commercial fuels demands that were derived for each economic sector and activity by applying these ratios are presented in Tables C.10 to C.13 in Appendix C. Tables C.18 to C.20 summarize the changes in energy allocations at the economic activity level that occur in the period 1975 to 2000.

** Mainly coking coal used in iron and steel production.



-13-

FIGURE 2.2-1 COMPARISON CASE DIRECT FUEL, ELECTRICITY FEEDSTOCKS AND NON-COMMERCIAL ENERGY DEMAND

The demographic policy and economic assumptions underlying the EGPC and the Ministry of Energy and Electricity projections were not explicitly stated. From the growth percentages shown in the figure, the use of all energy forms decelerates; that is particularly true for electricity use (12.7 to 8.1 percent). Based on these projections, the total energy demand will grow at annual rates of 4.9 and 4.6 percent for the periods 1975-1985 and 1985-2000, respectively.

2.3 Primary Energy Resources

A variety of primary energy resources are available to Egypt, but only in limited quantities. More detailed discussions of oil, gas, coal, uranium, geothermal, water supply and energy-related mineral resources can be found in Annex 1-Energy Resources; discussions of hydro-electric resources are presented in Annex 6-Hydroelectric Power; and discussions of solar, wind and biomass resources are detailed in Annex 8-Potential Use of Renewable Energy Resources. This section presents a brief summary of the findings of the assessment for all major resources.

2.3.1 Oil: Significant production of crude oil began in Egypt in 1969 (85.2 million barrels were produced during that year). Published estimates of proven recoverable reserves range between 1.67 and 5.1 billion barrels. (Figure 2.3-1 illustrates the location of the oil fields.) Most of the known reserves are located in the Gulf of Suez Basin, where 20 fields are now producing. Six additional commercial fields have been discovered in the Western Desert. Prospects appear very favorable for substantial undiscovered reserves in many parts of an area of more than 600,000 sq. km, of which only about one-third have received more than a cursory examination. Although the Western Desert, the Delta Basin and offshore tracts should be given special emphasis, the Gulf of Suez Basin holds the most immediate promise. The Nile Basin and northern Sinai also hold out some potential. To meet Egypt's oil production target of 1 million bbl/day by 1982 will require discovery of new reserves 4-6 times current reserves. These new reserves are needed to both balance withdrawals and increase total reserves.

The residual fuel oil (mazout) obtained from the refining of crude oil in Egypt contains a relatively high sulfur content (approximately five percent) and has an energy content of about 40.7×10^9 joules/tonne compared to about 43.8×10^9 joules/tonne which is normally assumed for residual fuel oil used in the U.S. These factors are coupled with a significant vanadium content in Egyptian crude oil which remains, to a large extent, in the residual fuel oil.

2.3.2. Gas: Figure 2.3-1 shows the location of the gas fields. Proven reserves of nonassociated gas (that not associated with petroleum production) are 71 to 113 billion cubic meters in the Delta Basin and the Western Desert. Additional associated gas is available in the

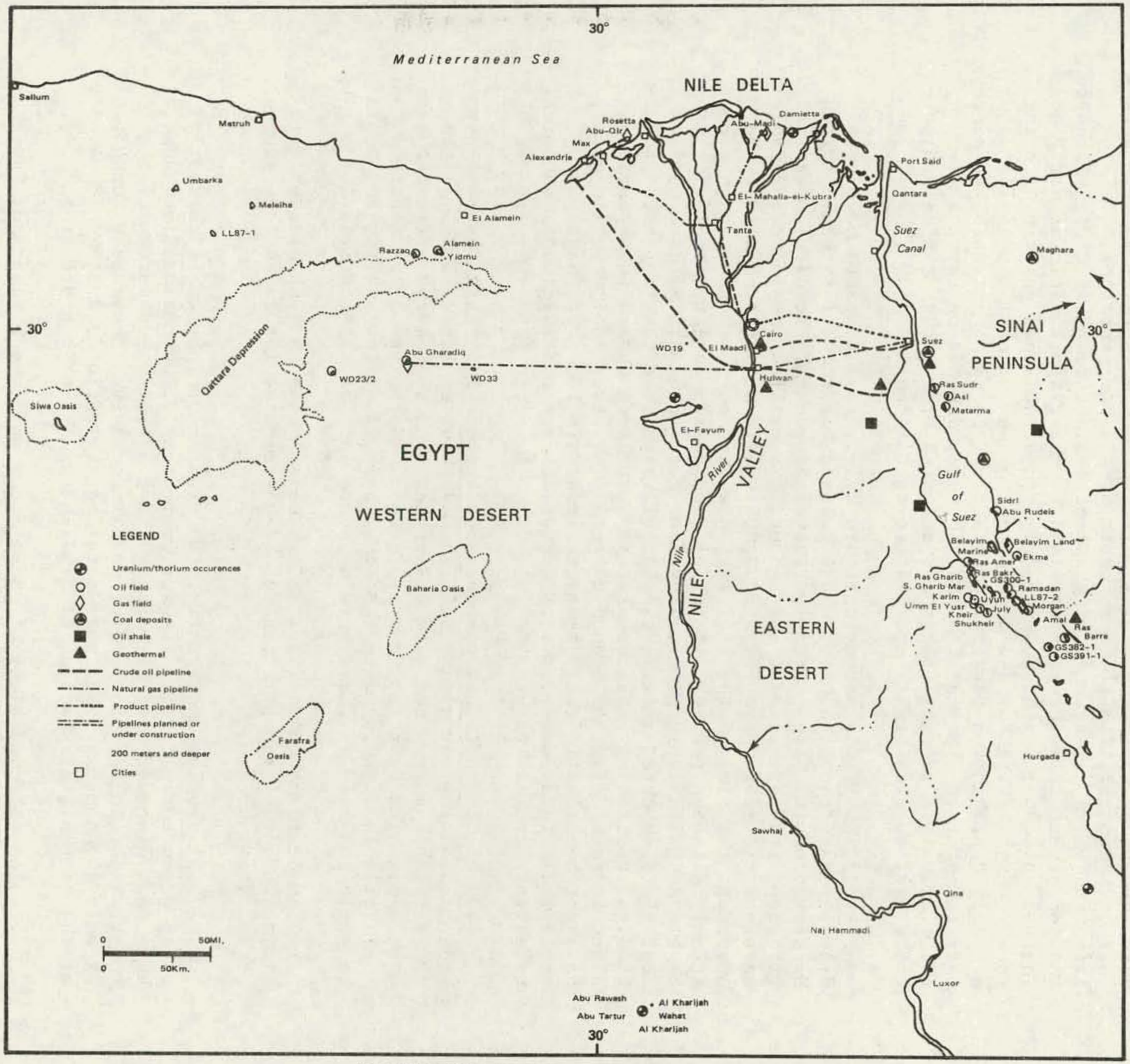


FIGURE 2.3-1 LOCATION OF RESOURCES IN EGYPT

Gulf of Suez Basin, some of which is now being used for gas lifting of oil in producing wells while the balance is flared. Available data on associated gas reserves are limited, but current production rates in the Gulf of Suez vary from 11 to 28 cubic meters per barrel of oil. The extent to which new associated gas reserves are found is closely tied to the petroleum exploration program and to the gas/oil ratio of new finds. There is also promise of new natural (non-associated) gas fields being found. Exploration for and development of new natural gas fields is strongly dependent on developing capability to use these gases at nearby facilities or in pipelines. This, in turn, depends on Egypt's gas policies. Accordingly, the total quantity of gas that can be projected to be available is highly speculative at this point.

2.3.3 Coal: As shown in Figure 2.3-1, coal deposits have been discovered in the Sinai and in the Western Desert. Of these, only the Maghara deposits have currently recognized economic recovery potential, with deposits estimated at only about 35.6 million tons of recoverable reserves. A mine operating at 300,000 tons/year was scheduled to be opened at the time of the 1967 war, however, no further action has been taken. Although the coal is not of good coking quality itself, it can be blended with imported metallurgical coal (one part Maghara coal to four parts imported metallurgical coal) as a feedstock for coke production in steelmaking. The deposit is just large enough to support one electric power plant of economic size. The other coal deposits either have not been sufficiently characterized, are too deep, have poor geological characteristics for recovery or are otherwise not economical to exploit at this time.

2.3.4 Oil shale and carbonaceous shale: Oil shale deposits have been located in four places in Egypt as shown on Figure 2.3-1, although no systematic survey has been undertaken and no reserve estimates have been made. The Egyptian General Petroleum Corporation has reported that the available data indicate that the shale is of low quality and could be exploited only if there were a severe lack of alternatives.

Some carbonaceous (liqnitic or coaly) shale is also available in limited quantities but it has not been evaluated for extent of reserves or potential uses.

2.3.5 Uranium and thorium: No uranium or thorium is currently being produced in Egypt. However, more than 7,000 radioactive anomalies have been discovered in airborne surveys over 200,000 sq. km of the country. Of these, prospecting and ground surveys have been conducted at only 50 anomalies, and more detailed evaluations have been done only at the Qatrani, El Erediya, El Missikat and El Atshan areas.

Geological conditions at these areas and in many parts of Egypt appear favorable for finding uranium deposits, but no matching of many of the geologically favorable areas to the anomalies has been undertaken.

With proper exploration there is a good chance of finding new and significant deposits, although this could take ten years or longer.

2.3.6 Geothermal energy: There is now only limited information available on the extent of geothermal energy sources in Egypt. The potential for geothermal energy has been noted by the presence of hot springs on the east and west sides of the Gulf of Suez and, in several cases, by higher than normal heat flows along the west coast of the Red Sea, by hot wells in the Western Desert, by evidence of extinct geysers east of Cairo toward Suez, by mineral springs in the Helwan area and by evidence of extinct hydrothermal activity in the Qatrani area.

With this limited information, it may be inferred that the high-temperature (>200°C) geothermal reserves necessary for direct electricity generation from steam are probably not going to be available, that the availability of moderate temperature reserves (~150°C) that could be used for electrical generation using a binary fluid system is more likely and that the potential for low-temperature (<100°C) geothermal energy development is most probable.

2.3.7 Water supply: The Nile River is the only significant source of surface water in Egypt. Since construction of the High Dam at Aswan, approximately 56 billion cubic meters (m^3) of water per year have been available for downstream uses. Of this flow, about 93 percent is used for irrigation, 5 percent serves municipal and industrial purposes and the remainder, plus 5.2 billion m^3 in groundwater and irrigation return, is surplus. The maximum yield of the Nile is estimated to be 73 billion m^3 which is just enough to meet projected agricultural (44 percent increase) and industrial (87 percent increase) requirements if conservation and irrigation efficiency programs are implemented.

The Nubian aquifer in the Western Desert has a very large amount of high quality, nonrenewable groundwater suitable for irrigation and/or industrial purposes. With this water, it is estimated that 500,000 feddans* of land could be economically irrigated. Any use of this water for energy production will compete directly with agricultural or industrial purposes.

Adjacent to currently populated areas, a quantity of brackish and other waste water equal to at least one-fourth of the annual flow of the Nile is available from irrigation returns, drainage canals, dewatering wells and municipal/industrial waste systems. Although the dissolved solids content of these waters range from several hundred to several

---

* A feddan is the standard Egyptian unit of land measurement; it is approximately one acre.

thousand parts per million, much of it is suitable for use in energy systems. Water resources in the Eastern Desert and the Sinai Peninsula are largely unexplored.

The projected water requirements for the development of the energy sector in Egypt are only about 0.25 percent of the Nile flow, and no constraints on the availability of this quantity of water are foreseen. Adequate water should be available for the development plans if water is managed properly. Limitations on energy facility siting along the Nile could occur, however, from the prospective water discharges from such facilities into the Nile.

2.3.8 Solar energy: Because of its location and dry climate, Egypt has a very high incidence of solar radiation that could be used as an energy source. In winter, the sun shines for between 7 and 9.5 hours; in summer, sunshine is available for 12 hours. Direct solar intensity varies between 260 and 420 calories per square centimeter per day §cal/cm^2-day† in winter, and is about 710 cal/cm^2-day in summer. (As a point of comparison, northern Egypt receives 12.5 percent more direct solar radiation than Albuquerque, New Mexico, in the U.S., and southern Egypt receives 70 percent more. Albuquerque is one of the sunniest regions in the U.S. and is considered to be one of the most favorable for solar energy development.) Cloudiness and sand storms are the main causes of obstruction of direct solar insolation, but their adverse effects do not exceed 4 percent of the total available.

2.3.9 Wind energy: Egypt has at least two locations with average daily and annual wind speeds high enough to be considered for the development of wind-power generators. The available data indicate that the Mersa Matruh region on the Mediterranean Sea has an annual average wind speed of about 20 km/hr and the Hurghada region on the Red Sea coast an annual average wind speed of about 22 km/hr.

2.3.10 Biomass resources: The principal sources of biomass materials in Egypt are animal waste and agricultural residues; both are currently being utilized in rural areas to provide both fuel and fertilizer. No information was available on the quantity of material produced. As discussed in Section 2.4.1.8, estimates of biomass use were made by the U.S. team members. Substantial quantities of urban refuse and sewage are also available and could be used as an energy material. No quantitative information on current and projected biomass resources in Egypt was available or collected during this stage of the assessment.

2.4 Comparison Case Supply/Demand Balance

Using the energy demand projections as described in Section 2.2 and the supply alternatives as described in Section 2.3, a Comparison Case was constructed that matches supply and demand for Egypt for 1985 and 2000. This base strategy is intended to serve as a point of comparison against which the impact of alternative energy strategies can be measured. The examination of alternative strategies is presented in Section 2.6. The Comparison Case is not intended to be a prediction of the most probable future of energy development in Egypt, nor is it intended to reflect official Egyptian policies or a recommended course of action.

The Comparison Case is constructed for three years: 1975, 1985 and 2000. No attempt was made to characterize fully the system in the intervening years, although construction schedules for the necessary energy supply facilities were prepared to provide some continuity between the three target years. The construction supply facility schedules are presented in Appendix E and are an integral element in the estimates of cumulative capital requirements presented in Section 2.5.

2.4.1 Construction of comparison case energy supply structure: A number of important assumptions are applied in developing the Comparison Case description of how the energy supply system could be structured to meet the projected demand. This section provides a summary; the details of the Comparison Case structure can be found in Appendix D. Figure 2.4-1 shows the location of the existing and planned energy facilities.

2.4.1.1 Oil production: Production of oil in 1977 was 397,000 barrels per day (bbl/day). The Egyptian Government has stated its objective to achieve 1 million (bbl/day) before 1985. This level of production is assumed in the Comparison Case for 1985 and 2000. Implicit in this assumption is the fact that exploration activity and the rate of successful discovery will be adequate to support this production level. Because of the time necessary to develop new discoveries, the uncertainty of oil company exploration commitments in Egypt relative to their worldwide exploration activities, the degree of understanding of the geology and tectonics in Egypt and the development of new exploration technology, the chances of actually reaching the goal are unclear.

Egypt expects to export 65 percent of its total oil production in 1982 (including partners' share). It is assumed in the Comparison Case that sufficient oil will be refined locally to meet domestic needs while the remainder will be exported. As shown in Figure 2.4-2, this implies an export of 69 percent of production in 1985 and 51 percent in 2000.

For the Comparison Case it is assumed that refinery capacity will include a new 100,000 bbl/day unit at Suez before 1985 and two additional 100,000 bbl/day units between 1985 and 2000. No retirement of existing

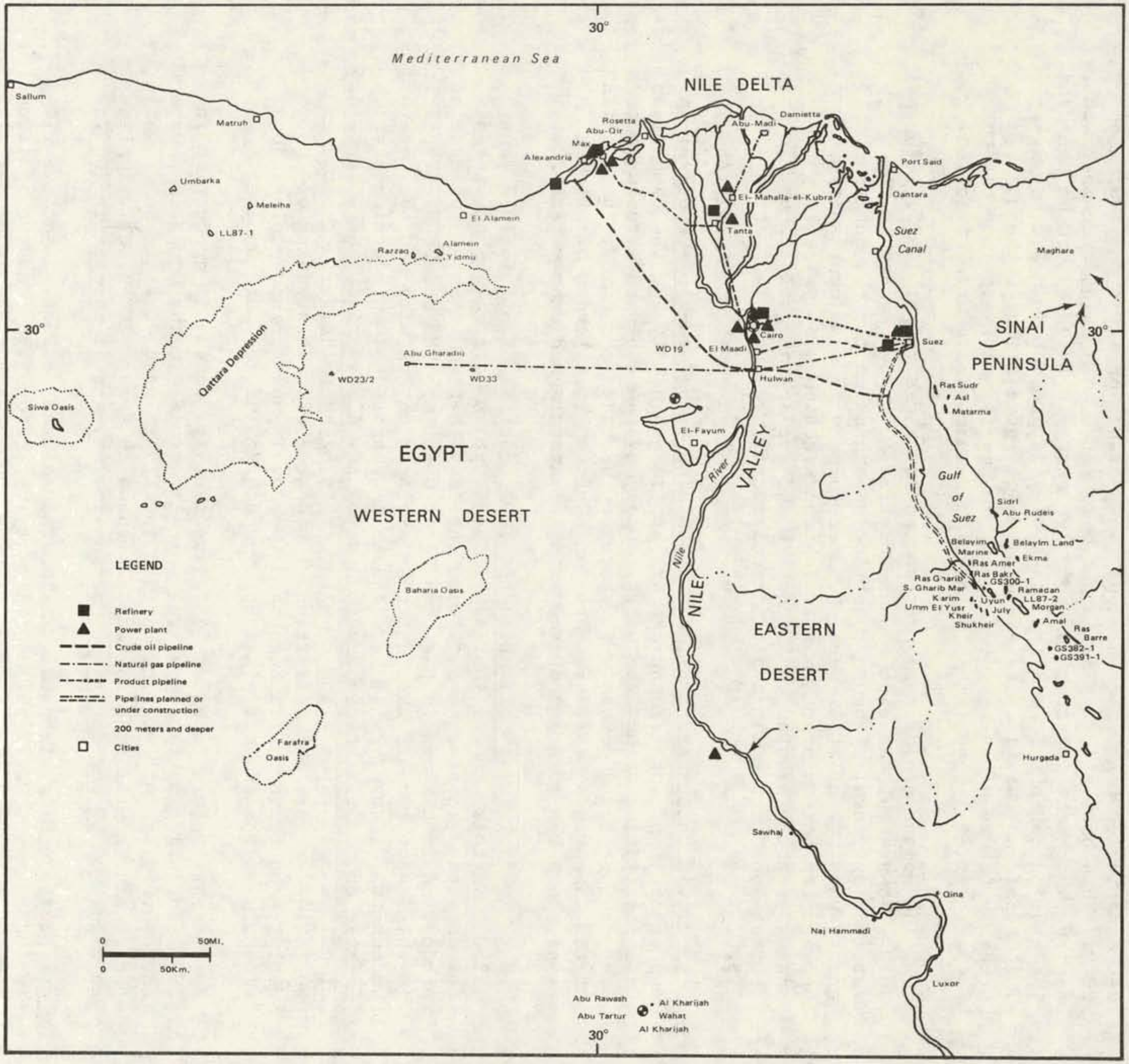


FIGURE 2.4-1 REFINERY AND POWER PLANT LOCATIONS

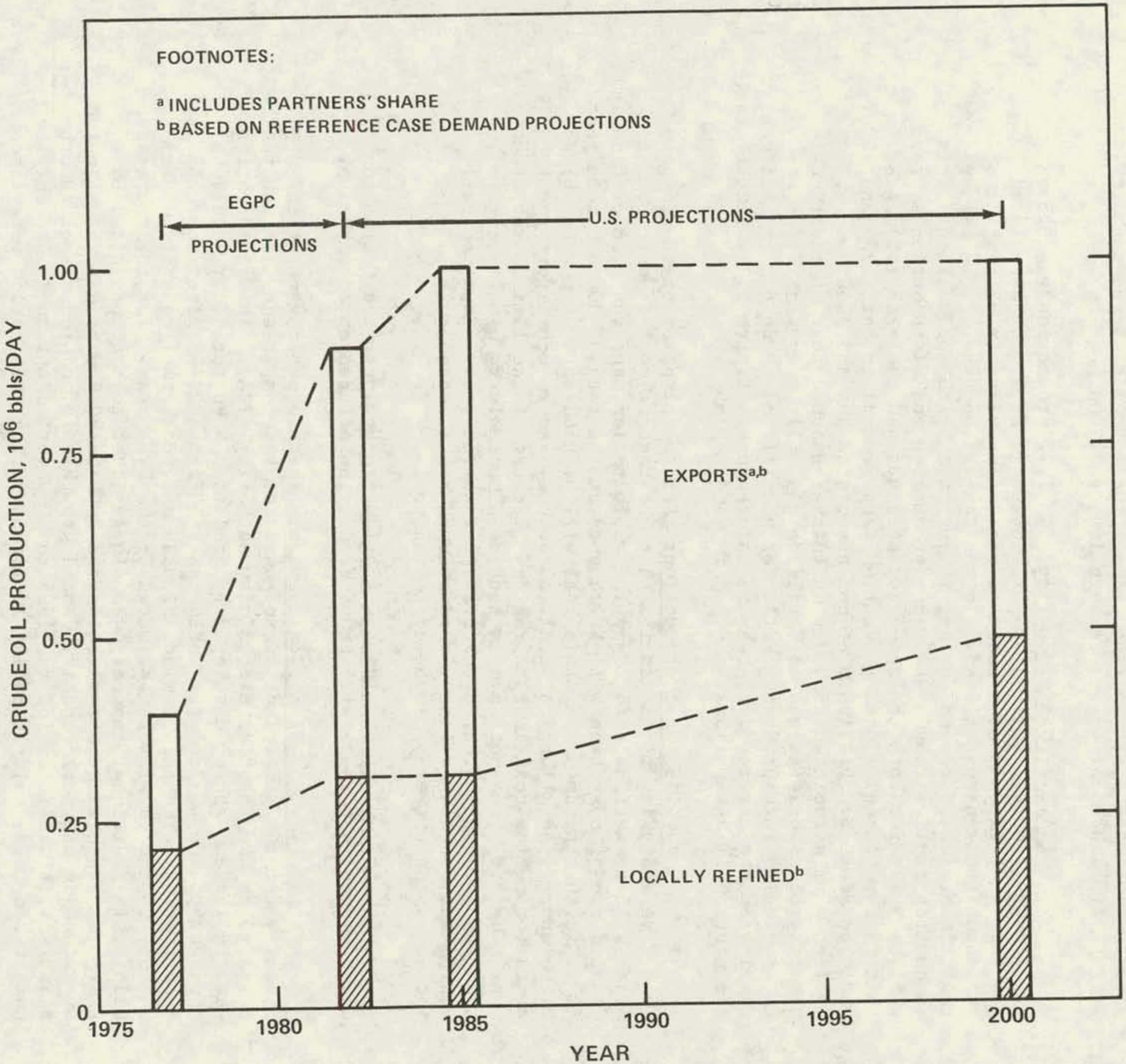


FIGURE 2.4-2 CRUDE OIL PRODUCTION

capacity was assumed. Total capacity in 2000 was assumed to be 519,000 bbl/day. All refinery units are assumed to be of the low gasoline configuration. Figure 2.4-3 shows the refinery product mix matched against the projected product demand. Egypt will continue to require imports of butane and kerosene out to the year 2000. Surpluses of gasoline and naptha, gas oil and diesel fuel, fuel oil, and asphalt will be available for export in both 1985 and 2000.

2.4.1.2 Gas production: In 1977 production was 0.5 billion cubic meters (m^3) (17.65 billion cubic feet) non-associated gas and 1.7 billion m^3 of associated gas. Approximately 88 percent of the associated gas was flared. In the Comparison Case, it is assumed that the projected demand for gas is just met by the production. This assumption implies that appropriate production and distribution systems will be built for both the non-associated gas and the associated gas that is now flared. Total production (and demand) in both 1985 and 2000 would be about 3.2 billion m^3 of non-associated gas and about 0.8 billion m^3 of associated gas. It is further assumed that an additional quantity of associated gas (3.3 billion m^3) will be available for recirculation into producing wells for gas lift of crude oil or this gas remains in the gas cap for pressure maintenance. Figure 2.4-4 illustrates the gas supply assumptions.

2.4.1.3 Coal production: For the purposes of the Comparison Case analysis, it is assumed that the Maghara coal deposits in the Sinai will be available for Egyptian exploitation, and that the originally planned mining operation will be resumed at the rate of 300,000 tons/year. It is further assumed that this coal will be used as a 20 percent blend with imported metallurgical coal (80 percent) to reduce import requirements for coking coal in steelmaking. Because of the limited resources, a high density transport system such as a coal slurry pipeline or railroad was not considered; truck transport was assumed. Expanded rail equipment, but no new lines, were assumed to be needed to handle increased quantities of imported coking coal.

2.4.1.4 Uranium and thorium production: The Comparison Case assumes that there will be no production of uranium and thorium.

2.4.1.5 Electrical sector: The projected generation capacity for the electrical sector used for the Comparison Case was that provided by the Egyptian Electricity Authority (EEA). This information was, in large measure, developed by Sanderson & Porter, Inc., under contract to the EEA and the World Bank. Figure 2.4-5 gives the capacity distribution. The solar, wind, biomass and geothermal capacity contributions to the total were estimated by the U.S. team. For the Comparison Case, this additional capacity was simply added to that projected by EEA. The capacity requirements in the 2000 to 2010 period were estimated by extending the peak capacity demand growth rate and the mix of generation facility additions of the 1995 to 2000 period out to 2010. For the Comparison Case, solar capacity additions during this period were also extended at the same ratio to other generation capacity additions as

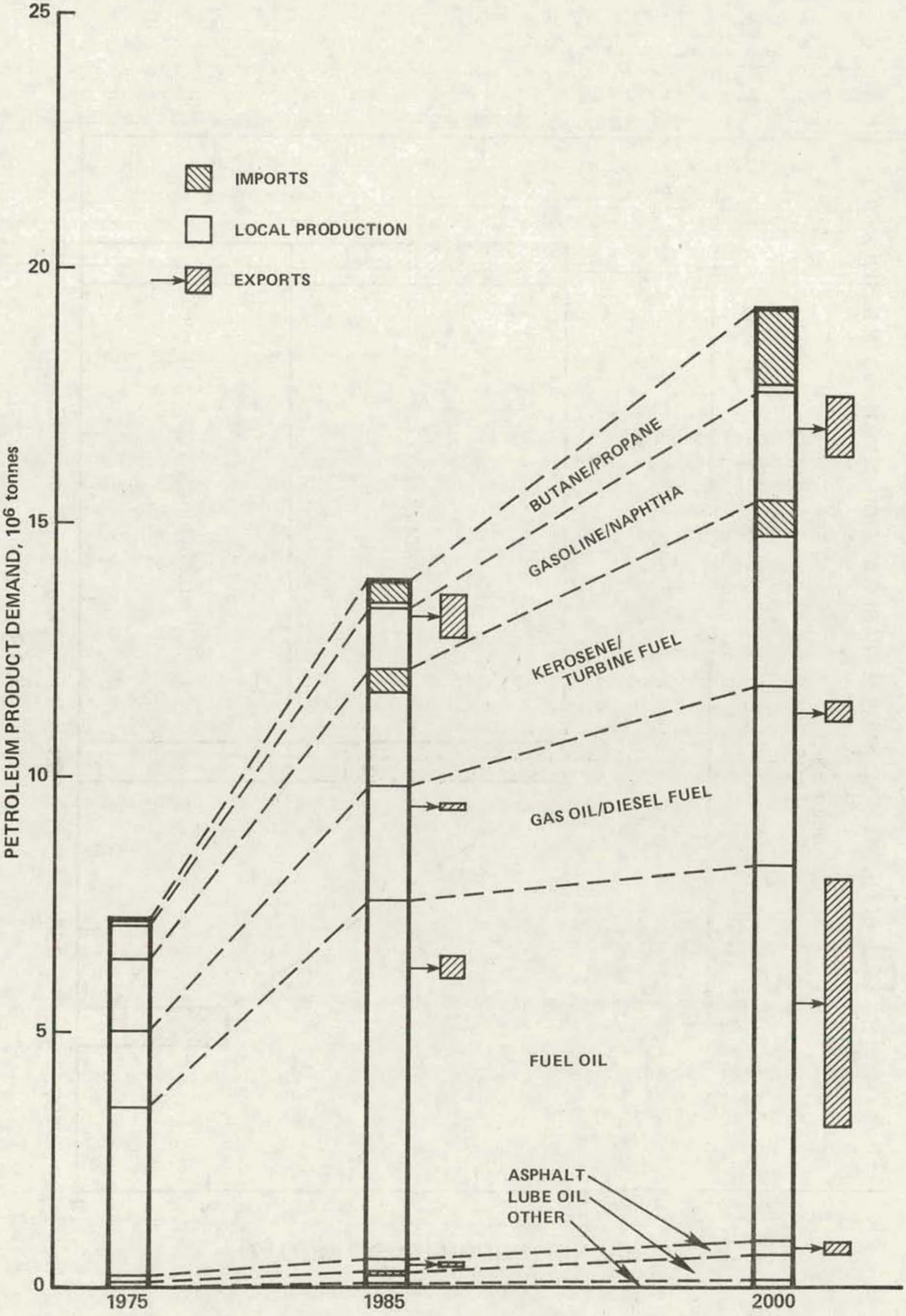


FIGURE 2.4-3 DEMAND FOR PETROLEUM PRODUCTS VS. SUPPLY

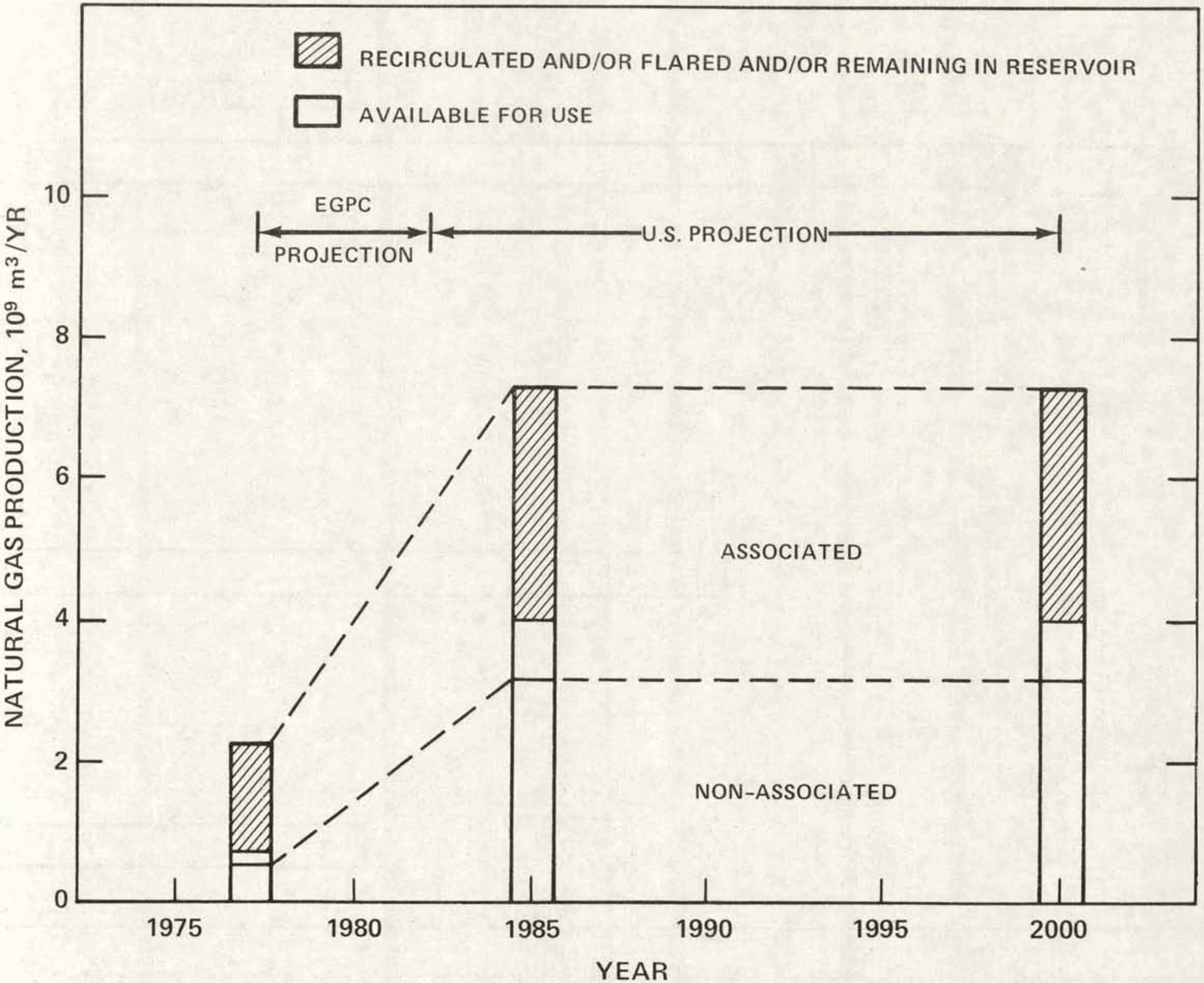


FIGURE 2.4.4 NATURAL GAS PRODUCTION

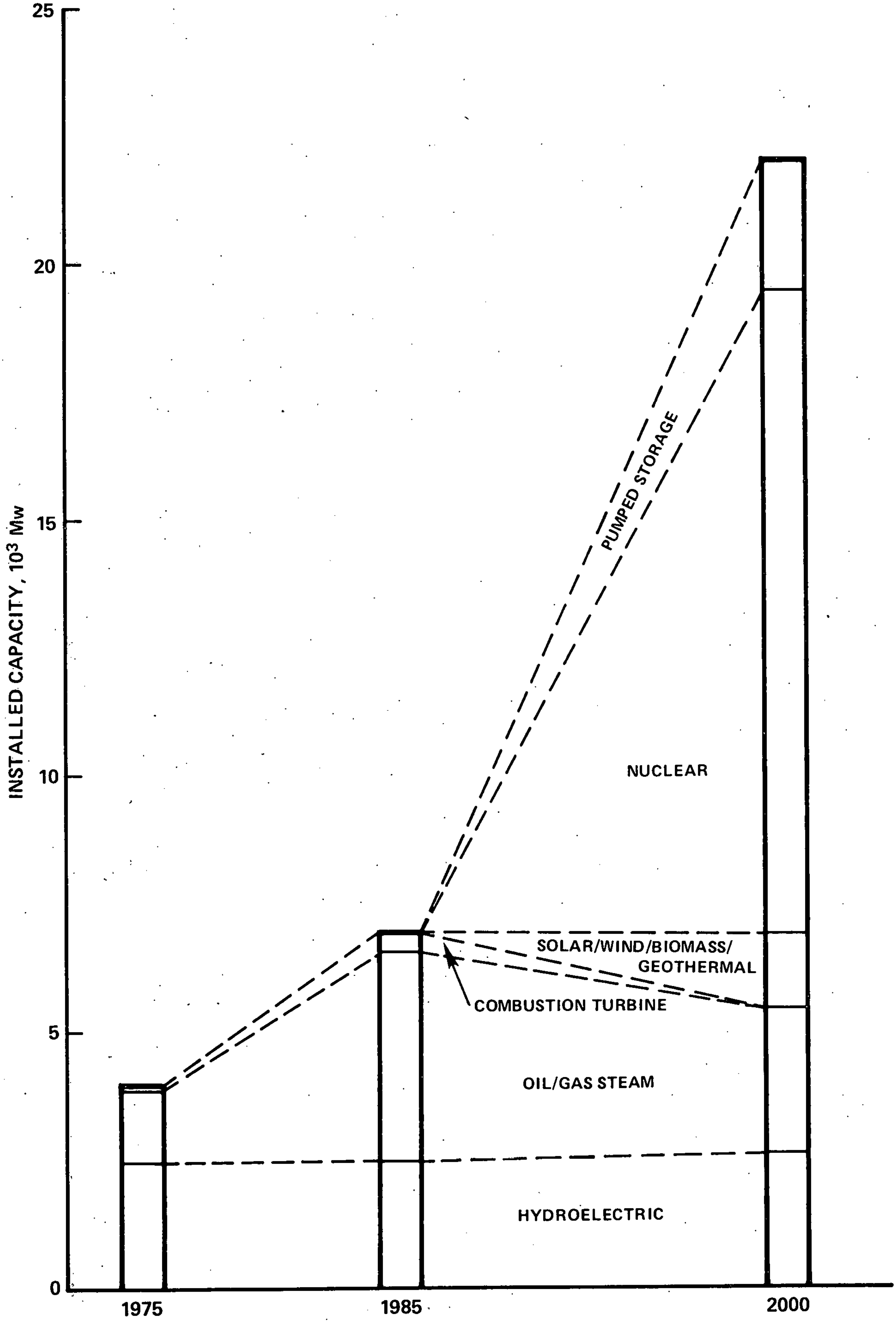


FIGURE 2.4-5 COMPARISON CASE INSTALLED CAPACITY

that of the year 2000. (This was not the approach taken in the accelerated renewables resource strategy, the results of which are presented in Section 2.6. In that strategy, solar capacity additions resulted in reductions in the capacity additions of alternative types of generation.)

The only existing hydroelectric power facilities on the Nile River are the High Dam (2100 Megawatts Electric, MWe) and the Aswan Dam (345 MWe). The only potential to expand this capacity includes additional turbines at the Aswan Dam (160 MWe), the electrification of three existing barrages (Esna - 89.4 MWe, Nag Hammadi - 52.5 MWe and Assiut - 48 MWe), the building and electrification of four additional barrages (Silsila, Qift, Sohag, Deirout, 160 MWe total) and the building of pumped storage sites along the river. The addition to Aswan and the electrification of the three existing barrages are feasible under current conditions and were included in the Comparison Case. The new barrages would not be feasible until and if irrigation and channel degradation requirements dictated their need. Use of Nile water for pumped storage can conflict with irrigation requirements since the water must be returned to the river the same day. Accordingly, the new barrages and pumped storage capacity using the Nile were not included in the Comparison Case.

Seven other pumped storage sites have been identified near the City of Suez, two of which appear promising (Galala el Bahariya, 1000 MWe and 1900 MWe; and Ataga, 1400 MWe). These sites are currently being investigated and were included in the Comparison Case up to the required capacity (2550 MWe). An adjustment to the electricity demand to account for the net energy consumption of pumped storage facilities was also included. This amounted to 11.2 QJ or about 3 percent of total electric energy needs in 2000.

The Qattara Depression Project, which would involve the excavation of a canal or tunnel and the generation of electricity from the the flow of water from the Mediterranean Sea into the Depression, is the subject of a current feasibility study. This project was not included in the Comparison Case, although it was incorporated in the accelerated renewable resource strategy. In that case, the facility is assumed to have a capacity of 670 MWe in the year 2000. The Qattara Depression Project also has additional pumped storage potential of 1200 MWe, if the tunnel were used as a storage basin, or 2400 MWe using an adjacent upper reservoir; neither augmentation was included in the Comparison Case or the accelerated renewable resource strategy, as it was assumed that this capacity would not be installed by the year 2000.

The fossil-fired steam (thermal generating) capacity consists of the existing plants plus 1200 MWe of additional thermal generating capacity of two 600 MWe units to be completed in 1984 and 1985. No construction of additional fossil-fueled plants is scheduled after 1986. The retirement of some existing oil-fired plants is scheduled in accord with the generation capacity schedule provided by the EEA. This process of retiring older plants and adding new ones is assumed to lead to an increase in efficiency for oil-fired electric generation from 23 percent in 1976 to 30 percent in 1985 and 2000. Gas turbine units are expected to be used in the 1985 to 2000 period but are expected to be out of service by 2000. An energy content of 40.7 x 10^9 joules/tonne was assigned to the fuel oil (mazout) used in electric generation plants based on information provided as to mazout properties. This is about 7 percent lower than the energy content of residual fuel oil normally assumed for U.S. oil-fired power plants.

Following the generation capacity schedule provided by the EEA, the expansion of nuclear generating capacity calls for 600 MWe units to begin operation in 1986, a series of 900 MWe units to start in 1994 and a total of 12,600 MWe by 2000. Nuclear power accounts for 60 percent of the installed capacity and 80 percent of the electricity generated in 2000. Along with the nuclear capacity, 2550 MWe of pumped storage facilities are included in the Comparison Case. This pumped storage capacity permits utilization of the nuclear units at high capacity factors; a nuclear plant capacity factor of 0.7 was assumed for the analysis.

In addition to the information supplied by the Egyptian Electricity Authority (EEA), data on the potential application of advanced renewable energy resources for electricity generation were included. It was estimated that 3.6 MWe of solar-, wind- and biomass-electric generation capacity could be available in 1985 and that this would be increased to 1506 MWe of generation capacity by 2000. This installed solar capacity provides for approximately 4 percent of the electricity generated in 2000 at an average generation plant capacity factor of 0.4. Construction of this magnitude of solar capacity assumes no aggressive promotion of renewable resource technologies by the Government of Egypt. In addition, it was assumed that the geothermal energy potential could be exploited to provide 20 MWe of electric capacity in 2000 operating at a 0.65 plant capacity factor.

To properly account for basic resource needs in fuel substitutions, a net conversion efficiency of 30 percent was arbitrarily assigned to electrical generation systems such as hydroelectric, geothermal, solar electric and biomass systems.

2.4.1.6 Transmission and distribution system: The current transmission and distribution system in Egypt is based upon generation of a major portion of the electricity at Aswan in upper Egypt and transmission of the power to the major load centers in Cairo and the Nile Delta region in lower Egypt, a distance of over 600 miles. Between now and the year 2000, there will need to be major and fundamental changes in this existing transmission system. These changes will be required not only by the significant growth (approximately seven-fold) in the size of the system, but also because new generating facilities will be located in closer proximity to load centers as new plants are built along the Mediterranean and Red Sea coasts. The projected increase in dependence on electric power will require improved system reliability as industrial, residential and commercial use of electricity increases.

The use of solar electric systems connected to the grid will make large, but variable and unscheduled quantities of electric energy available to be absorbed by the grid. This requires increased storage capacity on the transmission grid. The increased use of pumped storage will require the transmission and distribution system to be able to accommodate relatively large transfers of power between generating plants, storage locations and load centers. Similarly, the introduction of large generation units will place requirements on the system for heavy emergency load capacity in the event of the unscheduled outage of one or more of these large units.

The planning for the transmission and distribution system must proceed in consonance with the definition of the expansion in new generating capacity, the retirement of existing capacity and the above discussed factors to assure that the system will efficiently and reliably meet system energy transfer and stability needs. In the Comparison Case, it is assumed that the necessary system modifications will be made and transmission limitations will not constrain the expansion or operation of the overall system. Transmission and distribution losses were assumed to be 10 percent.

<u>2.4.1.7 Solar water heating</u>: The Comparison Case assumes that the Egyptian Government does not aggressively promote solar water heating technology, but that there is some penetration of the market based on a moderate level of government activity (through encouraging its use wherever it is economically competitive). It is assumed that solar water heaters will supply about 0.22 quadrillion joules (1 quadrillion joules = 10^{15} joules = 1QJ) of energy by 1985 and 10.0 QJ in 2000. In the Comparison Case, it is assumed that the solar hot water heaters do not displace other fuels, but instead satisfy new demand created by the availability of solar water heating. Fuel switching based on the availability of solar water heating is addressed in the accelerated renewable resource strategy.

<u>2.4.1.8 Treatment of noncommercial energy</u>: Noncommercial energy constitutes a significant portion of the total energy now consumed in Egypt. In 1975 the consumption of crop residues, animal dung and firewood was estimated by the U.S. team to be on the order of 172 QJ, 43 QJ, and 1.5 QJ, respectively. Combined, they supplied about one-third of the total energy consumed in Egypt in 1975 if these estimates are reasonably accurate. They provide the greater part of the energy used in rural areas that is primarily used for cooking and baking, with some subsidiary use for space heating. The constructive work output of animal and human energy, however, is relatively small when compared to the energy obtained from noncommercial fuels.

The use of noncommercial energy is expected to decrease as the income of rural households increases and more commercial energy becomes available to and adopted by rural households. Accordingly, analysis of noncommercial fuels consumption in the future is important for the projection of demand for commercial energy which will be used as a substitute for noncommercial energy.

At the present time, there is no standard or systematic way of projecting the consumption of noncommercial fuels and animal and human energy. The Egyptian counterparts indicated that little data and analysis existed with respect to the use and availability of noncommercial energy. Accordingly, the methodology adopted in the study for representing the prospective role of noncommercial fuels demand is to estimate the potential future availability of the principal noncommercial fuels and assume they continue to be fully used.

Firewood use has been held constant at the 1975 level, due to the limited potential for firewood production in Egypt. Consumption of animal dung was extrapolated to the year 2000 at an annual rate of 0.6 percent, which assumes that animals displaced from operation of irrigation pumps will become food animals. Crop residues are assumed to increase at 1.5 percent per year; this assumes a partial correlation with total crop production. Human energy was linearly extrapolated to 2000 based on the current population growth rate of 2.5 percent, as reported by the World Bank. The total projected use of all noncommercial fuels is present in Table 2.4-1 for 1975, 1985 and 2000.

Although the use of noncommercial fuels is projected to grow gradually, their relative share in total energy demand will decline sharply from 32 percent in 1975 to about 12 percent in 2000. This is attributable to the fact that rural households are gradually replacing noncommercial fuels with commercial fuels such as kerosene, LPG and electricity, and the Government of Egypt expects this trend to accelerate. Mechanization in agricultural production is also expected to replace much of the use of animal and human power.

Noncommercial energy enters into the demand/supply balance however, its interaction with commercial energy forms in the fuel substitution process is not explicitly shown because it is not practical to assign efficiencies to the uses of noncommercial energy. As a result, the available noncommercial energy resources presented in the supply side of the supply/demand diagram have been directly carried over to the demand side, without reflecting their end-use efficiencies (typically, on the order of 10 to 15 percent).

<u>2.4.2 Comparison case balance of supply and demand</u>: A framework based on the Reference Energy System was used to display the balance of energy supply and demand. Figures 2.4-6a, b and c present the energy balances for the Comparison Case in 1975, 1985 and 2000. The process of balancing the energy supply system against demand projections for 1985 will be described here to illustrate the basic procedures that are involved.

The right-hand column, labeled "Fuel Use", displays the projections of electricity and direct fuel demand that were described in Section 2.2. All energy entries in this analysis were converted to a common unit which was their joule equivalent. The units used in the chart are 10^{15} joules or quadrillion joules or QJ's. This is the starting point for the balancing process.

Table 2.4-1

EGYPT

PROJECTIONS OF NONCOMMERCIAL FUEL

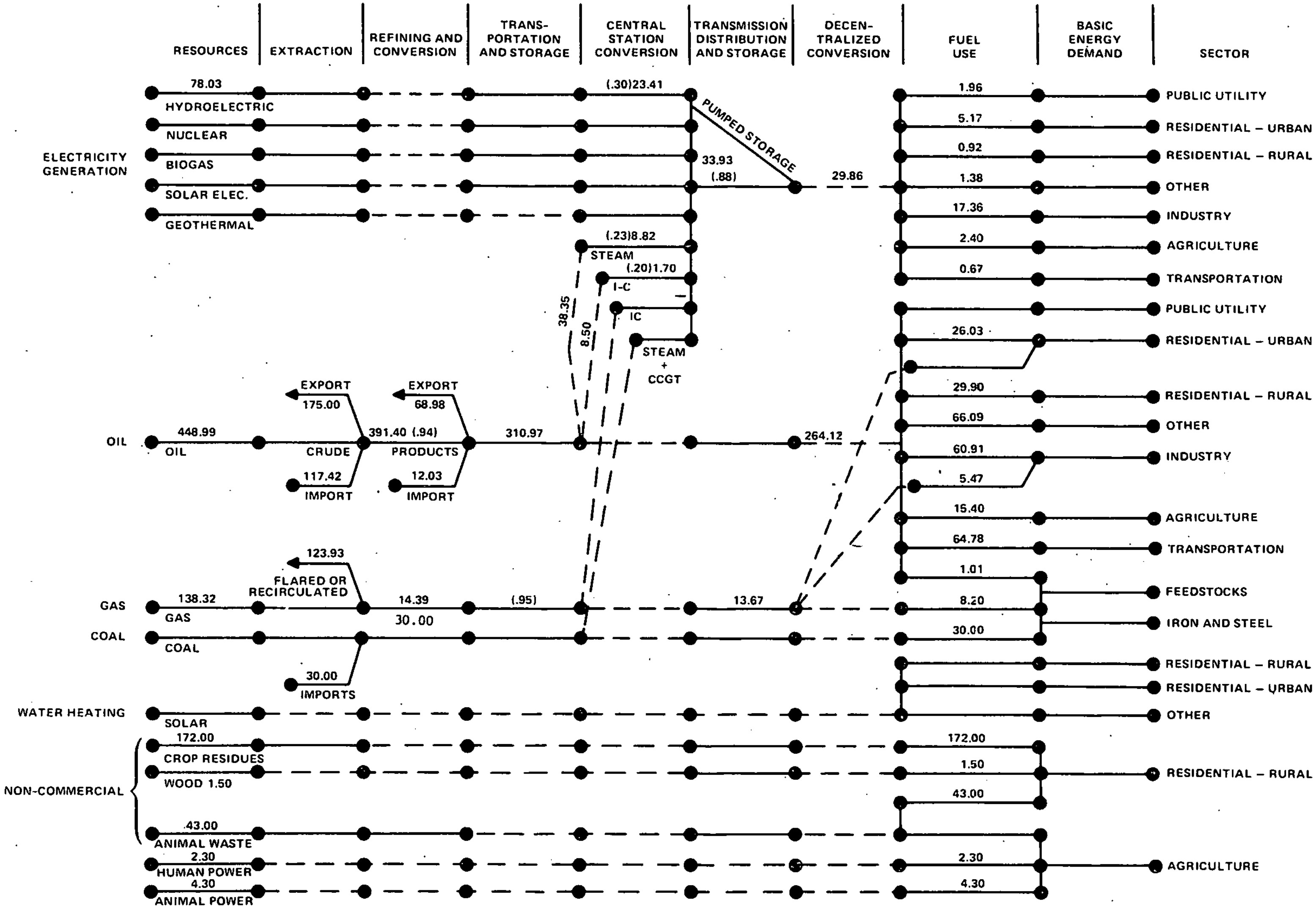
HUMAN AND ANIMAL ENERGY

(10^{15} Joules)

Noncommercial Fuel	1975	1985	2000
Firewood	1.5	1.5	1.5
Crop Residues	172.0	200.0	250.0
Animal Dung*	43.0	46.0	50.0
Human Energy	2.3	3.1	4.5
Animal Energy	4.3	5.2	6.5

* Used as organic fertilizer and cooking fuel.

FIGURE 2.4-6a COMPARISON CASE — 1975
REFERENCE ENERGY SYSTEM — EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	433.39
NON-COMMERCIAL	216.50
HUMAN & ANIMAL	6.60
TOTAL	656.34
NET EXPORTS	84.53

NOTES

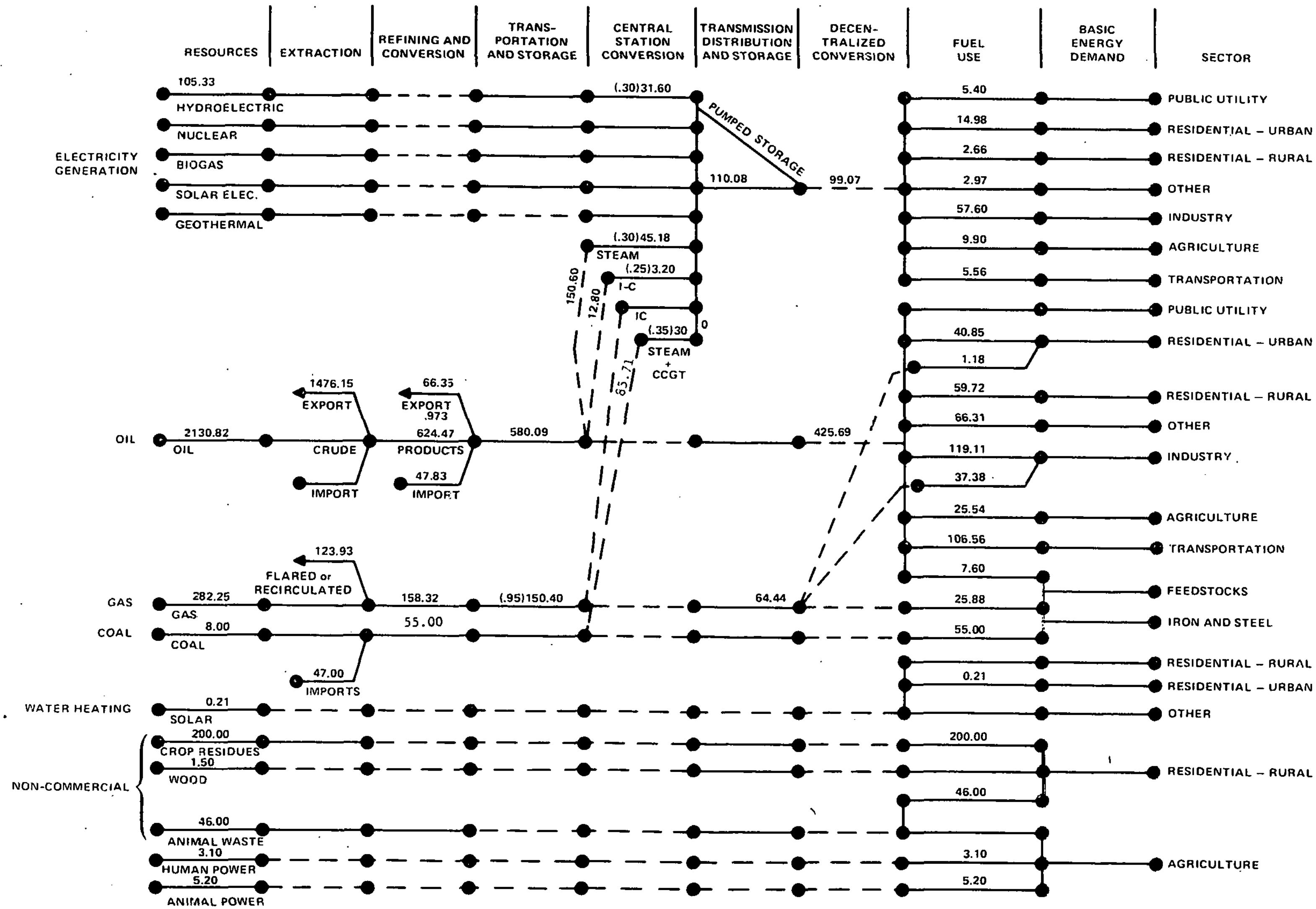
1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	337.65
NON-COMMERCIAL	216.50
HUMAN & ANIMAL	6.60
TOTAL	560.75

88–484

FIGURE 2.4-6b COMPARISON CASE – 1985
REFERENCE ENERGY SYSTEM – EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	898.95
NON-COMMERCIAL	247.5
HUMAN & ANIMAL	8.30
TOTAL	1154.75
NET EXPORTS	1447.67

NOTES

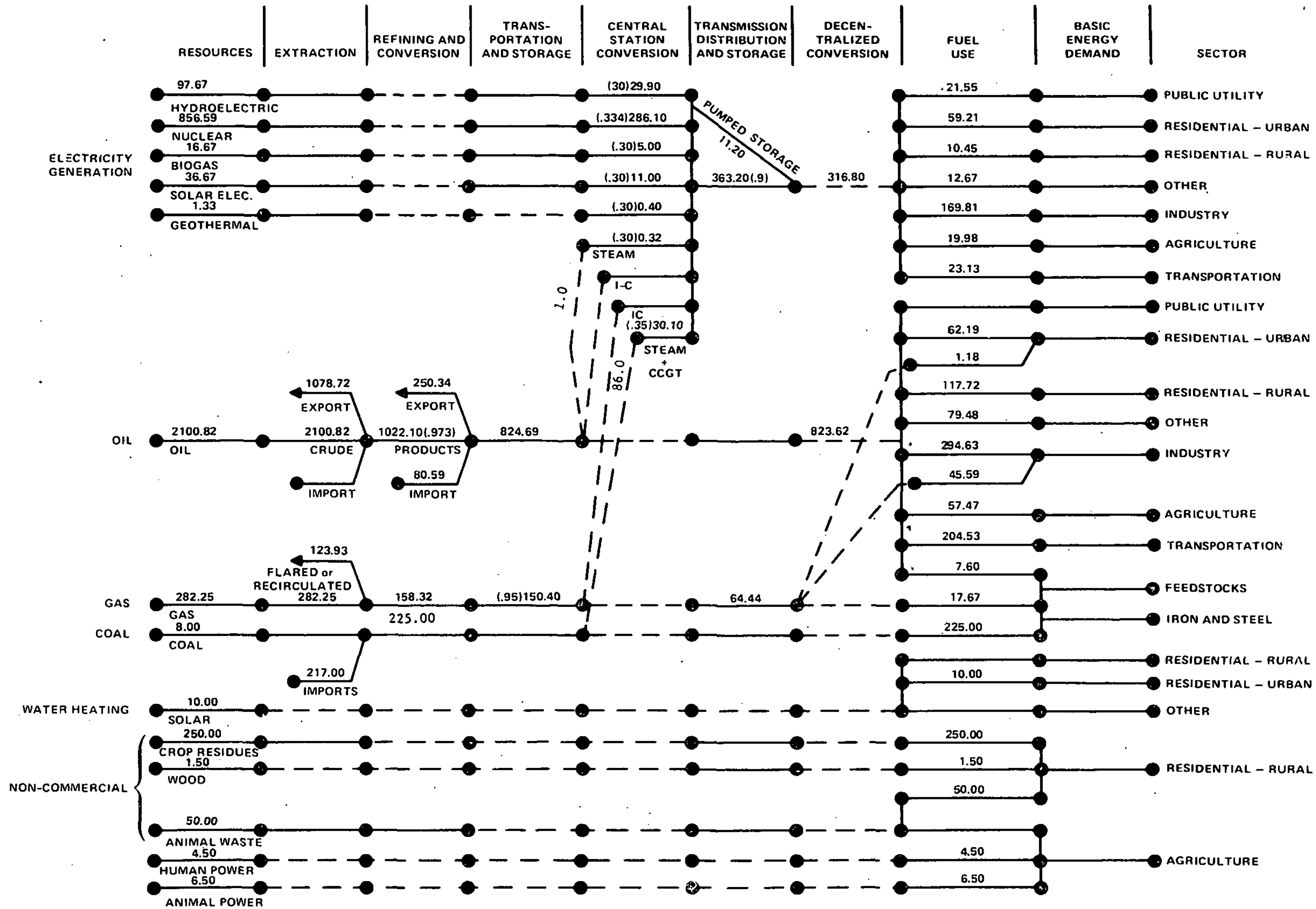
1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	644.41
NON-COMMERCIAL	247.50
HUMAN & ANIMAL	8.30
TOTAL	900.21

88-436

FIGURE 2.4-6c REFERENCE ENERGY SYSTEM
COMPARISON CASE – 2000



ENERGY RESOURCE REQUIREMENTS:	
COMMERCIAL	2226.94
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	2539.44
NET EXPORT	1031.47

NOTES

1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:	
COMMERCIAL	1439.86
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	1752.36

88-436

The electricity demand of the six individual consumption sectors is summed to obtain 99.07 quadrillion joules [2.37 million tons of oil equivalent (t.o.e.)*], the total demand for electricity in 1985. Using a transmission efficiency of 90 percent (i.e., assuming 10 percent transmission and distribution losses), the total electrical generation requirement is then 110.08 quadrillion joules (2.63 million t.o.e.). The 1985 generation mix of Fig. 2.4-5 was used, and the total amount of electricity generated by each type of unit was then computed, taking into consideration projected installed generation plant capacities and using appropriate plant capacity factors to represent river flow or system operational plans and limits. As a result, 31.60 quadrillion joules (755 thousand t.o.e.) would be generated by hydroelectric plants, 45.18 quadrillion joules (1.08 million t.o.e.) by oil-fired steam plants, 3.20 quadrillion joules (76.4 thousand t.o.e.) by combustion turbines and 30.10 quadrillion joules (719 thousand t.o.e.) by gas-fired steam plants. To compute the quantity of oil and gas required to fuel the generating plants, the following plant thermal efficiencies were used for the 1985 and 2000 projections: 30 percent for oil-fired facilities, 25 percent for combustion turbines and 35 percent for gas-fired generators. The result is the need for 150.60 quadrillion joules (3.59 million t.o.e.) of mazout (residual fuel oil), 12.80 quadrillion joules (306 thousand t.o.e.) of gasoil and 85.96 quadrillion joules (2.05 million t.o.e.) of gas, respectively. To properly account for fuel substitution possibilities, a conversion efficiency of 30 percent for hydroelectric power was assumed, which leads to a basic resource requirement of 105.33 quadrillion joules (2.52 million t.o.e.). This can be interpreted as the equivalent amount of fossil fuel required to replace that quantity of hydropower. (This same procedure was used for solar, wind, biomass and geothermal electricity in subsequent balances.)

The petroleum product demand from all consumption sectors, including both direct fuels use and chemical feedstocks, was added for a total demand of 425.69 quadrillion joules (10.2 million t.o.e.) for several petroleum products. (In the balancing process, the demand for each individual product e.g., gasoline, kerosene, etc. was addressed separately.) Adding the mazout (residual fuel oil) and gasoil requirements for electricity generation, the total demand for all liquid petroleum products is 589.09 quadrillion joules. The mix of petroleum products from the refineries is computed using the proportions shown in Figure 2.4-3. The refinery output was matched against the demand for each of the six petroleum products that is specifically addressed. Where the production level for a particular product by the refineries was less than the demand, the difference was assumed to be made up by imports. When the production level in Egyptian refineries was in excess of projected demand, export of the balance of that product was assumed. As a result, there are both imports (47.83 quadrillion joules) of some products and exports (66.35 quadrillion joules) of others. The amount of crude oil to be processed by input to the refineries is computed using a 94.5 percent refinery efficiency; 624.47 quadrillion joules (14.9 million t.o.e.) of crude oil are thus required.

---

*The energy equivalent in metric tonnes of oil equivalent was used as a standard energy unit in accord with suggestions by the International Energy Agency, Organization for Economic Cooperation and Development Standing Group on Long Term Cooperation in Paris, 1978.

The projected production of crude oil in 1985 (1 million bbls/day) is equivalent to 2100.82 quadrillion joules (50.2 million t.o.e.) and the balance not refined is assumed to be exported (1476.15 quadrillion joules or 35.3 million t.o.e.).

In similar fashion, the direct fuels, chemical feedstocks and electricity fuels demand for natural gas were summed to derive the demand for both associated and non-associated natural gas, which is 150.40 quadrillion joules (including 85.96 quadrillion joules for electricity generation and 64.44 quadrillion joules for other uses). Assuming a 5 percent loss in gas to meet pumping and distribution requirements, 158.32 quadrillion joules (3.8 million t.o.e.) of gas production is required. The production potential is 282.25 quadrillion joules (6.7 million t.o.e.); the balance not required is assumed to be flared, used for oil lifting and/or reinjected to maintain pressure in producing oil wells as previously described.

The demand for coal is 55.00 quadrillion joules (1.3 million t.o.e.) for iron, steel and aluminum processes. Imported metallurgical coal (47.00 quadrillion joules) and blended Maghara coal (8.00 quadrillion joules) comprise the required supply. Coal is not used as a fuel for the generation of electricity.

As described above, the 0.21 quadrillion joules (5 thousand t.o.e.) of solar water heating does not displace other fuels in the Comparison Case. All of the energy generated from solar water heating has been directly transferred to urban-residential applications. Fuel substitution possibilities made possible by the availability of solar water heating are treated in the alternate accelerated renewable resource strategy.

Noncommercial energy resources, such as crop residues, wood and animal waste, have been included in the diagram. However, no explicit treatment of the interaction of noncommercial and commercial fuels has been presented due to the inadequacy of the available information. While it is known that the efficiencies of noncommercial fuels in primitive applications are very low (on the order of 10 percent), there are great uncertainties in estimating these efficiencies. As a result, the resources which were estimated to be available have been carried directly over to the demand side for illustration only. The interactions of animal and human power with commercial fuels are also not explicitly considered in the integrated balance of supply and demand projections. To some degree, the effect of the low growth in the availability of noncommercial fuels are reflected in the projected increases in the demand for the corresponding commercial fuels (kerosene and butagas) that will eventually displace them.

This same process of balancing the energy supply system against the demand projections was carried out for the Comparison Case in the year 2000 and for the subsequent analyses of the various strategies. The more complex strategies result in fuel substitutions, which are conveniently displayed in this format. These results are given in Section 2.6.

Note that the efficiency of energy consumption devices is not explicitly considered in this analysis because of the lack of data. Thus, the values of energy demand in the right-hand column denote the amount of fuel (or energy) that is provided to a utilizing process or device and do not account for efficiency of utilization. The only area in which consumption efficiency is considered is in the implementation of specific energy conservation options. These cases are treated individually by examining alternative end-use processes which offer either increased efficiencies or demand for different fuels. These changes are then converted into changes in fuel demand and incorporated into a revised supply/demand balance. These strategies are discussed in detail in Section 2.6.

2.4.3 Results of the Comparison Case: In reviewing the results of the Comparison Case, it is important to reemphasize a point that was made previously: as the title "Comparison Case" conveys, these results do not represent either a preferred or a most probable projection. Rather, it has been developed solely as a reference point for assessing the effects of the implementation of possible energy demand or supply options. Accordingly, the reader is cautioned not to draw conclusions about the specific future of Egypt's energy development plans, priorities or expectations from an examination of the Comparison Case.

A number of observations can be made once the balancing process depicted in Figures 2.4-6a (1975), 2.4-6b (1985) and 2.4-6c (2000) is completed. Among other things that may be pertinent to the analysis of alternative energy policies, one can determine:

(1) the total quantity and distribution of energy resources required by postulating the demand levels and the structure of the supply system;

(2) the portion of the energy requirements that can be satisfied by domestic resources and that which must be met with imports (that portion of resource production that is available for export is also shown);

(3) the mix of fuel types required for electricity generation; and

(4) the changes in energy demand and supply over time and the corresponding growth rates in various portions of the overall energy system.

For example, Figure 2.4-7 shows the growth in commercial energy demand (based on the projection provided by the Government of Egypt for this analysis) compared to the historical growth of energy demand. As can be seen, there is no abrupt change in the general trend of energy consumption. Figure 2.4-7 also compares the energy demand projection of this analysis with one derived earlier by the Brookhaven National Laboratory. This BNL projection was based upon a World Bank projection of potential economic growth in Egypt and applied general macro-relationships between economic growth and the demand for commercial forms of energy. As can be observed, the two projections compare very well with the difference deriving from a 0.8 percent difference in the projected growth of consumption of commmercial energy resources in the 1975 to 1985 period and a reduced and reversed 0.2 percent difference in the growth rates of the 1985 to 2000 period. The lower indicated historical average annual growth rate reflects the reduced economic growth in Egypt during the mid-1960's.

Figure 2.4-8 summarizes the energy resource requirements derived from the left-hand side of the energy balance diagrams. It displays the declining role of noncommercial sources, hydroelectric power and oil in meeting the total demand for energy in Egypt and shows that renewable resources will have only a small impact over the period to 2000. It also shows the increasing extent to which nuclear power is projected to meet the energy requirements stated in the Comparison Case and that gas utilization will increase somewhat in 1985, but decline in importance (relative to nuclear power) between 1985 and 2000. (This variation in the use of gas results from Egyptian General Petroleum Corporation projections of the production levels and use of associated and non-associated gas.)

Figure 2.4-9 illustrates the energy resource import and export implications of the Comparison Case. It can be seen that Egypt is essentially self-sufficient in energy in 1985 and that a substantial export capability can exist if oil production targets can be met. However, this self-sufficiency is heavily dependent by 2000 on: (1) the ability of Egypt to maintain the target 1,000,000 bpd level of oil production, and (2) the character of the nuclear program. Maintenance of the 1,000,000 bpd oil production will require finding new oil reserves 6 to 8 times Egypt's currently known reserves. There is, of course, considerable uncertainty in the ability to find these new reserves. If sufficient indigenous uranium reserves can be discovered, then the planned extensive use of nuclear energy can be fueled with indigenous resources. If, on the other hand, uranium for the nuclear reactors must be imported, Egypt will be in the position of relying on foreign sources for approximately 42 percent of its internal commercial energy consumption (uranium imports would constitute 39 percent of internal energy consumption or almost all of the import requirement). The export of energy in the form of crude oil and petroleum products continues at a slightly decreased level because of the assumed constant oil production rate and increasing internal petroleum demands.

Figure 2.4-10 displays the mix of generation types for electricity. Nuclear power accounts for almost 80 percent of delivered electric energy by 2000 in the Comparison Case. This is a dramatic change from the current system, where approximately 70 percent of delivered electricity is from hydroelectric sources. Neither combustion turbines nor renewable resources plays a significant role in the total energy generation, although they are important in terms of generation capacity. Pumped storage does not appear as a generation option because it is a net user of electricity.

Table 2.4-2 shows some of the growth rates (both absolute and per capita) that can be computed from the supply/demand balances and some

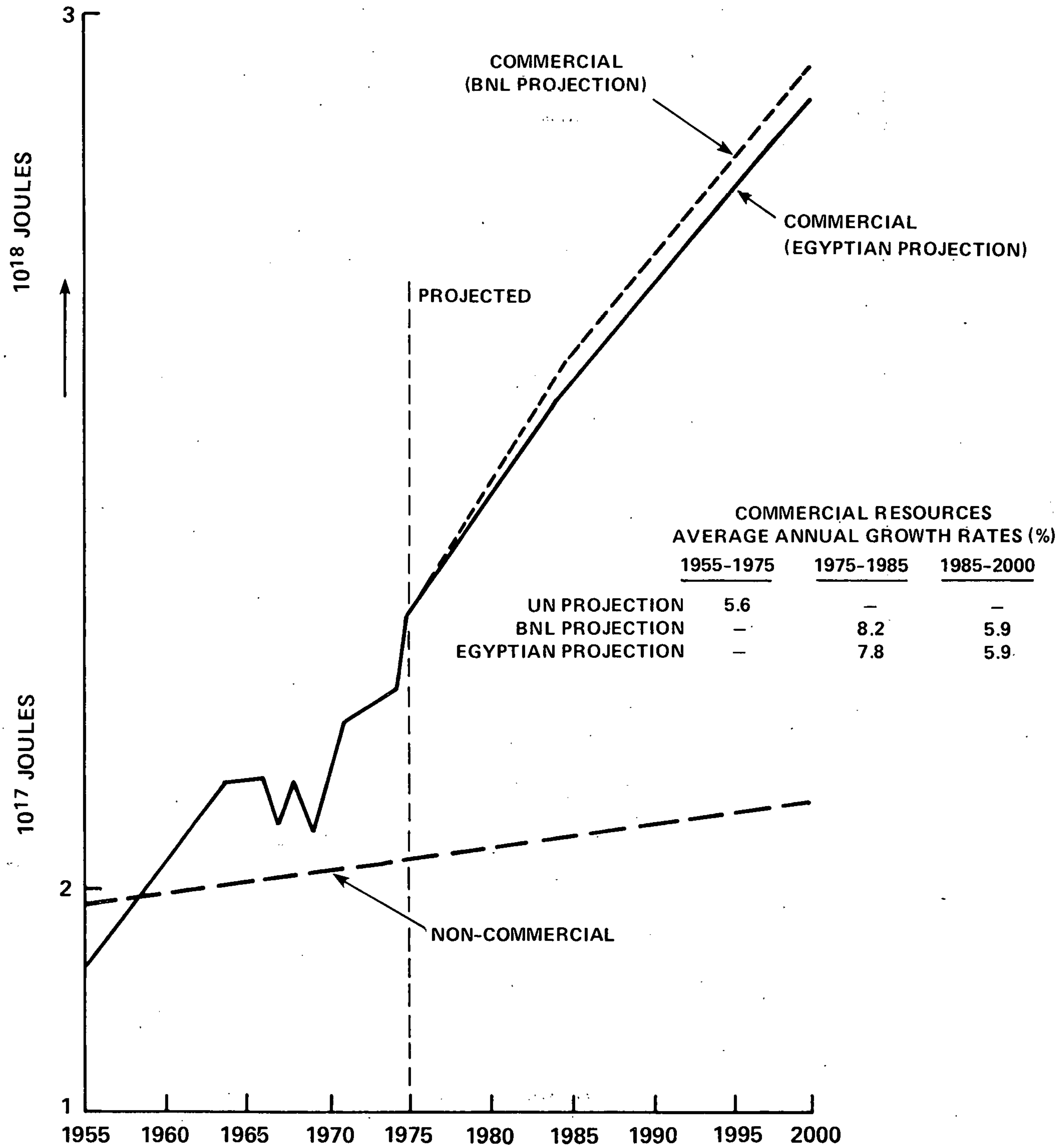


FIGURE 2.4-7 EGYPT CONSUMPTION OF COMMERCIAL AND NON-COMMERCIAL RESOURCE HISTORICAL AND PROJECTED. 1955 – 2000

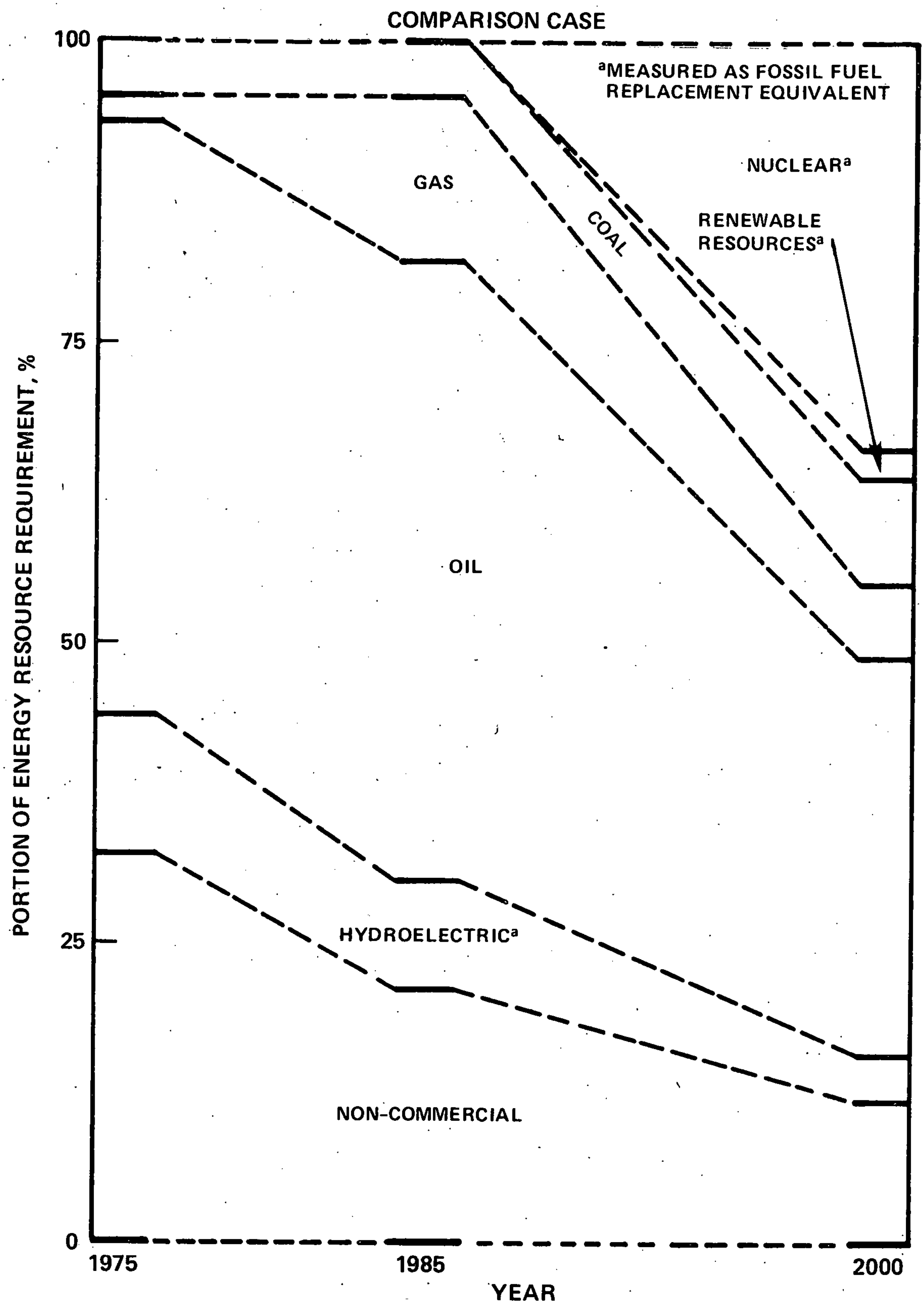


FIGURE 2.4-8 COMPARISON CASE ENERGY RESOURCE REQUIREMENTS

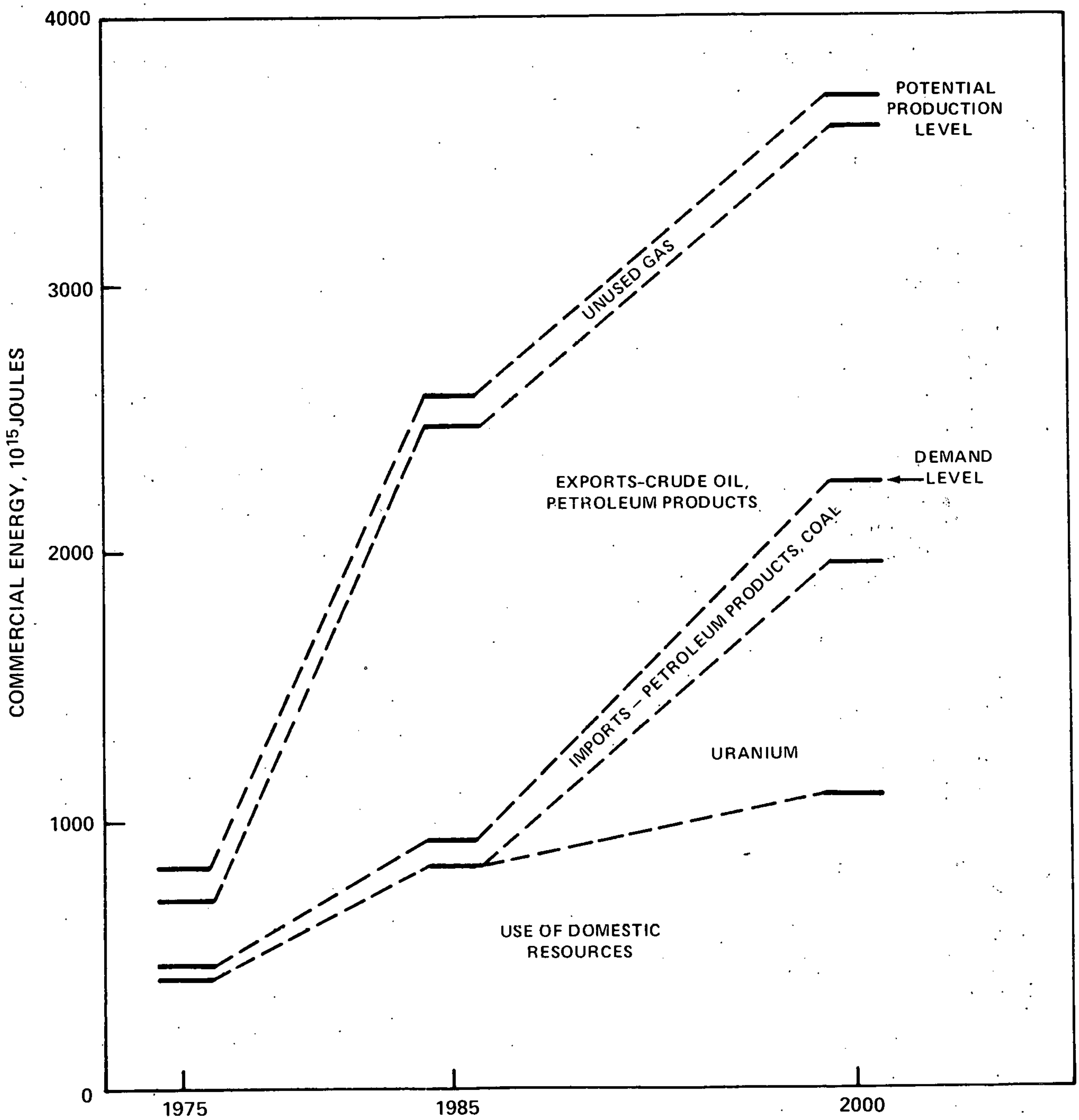


FIGURE 2.4.9 COMPARISON CASE EFFECTS ON ENERGY IMPORTS AND EXPORTS

COMPARISON CASE: DISTRIBUTION OF ELECTRICITY GENERATION MIX

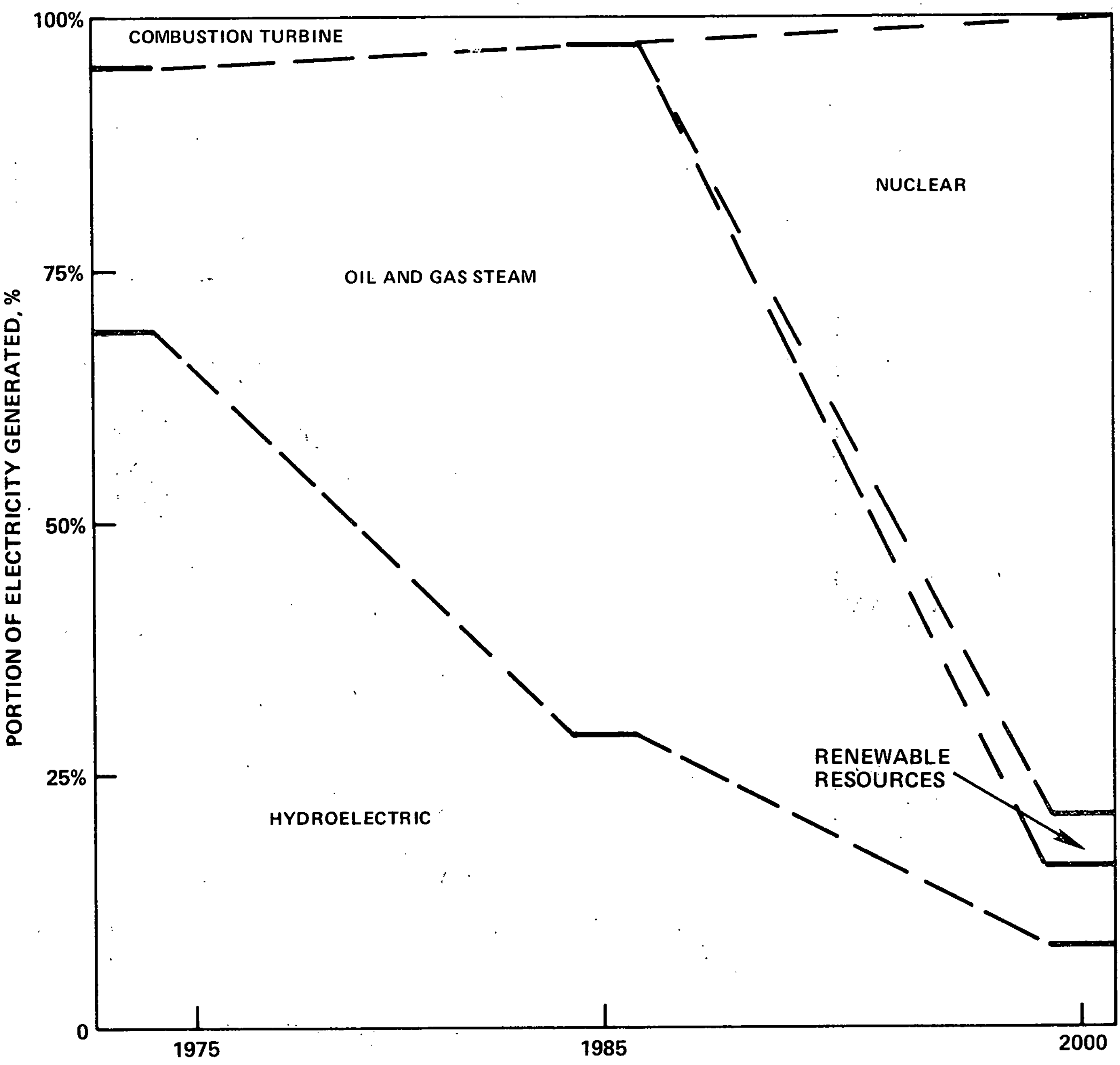


FIGURE 2.4-10 COMPARISON CASE: DISTRIBUTION OF ELECTRICITY GENERATION MIX

TABLE 2.4-2

COMPARISON CASE GROWTH RATES AND RATIOS

Variable		1975-2000	1975-1985	1985-2000
		GROWTH RATES (%)		
Growth in Availability of Energy Resource	1	5.917	12.021	2.033
Total End Use	2	4.663	4.830	4.552
Growth in Commercial Energy Use	3	5.973	6.677	5.506
Growth in Commercial Fuel Resources Consumed	4	6.645	7.444	6.116
Growth in Noncommercial Resources	5	1.357	1.377	1.344
Growth in Electric End Use	6	9.908	12.742	8.058
Growth in Commercial Fuels End Use	7	5.314	5.887	4.934
Inputs to Electric Energy Production	8	9.001	11.093	7.628
Inputs to Direct Commercial Fuels	9	5.524	7.251	4.388
Total Energy Inputs-Commercial/Noncommercial	10	4.286	5.228	3.663
		PER CAPITA GROWTH RATES (%)		
Growth in Availability of Energy Resource	1	3.644	9.474	0.001
Total End Use	2	2.417	2.446	2.398
Growth in Commercial Energy Use	3	3.699	4.251	3.332
Growth in Resources Consumed	4	4.357	5.001	3.930
Growth in Noncommercial Resources	5	-.818	-.928	-.744
Growth in Electric End Use	6	7.549	10.178	5.832
Growth in Commercial Fuels End Use	7	3.054	3.479	2.772
Inputs to Electric Energy Production	8	6.662	8.567	5.411
Inputs to Direct Commercial Fuels	9	3.259	4.812	2.237
Total Energy Inputs-Commercial/Noncomercial	10	2.048	2.835	1.527
		RATIOS		
		1975	1985	2000
Electric/Total End Use	1	.053	.110	.181
Electric/Commercial End Use	2	.088	.154	.220
Fuels End Use/Total End Use	3	.549	.607	.641
Fuels End Use/Commercial End Use	4	.912	.846	.780
Inputs to Electricity/Inputs to Direct Commercial Fuels	5	.397	.564	.892
Direct/Electric	6	10.308	5.505	3.545

The above calculations are based on the following population estimates (in millions):

	1975	1985	2000
Population	38	48	65

energy ratios that result. These growth rates and ratios present in an alternative form the data of the Comparison Case supply/demand balances for 1975, 1985 and 2000. The population growth rate assumed for the per capita calculations was 2.3 percent per year with the 1978 population assumed to be 39 million. Examination of these growth rates and ratios can provide insights as to what is taking place both in terms of energy demand relationships and projected energy supply dependence. An illustration is presented below.

- The availability of energy resources grows rapidly in the 1975 to 1985 period as oil and gas production expands. This growth then slows markedly as oil and gas production are assumed to remain constant.

- Demand for electricity is growing over 80 percent faster than the demand for direct end-use of commercial fuels. Electricity demand is projected to grow very rapidly (12.7 percent/yr) during the 1978 to 85 period and then slows somewhat (8.1 percent/yr) in the 1985 to 2000 period. On the other hand, growth in the direct end-use of commercial fuels grows at a more constant rate over the whole period.

- Fuels resource inputs to electricity energy production grow at a somewhat lower rate (9.0 percent/yr) than does the growth in electric energy demand (9.9 percent/yr) due to assumed improvements in the efficiency of electric generation plants as older, low-efficiency plants are replaced by new plants.

- Per capita use of commercial energy grows at less than 4 percent per year. Per capita use of noncommercial energy declines since the assumed growth in the availability of this form of energy resource is less than the population growth rate.

- Electricity use is 8.8 percent of the end-use of all forms of commercial energy in 1975 but grows to 22 percent of the end-use of commercial energy by the year 2000. By 2000, fuels (including equivalent fuels inputs) to electricity generation will be approaching 90 percent of the fuels inputs for direct end-use of commercial fuels including industrial feedstocks.

All of these data provide needed inputs into the decision-making process. These are especially significant when alternatives are being considered. Possible general alternative energy planning strategies are discussed in Section 2.6.

2.5 Cost, Equipment and Manpower Estimates For the Comparison Case Energy Supply Facilities

As discussed in Section 2.1.3, the assessment analysis includes estimates of the cost, equipment and manpower requirements for the energy supply facilities specified in the projections of the path of Egyptian energy development. These estimates, in turn, formed a principal basis for a limited analysis of the financial aspects of various alternative strategies. This section presents the results of these analyses of the Comparison Case. The results for the Comparison Case are presented in some detail to illustrate the foundation that exists for the comparative presentations of cost, equipment, manpower and financial data on the alternative strategies that are presented in Section 2.6.

Using the energy demand-supply balance Comparison Case of Section 2.4 as input to ESPM, supported by electric power facility "build schedules," estimates were made by ESPM of the cost, equipment and manpower resources required to design, construct, startup, operate and maintain such energy supply and energy transport facilities. Similar estimates for the solar energy system were provided by the U.S. solar specialists.

As noted earlier, no attempt was made to estimate similar requirements for the industrial, commercial, residential and agricultural facilities that use this energy since that estimation would involve the entire scope of Egyptian development plans. It is also important to reemphasize that the supply facility calculations are based on "typical" facilities and, therefore, are not comparable in detail and accuracy with estimates for well specified facilities on selected sites. In this sense, our calculations are most appropriate for aggregate analysis as performed in this assessment. Used as such, the estimates can serve to both: (1) indicate the order of magnitude of costs, equipment and manpower associated with developing a broadly based energy supply system and (2) provide a point of reference for comparisons particularly when reflected against the results of similar facility cost calculations for the alternative energy strategy cases discussed in Section 2.6

2.5.1 Energy supply facility schedules: As described in Section 2.1.3, it was necessary to develop the annual construction schedule of required new facilities. The cumulative results of these prescribed facility construction schedules are presented in Table 2.5-1. All schedules were determined to the year 2010 so that resource requirements could be calculated through 2000 after accounting for construction lead-times. The size and impact of the "end effects" for post-2000 facilities are extremely important and are discussed in Section 2.6 and Appendices E and F.

Energy transportation facility requirements necessary to support the Comparison Case were also derived using ESPM. The "construction schedules" for these energy transportation facilities are given in Table 2.5-2. Calculation of transportation requirements is subject to a much

TABLE 2.5-1

SCHEDULE OF ENERGY SUPPLY FACILITY ADDITIONS FOR THE COMPARISON CASE

FACILITY NAME	TOTALS				
	1975	1978-85	1985-2000	1978-2000	2000-2010
ON SHORE PRIMARY OIL RECOVERY - (1,000 BPD)	66	136	206	342	140
OFFSHORE OIL RECOVERY (12,500 BPD)	11.8	25	39	64	30
LOW-GASOLINE REFINERY (100,000 MBPD EFFECTIVE)	2.0	1	4	5	2
ONSHORE CONVENTIONAL GAS RECOVERY (100 MMCF/D)	0.4	2	3	5	1
SURFACE URANIUM MINE (275,400 TONNES/Y)	0.0	0	4	4	4
URANIUM MILL (275,400 TONNES/Y)	0.0	0	4	4	4
OIL-FIRED POWER PLANT (800 MWE)	0.0	4	0	4	0
OIL-FIRED POWER PLANT (500 MWE)	3.2	1	0	1	0
GAS TURBINE POWER PLANT (133 MWE)	1.0	1	0	1	0
LIGHT WATER REACTOR (LWR) (1200 MWE)	0.0	0	1	1	18
LIGHT WATER REACTOR (LWR) (900 MWE)	0.0	0	8	8	0
LIGHT WATER REACTOR (LWR) (600 MWE)	0.0	0	7	7	0
DAM & HYDROELECTRIC POWER PLANT (200 MWE)	12.2	0	1	1	0
PUMPED STORAGE (500 MWE)	0.0	0	5	5	8

TABLE 2.5-2

SCHEDULE OF ENERGY TRANSPORT FACILITY ADDITIONS FOR THE COMPARISON CASE

FACILITY NAME	TOTALS				
	1975	1978-85	1985-2000	1978-2000	2000-2010
OIL BARGES (90,000 BBL)	3.0	5	2	7	0
OIL TANK TRUCK (226 BBL)	290.3	1200	2472	3672	1030
PRODUCTS PIPELINE (70 MB/D, 160.9 KM)	0.5	1	0	1	0
HOT OIL PIPELINE (40 MB/D, 80.5 KM)	2.4	2	4	6	1
REFINED PRODUCTS BULK STATION (69 MB/D)	1.6	2	2	4	1
MIXED TRAIN (6556 TONNES)	2.3	3	14	17	20
COAL BARGES (19,048 TONNES)	0.2	0	1	1	0
COAL TRUCK (22.7 TONNES)	4.8	10	57	67	60
GAS DISTRIBUTION FACILITIES (50 MMSCF/D)	0.7	3	0	3	0
230 KVAC TRANSMISSION LINE (250 MWE, 805 KM)	0.5	1	4	5	1
500 KVAC TRANSMISSION LINE (1200 MWE, 805 KM)	0.2	1	1	2	0
ELECTRICITY DISTRIBUTION-AERIAL LINES (131.6 MWE)	9.0	20	69	89	60

wider range of uncertainty than is the case for the supply facilities since the allocation of flows to competing transport modes and the average distances over which the energy forms will be moved must be considered.

2.5.2 Capital requirements: Capital costs for facility additions to the total energy industry and to each subsector of the energy supply industry were calculated using the Comparison Case facility construction schedules and information in the ESPM data base. The accumulated capital cost for the energy supply facility additions necessary in the 1978 to 2000 period is given in Table 2.5-3 in 1978 Egyptian pounds. These costs represent direct construction costs factored to account for working capital. They exclude such owner's costs as land, escalation, leasing fees and interest during construction. Costs for the solar facilities were calculated separately and added to the results.

Cumulative capital requirements for Egyptian energy facilities for the Comparison Case are estimated at ĿE 3.5 billion for the 1978 to 1985 period and ĿE 17.6 billion over the 1978 to 2000 period. These 1978 to 2000 costs by sector can be summarized as follows:

- Oil, gas and coal supply = ĿE 4.0 billion
- Hydro and pumped storage electric = ĿE 1.0 billion
- Solar = ĿE 1.4 billion
  - Solar electric = approximately ĿE 1.2 billion
- Oil and gas electric = ĿE 0.5 billion
- Nuclear-electric = ĿE 8.9 billion
- Electric transmission and distribution = ĿE 1.7 billion.

It can be seen that on the basis of these estimates, the fuels supply sectors would account for roughly 25 percent and the electric utilities for about 75 percent of total capital requirements.

There are, however, substantial uncertainties in these capital requirements estimates. The largest uncertainties are related to oil and gas, hydroelectric and solar capital requirements. The basis for the substantive uncertainties in these three areas are discussed below.

Major uncertainties exist with respect to future oil exploration and field development costs. Oil production at the levels assumed in the assessment analysis will involve exploring for and developing extensive new oil fields in new geologic provinces. There is no way to even reasonably estimate the exploration efforts that will be needed, the size of the fields to be found, the depth and production rate of the wells and, consequently, the number of wells needed, the availability of

TABLE 2.5-3

CUMULATIVE CAPITAL REQUIREMENTS (MILLION POUNDS, JAN 1978) OF THE ENERGY FACILITY ADDITIONS 1978-2000 BY RESOURCE GROUPING

(1978-2000) EGYPT-Comparison Case

FACILITY	TOTAL
OIL	
EXPLORATION, DEVELOPMENT, AND PRODUCTION	1922
REFINING AND PROCESSING	1469
PIPELINES	80
TANKERS, BARGES, TRUCKS	385
BULK STATIONS	25
OTHER	0
TOTAL OIL	3881
OIL SHALE	0
GAS	
EXPLORATION, DEVELOPMENT, AND PRODUCTION	23
GEOPRESSURED METHAND	0
PIPELINES	0
LNG TANKERS	46
DISTRIBUTION	0
OTHER	69
TOTAL GAS	
COAL	
UNDERGROUND MINING	0
SURFACE MINING	0
RAIL	73
PIPELINES	0
BARGES, TRUCKS	10
TOTAL COAL	83
NUCLEAR FUEL CYCLE	108
SOLAR FACILITIES	1339
ELECTRIC GENERATION (EXCLUDING SOLAR)	
COAL-FIRED	0
SULFUR REMOVAL FACILITIES	0
COAL-FIRED (FLUID BED)	0
NUCLEAR	8943
HYDRO AND PUMPED STORAGE	968
OIL AND GAS	452
GEOTHERMAL	0
TOTAL GENERATION (EXCLUDING SOLAR)	10363
TRANSMISSION	670
DISTRIBUTION	1051
TOTAL UTILITIES (EXCLUDING SOLAR)	12084
TOTAL ENERGY INDUSTRY	17564

associated gas, oil and gas gathering system requirements, etc. Therefore, there exists no ready means to estimate the capital requirements of future oil and gas exploration and development. Since an order of magnitude estimate was needed, it was decided to use historic data on Egypt's oil and gas production as a basis for the necessary inputs to the ESPM. Table 2.5-4 summarizes some of the key input parameters used for the Egypt calculation and comparable input parameters for a U.S.

TABLE 2.5-4
OIL EXPLORATION AND DEVELOPMENT
Cost and Resource Estimate Input Parameters

	ONSHORE OIL		OFFSHORE OIL	
	EGYPT	USA	EGYPT	USA
Production Per Well (BPD)	200	18.25	2,500	160
#Producing Wells Per Field(#)	5	100.00	5	125
Production Per Field (BPD)	1,000	1,825.00	12,500	20,000
Depth of Wells (ft)	8,000	4,450.00	10,000	9,350
# Dry Holes Per Field	6	75.00	6	95

calculation. As can be readily observed the unit production of Egypt's oil wells, both onshore and offshore, are on the order of 10 or higher than comparable U.S. average oil well production rates. Similarly, the dry holes experienced per field in Egypt has, to date, been considerably lower than that experienced in the U.S. Since in the calculation for Egypt, the ESPM investment costs for oil exploration and development was made proportional to drilling feet required, the impact of a change in the future from Egypt's past oil exploration experience and well unit production rates could increase the ESPM cost estimates to several times the current estimate. Because future oil production in Egypt will involve production from new geologic provinces, there is no reliable way of speculating on the possibility of such increases.

Gas exploration and development costs share the same types of uncertainties. In fact, about 25 percent or more of the gas exploration costs were for associated gas and, thereby, embodied in the estimated oil exploration and development investment. The other key uncertainty is the production lifetime of existing natural and associated gas fields and, thereby, the need for development of new gas fields. Little data was available to support such an analysis and the assumed new production requirements could, thereby, be significantly underestimated.

The key uncertainty with respect to capital requirements for new hydroelectric generation facilities stems from the lack of site specific data and related engineering based cost estimates. Where power generation facilities were to be installed in existing water control structures, reasonable estimates were available to the U.S. hydroelectric specialist. A single ESPM typical facility of similar cost, a 200 MWe dam, was then used as a surrogate facility for purposes of estimating manpower and equipment requirements. Since only one such facility was involved, the uncertainty stemming from the approximation in terms of the overall hydroelectric uncertainty was small. However, five 500 MWe pumped storage facilities are assumed to be constructed by 2000 and 13 more in the 2000 to 2010 period. Since no site specific data was available for these facilities, the typical 1000 MWe U.S. pumped storage facility of the ESPM was scaled down to a 500 MWe unit size and this unit cost, equipment and manpower estimate was then applied for the Egypt ESPM calculation. There is no measure at this time by which to compare specific site engineering estimates for actual pumped storage sites in Egypt with the ESPM estimate.

Solar heating and solar electric system (i.e., photovoltaic, solar thermal, wind and biomass) cost, equipment and manpower requirements were estimated separately from ESPM by the solar specialists of the U.S. team. There has not been sufficient experience with solar facilities to develop well founded data on the system engineering and operational requirements of these systems when they are widely applied under commercial conditions. Also, in this assessment, application of a number of different types of solar systems was assumed but no detailed apportioning of the total estimated market penetration to the different types of solar systems was attempted. Rather, an aggregated estimate of costs and resources was made assuming a general but undefined mix in the use of the various competing solar systems. Requirements based upon information available to date and the time phased scenarios are given in Table 2.5-5 for both a low and an accelerated case. The low case, which reflects growth sufficient to supply 4 percent of electric demand in 2000, was used in the Comparison Case. The accelerated solar case was used in the accelerated renewable resource strategy discussed in Section 2.6.

Table 2.5-6 presents the major categories of resource requirements that make up the estimated capital investments. Manpower requirements are broken down into three subcategories since this could be important in Egypt's manpower planning.

TABLE 2.5-5

RESOURCE REQUIREMENTS
RENEWABLE ENERGY RESOURCE SCENARIOS

2.5-5a. MATERIAL REQUIREMENTS (TONS)

	1985		1990		2000	
	CASE A	CASE B	CASE A	CASE B	CASE A	CASE B
Steel	600	17,000	17,000	55,000	35,000	97,000
Glass	300	8,500	7,500	27,000	20,000	45,000
Aluminum	80	400	3,000	11,000	9,000	18,000
Cement	300	15,000	14,000	44,000	33,000	68,000

2.5-5b. ANNUAL FINANCIAL REQUIREMENTS (MILLIONS OF EGYPTIAN POUNDS, 1978)*

	1985		1990		2000	
	CASE A	CASE B	CASE A	CASE B	CASE A	CASE B
Materials/Components	1.2	47	37	122	77	179
Labor (Man. & Install.)	1.3	46	45	125	80	188
O&M	.2	5	6	31	42	122
TOTAL	2.5	98	88	278	199	489

2.5-5c. LABOR REQUIREMENTS (PERSON-YEARS)

	1985		1990		2000	
	CASE A	CASE B	CASE A	CASE B	CASE A	CASE B
Technical/Management	25	500	430	1,420	1,050	2,100
Manufacturing and Installation	180	5,200	5,150	16,700	10,900	25,000
O&M	25	670	750	3,700	4,800	16,000

* Does not include expenditures for production facilities.

TABLE 2.5-6

SUMMARY OF CAPITAL REQUIREMENTS FOR MANPOWER, MATERIALS AND EQUIPMENT (MILLION POUNDS, JANUARY 1978) FOR THE DESIGN, CONSTRUCTION, AND STARTUP OF ENERGY RELATED FACILITIES IN THE COMPARISON CASE (EXCLUDING SOLAR ELECTRIC FACILITIES)

CATEGORY	ANNUAL 2000	TOTAL 1978-2000
NON-MANUAL TECHNICAL MANPOWER	105	1299
NON-MANUAL NON-TECHNICAL MANPOWER	22	264
MANUAL MANPOWER	115	1474
MANPOWER TOTAL	243	3036
MATERIALS TOTAL	171	2574
EQUIPMENT TOTAL	363	4774
CONSTRUCTOR COST TOTAL	1038	13640

CONSTRUCTION CAPITAL COSTS TOTAL INCLUDES MANPOWER, MATERIALS AND EQUIPMENT SUBTOTALS ABOVE PLUS OTHER (OVERHEAD, PROFIT, ETC.) COSTS. IT EXCLUDES OWNER'S COSTS (LAND COSTS, INTEREST DURING CONSTRUCTION, ETC.).

2.5.3 Annual construction requirements: Table 2.5-7 presents the growth in the annual requirements for construction materials and key capital equipment items excluding that for solar facilities. It also presents the peak annual demand for these inputs to the supply facility construction program and the year in which that peak demand is projected to occur. Such a presentation provides insight into the growth in trained manpower availability and in construction and equipment purchase or supply capability that must be planned for if the postulated facility construction program is to be able to proceed on schedule. To illustrate, the annual demand for concrete by the energy supply industry would increase from about 93,000 metric tonnes per year in 1976 to about 1,100,000 metric tonnes per year in 2000. Annual requirements for carbon steel are estimated to increase from about 40,000 tonnes per year in 1976 to about 125,000 tonnes per year in 1993 and remain at that level through 2000. Aluminum demand will increase from 625 tonnes per year in 1976 to 12,000 tonnes in 1993 and then decline to 1800 tonnes per year in 2000. Thin-walled, non-nuclear pressure vessel requirements will grow from 54 tonnes/year in 1976 to 2095 tonnes per year in 1985 with 2062 tonnes per year needed in 2000 under current plans. On the other hand, equipment and material needs for oil and gas drilling remain essentially constant throughout the period of the analysis due to the assumptions discussed earlier in this section.

As expected in a program of continued expansion in many areas, most of the years of peak requirement occur in the year 2000. It should be kept in mind that much of the requirements of that year are related to the construction of facilities that would begin operation in the post-2000 period.

Annual manpower requirements for the Comparison Case, excluding those for solar facilities, are provided in Table 2.5-8. If the requirements for solar are added (solar is estimated to use about another 10,000 man-years in the year 2000) energy-related manpower needs will increase at a rate of 9.2 percent per year from 5,800 man-years in 1976 to 48,000 man-years in 2000.

TABLE 2.5-7

SELECTED MATERIALS AND EQUIPMENT ITEMS REQUIRED FOR THE DESIGN, CONSTRUCTION, AND STARTUP OF ENERGY RELATED FACILITIES IN THE COMPARISON CASE (EXCLUDING SOLAR ELECTRIC FACILITIES)*

CATEGORY		ANNUAL REQUIREMENTS 1976 (CALC'D)	2000	1978-2000 AVERAGE	PEAK	YEAR
CEMENT	(TONNES)	17594.	123380.	67520.	123380.	(2000)
CONCRETE (INCLUDES CEMENT)	(TONNES)	93526.	1115214.	579114.	1115214.	(2000)
BENTONITE (IN DRILLING MUD)	(TONNES)	2719.	2300.	2399.	2971.	(1978)
BARITE (IN DRILLING MUD)	(TONNES)	2636.	2277.	2339.	2893.	(1978)
CARBON STEEL	(TONNES)	41076.	124618.	84202.	125655.	(1993)
ALLOY STEEL	(TONNES)	2601.	11428.	6955.	11428.	(2000)
STAINLESS STEEL	(TONNES)	178.	3788.	1961.	3788.	(2000)
STEEL TOTAL	(TONNES)	43854.	139834.	93117.	139834.	(2000)
COPPER	(TONNES)	432.	4779.	2991.	5721.	(1993)
ALUMINUM	(TONNES)	625.	1876.	3091.	12028.	(1993)
MANGANESE	(TONNES)	332.	1055.	710.	1055.	(2000)
CHROMIUM	(TONNES)	131.	981.	567.	981.	(2000)
NICKEL	(TONNES)	8.	151.	80.	151.	(2000)
CAST IRON	(TONNES)	502.	3126.	1849.	3126.	(2000)
STEEL CASTINGS	(TONNES)	363.	1776.	1024.	1776.	(2000)
ALUMINUM CASTINGS	(TONNES)	31.	160.	96.	160.	(2000)
BRASS & BRONZE CASTINGS	(TONNES)	31.	245.	143.	245.	(2000)
IRON & STEEL FORGINGS	(TONNES)	318.	1597.	924.	1597.	(2000)
STRUCTURAL STEEL SHAPES	(TONNES)	2274.	16639.	11965.	26229.	(1993)
STEEL PLATE < 3.8 CM THICK	(TONNES)	3333.	20139.	13002.	20139.	(2000)
STEEL PLATE > 3.8 CM THICK	(TONNES)	2.	3857.	1851.	3857.	(2000)
PIPE, CARBON STEEL	(TONNES)	13168.	11653.	10122.	17643.	(1982)
PIPE, ALLOY & STAINLESS STEEL	(TONNES)	98.	5801.	2895.	5801.	(2000)
OIL COUNTRY TUBULAR GOODS	(TONNES)	16166.	13901.	14426.	18061.	(1978)
REINFORCING BAR (REBAR)	(TONNES)	935.	22341.	11431.	22341.	(2000)
VALVES, CARBON STEEL	(TONNES)	163.	1076.	693.	1076.	(2000)
VALVES, ALLOY & STAINLESS STEEL	(TONNES)	7.	513.	262.	513.	(2000)
STEAM TURBOGENERATORS	(MEGAWATTS)	331.	1847.	1007.	1847.	(2000)
STEAM TURBINES (EXCL TRBGENS)	(MEGAWATTS)	7.	34.	20.	34.	(2000)
GAS TURBOGENERATORS	(MEGAWATTS)	136.	3.	3.	136.	(1976)
DRAGLINES	(CUBIC METERS)	0.	0.	0.	0.	
DRILL RIGS, ONSHORE	(RIG YEARS)	16.	15.	15.	18.	(1978)
DRILL RIGS, OFFSHORE	(RIG YEARS)	5.	5.	4.	5.	(1979)
DRILL BITS	(NUMBER)	1358.	1198.	1237.	1494.	(1978)
PUMPS & DRIVERS > 745 MGAWTS	(MEGAWATTS)	8.	146.	76.	146.	(2000)
PUMPS & DRIVERS < 745 MGAWTS	(MEGAWATTS)	20.	30.	25.	30.	(2000)
AXIAL COMPRESSORS > 3727 MGAWTS	(MGAWTS)	0.	0.	0.	0.	
CENTRIF COMPR & DRV > 7455 MW	(MGAWTS)	0.	19.	12.	19.	(1979)
CENTRIF COMPR & DRV < 7455 MW	(MGAWTS)	1.	4.	3.	4.	(1979)
HEAT EXCHANGERS	(SQUARE METERS)	7053.	101495.	59483.	101495.	(2000)
NON-NUC PRESS VESS < 3.8 CM WALL	(TONNES)	54.	2062.	1349.	2095.	(1984)
NON-NUC PRESS VESS 3.8-10 CM W	(TONNES)	4.	4.	4.	4.	(1979)
NON-NUC PRESS VESS > 10 CM WALL	(TONNES)	0.	0.	0.	0.	
BOILERS	(TONNES STEAM PER HOUR)	981656.	313796.	489200.	1486156.	(1978)
NUCLEAR STEAM SUPPLY SYSTEMS	(MEGAWATTS)	0.	1820.	893.	1820.	(2000)

* INCLUDES REQUIREMENTS FOR ENERGY SUPPLY AND TRANSPORTATION FACILITIES

TABLE 2.5-8

GROWTH IN MANPOWER REQUIREMENTS (MAN-YEARS)
FOR THE DESIGN, CONSTRUCTION, AND STARTUP OF ENERGY RELATED FACILITIES
IN THE COMPARISON CASE

(EXCLUDING SOLAR FACILITIES)

CATEGORY	ANNUAL REQUIREMENTS 1976 (CALC'D)	2000	1978-2000 AVERAGE	PEAK	YEAR
CHEMICAL ENGINEERS	0.	18.	22.	39.	(1987)
CIVIL ENGINEERS	96.	945.	540.	945.	(2000)
ELECTRICAL ENGINEERS	87.	740.	473.	740.	(2000)
MECHANICAL ENGINEERS	62.	563.	340.	589.	(1999)
MINING ENGINEERS	0.	4.	2.	5.	(1994)
NUCLEAR ENGINEERS	0.	77.	37.	77.	(2000)
GEOLOGICAL ENGINEERS	29.	41.	34.	41.	(2000)
PETROLEUM ENGINEERS	29.	25.	26.	32.	(1978)
OTHER ENGINEERS	1.	12.	14.	24.	(1991)
ENGINEERS TOTAL	305.	2425.	1488.	2442.	(1999)
DESIGNERS & DRAFTSMEN	115.	936.	606.	993.	(1999)
SUPERVISORS & MANAGERS	96.	520.	302.	520.	(1999)
NON-MANUAL, TECHNICAL TOTAL	515.	3881.	2397.	3955.	(1999)
NON-MANUAL, NON-TECHNICAL	346.	3732.	2079.	3732.	(2000)
NON-MANUAL TOTAL	861.	7613.	4476.	7613.	(2000)
PIPEFITTERS	748.	5026.	2605.	5026.	(2000)
PIPEFITTER/WELDERS	391.	2186.	1155.	2186.	(2000)
ELECTRICIANS	356.	4928.	2514.	4928.	(2000)
BOILERMAKERS	309.	616.	391.	616.	(2000)
BOILERMAKER/WELDERS	103.	437.	258.	437.	(2000)
IRON WORKERS	148.	2579.	1763.	4496.	(1993)
CARPENTERS	160.	3430.	1687.	3430.	(2000)
EQUIPMENT OPERATORS	546.	2709.	1616.	2709.	(2000)
LINEMEN	167.	1004.	1121.	3123.	(1993)
TEAMSTERS & LABORERS	1014.	5713.	3244.	5713.	(2000)
OTHER	978.	2075.	1473.	2075.	(2000)
MANUAL TOTAL	4919.	30703.	17828.	30703.	(2000)
CONSTRUCTION MANPOWER TOTAL	5780.	38316.	22304.	38316.	(2000)

* INCLUDES REQUIREMENTS FOR ENERGY SUPPLY AND TRANSPORTATION FACILITIES

2.5.4 Operation and maintenance costs: Annual cost for the operation and maintenance of the energy related facilities for the Comparison Case increases from about LE 50 million in 1976 to LE 310 million in 2000. These costs for conventional energy supply facilities are indicated in Table 2.5-9. Estimated fuel cycle costs are based on the prevailing world costs of fuel oil or uranium and nuclear fuel cycle facilties. Annual manpower requirements for operation and maintenance of energy supply facilities are estimated to grow from 5,800 to 27,000 man-years over the period 1976 to 2000. Solar facilities are estimated to add operation and maintenance costs of LE 42 million to these estimates in the year 2000; and over 4,800 man-years will be expended for solar O&M in that year. More details on these O&M estimates are provided in Appendix E and Annex 8-Potential Use of Renewable Energy Resources.

TABLE 2.5-9

GROWTH IN ANNUAL COSTS (MILLION POUNDS JANUARY 1978) FOR THE OPERATION AND MAINTENANCE OF ENERGY-RELATED FACILITIES IN THE COMPARISON CASE (EXCLUDING SOLAR FACILITIES)

CATEGORY	ANNUAL REQUIREMENTS				
	1978 (CALC'D)	2000	1978-2000 AVERAGE	PEAK	YEAR
NON-MANUAL TECHNICAL MANPOWER	3	19	10	19	2000
NON-MANUAL NON-TECHNICAL MANPOWER	1	4	2	4	2000
MANUAL MANPOWER	9	43	27	43	2000
MANPOWER TOTAL	12	66	39	66	2000
MATERIALS TOTAL	17	83	48	83	2000
EQUIPMENT TOTAL	8	38	20	38	2000
UTILITY TOTAL	7	37	18	37	2000
SERVICES AND MISCELLANEOUS	10	57	31	57	2000
ANNUAL OPERATING COST (EX FUEL)	53	271	152	271	2000

2.5.5 Foreign labor, materials and equipment requirements: The proportion of the above summarized estimates of resource requirements that would have to be obtained from sources outside of Egypt were also estimated. Critical to these estimates are the assumptions made as to the equipment, manpower and materials which it is believed Egypt could provide to meet the construction needs. This, of course, varies from one type of facility to another. It would also be expected to change as Egypt's capabilities are increased over the period to 2000. However, to simplify the calculations, the estimated share of those equipments, manpower and materials which Egypt could supply for each type of facility were held constant over the 1976 to 2000 period.

Table 2.5-10 provides examples of some of the import ratios for facilities in the Comparison Case. Considering all facilities, the imported component was approximately 80 percent of the total capital requirements, about 20 percent of operating costs and 25 percent of construction labor (45 percent for non-manual and 20 percent for manual). These results can be important in determining potential effects on efforts to reduce Egyptian reliance on overseas supplies of resources as well as in indicating the needs for external borrowing and foreign exchange.

TABLE 2.5-10

IMPORT COST FRACTIONS FOR CONSTRUCTION OF VARIOUS ENERGY FACILITIES IN THE COMPARISON CASE (IN PERCENTS)

FACILITY	MANPOWER	MATERIAL	EQUIPMENT	TOTAL CONSTRUCTION COST
CRUDE OIL PIPELINE 800 MB/D, 241.4 KM	64	89	85	85
HIGH GASOLINE REFINERY (200 MB/D EFFECTIVE)	57	54	84	70
OIL FIRED POWER PLANT (600 MWE)	50	59	83	73
LIGHT WATER REACTOR (600 MWE)	81	92	85	73

<u>2.5.6 External debt and debt service</u>: Using the interest, inflation and debt repayment assumptions given in Appendix F, and assuming all imports for facilities are externally financed, imported capital for energy facilities could yield external debt factors similar to those given in Table 2.5-11. Further discussion of the debt calculations for alternative energy supply strategies is found in Section 2.6 and in Appendix F, Section 5.

TABLE 2.5-11

EXTERNAL DEBT AND DEBT SERVICE PROJECTION
FOR THE COMPARISON CASE*

(MILLIONS OF 1978 EGYPTIAN POUNDS)

YEARS	DEBT	GRACE	TOTAL	DEBT SERVICE
1978	306	243	549	14
1980	664	290	954	47
1982	941	616	1557	77
1985	1258	1244	2502	144
1990	2419	1988	4407	210
1995	4184	3084	7268	375
2000	6077	3713	9790	562

*EXCLUDES OIL EXPLORATION AND EXTRACTION WHICH WOULD BE PAID ON CONCESSIONS BASIS.

2.6 Option And Strategy Evaluation

With the Comparison Case as a starting point, it was possible to evaluate the impact of several energy supply and demand alternatives which the U.S. team identified as possibly warranting examination by Egypt's planners. These alternatives, referred to as options, included such things as changes in industrial processes, increased availability of certain fuels, changes in the electrical generator mix and others. The options were grouped into sets based on a common impact and these sets are referred to as strategies. Four basic strategies were developed in this way: (1) maximum gas use; (2) improved efficiency in energy use; (3) accelerated use of renewable resources; and (4) nuclear capacity variations, (a medium capacity, a low capacity and one labeled combined strategies which made use of select features of the other strategies).

As will be seen from the description of the strategies, the alternatives presented do not represent an exhaustive list of the possible energy supply and demand configurations for Egypt. Rather, they are representative of those alternative strategies which, at first review, appear to warrant further examination. It is to be expected that more detailed analyses will uncover additional possibilities or show that some of those evaluated here are not practicable from either a technical or policy standpoint.

The basic premise of the strategies evaluated here was not to change the level of activity growth and development that was embodied in the demand projection provided for the analysis by Egypt. Time and the limited availability of data did not permit an assessment to be made of alternative activity growth patterns and growth rates.

With the exception of the nuclear capacity variations strategy and some subsets of the other strategies, the alternatives considered here are not mutually exclusive. It is possible that one strategy or set of options could be superimposed on another without creating conflicting conditions. In fact, the nuclear capacity combined strategy considers such a situation.

2.6.1 Strategy descriptions: Table 2.6.-1 lists the options and the strategies in which each is included. Appendix F contains a detailed description of each of the strategies.

Maximum Gas Use. The objective of this strategy is to make full use of the available non-associated and associated gas. It assumes that an additional quantity of associated gas (3.3 billion m^3) that could economically be made available for use in the energy, industrial and residential sectors of the economy of Egypt. The source of this gas would be a combination of new fields of non-associated gas and associated gas that was previously flared, recirculated for oil lift or left in the gas cap for field pressure maintenance. The strategy hinges upon a combination of three assumptions: (1) that additional non-associated

Table 2.6-1 Use of Options in the Strategies Considered for Egypt

Energy Sector Options	Comparison Case	Maximum Gas Use: Res/Ind Priority	Maximum Gas Use: Electricity Priority	Strategies: Improved Efficiency	Strategies: Accelerated Renewable Resources	Nuclear Capacity Variations: Medium Nuclear	Nuclear Capacity Variations: Low Nuclear	Nuclear Capacity Variations: Combined Strategies
<u>FOSSIL FUEL USE</u>								
1. <u>Oil Option</u>								
a. 1 million bbl/day production	X	X	X	X	X	X	X	X
b. 3 new refineries 1977-2000	X	X	X	X	X	X	X	X
c. Constant product mix	X	X	X	X	X	X	X	X
d. Import/export balance of demand	X	X	X	X	X	X	X	X
2. <u>Gas Option</u>								
a. 3.2 x 10 m non-associated gas production	X	X	X	X	X	X	X	X
b. o.9 x 10 m associated gas production	X			X	X	X	X	
c. Increased availablity of nonassociated and associated gas for								
(1) Use in new cities		X	X					X
(2) Use in new construction		X						
(3) Use in iron and steel		X						
(4) Use in electricity		X						
3. <u>Coal Option</u>			X					
a. 0.3 x 10 ton/yr production	X	X	X	X	X	X	X	X
b. Use as blend with metallurgical coal	X	X	X	X	X	X	X	X
<u>HYDROELECTRIC OPTIONS</u>								
1. Additional unit at Aswan Dam	X	X	X	X	X	X	X	X
2. Electrify 3 existing barrages	X	X	X	X	X	X	X	X
3. Qattara - Phase 1					X			X
<u>RENEWABLE RESOURCE OPTIONS</u>								
1. <u>Solar Electric (thermal & photovoltaic)</u>								
a. business as usual	X	X	X	X		X	X	
b. Accelerated program					X			X

Table 2.6-1 Cont'd

Options/Energy Sector	Comparison Case	Maximum Gas Use: Res/Ind Priority	Maximum Gas Use: Electricity Priority	Strategies: Improved Efficiency	Strategies: Accelerated Renewable Resources	Nuclear Capacity Variations: Medium Nuclear	Nuclear Capacity Variations: Low Nuclear	Nuclear Capacity Variations: Combined Strategies
RENEWABLE RESOURCE OPTIONS (cont'd)								
3. <u>Biomass Electric</u>								
a. Business as usual	x	x	x	x		x	x	
b. Accelerated program					x			x
4. <u>Solar Water Heating</u>								
a. Business as usual	x	x	x	x		x	x	
b. Accelerated program					x			x
5. <u>Geothermal</u>								
Development of 20 MW	x	x	x	x	x	x	x	x
<u>NUCLEAR POWER OPTIONS</u>								
1. <u>Major program (12,600MW)</u>	x							
2. <u>Major program-strategy demand matched</u>		x	x	x	x			
3. <u>Medium program-1/2 demand matched</u>						x		
4. <u>Minimum program-1900MW</u>							x	x
<u>ENERGY EFFICIENCY OPTIONS</u>								
1. Business as usual	x	x	x		x	x	x	
2. <u>Residential conservation</u>				x				x
a. Use of fluorescent lights				x				x
b. Transistorize TV				x				x
3. <u>Transportation Fuel Savings</u>								
4. <u>Industrial Process Variations</u>								
a. Cement				x				x
b. Automotive				x				x
c. Aluminum				x				x
d. Textile				x				x
e. Fertilizer				x				x
f. Chemicals				x				x
g. Food Processing				x				

gas production was possible; (2) that the amount of associated gas that could be produced in existing and future oil fields is equivalent to the gas/oil ratio of the Ramadan field (400 standard cubic feet/bbl); and (3) that this gas could be economically recovered and applied to other uses taking into account any oil production loss that might result.

Two cases were considered with regard to the use of this additional gas. In the first case, Egyptian counsel was to give first priority to residential use and second priority to the possible industrial use of gas. Gas used in the residential sector was assumed to replace the use of butagas and kerosene in new housing units either in new cities or in new construction in existing cities. Because of the natural lead times and limits on this prescribed first priority use, increased residential use could consume only 7 percent of the additional gas available in 1985 and 28 percent of that available in 2000. Uses of gas in the industrial sector which were considered were: (1) replacing planned expansions of blast furnace steelmaking with direct reduction steelmaking using gas; (2) replacing the electrolysis process at the Kima fertilizer plant with a process dependent upon gas as a feedstock; and (3) production of methanol from natural gas. The stipulated priorities made it necessary to reserve some gas supplies for later application to residential demand. The high capital costs for gas transmission, distribution and consuming process equipment made it necessary that the availability of an adequate lifetime supply of gas be assured before any industrial process conversion would be considered. Because of these factors and the level of additional gas supply which was assumed would be available, the only industrial process conversion which was examined was 50 percent of the planned blast furnace expansion to direct reduction. With those assumptions, direct reduction steelmaking would consume 6 percent of the additional gas assumed to be available in 1985 and 45 percent of it in 2000. The balance of the associated gas (87 percent in 1985 and 27 percent in 2000) was assumed to be recirculated for oil lift or to remain available for well pressure maintenance. Additional consumption of this gas, which was unused in 1985 and 2000 by industry, confronted the economic life of supply factors that were not easy to assess and which could intrude on future uses which carried a higher priority.

In the second case, it was assumed that all of the additional gas available would be used for electrical generation in conventional steam and combined cycle power plants. All 3.3 billion m^3 were used for that purpose in both 1985 and 2000.

Improved Efficiency. The objective of this strategy is to reduce the demand for energy through improvements in the efficiency of the use of energy. The activity levels (i.e., industrial production rates, vehicle kilometers traveled, etc.) were held constant and only the energy conversion efficiencies were changed. In the residential sector, improved efficiency can be achieved through increased use of fluorescent lighting in place of incandescent light bulbs and through the transistorization of televisions. In the transportation sector, savings can be achieved through increased utilization of an expanded network of bus, rail and waterway transport in place of truck transport of freight and auto transport of people. In the industrial sector, process changes in the cement, aluminum, and fertilizer industries, improved "housekeeping" and maintenance in the chemical and food processing industries, waste heat use in the textiles industry, and shift changes in the automotive industry can be used to effect energy savings. The net energy savings in electricity, fuel oil (mazout), gasoil, gasoline and naphtha can amount to about 21 quadrillion joules in 1985 and 58 quadrillion joules in 2000 or three percent and four percent of commercial energy demand in 1985 and 2000, respectively. The overall reduction of approximately 6 percent in the electricity demand could result in a reduction in the required fossil-fired electrical generation capacity. A modified construction schedule can then be assumed for two plants, which provide excess reserve capacity in the Comparison Case.

Accelerated Renewable Resources. This strategy is designed to evaluate the effectiveness of an aggressive program to promote the use of renewable resources. A two-step process has been used in building this strategy. First, it is assumed that an accelerated program of governmental encouragement of solar, wind, and biomass electric systems and solar hot water heating is undertaken. This results in a penetration of these technologies into the market at an accelerated rate. The result is 178 MWe of electrical capacity in 1985 and 4333 MWe in 2000 (as compared to 3.6 MWe in 1985 and 1506 MWe in 2000, in the Comparison Case). About 15 percent of the total electricity demand can be satisfied by solar devices in 2000. A reduced requirement for fossil-fired electricity generation based on a modified construction schedule for two plants that would provide excess reserve peaking capacity is also included. Solar hot water heating applications amount to 3.1 quadrillion joules in 1985 and 44.0 quadrillion joules in 2000, and result in a displacement of butagas and kerosene use in the residential sector.

The second step of the strategy involves the development and beginning use of the Qattara Depression Project (Phase 1) to yield 670 MWe of hydroelectric capacity in 2000. It should be noted that a feasibility study on Qattara is scheduled for completion in 1979 and no judgment on its economic viability is made or implied by its inclusion in this strategy. The present analysis simply illustrates the potential impact of the project on the Egyptian energy balance; it is based on the completion of the project using a tunnel that would be excavated using conventional tunneling methods.

Nuclear Capacity Variations. The objective of this strategy was to reduce the quantity of nuclear power from the Comparison Case value of 12,600 MWe. Three cases were considered: (1) medium nuclear - replacement of one half of the projected nuclear electricity generation capacity with oil-fired generation; (2) low nuclear - replacement of all but 1900 MWe of nuclear power with fossil-fired capacity; and (3) combined strategies - implementing all of the other strategies (maximum gas use, improved efficiency, and accelerated renewable resources), limiting installed nuclear capacity to 1900 MWe, and meeting the balance of the electrical demand with fossil-fired capacity. These cases were designed to demonstrate the impact of intermediate levels of nuclear power development and of alternative means to achieve reduced levels of nuclear capacity. The 1900 MWe level of installed nuclear capacity was selected as the lower limit to reflect the capacity that is the subject of negotiations between the U.S. and Egypt. In the first two cases, the demand for electricity was held constant. In the third case, the electricity demand reductions resulting from the implementation of the various conservation options were also considered.

2.6.2 Results of strategy evaluations - energy demand and supply: The impact of each of the strategies on energy utilization in Egypt was determined by constructing a new supply/demand balance similar to the one constructed for the Comparison Case. First, the changes from the Comparison Case in the demand for energy (electricity, petroleum products, gas, etc.) were determined for each option. For example, as part of the strategy to maximize gas use the substitution of the direct reduction process for one-half of the blast furnace expansion of the iron and steel industry was determined in the year 2000 to: (1) increase the demand for gas by 1.5 billion m^3; (2) increase electricity demand by 2.2 billion kwh; (3) decrease the demand for metallurgical coke by 3.3 million tonnes; and (4) decrease demand for mazout (residual fuel oil) by 0.15 million tonnes. These changes were converted to joule equivalents and substituted into the right-hand side of the network diagram. (The details of these changes for each option considered are presented in Appendix F.) In a fashion analagous to that described in Section 2.4.2 for the Comparison Case, the energy supply system was reconstructed to account for this change in demand. Account was also taken of any changes in the energy supply system as a result of the strategy. For example, in the accelerated renewable resource strategy there are 3500 MWe more of electrical capacity available from renewable resources than in the Comparison Case for the year 2000. Both the energy generation by this solar capacity and its effect on total and reserve capacity requirements were estimated and accounted for. (The details of these differences are also in Appendix F and Annex 8-Potential Use of Renewable Resources). With a new supply/demand balance constructed for each strategy, it is possible to compare the results against the Comparison Case using the same parameters of interest: import vs. export of energy, distribution of electricity generation and the structure and growth rate of the energy system.

Figure 2.6-1 shows the effect of the total energy resource requirements for each of the strategies as matched against the Comparison Case for 1985 and 2000. Only the maximum gas use, improved efficiency and accelerated renewable resource strategies have any effect in 1985. Since none of the nuclear reactors is in operation by 1985 in the Comparison Case, the nuclear capacity variation strategies do not change anything in the 1985 diagram.

It is apparent that none of the strategies makes any major changes to the total quantity of energy resources required. (The largest difference is in the improved efficiency strategy, which reduces total requirements in the year 2000 by 104 quadrillion joules, or 4.1 percent, from the Comparison Case.) This is a result of the assumption that end use activity levels (e.g., industrial output, passenger and freight kilometers traveled, etc.) would remain constant. The biggest changes are seen in the distribution of resource requirements and of these, the nuclear capacity variations create the biggest displacements from the Comparison Case. The variations in the use of gas in the increased gas strategies result from assumptions made by the U.S. team about the quantities of associated gas that could be extracted and the effective uses to which it could be put. (Details on these assumptions can be found in Appendix F.)

Figure 2.6-2 shows the impacts on imports and exports. In 1985, the most significant impact is in the strategy for maximum gas use with priorities given to (a) process industry (fertilizers, petrochemicals and cement factories), (b) residential, and (c) electricity generation. Here the gas replaces the use of oil and permits a higher level of oil exports. In 2000, the import/export condition that existed in the Comparison Case is further emphasized; that is, if the uranium required to support the nuclear expansion program is not available from indigenous resources it will have to be imported, and Egypt will convert from being almost exclusively energy independent to relying on imports for more than half of its energy resources. If, on the other hand, indications of indigenous uranium resources are confirmed and developed sufficiently to meet direct Egyptian needs, Egypt could remain a significant energy exporter. In the three cases of the nuclear capacity variations, the import/export problem is complicated by the fact that the fuel oil needed for the thermal power stations that replace the nuclear power plants require the building of additional refinery capacity (i.e., more than the two new refineries between 1985 and 2000 in the Comparison Case). This would be at the expense of reduced exports of crude oil and would require external capital expenditures (about 400 million Egyptian pounds) for the refinery equipment. The alternative to building more refinery capacity would be to import fuel oil, but this is against Egyptian policy and is currently unacceptable. (Nonetheless, Figure 2.6-2 is based on this latter assumption.) A detailed cost/benefit evaluation would be required to ascertain the more effective approach.

Figure 2.6-3 shows the various mixes of electrical generating capacity for the strategies. The impact of each strategy is clear; the most significant changes occur in the accelerated application of solar electric systems and in the tradeoff between nuclear and oil-fired capacity. The gas-fired and renewable resource facilities make significant contributions to the installed capacity, but the principal components of the system remain oil-fired or nuclear.

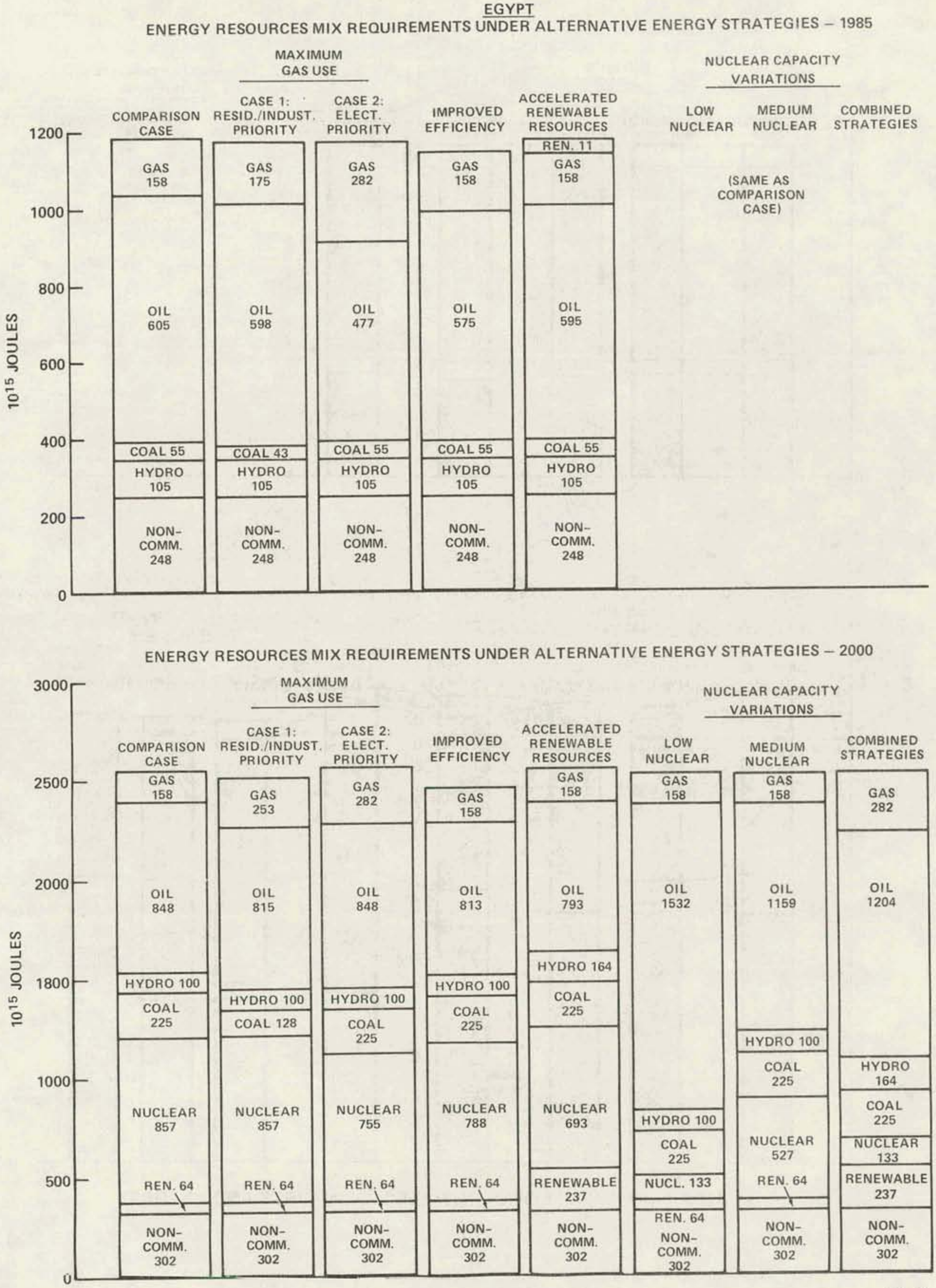


FIGURE 2.6-1 RESOURCE REQUIREMENTS FOR STRATEGIES

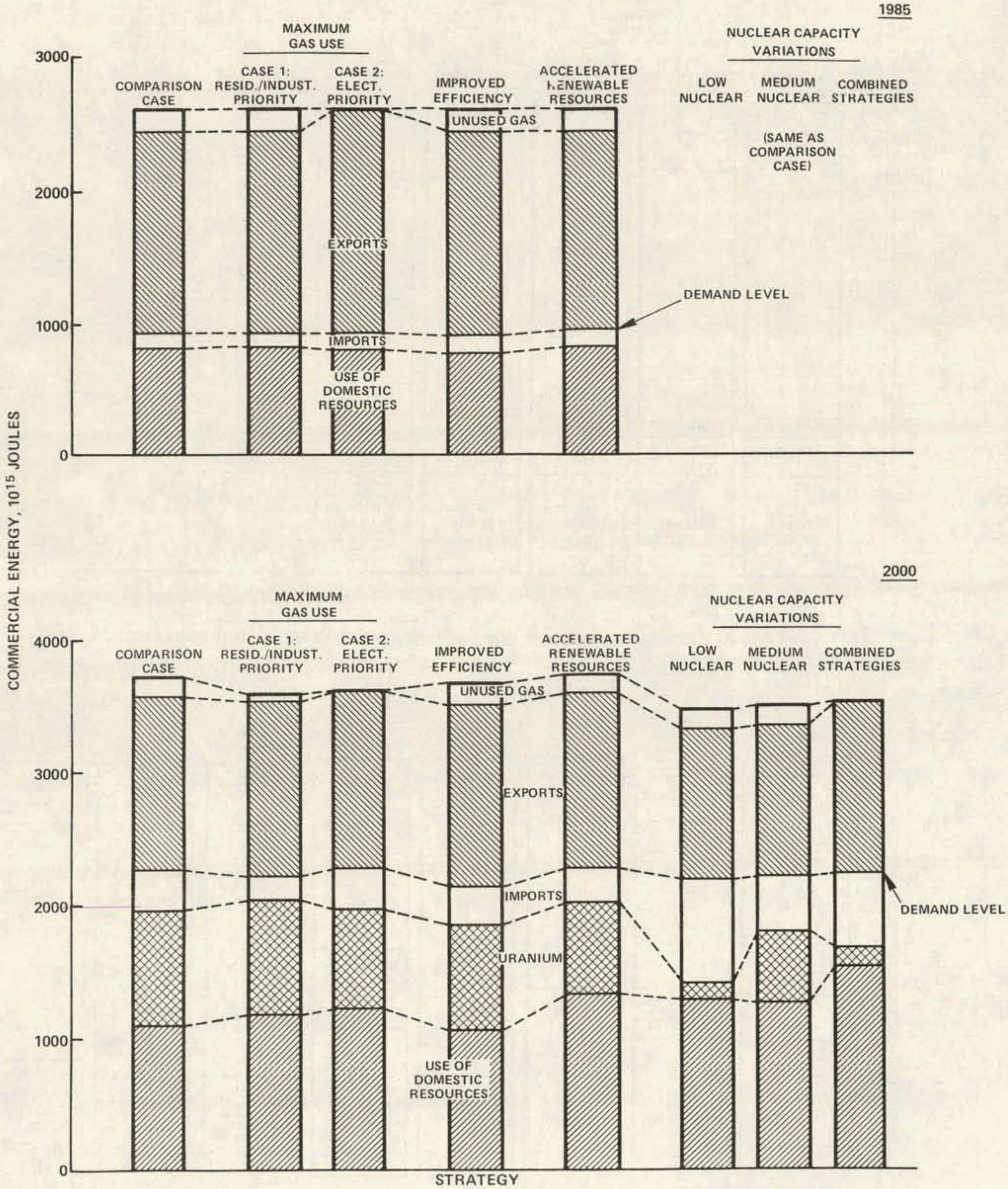


FIGURE 2.6-2 IMPACT OF STRATEGIES ON IMPORTS AND EXPORTS

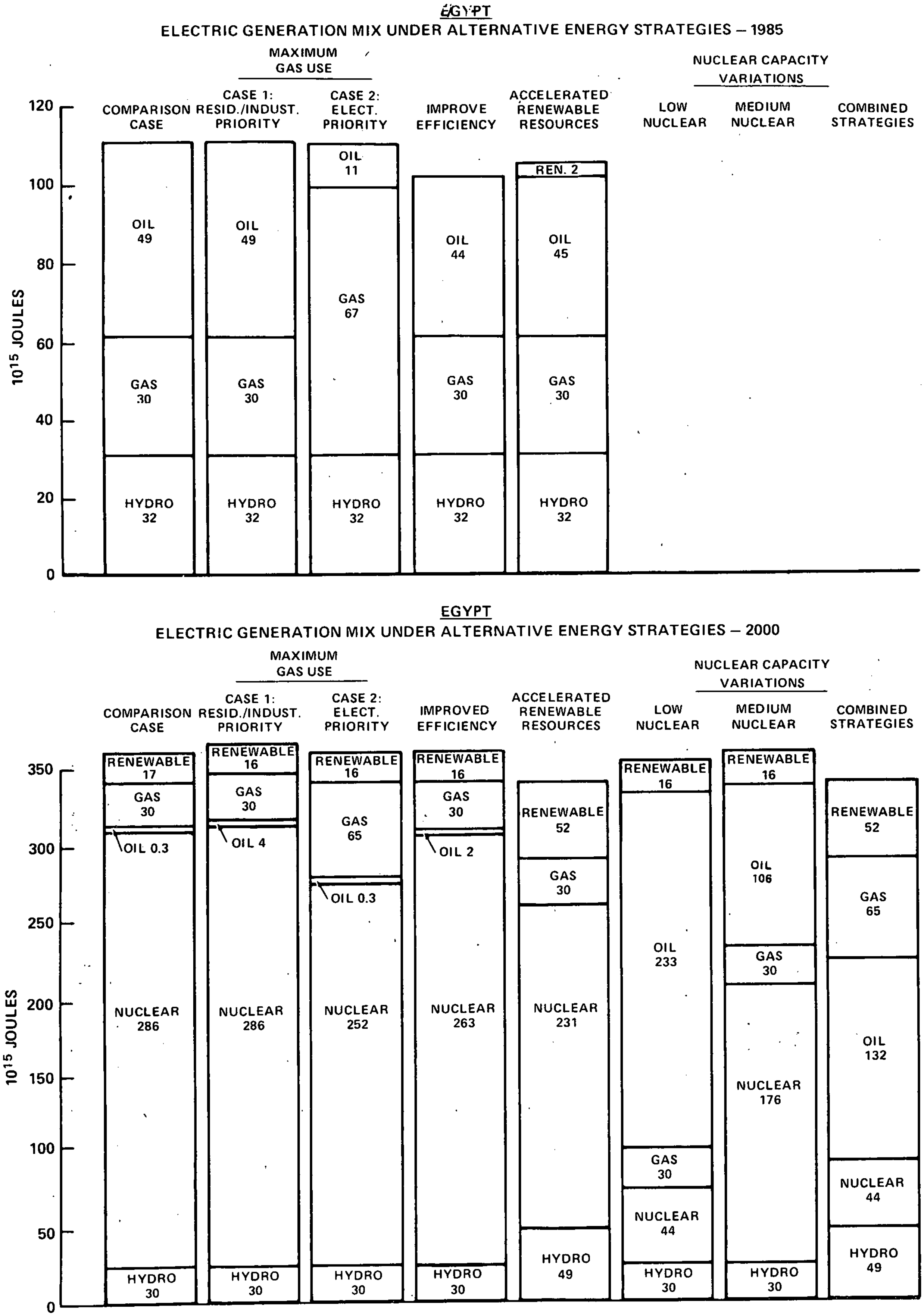


FIGURE 2.6-3 IMPACT OF STRATEGIES ON ELECTRICITY GENERATION

2.6.3 Results of strategy evaluations - cost and resource needs: This section describes the cost, equipment and manpower requirements for construction and operations and maintenance of commercial energy supply facilities for the different strategies. The "end-effect distortions" capital requirements (as discussed in Section 2.5.1) are reflected in this information, but they are also listed separately in Table 2.6-2.

There is little difference in the energy supply levels between the several strategies in 1985 because the interval 1978-1985 is short compared to the length of time required to design, construct and begin operation of a large energy supply facility of any type. As a result, the resource requirements presentations focus entirely on cumulative requirements to the year 2000 or on annual costs in 2000.

Table 2.6-2 summarizes cost and manpower requirements for four of the seven strategies. (Tables F.16 through F.19 found in Appendix F provide a next level of detail on these aggregate cost, equipment and manpower requirements). Annex 13 is the ESPM computer printouts which details energy supply and transport facility capital costs. Annual fuel and annual O&M costs in the year 2000 are displayed in Table 2.6-2 to indicate the impacts of greater reliance on oil, nuclear or solar energy systems. Cumulative capital investment requirements include investment for facilities that would come into operation after the year 2000. The entry "cumulative capital end effects" then indicates the amount of investment that has been included for these "post-2000" facilities. "Cumulative Capital for Imports" indicates the international financing requirements, based upon the imported/domestic ratios used in the Energy Supply Planning Model (ESPM) and the 30 percent average imported/domestic ratio that was assumed for the solar heat and solar electric applications. Total annual manpower requirements for the year 2000 are shown to indicate relative manpower requirements.

Nuclear has the greatest impact on end-effect capital commitments due to the high capital cost of these facilities and the long construction lead time involved. For those strategies involving a low initial nuclear capacity, and using residual fuel oil in oil-fired plants, there is a significant end effect due to the need to start construction of nuclear power plants prior to 2000 in order to provide for increases in electricity demand that will occur after 2000 and cannot be met with additional oil-fired plants due to lack of an assured domestic fuel supply.

Figure 2.6-4 displays the distribution of the cumulative capital costs to the year 2000 between the major energy supply elements; i.e., fossil, hydroelectric, nuclear, solar and transmission and distribution (T & D). For this sectoral assignment of capital costs, the fossil sector includes costs for oil and gas exploration, field development and production facilities, oil refineries and gas treatment facilities, pipelines, tankers, trucks and barges, and oil-fired electric generation plants. T & D is limited to facilities for transmission and distribution of electricity.

Figure 2.6-5 shows the annual construction expenditures for the four selected strategies; Comparison Case, accelerated renewable resources, medium nuclear and low nuclear. It shows the relative trends of capital expenditures as a function of time. The four strategies shown bracket the remaining strategies in all respects.

Figure 2.6-6 presents the total debt by strategy for the years 1985 and 2000. It shows that portion of debt which is in the process of being repaid at that time, compared with that portion which is in grace because facilities are under construction (but not completed) and for which costs are being incurred. This latter part of the total debt provides an indication of the additional debt which will become subject to repayment in the period beyond that directly examined in this assessment. The debt and repayment requirements were calculated using the assumptions and methods discussed in Appendix G.

Figure 2.6-7 shows the costs on both an annual basis for the year 2000 and cumulative to the year 2000 for debt service, operation and maintenance, and fuel. The relative costs of the five strategies previously examined are presented. This figure provides insight into the total and relative distribution of these annual expenses, and particularly identifies differences in fuel costs and O & M costs and their effects upon total strategy costs. It also illustrates the way in which the lack of debt service on facilities under construction (but not yet completed) materially reduces annual expenditure requirements.

TABLE 2.6-2

SUMMARY COMPARISON OF EGYPTIAN STRATEGIES

COSTS (LE 000,000) AND MANPOWER

	COMPARISON	CASE 2 MAXIMUM GAS USE	IMPROVED EFFICIENCY	ACCELERATED RENEWABLE RESOURCES	NUCLEAR CAPACITY VARIATIONS: MEDIUM NUCLEAR	NUCLEAR CAPACITY VARIATIONS: LOW NUCLEAR	COMBINED STRATEGIES
ANNUAL FUEL COST in YR. 2000	500	500	600	400	700	1,000	900
ANNUAL O & M COST in YR. 2000	300	300	300	400	300	300	300
CUMULATIVE CAPITAL TO 2000	17,600	16,100	16,000	19,200	15,200	14,900	14,800
CUMULATIVE CAPITAL END EFFECT							
Nuclear	3,050	2,100	2,100	2,100	1,700	2,100	300
Total	3,400	2,700	2,700	2,700	2,700	3,200	1,600
CUMULATIVE CAPITAL FOR IMPORTS (TO 2000) (Manpower, Equipment, and Materials)	13,400	12,100	11,900	13,170	11,200	10,800	9,400
ANNUAL MANPOWER NEEDS FOR THE YEAR 2000 (MAN/YEARS)	81,000	72,000	72,000	101,000	72,000	80,000	94,000

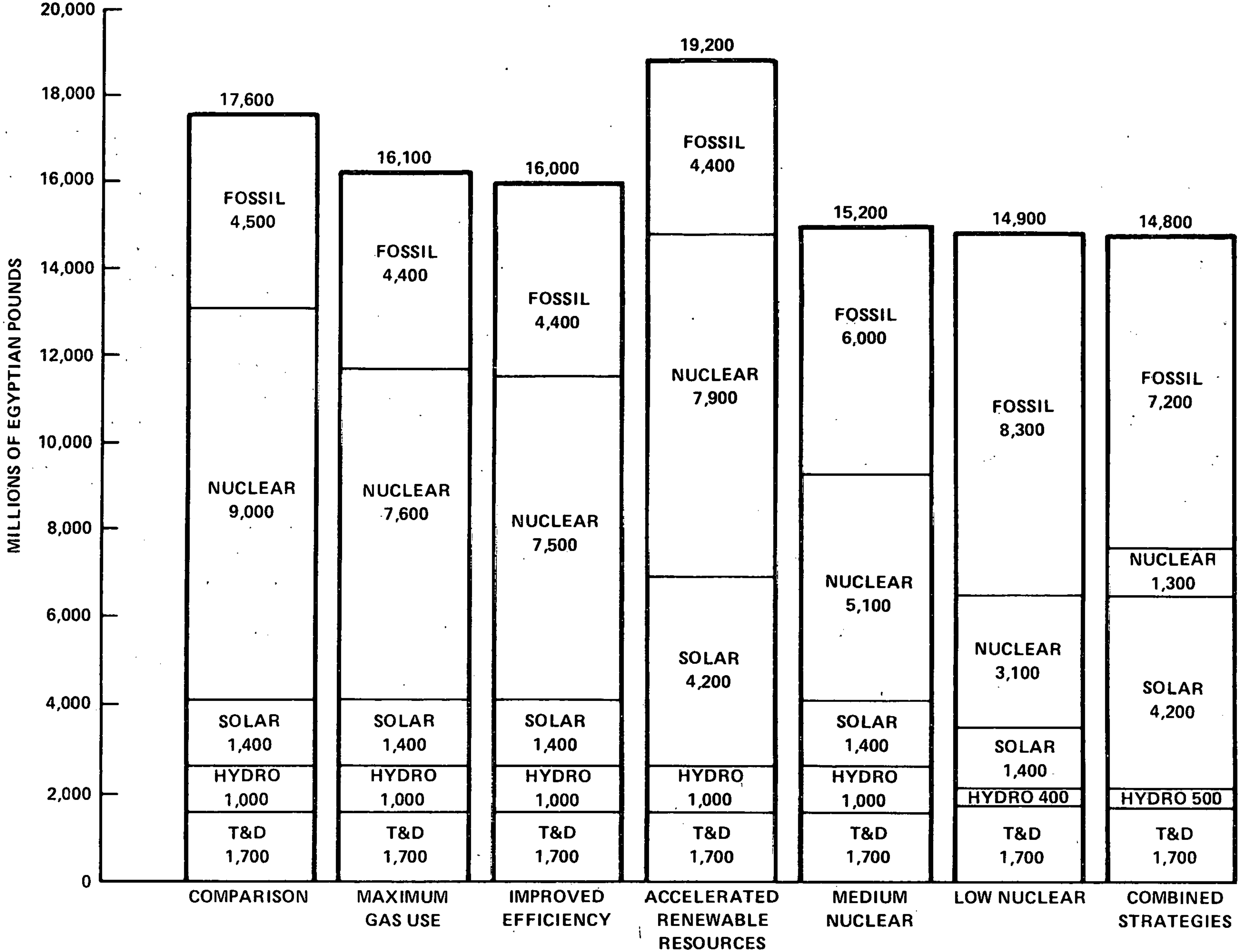


FIGURE 2.6-4 ASSIGNMENT OF CUMULATIVE CAPITAL COSTS BY SUPPLY SECTOR

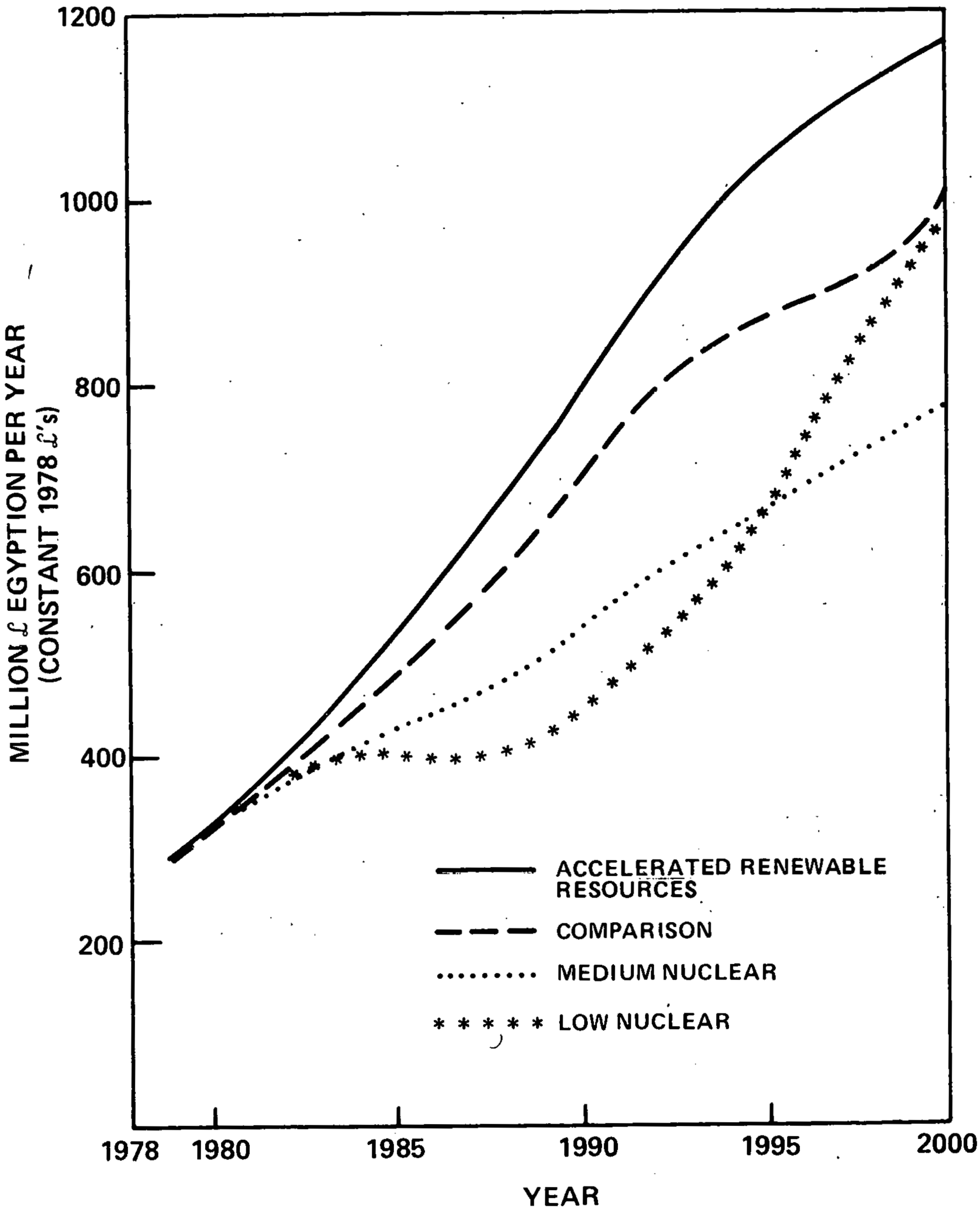
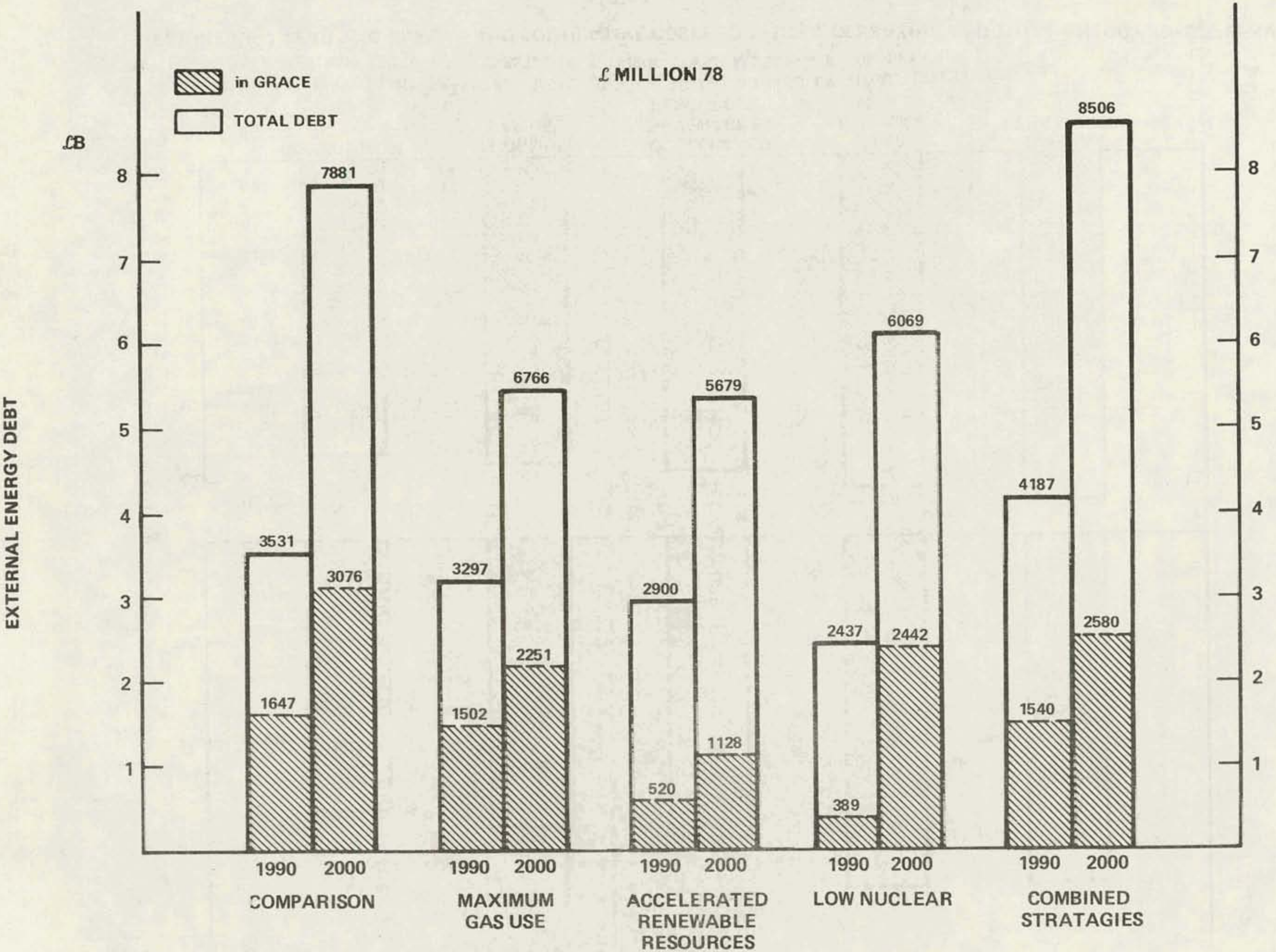
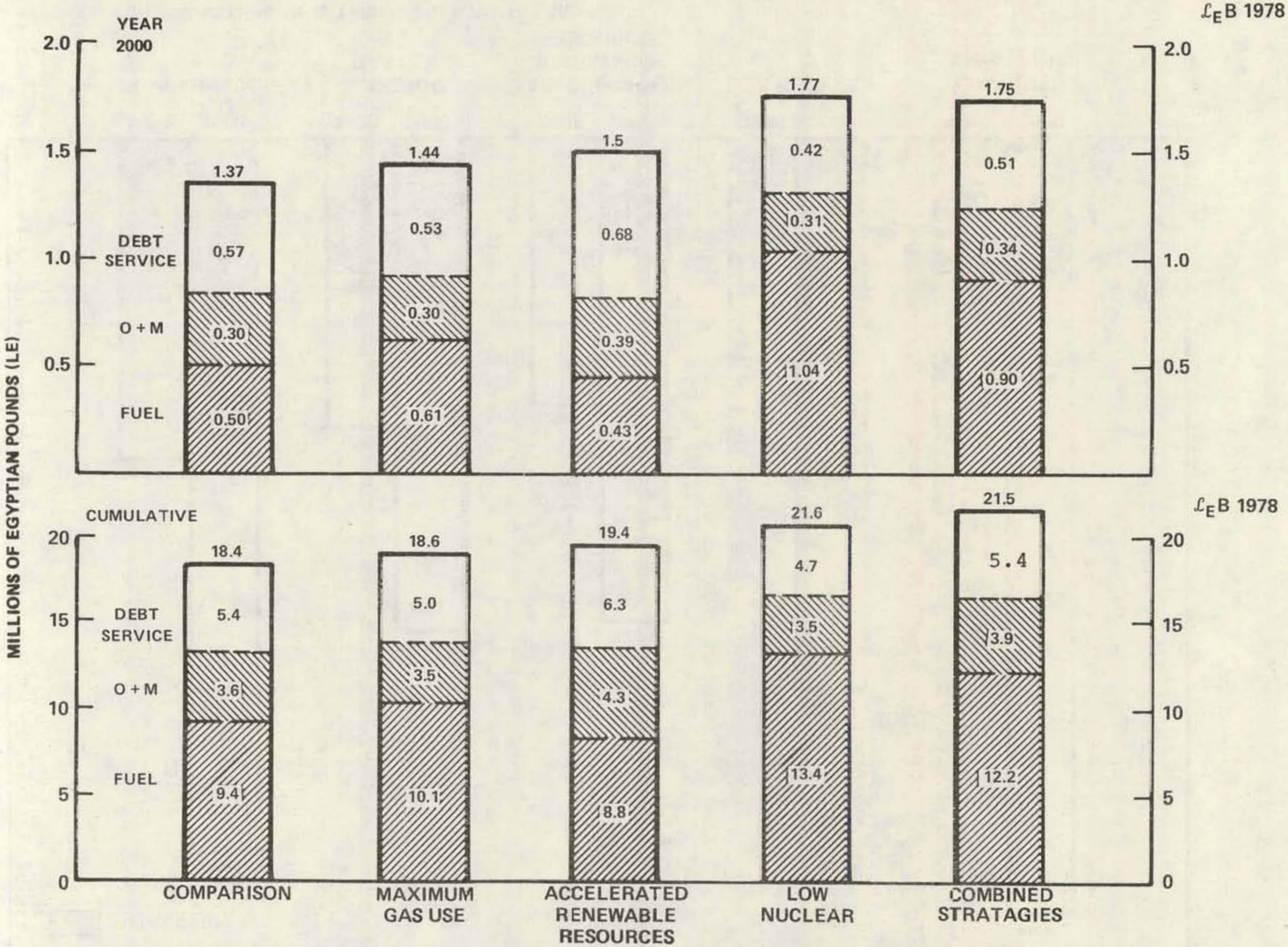


FIGURE 2.6-5 ANNUAL CONSTRUCTION EXPENDITURES



*SEE APPENDIX F FOR ASSUMPTIONS OF EXTERNAL ENERGY DEBT AND GRACE

FIGURE 2.6-6 EXTERNAL ENERGY DEBT IN GRACE TC TOTAL EXTERNAL ENERGY DEBT*



*DEBT SERVICE IN CONSTANT LE 1978. DEBT SERVICE IS CALCULATED ON TOTAL INVESTMENT COSTS AS A MINIMUM PROXY FOR INVESTMENT RETURNS. SEE APPENDIX F FOR DETAILS.

FIGURE 2.6-7 YEAR 2000 ANNUAL AND CUMULATIVE COSTS FOR FUELS, OPERATING AND TOTAL ENERGY "DEBT" SERVICE*

3.0 OBSERVATIONS

Section 2 of this report has presented the factual results of the cooperative analysis. However, much of the value of the analysis lies not in the numerical results, but rather in some basic messages that can be derived from the analysis. Because of the initial and limited scope of the assessment, these messages are termed "observations", rather than "conclusions" or "recommendations."

Although some observations about specific strategies were included in the previous section, the following observations attempt to adopt a broader perspective in order to draw from the analysis those messages which are important to the policy and management levels of government planning. Observations are presented on the following topics:

- Energy demand
- Energy supply capabilities including:
    - Basic resources
    - Fuels production and use
    - Electricity supply
    - Solar heating
    - Noncommercial fuels
- Absorptive capacity including:
    - Finance
    - Manpower
- Energy system planning and analysis

3.1 Energy Demand

1. The rate of growth in the use of commercial energy calculated from the energy demand projection provided by Egypt is 6 percent per year over the period 1975 to 2000. This is not a major break with the historical growth rate in commercial energy use by Egypt if one discounts the major perturbations in energy demand of the 1964 to 1971 period and considers the rapid growth in the 1971 to 1974 period a recovery from that perturbation (reference Figure 2.4-7). The use of non-commercial energy (e.g., crop residues, wood and animal dung) is estimated to grow at a significantly lower rate (1.36 percent per year) in general proportion to the availability of crop residues. It would appear that the projected rate of increase in the use of commercial energy could support a low to moderate rate of growth of gross domestic product (4.8 percent to 5.6 percent per year) over the 1975 to 2000 period if Egypt's income elasticity of energy demand is in the range of 1.0 to 1.15 (reference Appendix G, Figure G-2). Historically, middle income countries in Africa and West Asia have experienced income elasticities of energy demand in the range of 1.3. If this were to apply to Egypt, this would imply that the projected energy demand used in this analysis could only support a growth rate in gross domestic product in the range of 4.5 percent per year.

2 With Egypt's projected high rate of population growth, the projected energy demand which was provided for this assessment would appear to be able to support only a two-fold increase in per capita income over the period 1975 to 2000 (reference Appendix G Table G-3). Even the high rate of economic growth examined in the parametric analysis of Appendix G, Section 3 would not achieve a three-fold increase in per capita income, yet that higher rate of economic growth appears to be clearly unsupportable by the projected increase in energy demand used for this assessment (reference Appendix G Figure G-2).

3. Consumption of electricity is projected to increase at the rate of 9.9 percent/year over the period 1975 to 2000, with a rapid growth rate of 12.7 percent/year over the period 1975 to 1985. In comparison, the growth rate in the direct use of commercial fuels, (including feedstocks) is 5.3 percent/year over the period 1975 to 2000, with the rate between 1975 and 1985 being 5.9 percent/year, and the rate from 1985 to 2000 being 4.9 percent/year. With these relative growth rates, consumption of electricity by the year 2000 will be about 22 percent of total commercial energy consumption. This ratio of electricity consumption to total commercial energy consumption is considerably higher than that of developed countries, such as the U.S. and France, as well as that of most developing countries with a wide range of GDP/capita (reference Appendix C, Figure C-5).

When attempts were made to reconcile the projected electricity use and direct fuel consumption in individual industries, it appeared there were inconsistencies in the underlying assumptions of the separately prepared electricity and fuels demand projections. On the other hand the electricity and fuels demand projections could validly reflect Egypt's current economic, industry and energy planning.

Egypt's planners believe a relatively high use of electric energy could well be an appropriate basis of planning for Egypt. Nonetheless, since electricity is a highly capital intensive form of energy supply, examination might be warranted of measures available to reduce this high ratio of electricity demand to direct fuels demand. Industrial sector planning would appear to offer a major opportunity for such reductions. Possible measures to achieve this within the industrial sector include:

- greater emphasis of aluminum and steel forming and finishing activities in place of the processing of ores to metal ingots;

- greater use of natural and associated gas-based fertilizer production processes in place of the water electrolysis process;

- greater emphasis of service activities, (e.g., tourism, regional distribution and marketing, equipment maintenance and repair) in place of basic metal industries as the foundation for industrial sector expansion plans; and

- o greater emphasis of agro-industrial activities (e.g., food processing, flowers, vegetable and fruit products preparation, transportation and marketing; textiles weaving and clothing manufacture).

The impact of such measures could be significant. To illustrate, if such measures were to increase the use of direct fuels in industry by even a 0.5 percent per year higher growth over the period 1985 to 2000 with a commensurate reduction in industrial electricity demand, this could have significant results in the electricity intensity of final demand in the industrial sector. With this assumption, the ratio of electricity demand to total commercial fuels demand in the industrial sector would decline from about 22 percent down to 17 percent. (This assumes industrial shifts without reduction in the total energy demand by the industry sector.) It could also be the basis of a capital cost savings for electricity supply of about $800 million Egyptian pounds, and an apparent net savings in the cost for the same amount of delivered energy (see Appendix C, Section 3.4). In terms of the ratio of total electricity demand to total commercial energy demand, this would reduce the above noted 22 percent in the year 2000 down to about 19 percent.

4. The preparation of Egypt's economic, industrial and transportation development plans should be based upon expected higher prices for energy than those which currently apply. The cost of new electric generation will be much higher than that of the current generation system. Unless extensive new and easily recoverable oil and gas resources are found, the production cost of these fuels will also increase. A move toward reduced government subsidies of certain commodities would also introduce increases in the price of end-use energy. These potentially substantial price increases can significantly alter the economic analysis of potential development projects which will use large amounts of energy.

5. The degree to which industrial growth targets will be achieved is a critical element in projections of total energy demand. Industrial consumption of energy is projected to grow from 37 percent of total energy use in 1975 to 47 percent in 1985 and 53 percent in 2000. Even small changes in the 1975 to 2000 period's projected 7.6 percent industrial energy growth rate will have a marked effect on total energy demand and the requirement for new energy supply facilities. For example, a decline of one-half percent in this growth of industrial energy demand will decrease total commercial energy demand in the year 2000 by 7 percent, an amount equal to almost one-quarter of all present commercial energy demands. A major reason for this higher relative rate of growth of energy demand by the industrial sector is the emphasis given in current industrial expansion plans to energy-intensive industries. If the development objectives of Egypt permitted greater emphasis on less energy-intensive industrial and service activities, it is possible that a comparable increase of industrial sector product could be achieved with substantially less energy.

6. The extent of reductions in energy demand indicated as possible under an "increased energy use efficiency" strategy is only about 4 percent. This is considerably lower than that achieved by conservation measures that have been applied in the U.S. and other industrialized countries. To understand this low indicated savings of energy, it is important to keep the following in mind.

- The improved efficiency strategy examined means by which the efficiency of the use of energy could be increased; it did not examine all measures by which the use of energy could be reduced or eliminated.

- The total level of activity in each economic sector remained unchanged between the Comparison and increased efficiency strategies. For example, the total tons of steel or aluminum produced was kept unchanged. Similarly, the total transportation activity level was unchanged except for some minor adjustments to reflect feedback of customer reaction to transport quality or price.

- Due to the limited availability of quality data on the actual consumption of fuels and electricity by existing industrial plants, "textbook process efficiencies", assuming good practice of those processes, were applied in the examination of different industrial processes or transport modes. This eliminates a major area of potential energy savings due to poor practices in the actual operation of these processes.

- No significant energy savings were assumed to be available in the areas of space heating and cooling, hot water heating and electric appliance efficiencies.

7. In the Comparison Case, the projected energy demand for the transportation sector represents a change from recent trends in the growth and utilization of alternative transport modes. Greater utilization will need to be made of the more energy efficient modes of travel (e.g., railroads, waterways, buses and urban mass transit systems) if the fuels demand projected for the transportation sector in 1985 and 2000 is not to be exceeded. Achievement of these shifts toward more energy efficient transportation modes will require major capital investments in railroad, waterway and urban mass transit systems to expand the network and improve the quality of these transport systems. Although further transport energy savings beyond that of the Comparison Case can be postulated, their achievement would require system expansions and social/cultural changes which would be exceedingly difficult to achieve over the 1980 to 2000 period.

8. As Egypt is still in the early stages of economic development, its Government faces a unique opportunity to direct efforts toward the development of a more sound, effective and efficient transportation system. This assessment has discovered only limited amounts of

preliminary regional and national transportation planning to date. Extensive and integrated planning of the entire transportation sector is urgently needed. The second phase transportation planning study which is to be initiated by the Transport Planning Authority in the Fall of 1978 with support of the World Bank will be an important step in this regard. The Transportation Planning Authority's evaluations of future alternative transportation modes should be designed to consider:

- o Egyptian plans to open new lands, accommodate a large share of projected population growth in new cities, and shift the growth of economic activity toward greater dependence on industrial and service activities;
- o the relative energy intensities and other support requirements of different transportation modes (e.g., rails, waterways and roads); and
- o the increased cost of new energy supplies.

Close coordination of transportation, industrial and energy supply sector planning is essential to good planning in all three sectors.

3.2 Energy Supply Capabilities

3.2.1 Basic resources:

1. With the exception of sunlight and certain prevailing wind conditions, Egypt does not appear to be blessed with plenteous energy resources, although there are large regions of the country that remain unexplored. While the potential for oil and gas is encouraging, it also involves large uncertainties as to the extent of reserves that would be available which could be economically extracted. The economically recoverable coal resources in Egypt are limited. The potential for discoveries of oil shale is not promising although very little exploration has been carried out. There are some deposits of carbonaceous (lignitic or coaly) shale from which gas might be recovered but these have also not been extensively evaluated. Geologic conditions for uranium are favorable, but there has been insufficient exploration to support reserve estimates at this time. Effort is required to evaluate the well known uranium occurences. The general geologic potential for low temperature geothermal energy in certain areas of Egypt is good; however, there is no direct evidence to indicate existence of extensive high temperature or vapor sources in continental Egypt that could be used to generate electric energy. Some further exploration for exploitable geothermal sources along the Red Sea axial trough appears to be warranted.

2. Egypt has excellent conditions for the application of solar energy technologies; northern regions receive about 3000 hours per year of sunlight, and southern regions receive in excess of 4000 hours per year. (To place this in context, northern Egypt receives 12.5

percent more insolation than Albuquerque, New Mexico, and southern Egypt 70 percent more.) There are also areas along the Mediterranean Sea and Red Sea coasts that experience wind velocities of 16 km/hr or more about 75 percent of the time.

3. The water consumption requirements of energy developments along the Nile River is relatively small (less than 1 percent) in comparison with agriculture and domestic/industrial withdrawals. In the Western Desert, some balancing of water use between agricultural development of new lands and energy production might be required, although use of brackish waters for energy production might ease the need for this. Water resources of the Eastern Desert and Sinai Peninsula are largely unexplored.

4. The best available information indicates that there is only small potential in Egypt for finding substantial concentrated deposits of most energy-related raw materials (i.e., manganese, aluminum, barite, bentonite and copper). Only the raw materials for cement/concrete are classified as abundant. Current iron ore reserves at Bahariya are good for approximately 40 years at accelerated production rates, but these rates would not be adequate to meet the iron ore requirements for Egypt's projected steel-making capacity. An accelerated level of production of indigenous iron ore may require the exploitation of lower grade ores at increased costs. Known deposits of many other energy-related raw materials have not been completely evaluated.

3.2.2 Fuels production and use:

1. Achievement of the 1,000,000 barrel per day (bpd) production goal set by the EGPC for 1982 is of great importance to the energy situation in Egypt as it would permit Egypt to be a net exporter of petroleum during the period 1985 to 2000. These petroleum exports will provide a significant portion of the international funds that will be needed for the further expansion of industrial capacity and energy supplies in Egypt.

2. Achieving an oil production level of 1,000,000 barrels per day by 1982 to 1985 depends on many factors including: (a) the time necessary to develop new discoveries, especially those offshore; (b) the intensity of exploration in Egypt by oil companies as part of their world-wide exploration commitments; (c) the degree of understanding of the geology and tectonics of different basins in relation to oil generation and accumulation; and (d) the development and application of new technologies for oil exploration. At present, it is difficult to accurately judge the effect these factors will have upon Egypt's reserves and production capacities. A positive indication has been new discoveries in the Gulf of Suez in 1978. Some negative indications are: (a) recent declines in the ratio of Egypt's reserves to production; (b) a significant decline in exploratory drilling activity in the first quarter of 1978; and (c) the recent relinquishment by major oil companies of large leases in Egypt.

3. There is even greater uncertainty in assessing the capability of Egypt to maintain the target oil production level of 1,000,000 barrels per day over the period 1985 to 2000. To maintain an acceptable reserve and production level, new produceable oil reserves of the order of 8 to 10 billion barrels would need to be found. Even if the Gulf of Suez basin should prove to have twice its presently known reserves of about 2 billion barrels (i.e., reserves in the Gulf of Suez totaling 4 billion barrels), it would be exhausted by about 1994. This suggests that extensive produceable reserves in new petroleum provinces will need to be found. Exploration in such new geologic provinces should be given high priority in Egypt's oil programs. Preparation and publication of regional maps and cross sections that will attract companies to actively explore concessions in the most favorable areas is an important first step toward this objective. Then, local seismic exploration, stratigraphic tests and studies and, perhaps, drilling of exploration wells will follow. Initiation of many of these exploratory steps by the Egyptian General Petroleum Corporation could be required to spur sufficient private oil company participation in the exploration of new oil provinces.

4. Current refinery construction plans indicate the continued need to import butagas and kerosene throughout the period 1975 to 2000. Little can be done about the continuing need to import butagas since Egyptian crude oil contains little butane. Nonetheless, if the target 1,000,000 bpd oil production level is attained, Egypt could remain a net exporter of oil throughout the period.

5. Egyptian refinery planning appears to be consistent with their projected needs. There appears to be no need to modify new refinery design configurations to increase gasoline production. The construction of two additional refineries of the same general configuration in the period 1985 to 2000 appears reasonable. There will be increasing amounts of fuel oil available if the planned shift to nuclear power is implemented. Export of the surplus could result in an improved international balance of trade.

6. While availability of gas associated with oil production is an important factor in energy supply planning, there are also significant uncertainties. Associated gas production is usually higher during early phases of field exploitation, and the production of associated gas from existing fields would decline as oil production declines. Also, there is no assurance that associated gas will be present in new oil fields in the quantities necessary to justify the capital expenditures needed to collect and process it. It appears that the more promising potential is to find new fields of non-associated (natural) gas. The high cost of gas collection, processing and transport systems will also be critical to the ability of Egypt to develop and utilize new natural gas fields. The Egyptian government may have to participate actively in the development of new fields to expedite the availability of natural gas.

7. Even if a gathering system is installed in those oil fields with significant associated gas production, decisions will be needed as to how the gas would be used most effectively. Currently it is used in recirculation for gas lift of crude oil. In existing oil fields, it is judged to be uneconomic to reinject the associated gas into the gas cap for pressure maintenance. To permit the use of this gas for other purposes, an extensive capital investment is involved to collect the gas, bring it to a central processing plant to separate liquids and transport the dry gas to users by pipeline.

8. Egypt's current priority for use of natural and associated gases is: (a) industrial processes; (b) domestic residences; and (c) electric generation. Use of gas at high consumption industrial or power generation installations avoids the need for extensive and long-lead-time investments in local distribution systems. Such use also presents significantly fewer safety problems. Because of the long lead time involved in the financing and construction of large fertilizer or other industrial installations based on the availability of gas energy, the initial high consumption use of natural and associated gas is expected to be in existing power generation stations and industrial plants. A gradual expansion of the use of gas in domestic residences is planned. As the availability of gas supplies becomes more assured, preparation of plans for industrial expansions based upon use of this high quality fuel merit a high priority.

9. Because of the limited size of the resource and its remote location, the best use of the Maghara coal is likely to be as blend coal with imported coking coal for chemical feedstocks to the iron and steel industry. Alternative uses could include power plants, steam raising, cement kiln heating, gas works in Cairo and Alexandria and extracting lead and zinc from Red Sea coastal ores. These were not evaluated here because they are small demand options.

10. Although little exploration has been conducted, the known deposits of oil shale are of such character that they may never be economic. The use of carbonaceous (lignite or coaly) shale needs to be evaluated on an economic basis, comparing it to the use of gas.

3.2.3 Electric supply capabilities:

1. Further expansions of hydroelectric energy generation in Egypt are limited to about 8 to 14 quadrillion joules on the Nile River and up to 18 quadrillion joules if the Qatarra Depression project were completed for initial operation in the year 2000. This is at best 5 percent of the 363 quadrillion joules of electric energy which are projected to be required in the Comparison Case by 2000. Even with these additions, hydro-electric systems will be able to supply only about 49 quadrillion joules or 13 percent of the electric energy projected to be needed in the year 2000.

2. There are several promising sites for the addition of pumped storage electric generation capacity. While these can be advantageous in meeting peak capacity demands, some loss of electric energy will occur in the pumping process (about 11 quadrillion joules in the Comparison Case in the year 2000). Pumped storage or other large capacity electricity storage systems will be of increased importance if Egypt makes extensive use of either nuclear or solar/wind electric generation systems.

3. Solar electric generation (including wind, biomass and photovoltaic) might produce about 4 percent (16 quadrillion joules of the total 363 quadrillion joules) of electric energy needs in the Comparison Case by the year 2000. If an accelerated program of solar applications were undertaken by Egypt, solar electric energy generation in the year 2000 might approach 14 percent of total electric energy consumption (52 quadrillion joules). Under this accelerated solar electric strategy, the supply of electric energy produced by nuclear plants could be reduced from 286 quadrillion joules to about 231 quadrillion joules (19 percent). Whether a reduction in installed nuclear capacity might then be possible would depend upon an evaluation of the electric systems which takes into account the random capacity factors of the solar electric generation systems and the availability of electric energy storage capacity. The accelerated application of solar energy assumes successful implementation of a number of actions including the following:

- development and demonstration of solar, wind, and biomass technologies by the U.S. and other countries which significantly lower the cost of producing electric energy with these systems;

- demonstration of the acceptable performance of these systems in Egypt considering such things as sand and dust conditions, reduced maintenance capabilities, etc.;

- modification by the Egyptian government of existing fuel subsidies to keep initial applications of solar technologies in an economically competitive position;

- actions by the Egyptian government to overcome the natural reluctance of government agencies and individuals to select systems with high initial capital cost but lower operating costs;

- the buildup in Egypt of an equipment manufacturing capability adequate to manufacture and assemble large numbers of solar systems (e.g. it is estimated that by 1985, the solar industry would need to employ on the order of 5000 people if the accelerated solar application program is to remain on schedule); and

- o build-up of an infrastructure of technical and corporate capabilities to finance the purchase of solar systems, train people to install, operate and maintain solar systems, and educate the public as to the advantage of solar systems.

In view of the scope and complexity of these several necessary actions, the probability of attaining the above noted projected target for accelerated application of solar systems is low unless the above actions all receive priority commitment of Egypt's management, technical and financial resources.

4. On the basis of this analysis and the data provided by Egypt, it would appear that, through the year 2000, Egypt's demands for commercial energy will, in large measure, be supplied by conventional energy sources using existing technology. The four fuels; oil, gas, coal and uranium, in combination in the Comparison Case will provide over 88 percent of Egypt's energy needs throughout the period to 2000. The hydroelectric energy contribution will remain esssentially constant and will decrease as a percentage of total commercial energy needs from about 17 percent in 1975 to 11 percent in 1985 and 4 percent in 2000. Coal is expected to be used primarily as a feedstock (coke) to the iron and steel industry. Even under favorable assumptions as to an accelerated use of renewable resources, the conventional fuels will provide over 80 percent of Egypt's commercial energy needs in 2000.

5. Without considering an extensive use of imported coal as an energy fuel, the principal fuel interchange that appears to be available is between oil and uranium. Full utilization of the assumed availability of non-associated and associated gas increases the gas contribution to the total energy supply requirement to about 13 percent in 2000. Accelerated programs on renewable energy resources, including hydroelectric, might contribute as much as 18 percent of total supply requirements in 2000. The combination of oil and uranium based systems will need to provide the remainder and be available to make up for any shortfall in the target contributions by gas or the renewable resources. Unless commercially competitive concentrations of uranium can be found and developed by Egypt, the interchange between oil and uranium will also involve an interchange between an indigenous fuel resource and an imported fuel. If the favorable indications of uranium deposits can be confirmed and developed, this import/export consideration in the fuel interchange would be reduced but not eliminated due to the continuing extensive dependence of Egypt upon foreign countries for nuclear fuel processing and manufacturing services.

6. Feasible strategies that are directed at further reductions in the level of nuclear generation capacity can be postulated. However, they introduce significant potential costs in terms of:

- o increased reliance upon a fuel source of uncertain reserves and production capability;

- increased consumption of oil, with a corresponding reduction in oil exports and resultant adverse impacts on the Egyptian international trade balance;

- increased consumption of natural gas for electricity generation; and

- the prospect of constructing oil-fired generation capacity that would operate at very reduced capacity factors over a significant portion of its economic life, because it became necessary to allocate available fuel oil supplies to higher priority uses.

7. If Egypt attains and maintains the oil production target of 1,000,000 bpd, residual oil would be available to fuel oil-fired electrical generation capacity in amounts sufficient to avoid the need for nuclear generating capacity at levels above approximately 1900 MWe. However, if the Egyptian economy continues to expand after the year 2000, the oil necessary for the continued operation of these plants would need to come from increased oil production at levels above the 1,000,000 barrels per day target or increased oil imports. Alternatively, the use of these oil-fired plants could be reduced and accelerated construction started on alternative energy systems, either solar or nuclear. (The factors influencing the ability to achieve 1,000,000 barrels per day of oil production have already been discussed.)

8. In view of the potential shortage of fuel for oil-fired plants in the post-2000 period and the need to begin moving in the direction of reducing consumption of oil for electricity generation, consideration should be given to the use of combined-cycle-combustion-turbine plants for those oil-fired plants beginning operations in the 1990 period. In comparison with oil-fired steam boiler power plants, the combined-cycle plant concept might reduce capital investment requirements and increase operational flexibility.

3.2.4 Solar heating: Solar heating applications to provide hot water for cleaning and cooking could substitute for a significant portion of the petroleum products, butagas and kerosene, used in the urban and rural residential subsectors. (These amount to 60 JQ out of a total residential sector demand for energy of 131 JQ.) Since much of the butagas is imported, there is an increased incentive to reduce its demand. Manufacture, installation and operation of solar hot water systems do not require a large percentage of highly specialized management and technical skills. The relatively labor intensive nature of such systems should, therefore, be viewed as offering meaningful employment opportunities in Egypt.

3.2.5 Noncommercial energy: Greater attention to the role of noncommercial energy forms (i.e., crop residues, animal wastes and wood) in Egyptian energy supply capabilities is warranted. The U.S. team estimates (no Egyptian estimates were available) indicate that noncommercial energy forms provided over one-third of the total energy consumed in Egypt in 1975, (216 quadrillion joules of a total of 561) and that use of noncommercial energy could grow to about 300 quadrillion joules by 2000. If these estimates prove valid, noncommercial energy would still be supplying about 12 percent of Egypt's total energy resources in the year 2000. During the period to 2000, commercial energy will gradually substitute for noncommercial energy use in rural residences. (Noncommercial energy grows from 216.5 quadrillion joules to 301.5 quadrillion joules or 1.33 percent/year. Commercial energy use in rural residences grows from 30.82 quadrillion joules to 128.17 quadrillion joules or 5.87 percent/ year.)

3.3 Observations Financial/Economic

3.3.1 Macro economic and energy investment:

1. Energy investment costs are very high over the period and are likely to consume a growing proportion of total Egyptian investment over time. This analysis indicates that the required annual energy supply investments will grow from approximately 320 million Egyptian pounds per year in 1978 to about 560 million pounds per year in 1985, 800 million pounds per year in 1990 and almost 1400 million pounds per year in 2000. (These estimates are in constant 1978 Egyptian pounds and include direct and owners' costs for energy supply facilities, including solar and energy transport facilities.) With these estimated levels of required annual investments, it is quite possible that energy expansion will consume a considerably higher proportion of Egypt's total investments than it did during the peak of the High Aswan Dam construction period. As noted in Section 2.5, there is considerable uncertainty in these estimates of required investments with the prospect being that the investments estimated to be needed for oil and gas exploration and development might be considerably higher. Further details on the analysis of financing requirements are presented in Appendix F.

2. For low growth rates of the Egyptian economy, the energy expansion program is likely to be competing for and winning funds needed for the development of other sectors of the economy. Better integration of economic and energy supply sector planning is needed to assure that energy sector planning is financially compatible with plans for overall development of Egypt's economy.

3. Electricity expansion, particularly through nuclear and solar installations, shifts to even more highly capital-intensive projects than has been observed in past Egyptian electrical expansions.

In the period after 1990 when such expansion is most likely, their investment requirements will accelerate the already rising proportion of total Egyptian investment that will be necessitated by the projected high rate of growth of electricity demand.

4. At the same time, it should be recognized that energy investment programs will help spur Egyptian economic expansion, both from the large amounts of funds injected in the economy and from the increase in the country's productive potential. However, the concomitant risk of a high rate of expansion is that the economy could be vulnerable to downward economic accelerations created by investment declines from internal or external economic conditions, or from declines in availability of financing for large programs such as the energy supply facilities expansion.

3.3.2 Debt service:

1. Despite the size of the energy debt, interest and repayments as a percentage of total debt remain low through the year 2000 due to the long construction times for nuclear and pumped storage projects and to the grace period for interest and principal repayment during construction (40 percent of the energy supply debt may be in grace in the year 2000). A shift to a less capital-intensive energy supply expansion may not significantly affect this debt service requirement in 2000 because of concurrent changes that would occur in the construction times and grace periods of the alternative supply systems.

2. The absolute level of debt service for energy investments could place a severe burden on foreign exchange and the achievement of export and import plans. This is so particularly for the post-1990 period, when debt service for energy supply and energy transport facilities could amount to more than 7 percent of projected total foreign exchange value of projected national exports at that time. (See Appendix F.)

3. The choice of energy strategies could substantively affect foreign exchange requirements for Egypt, from the effect of total borrowing, from the construction time and grace period, and from the choice of fuel types.

3.3.3 Sources of financing:

1. The supply of external funds for energy development cannot be viewed at this time as a direct constraint on an energy expansion program. However, this view is founded in the expectation of future economic growth and reforms that would adequately justify the financing of specific energy supply projects on the basis of adequate economic returns.

2. Now and in the recent past, a major constraint to investment has been the lack of domestic savings. Success of the measures that have been proposed to increase the level of domestic savings in Egypt could be crucial both to financing the construction of energy supply facilities and to developing the industrial capacity to use this energy.

3.3.4 Economic and industrial planning structure to effectively use and pay for the energy investments:

1. In the past, a number of industrial investments in Egypt were predicated on the availability of cheap energy. Since energy has become an important cost and investment element in industrial expansion, Egypt's industrial plans warrant reexamination taking into account the delivered cost of energy and the resources required to expand energy supply capabilities.

2. Energy tariffs and industrial pricing are embedded in industrial planning decisions. The Egyptian system of subsidized prices for energy and energy imports can, in the absence of careful national direction, produce planning decisions at variance with national objectives. Given the increased levels of borrowing over longer periods that will be required by proposed energy projects, the revenues from the sale of energy should fully reflect current capital and fuel costs. These revenues should also be promptly available if cash flow difficulties and problems in acquiring future energy investment are to be avoided.

3.3.5 Egypt's capacity to absorb the energy investments: Egypt's ability to successfully undertake a large scale energy development program is only a part of the larger issue of Egypt's capacity to effectively generate and utilize large investments in general economic development. Egypt has considerable potential to continue its development into a modern industrial state, but problems of manpower, infrastructure planning and organization, domestic saving and physical resource mobilization must continue to be addresed. The rapid energy expansion could severely tax each of these areas.

3.3.6 Other absorptive capacity factors:

1. The ability to assure adequate manpower capabilities is a critical element in Egypt's ability to expand its energy supply capability and achieve its other development objectives. It is a complex issue which includes:

- o the availability of technically trained people;
- o an improved management capability at all levels which can effectively apply the manpower available to the timely production of a quality product;

- the retention of skilled managers, professionals and master-level trades and craft personnel who can install a pride of performance in a job well done;

- a reinstitution of adequate wages combined with improved standards for job performance; and

- the overcoming of certain social/cultural standards as to the acceptability of certain types of jobs.

2. Egypt has an ample cadre of theoretically trained scientific, engineering and other technical personnel. Urgently needed are personnel who are oriented toward practical applications of available technologies, the effective planning and implementation of major projects, the manufacture and timely delivery of equipment and materials and the safe, reliable and well-maintained operation of major energy systems. In this sense, greater emphasis needs to be given in Egypt's training programs to short-term (3-6 month) applications and technician type courses followed by on-the-job training in the application of course lessons. This should be followed by work assignments on technology applications projects in Egypt. Training of this type should be directed toward administration, craft and technician levels, as well as management and engineering levels.

3. There are significant differences in alternative energy supply systems in terms of their requirements for foreign equipment and expatriate labor. Both nuclear and solar systems in their initial applications could involve a major portion of the high technology equipment and technical/engineering labor to be imported. The technology and manufacturing and assembly standards of nuclear plant equipment and construction is such that even by 2000, much of the equipment and significant portions of the technical labor could still need to be imported. (Areas where Egypt can expand its participation in nuclear plant supply and construction are addressed in Annex 7-Nuclear.) Solar systems, on the other hand are more amenable to local manufacture and can be less demanding with respect to system construction, operation and maintenance. This fundamental difference could factor importantly in Egypt's planning for the utilization of the alternative energy systems and warrants careful examination in future more in-depth comparative planning evaluations.

3.4 Energy System Planning and Analyses

1. The interrelationship between energy planning and analysis, national economic planning, and individual sectoral planning activities needs to be more fully recognized in the preparation of national and sectoral plans. Adequate energy supply is essential to economic

growth. Construction and operation of energy production and delivery systems are major elements in the economic activity of the nation, and they place heavy demands upon the manpower, equipment and service capabilities of the country. They can also involve substantial foreign trade requirements. Close interactions between energy and other economic sectoral planning activities are essential to effective planning in all areas. The availability and cost of energy has a critical effect on the economic feasibility of various industrial, transport or other sectoral options. Similarly, the projection of economic activity levels, energy consumption and conversion efficiencies are essential to accurate forecasts of energy demand.

2. A major value of the preparation and application of a comprehensive framework for energy planning is its ability to expose inconsistencies and gaps in the planning within various sectors. These inconsistencies and gaps are to be expected. A first step in removing them is to establish a strong planning structure which would:

- assign the lead responsibility and authority for integrated planning activities to a single agency;
- provide for the active participation of the other agencies that may be responsible for planning in individual sectors of the economy;
- include the active involvement of economic, finance and budget agencies in the planning activity; and
- establish a structured process for policy level reviews of the final product.

3. The correlation of energy demand projections with development goals and macroeconomic targets can help place the energy demand projections in context. Macroeconomic analysis should attempt to reflect real planning objectives rather than simply to extend past trends. This is particularly true of developing countries, where development goals can embody a clear break with past trends. Similarly, the classical econometric demand projection tools that are frequently applied in the U.S. and other developed countries are frequently not well suited for long-range planning or are not directly applicable to the planning needs of developing countries. Additional work is needed to develop long-range macroeconomic models which more effectively describe conditions in developing countries.

4. There is a need for the systematic collection of data on energy supply, energy use and economic activity levels for which the energy is used. This should be a continuing process, and it should be

computerized, if possible. As better energy demand and supply data become available, more detailed analyses of possible energy supply and demand substitutions can be developed. If desired, and if the necessary data are available, these methods can produce optimized solutions to specified objective functions.

5. The Energy Supply Planning Model provides estimates for cost, manpower and equipment requirements for energy supply facilities. However, no comparable capability has been developed to estimate those same requirements for energy consumption facilities. As a result, a full and complete presentation of the overall cost, manpower, and equipment requirements for an energy strategy cannot be developed. Moreover, since these demand related resource requirements can range from a few to several times that of the energy supply facilities, this is a significant shortcoming in the current comprehensive energy planning process.

4.0 NEXT STEPS FOR CONTINUATION OF THE ASSESSMENT

The energy assessment described in this joint report is only the first step in the development of a comprehensive evaluation of Egypt's energy capabilities. Through this initial assessment, the groundwork has been laid for conducting more detailed and definitive investigations with a clearer understanding of problem areas that need early attention. This section attempts to outline the next steps that Egypt must take to continue more systematic energy analyses and planning. These steps can be divided into several areas of activity: (1) long-term planning; (2) energy sector planning including development and use of new energy resources and supply capabilities; (3) other economic sector planning; (4) development of analytical methods and data; and (5) near-term infrastructure requirements.

4.1 Long-term Planning

The energy requirements and supply capabilities must be integral elements in establishing needed and achievable economic growth targets. The need for energy will be strongly dependent upon the expected population growth in Egypt, plans to accommodate much of the increasing population in new lands and urban areas and Egypt's objective to employ a much larger part of the population in industrial and service activities. On the other hand, the availability of adequate energy fuels, conversion and delivery capabilities at reasonable cost will significantly influence Egypt's ability to attain these development goals.

Egypt can no longer look to plenteous supplies of inexpensive hydroelectric energy as a basis for its industrial expansion. The increased cost of new energy supplies will figure importantly in Egypt's ability to compete with other countries in international markets. Similarly, Egypt's capability to directly export oil and to engage in other energy-related commerce is expected to be an important factor in its balance of trade. Finally, the construction and operation of the energy supply facilities in and of themselves will be a substantial element of economic activity, both in terms of domestic employment and imported equipment and services.

Accordingly, Egypt needs to re-examine its demographic, economic and other development goals, in order to account for the substantive role that energy must play in the attainment of those goals. The comprehensive assessment of Egyptian capabilities which has been cooperatively carried out has identified certain deficiencies and inconsistencies in energy information and plans. Steps to correct these should be promptly initiated.

Moreover, the high cost of future energy supplies and the lack of abundant mineral resources in Egypt must be fully considered in their plans for industrial transport and urban expansions. It appears that basic changes in the energy consumption pattern of the industrial, service and transportation sectors are possible. However, these could involve major changes from current trends and plans. The implementation of these changes could also involve substantial social and cultural problems and these factors need to be addressed in reexamination or expansion of prior plans.

The current projections of energy production, conversion and transport facilities require manpower, equipment and financial resources to a degree that warrants a careful evaluation of Egypt's ability to fully implement its energy supply plans. Since these same resources will also be required for the expansion of those economic sectors that create the demand for energy, an evaluation of the total required resource capabilities must include more than the energy supply sector alone. This additional resource requirement could be crucial to comprehensive planning but was not able to be addressed in this "energy assessment."

Because the energy supply sector involves major facilities and long construction times, early attention to those long lead-time energy supply facilities is essential to assure the required fuels resources and conversion facilities which will be available as growth in the industry and other economic sectors increase energy demand.

Two other factors that should weigh importantly in Egyptian long-term planning are: (1) the environmental impact of its planned expansion; and (2) the sophisticated technological character of many of the facilities that will be involved, and therefore, the need to reinstitute the concept of high quality products and job performance.

The energy supply system and industrial expansion are two of the most significant contributors to the environmental impacts of development. This study (see Annex 11-Environmental Issues Associated with Egypt's Energy Options) has indicated that there is a lack of information on current environmental quality in Egypt upon which to base an evaluation of the potential environmental impacts of effluents from energy and industrial systems. This baseline information needs to be collected both at the ambient level for public exposure and at the occupational level for worker exposure. Studies of the impact of various environmental contaminants on the health of the Egyptian population also need to be done, as there is some information to indicate that data on health impacts experienced in developed nations may not be applicable in Egypt. The process of establishing health and safety standards appropriate in Egypt needs to be initiated. The environmental institutions in Egypt need to be strengthened and processes for conducting systematic environmental assessments prior to siting new energy and industrial plants need to be established. Also, procedures for monitoring and enforcing realistic standards needs to be put in place.

The development of a strong quality assurance capability is essential to the implementation of a technologically sophisticated energy supply system or a broad scope expansion of Egypt's industrial and service sector. Achievement of higher quality performance is a complex undertaking. It involves all levels of management, from the top manager to the laborer. In the case of Egypt, it also appears to confront basic institutional and social/cultural factors which could make the achievement of success particularly difficult. This makes early attention to quality assurance programs all the more essential. Although a broad range of possible actions can be identified, no single path is clearly optimal. However, quality assurance needs and the measures required to fulfill them merit attention at every stage of the planning and management process in Egypt.

4.2 Energy Sector Planning

The planning of the future energy supply system in Egypt should comprehensively address all potential energy sources. These are discussed in the following sections.

4.2.1 Fossil fuels:

Oil. A better definition of Egyptian oil reserves and their production potential is essential. Comprehensive geological and geophysical data about sedimentary basins needs to be compiled in a systematic fashion. The basin framework of "basement" crystalline rock, overlying sedimentary rock and successively younger rock needs to be constructed. Seismic refraction profiles of Western Desert basins need to be made. Although a substantial amount of data already exists, it has not been systematically reviewed and assembled into a readily usable form. Also, there are new and better techniques for data acquisition and evaluation that need to be applied to this data.

Maps and reports need to be published periodically that would show the geological, structural and stratigraphic correlations to possible source rocks and reservoir rocks of sedimentary basins favorable for the accumulation of oil and gas. This is extremely important to efforts to encourage and guide future exploration and development.

In addition, the optimum mix of crude oil exports and new refinery capacity needs to be studied in the light of both domestic Egyptian requirements and world markets for oil and petroleum products.

Gas. The location, quantity and constitution of non-associated and associated natural gas reserves and the relative merit of alternative uses of current and projected gas production need more thorough evaluation. The evaluation should include: (1) an assessment of current gas reserves, performed separately for non-associated gas and in conjunction with oil exploration activities discussed above for associated gas; (2) an estimate of the duration of continuing gas supplies; (3) relative cost and benefits of collecting and transporting the gas; and (4) an evaluation of alternative uses and markets for the gas.

Coal. The extent and recoverability of coal reserves needs to be reexamined as the ability to acquire new data is renewed. The economics of alternative means of transporting Maghara coal needs to be investigated, and the extent to which the Maghara coal can be blended with imported metallurgical coal needs further evaluation. The potential exploitation of present reserves to generate revenue for further exploration needs to be evaluated.

4.2.2 Hydroelectric power: The potential for the expansion of hydroelectric power appears to be limited, but several issues need resolution. The technical feasibility, costs and benefits of electrifying existing barrages on the Nile and building additional barrages need to be assessed in light of irrigation and channel degradation requirements. This should be done cooperatively by the interested water and energy ministries. A number of sites for pumped storage facilities near the Suez need to be surveyed to determine their development potential. Once their development potential has been clearly established, engineering and cost evaluations need to be carried out to assess the relative merits of these alternative pumped storage sites. The feasibility study on the Qattara Depression project needs to be carefully reviewed in light of the secondary benefits and impacts which are likely to occur. The use of low-head, run-of-the-river hydropower systems that minimize impacts on irrigation requirements should also be investigated, particularly for small-scale village applications.

4.2.3 Nuclear power: Egyptian reserves of uranium and thorium need to be thoroughly appraised, beginning with an evaluation of the indicated deposits at Gebel El Missikat, El Erediya, El Atshan and Qatrani. Egyptian professional and technical personnel will need additional training in the latest field survey and analytical laboratory techniques. Detailed geologic maps of prospect areas need to be prepared.

Egypt should reassess and plan carefully the dependence it intends to place upon the use of nuclear power systems. Important attention must be directed at the resources required and Egypt's capability to provide those resources. Key practicability issues which need to be examined include:

- the execution of international agreements and contracts requisite to establishing the framework for obtaining nuclear power systems;
- obtaining the international financing for the planned use of nuclear systems;
- development of a qualified cadre of senior and middle management personnel to plan and carry out the extensive effort involved in the purchase, siting, construction and safe operation of nuclear power plants; and
- establishing functional quality assurance programs as integral parts of all elements of the Egyptian nuclear applications effort.

Early commitments are needed with respect to each of these areas consonant with the policy level approval of a program for use of nuclear power systems.

A regulatory program to assure safe and environmentally sound siting, design and operation of nuclear power plants needs to be established. Regulatory guides, evaluation criteria, design requirements and design review and safety assessment procedures also need to be prepared for implementation.

4.2.4 Renewable resources - solar and geothermal technology: The availability of solar radiation, wind power and biomass for energy uses should be established more quantitatively through field measurements of these resources carried out in a systematic fashion. In parallel with this more detailed resource assessment, the potential roles of the wide variety of solar system configurations need to be evaluated, taking into account the current status of the several technologies, relative economics, potential for local manufacture and other factors. A technology demonstration program should be conducted to field-test some of the different concepts. Systems that could be tested include solar thermal power units (1-25 kw), photovoltaic power units (0.5-5 kw), small (5-25 kw) and large (100-200 kw) wind tubines and anaerobic digestor systems.

The development of an industrial base for solar water heating systems is of special significance, because of the current availability of proven technology and the wide range of possible applications in Egypt. Organizational structures to manage the development of a solar water heating industry need to be established, and government subsidy and regulation policy alternatives need to be identified. Alternative system configurations need to be evaluated and the demonstration of preferred configurations need to be conducted.

Exploratory programs to determine the availability of geothermal energy sources need to be initiated. These should include heat flow and geotemperature measurements, deep electrical resistivity, seismic refraction, gravity changes and aeromagnetic surveys.

4.2.5 Electrical systems: Three areas in the electrical sector have been identified as having the need for additional evaluation. The improvement in the efficiency and performance of existing thermal generating stations is of considerable importance and early potential benefit. A review of the performance, forced outage rates, maintenance and operational data at all stations need to be conducted to determine the steps needed to improve plant performance. Steps to be evaluated include equipment repair and replacement, operations and maintenance procedures, operator training programs, improved management of plant operations and maintenance, system derating, etc.

There is need to determine the role that combined cycle combustion turbine plants can make to improving overall system efficiency. The possibility of using combined cycle in place of conventional steam turbine plants needs to be evaluated in the light of economics, system planning, load duration projections, reliability requirements and other factors.

The capability of the transmission and distribution (T & D) system to support projected growth and changes in load centers (e.g., new cities and new industrial centers), generator locations (e.g., Mediterranean and Red Sea coasts) and the possibility of integrating small-scale dispersed generators (e.g., solar and wind) into the system need to be evaluated. The feasibility and desirability of increasing the power transfer capability between the High Dam and Cairo need to be evaluated in the light of the potential need to transfer power from Lower to Upper Egypt by the year 2000. The current plans for T & D system expansion should then be adjusted as necessary.

4.3 Other Economic Sector Planning

4.3.1 Industry and services sector: Expansion of the industry and service sector is a keystone of Egypt's development programs. Consumption of energy in the industry and service sector is projected by Egypt to increase from 37 percent of total commercial energy consumption in 1975 to 53 percent in 2000. Energy costs are expected to increase at a faster rate in the future than are other economic costs. Hence, it is imperative that the planning for the industrial and service sectors in Egypt be particularly cognizant of the energy implications of their expansion programs. Based upon this initial assessment, it appears that a comprehensive reexamination of Egypt's plan for expansion of its industry and service sectors is warranted. This reexamination should begin with an assessment of the indigenous availability of those minerals and other resources which would be needed to support prospective expansions of Egypt's industry and service activities. Where indigenous resources are not available, the availability and cost of import materials needs to be assessed. The impact of importing such raw materials upon the ability of Egypt to compete with other international suppliers then needs to be evaluated.

The cost impacts of transporting people, raw materials and manufactured products within Egypt are also important factors in the competitive capability of new industry or service activities. This merits early attenton in the reexamination. Similarly, the cost of energy and its balance-of-trade aspects can materially offset the potential economic competitiveness of prospective industry or service activities as well as their relative attractiveness in terms of Egypt's development goals. The reexamination should balance these three major factors, taking into account policy objectives, regional development goals and the ability to provide the supporting infrastructure that would be required.

Well founded information on current energy consumption patterns of industry in Egypt was not available for this assessment. There is a need for process-specific surveys of energy use in industry to provide the data that planners can use in determining energy implications of future plans.

This first step assessment also identifies specific industrial options that might be considered in more depth. The details of these possibilities are set forth in Appendix F of this report and Annex 5-Industrial/Agricultural Sector Options. They involve process and operational changes in the cement, aluminum, iron and steel, textile, automotive, fertilizer, chemicals and food processing industries. More detailed evaluations of these processes or operational changes are warranted and could lead to both early benefits and changes in Egypt's longer term industry service sector planning.

4.3.2 Transportation sector: .A transportation system plan needs to be prepared that comprehensively addresses the demands that the national and regional development plans will make on the transportation system and the demands that it will make, in turn, on energy supply. The currently planned comprehensive transport planning assessment being initiated with support from the World Bank is an important first step in this regard. This transport system assessment should evaluate optimal energy efficiency, as well as the more traditional factors of people and freight transport needs, relative costs and land requirements, and the effective utilization of different transport modes. Alternative system configurations for intercity and intracity movement need to be evaluated for their energy effectiveness as well as their transport capabilities. The energy efficient railroad, pipeline and waterway systems need to be evaluated in terms of their current use patterns and the potential for higher utilization rates in the future. More specific descriptions of evaluations are set forth in Annex 4-Transportation.

4.3.3 Urban sector: Due to the favorable climatic conditions in Egypt, energy consumption by the residential and commercial sector of Egypt remains at about 18 percent of Egypt's total consumption of commercial energy throughout the 1975 to 2000 period. The gross energy value of fuels used in rural residential and commercial applications do not differ by as large an amount as their relative levels of development would indicate. However, because urban appliances use fuels far more efficiently than those in rural areas (e.g., butagas stove versus wood or crop residue ovens and stoves), the useful energy output from fuels in urban areas is more than double that of rural areas. Per capita energy consumption in the urban sector is projected to double between 1975 and 2000. Most of this increase in energy consumption is in lighting, cooking, washing, and convenience and entertainment appliances.

Some energy savings appear to be available through improved lighting: (e.g. fluorescent versus incandescent) and improved energy efficiency (e.g., transistorized television). However, the potential energy savings and cost/benefits of these approaches to energy savings merit more detailed evaluation before decisions to implement such changes are made.

Solar water heating can substitute significantly for use of butagas and kerosene to heat water for cooking and washing. However, widespread application of some solar systems could face social and cultural limitations. Applications of solar water heating might be most effective in urban areas, where provisions for its use can be provided in new residential structures. This also warrants detailed evaluation.

Effective use of solid and sewage waste for fuels or electric energy generation also appears to merit evaluation. Finally, as new cities are planned, attention should be directed to urban layouts and residential structures which can facilitate these and other energy saving measures.

4.3.4 Agriculture and rural sector: Consumption of commercial energy by the agricultural sector is projected to increase at a rate consistent with overall demand for commercial energy. Therefore, energy consumption by the agriculture sector in 1985 and 2000 remains at about 5 percent of total commercial energy consumption, the same relative level as in 1975. Commercial energy use per person in rural residences is projected to double by 2000. Much of this growth in per capita commercial energy consumption will be used to displace non-commercial energy use by rural residents.

Areas in which energy utilization in the agricultural sector and in rural residences can be significantly modified appear to be limited. The use of energy-intensive chemical fertilizers could be examined to determine the optimum nitrogen/phosphorus ratio for Egyptian soils as well as to identify the most efficient means for producing the appropriate fertilizer. A better understanding of the use of noncommercial fuels in these sectors could point the way to: (1) how use of such energy forms might be made more effective; or (2) how consumption of commercial energy in rural villages could be more accurately projected and effectively planned. Similarly, the introduction of electric energy in rural areas could bring about significant changes in energy consumption patterns. These potential changes warrant closer examination. The use of solar power water pumps to displace animal or gasoline pumps should be demonstrated and, if successful, extended applications of such systems should be planned.

4.4 <u>Analysis Methods And Data</u>

The assessment revealed a number of deficiencies in the availability of data and gaps in the planning that has been conducted to date in Egypt. This section summarizes steps which could be taken to reduce these deficiencies and gaps.

<u>4.4.1 Macro-economic planning models</u>: This initial assessment made no attempt to define and analyze various alternative development strategies or goals which Egypt might consider as a basis for its energy planning. The macroeconomic analysis conducted in the course of the assessment was performed only to attempt to indicate the general context of the energy demand projection provided by Egypt for this assessment. However, as discussed in section 4.1, it is suggested that Egypt conduct a more thorough examination of its near- and long-term development goals and assess their effect upon energy demand. These subsequent analyses should couple the analyses of Egypt's economic planners to energy analysis and planning activities.

Analytic tools exist that address both economic and energy demand for the economic systems of the developed countries. However, it is recognized that many of the features of these analytic models probably are not applicable to developing countries and that new or modified models appropriate to developing countries will probably need to be developed. Before applying either existing or new macro-economic analysis methods to the planning process for Egypt, their capability to address specific Egyptian needs must be ascertained and modifications must be made, as necessary, to achieve an accurate representation of Egypt's economic and energy systems.

4.4.2 Integrated energy supply/demand analysis: The scope of this first assessment allowed the use of a simplified energy supply/demand network structure. No optimization with respect to costs, energy efficiency, foreign exchange requirements or other objective functions was attempted. Similarly, regional transfers of energy commodities were identified only to the extent of projecting Egypt's oil and coal imports and oil export capabilities. An examination of energy commodity transfers between Egypt and other mid-East or European countries might identify mutually beneficial commodity interchanges. These more complex energy analysis and planning steps merit inclusion in a comprehensive planning process.

Analysis tools which are available can probably be applied to these more comprehensive analysis and planning evaluations with some modification of their existing capabilities. The availability of appropriate data will probably be more of a limit on the utilization of these analytic methods to Egypt's planning.

The Energy Supply Planning Model used to estimate costs of energy facilities and related manpower equipment requirements needs additional work to permit it to more accurately reflect Egyptian conditions. Adjustments to the model that considers different construction practices (e.g., wider use of reinforced concrete instead of structural steel as in U.S. practice), differences in project labor efficiency and variations in construction and operational practices need to be made.

As has been noted, no attempt was made to estimate the cost and resource requirements that are involved in the facilities and equipment that create the energy demand. This information will be needed if a complete picture of the impacts and requirements of any strategy is to be comprehensively portrayed. However, it should be recognized that a complete cost and resource estimate for energy demand requirements would be a massive undertaking.

4.4.3 Data: Some of the more significant data gaps have already been addressed in earlier sections. In addition to these, data on energy demand that is coordinated and validated with the information from the sectoral planning activities needs to be assembled. This lack of "bottom-up" energy demand projections is one of the major uncertainties of this first assessment. Availability of better data of energy consumption patterns could result in significant improvements of Egypt's energy planning. Data on end use efficiency (i.e., the efficiency at which energy is converted into useful work) were not available. As a result, the analysis stopped short of detailed investigations of fuel substitution possibilities. Fuel utilization was carried only to the point of energy input into the end-use device. An optimal subsequent assessment should be based upon data on the efficiencies of end-use devices, their relative application in each activity, and through that process, the energy intensity of each activity in each economic sector. If such data is to be available, early action is needed to define the needed data, establish a system for its collection and assembly, and assign responsibilities for both data collection, assembly and storage.

4.4.4 Project Evaluation Factors: One principal end product of an effective energy planning process is better decisions on specific proposed energy demand programs or supply facility projects. In this context, more effort is needed to specify the criteria which should apply to the evaluation of alternative projects. Preparation of such criteria should be done in a systematic fashion and made a regular part of the decision-making process. They should draw upon every facet of the energy planning process. Conflicts in the achievements of different development goals should be fully defined. The interrelationships of the project being evaluated with other projects should be fully understood and accounted for. Issues of technical state-of-the-art, environmental impacts, social and cultural considerations, and schedule and lead time requirements need to be assembled and reviewed for mutual agreement. The cost and resource requirements of the projects and the measures needed to provide for them should be clearly delineated.

Evaluation criteria which embody all of these factors should be prepared for each major project to be considered. Before their application, the criteria should be reviewed and approved at policy and management levels to assure that they properly reflect current national policies and objectives.

4.5 Near Term Institutional Requirements

In the course of the assessment, possibilities for changes in the structures of the organizations that deal with energy problems in Egypt were identified as having the potential to improve the treatment of energy issues.

4.5.1 Assignment of energy analysis and planning responsiblities: In some cases, there was no clear definition of which agency had prime responsibility for conducting a particular energy evaluation; in other cases, there were overlapping responsibilities. (This situation is typical of large organizations, and the problem is exacerbated by the fact that energy issues cut across so many organizational boundaries.) Early decisions are needed as to the central and supportive responsibilities of Egypt's ministries with respect to comprehensive energy analysis and planning.

4.5.2 Coordinated assessments from different ministries: In the course of the assessment, information on the same subject was received from different sources; and subsequent analysis showed that conflicting viewpoints had been adopted in developing the planning data which was made available. Although universal consensus is not possible, particularly when it comes to forecasting future events, subsequent assessments will need to resolve the differences among the varying viewpoints, at least to the level of understanding the reasons for the discrepancies. This process is useful in and of itself, as it provides a mechanism for all of the agenices involved to consider their planning perspectives in a much broader context.

4.5.3 Closer involvement of the financing and budget agencies: As most energy system configurations involve major financial considerations, it is imperative that the economic and financial planners be involved in the energy assessment and planning processes to identify financing constraints and show how the financing needed for preferred strategies might be arranged.

4.5.4 Establishment of regulatory body and development standards: The need for this kind of organizational structure has already been indicated with respect to the nuclear energy and the environmental management programs. Since the process of setting regulations, standards and guidelines is a long and tedious one, establishment of an institutional structure to be responsible for these activities should be initiated at an early stage.

4.5.5 Manpower Training: Manpower training in Egypt should place greater emphasis upon management, engineering applications, technician, administrative and craft supervision skills. The existing cadre of theoretical scientist and technology specialists appears to be adequate in quantity but could produce more benefit to Egypt if it could be effectively applied to the implementation of projects for the design and construction of technically sophisticated facilities. Revised training programs are needed which focus upon: (1) the practical application of existing technologies to Egypt's needs; (2) the organization, mobilization and effective implementation of major procurement and construction projects; (3) the middle management, administrative and craft supervision requirements of such projects; and (4) the provision of high quality materials, equipment and services. Greater use of specialized short courses appears to be advisable followed by on-the-job training in on-going energy supply projects.

4.5.6 Establishment of a policy review structure: There is a need both to develop consistent energy policies and to establish a mechanism by which energy development plans and programs can be reviewed for consistency with that policy. Because of the wide range of effects of energy policies, this is not a simple undertaking as the experience of some of the developed nations show. Nonetheless, Egypt should take steps to provide this policy review capability in its improved energy planning process.

GLOSSARY OF ACRONYMS

ANL - Argonne National Laboratory

BNL - Brookhaven National Laboratory

DOE - Department of Energy

EEA - Egyptian Electricity Authority

EGPC - Egyptian General Petroleum Corporation

ESPM - Energy System Planning Model

GNP - Gross National Product

GOFI - General Organization for Industrialization

INP - Institute of National Planning

PD-8 - Presidential Directive Number 8

RES - Reference Energy System

RD&D - Research Development and Demonstration

T&D - Transmission and Distribution

USGS - United States Geological Survey

APPENDICES

TABLE OF CONTENTS

LIST OF FIGURES

Page

B. PARTICIPATION OF EGYPTIAN OFFICIALS

LIST OF FIGURES

C. PROJECTION OF ENERGY DEMANDS

LIST OF TABLES

ATTACHMENT A TABLES

Fuel Mix Tables

ATTACHMENT A TABLES
(Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

D. DETAILS OF THE COMPARISON CASE ENERGY SUPPLY

LIST OF TABLES

LIST OF FIGURES

E. APPENDIX E - ASSUMPTIONS IN THE COST, MANPOWER, EQUIPMENT AND MATERIAL REQUIREMENTS

LIST OF TABLES

F. DETAILS OF OPTIONS AND STRATEGIES CONSIDERED

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

G. CONSIDERATION IN ENERGY PLANNING AND ANALYSIS IN EGYPT

LIST OF TABLES

LIST OF FIGURES

APPENDIX A - U.S./EGYPTIAN COUNTERPART TEAM CONCEPT

1.0 U.S./EGYPTIAN COUNTERPART TEAM CONCEPT

The United States/Egypt Country Team was composed of specialists with diversified backgrounds. The delegation consisted of functional teams including: Management and Integration, Supply, Demand, and Supply/Demand Analysis teams. A detailed breakdown of these individuals by position on the team and responsible organization is found in Figure A. 1 Figure A.2 indicates the members of the Integration Team. These individuals functioned as technical directors of the team subgroups. Figure A. 3 illustrates the organizational structure for the Egypt team.

2.0 U.S. TEAM MAKEUP

2.1 Management and Integration Team

2.1.1 Management: The primary functions of the management team were threefold.

- o Managerial Function - The team leader chaired and directed the Integration Team, a group composed of the technical directors of the supply, demand and supply/demand teams.
- o Liaison Function - A close liaison was established between the executive officer and country officials to formulate an effective working relationship. This was initiated in preliminary discussions to identify counterpart relationships and continued throughout the duration of the in-country assessment and review of the assessment report with Egypt.
- o Administrative Support - Provision of administrative support was necessary for the day-to-day operations of the team in Egypt. This included budgetary disbursements, lodging and transportation arrangements, direction of the team office and document control.

2.1.2 The integration team: The Integration Team was resonsible for the technical direction and coordination of the Egypt energy assessment. It was led by the Team Leader and was comprised of technical managers of the Supply, Demand and Supply/Demand Analysis Teams, who in turn reported directly to the Team Leader. As part of its responsibility for technical coordination of the study, the Integration Team selected overall energy development strategies for Egypt, and then transmitted these strategies to their sub-integration teams (i.e., Supply, Demand, Supply/Demand Analysis Teams). The sub-integration teams were then responsible for translating these general strategies into specific energy resource and technology options for purposes of assessing policy implications. The Integration

Fig. A. 1

EGYPT/U.S. COOPERATIVE ENERGY ASSESSMENT

U.S. TEAM

POSITION	NAME	ORGANIZATION
MANAGEMENT		
Team Leader	McFarren, Robert	Department of Energy
Supply Technology Team Leader	Cirillo, Richard	Argonne National Laboratory
Demand Option Team Leader	Anderson, B. Jennine	G.E. Tempo
Demand Projections Team Leader	Ezzati, Ali	Brookhaven National Laboratory
Executive Officer	King, Karla	Department of Energy
Administrative Support		
ANL Supervisor	Janson, Thomas	Argonne National Laboratory
Assistant to Team Leader	Hogan, Judith	Argonne National Laboratory
Editorial Control	Rohse, Bette	Argonne National Laboratory
Secretary	Hulit, Rebecca	Argonne National Laboratory
TECHNOLOGY SPECIALISTS		
Solar	Kaplan, George	Department of Energy
	Teagan, Peter	Arthur D. Little Corporation
Fossil Energy	Bliss, Charles	Mitre Corporation
	Watkins, Wade	Department of Energy
Nuclear	Purvis, Edward	Department of Energy
Hydro	Graham, William	Armstrong Associates
Environment	Cooper, Raymond	Department of Energy
	Zussman, Ronald	Argonne National Laboratory
Energy Systems	Palmedo, Philip*	Brookhaven National Laboratory
	Ezzati, Ali	Brookhaven National Laboratory
	Lee, John D.	Brookhaven National Laboratory
	Davidoff, Jack	Brookhaven National Laboratory
Energy Facility Cost	Gallagher, Michael	Bechtel Corporation
Transmission and Distribution	Warchol, Edward	Bonneville Power Administration
Conservation - Industry	Moore, Christopher	Gordian Associates
	Kumar, Victor	Gordian Associates
	Thorne, Paul	Gordian Associates
Conservation - BCS	Berstell, Gerald	Resource Planning Associates
	Mead, Kirtland	Resource Planning Associates
	Kapus, Ted	Department of Energy
Conservation - Transportation	Tomazinis, Anthony	University of Pennsylvania
Development Specialist	Cole, Henry	G.E. Tempo
	Walpole, Norman	G.E. Tempo
Manpower	Roman, Richard	Argonne National Laboratory

* Manager Brookhaven National Laboratory Support

Fig. A.1 (continued)

EGYPT/U.S. COOPERATIVE ENERGY ASSESSMENT

U.S. TEAM

POSITION	NAME	ORGANIZATION
RESOURCE SPECIALISTS		
Energy-Related Minerals	Tolbert, Eugene	U.S. Geological Survey
Petroleum Geologist	Maher, John	U.S. Geological Survey
Specialist for Geophysical Exploration for Petroleum, and Reservoir Analysis	Fouda, Ahmed	U.S. Geological Survey
Specialist for Electrical Geophysical Methods and Geothermal Energy	Zohdy, Adel	U.S. Geological Survey
Coal Geologist	Olive, Wilds	U.S. Geological Survey
Water Resources	Clarke, Frank	U.S. Geological Survey
Nuclear Materials	Page, Lincoln	U.S. Geological Survey

Fig. A. 2

INTEGRATION TEAM

POSITION	NAME	ORGANIZATION
Team Leader	McFarren, Robert	Department of Energy
Supply Technology Team Leader	Cirillo, Richard	Argonne National Laboratory
Demand Options Team Leader	Anderson, B. Jennine	G.E. Tempo
Demand Projections Team Leader	Ezzati, Ali	Brookhaven National Laboratory
Electric System and Nuclear Power	Purvis, Edward	Department of Energy
Financial Evaluations	Cole, Henry	G.E. Tempo
Supply Facility Costs	Gallagher, Michael	Bechtel Corporation
Executive Officer	King, Karla	Department of Energy
Administrative Officer	Hogan, Judith	Argonne National Laboratory
Secretary	Hulit, Rebecca	Argonne National Laboratory

PROJECT ORGANIZATION

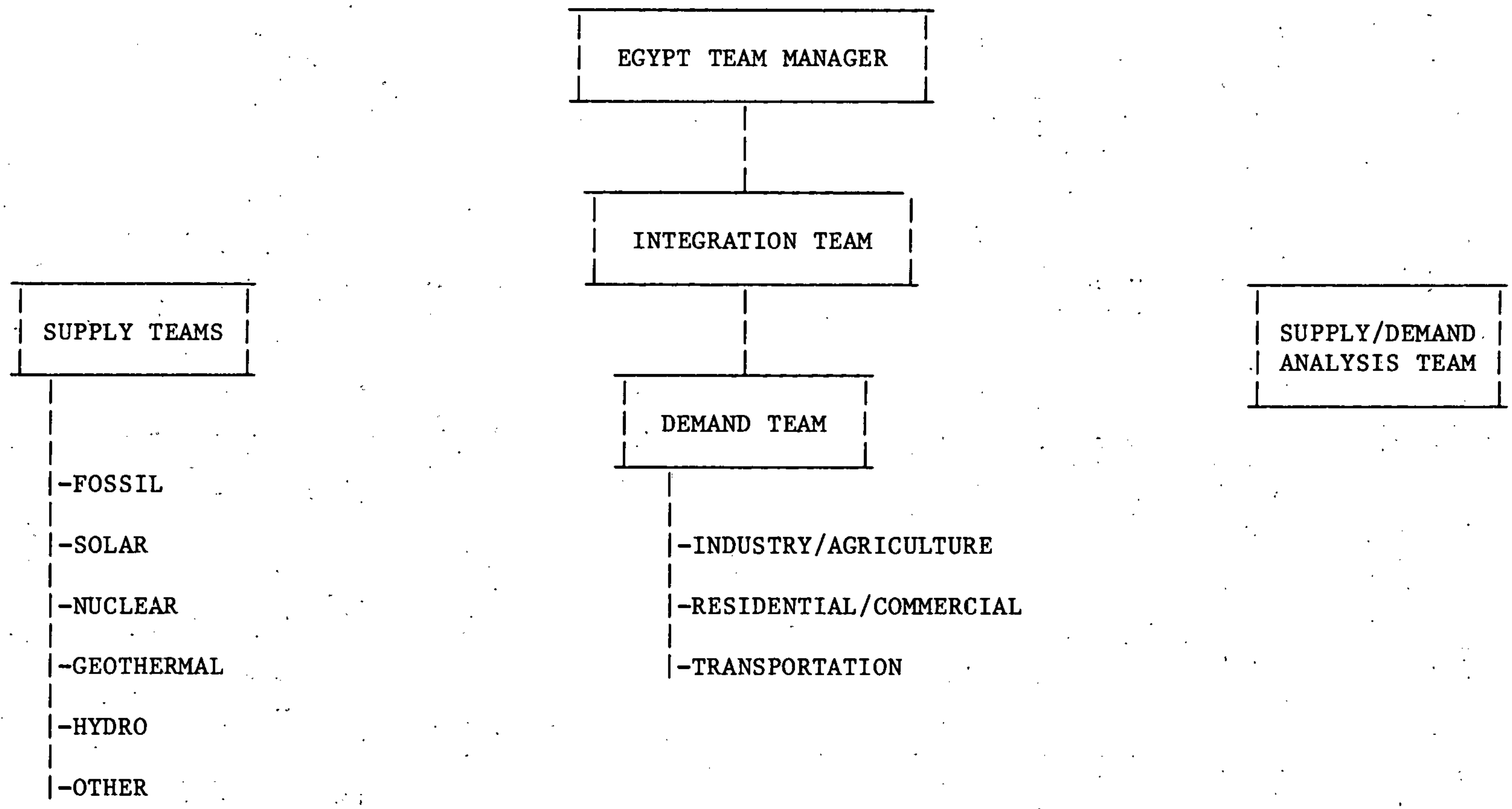


FIG. A.3

Team was also responsible for the preparation of the energy assessment final report and Presidential summary. In their capacity as technical team managers, members of the Integration Team had lead responsibility for the sub-integration team specialist report Annexes attached to the final report.

As members of the Integration Team, the technical managers assisted in defining the overall energy development strategies assessed in the study; and they transmitted these to the supply and demand teams. In addition to these overview responsibilities, the technical managers:

- o provided guidance to the supply and demand sub-integration team (including the cross-cutting functions) prior to incountry visits, on the type of analysis required, methods to be used, level of detail needed and report to be generated;
- o provided guidance to supply and demand sub-integration teams during in-country visits on resolution of technical issues, use of simplified approaches, strategies for data collection, etc.;
- o assisted selected supply fuel cycle groups where there were gaps in the analyses;
- o conducted post-visit debriefing and Delphi sessions for supply and demand teams; and
- o prepared a summary of the supply and demand team results for use by the integration team.

2.2 Supply Team

The role of the Supply Team was to define specific resource and technology options that address each of the energy development strategies established for Egypt by the Integration Team.

2.2.1 Organization of the supply team: Figure A.4 illustrates the detailed organization of the supply team. This structure was designed to facilitate the development of an integrated assessment of alternative energy supply options available to Egypt. The team was headed by a technical manager who served on the Integration Team, and was comprised of six fuel cycle groups, consisting of resource and technology specialists. In addition, there were several cross-cutting specialists who provided information to the fuel cycle group and were responsible for examining the overall impact and policy implications for packages of supply options selected for study.

2.2.2 Fuel cycle groups: Each fuel cycle group was responsible for defining, analyzing and evaluating options that addressed the energy development strategies established by the Integration Team. In this capacity each fuel cycle group was responsible for the following elements of the assessment:

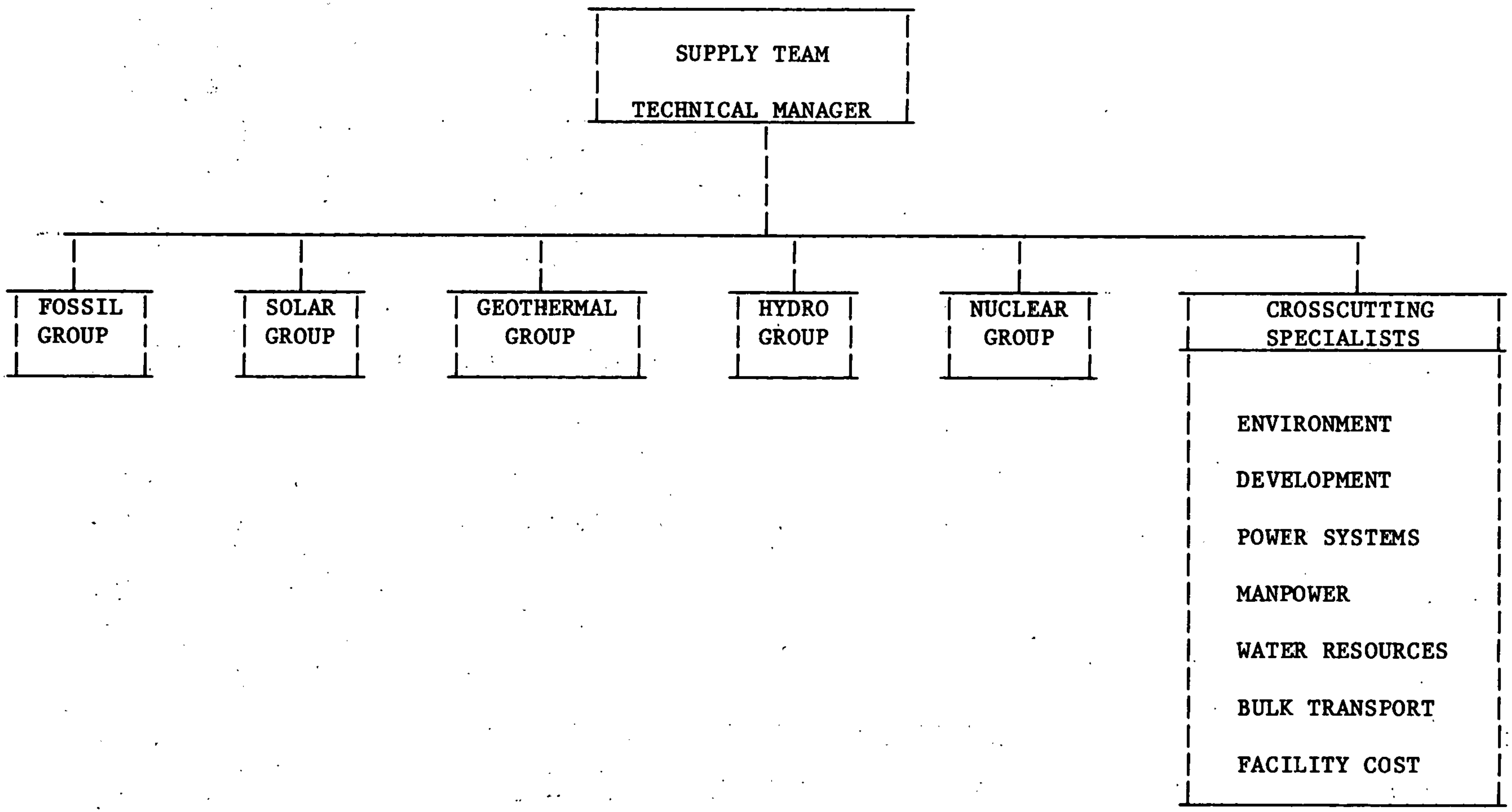


FIG. A. 4 SUPPLY TEAM ORGANIZATION

- Resource Assessment
    - Reserves - quantity, quality, location
    - Availability and reliability of data
    - Resource survey conduct
    - Additional surveys needed
- Selection of Resource and Technology Options (Extraction to End Use)
    - Criteria for selecting options
    - Description of options considered
    - Potential applications - sites, regions, uses
- Technology Characterization and Evaluation
    - Performance capabilities
    - Availability and timing
    - Construction, operation, maintenance characteristics
    - Engineering construction and operation costs

In consultation with the cross-cutting specialists (e.g., power systems, environmental, etc.), the fuel cycle groups are also expected to consider the options they analyze according to the broader concerns of the Supply Team as a whole. These broader concerns include: (1) the assessment of impacts (e.g., environmental, socioeconomic, etc.); (2) evaluation of policy implications; (3) identification of key actions required for initiation; and (4) recommendations regarding implementation for each of the supply options analyzed.

2.3 <u>The Roles of the Supply Team Participants</u>

The scope of the Supply Team concerns were divided into three major categories: (1) resource assessment; (2) evaluation of alternative technology applications, and (3) policy analysis.

These concerns were so intimately related that it was impossible to separate them along distinct task lines. Instead, the Supply Team concept was devised to ensure that the resource, technology and cross-cutting specialists were aware of each others' role and that they were directly involved in coordinating their efforts during the study. The following role descriptions were designed to facilitate the coordination of efforts within the Supply Team.

2.3.1 Resource specialists: A resource specialist with the appropriate background was assigned to each fuel cycle group. In the first phase of the study, these resource specialists identified and evaluated the existing information on energy resources available in the country, and recommended actions that could be taken to encourage exploration and development of the available energy resources. More detailed resource assessments were then conducted in a second phase of the study with visits to Egypt. During the in-country visit, the U.S. resource specialists, in cooperation with the host country counterparts, assembled, reviewed and evaluated the available information on their assigned resources. Such effort included consultation, data gathering and field inspection in cooperation with the Egyptians.

Based on the preliminary assessment and on consultation with the technology specialist, the resource specialist ranked those resources within their area of responsibility that were considered sufficient to support potential utilization options. These options were defined in terms of the overall energy development strategies developed for each country study. During the second phase of their involvement, the resource specialists were responsible for developing a more detailed resource assessment of the country. This assessment considered the potential for future resouce development including: (a) additional data requirements; (b) exploration strategies; (c) constraints to exploitation; and (d) feasibility of utilization, conversion, application, etc.

2.3.2 Technology specialists: In addition to the resource specialist, a technology specialist was assigned to each fuel cycle group. These individuals were responsible for identifying, characterizing and evaluating technology options that may be applied to Egypt's energy demand based on the availability of indigeneous resources.

The technology specialist first identified technology options that addressed the broad energy development strategies selected for the study. As a prelude to this identification process, it was necessary for the technology specialists to review the preliminary energy assessments and consult with their resource counterparts. Based on this background, the technology specialist specified, for each overall energy development strategy, specific technology options that could be applied. It was necessary for these technology options to span the breadth of the fuel cycle to consider resource extraction, processing, transport, conversion, and transmission/distribution. From the initial sets of options, the team technical manager developed, in consultation with the technology specialists, a mix of fuel cycle options that were appropriate for the energy strategies established for the Egypt study. The technology options that were selected for these mixes were the ones that the technology specialists were responsible for assessing.

As a second part of their assessment responsibilities, the technology specialists developed characterizations for each technology that was considered applicable to a particular fuel cycle option. These characterizations were developed using a brief fact-sheet format (see Appendix C).

When these fact sheets were completed, they provided data input to the Reference Energy System (RES).

A third area of responsibility was for the technology specialists to provide an evaluation of the overall "implementation practicability" of the various fuel cycle options. This evaluation considered the specific engineering and economic characteristics of technologies that comprised the various options; but they also considered impacts from the utilization of these options, policy implications, key actions required to implement them and recommendations regarding their implementation. The cross-cutting specialists directly assisted the technology specialists in developing these assessments. These broader technology concerns are documented in the technology specialist annexes of the Egypt Country Report.

<u>2.3.3 Cross-cutting specialists</u>: As indicated in Figure A. 4, the cross-cutting specialists served in staff capacities to the Supply Team by applying their expertise across all of the fuel cycle groups. These cross-cutting specialists were responsible for profiling input to the following elements of each fuel-cycle options assessment report (i.e., the annexes to the country report).

- o Impacts from Utilization of Options
  - o Environmental
  - o Social/economic/institutional
  - o Manpower
  - o Other Resources (i.e., infrastructure, distribution capacity, etc.)
- o Policy Implications of Options
  - o Achievement of National Objectives
  - o Impact-Mitigation Factors
  - o Government Policies or Regulations
- o Key Actions Required to Initiate Options
  - o Government Actions or Policies
  - o Projects
- o Conclusions and Recommendations
  - o Ranked List of Options

However, prior to their direct involvement with any of the fuel cycle groups, the cross-cutting specialists played important roles in establishing overview criteria and assisted in the selection and ranking of options to be studied. They achieved this in three ways. First, the cross-cutting specialists advised the technical manager of overriding impacts, policy implications or bottlenecks and constraints that precluded options from consideration in the study. Second, they established the environmental, socioeconomic, manpower and power systems criteria to be used in ranking the mix of options across all of the fuel cycles. Finally, they were instrumental in identifying sites or regions within Egypt where the energy supply options could or should be applied.

2.4 Demand Team

The demand component of the Egyptian energy assessment was directed toward characterizing current and projected energy demand so that: 1) alternative paths of energy resource and technology development may be better designed to meet these projected demands; and 2) the energy implications of Egyptian national plans and goals may be outlined.

2.4.1 Demand team responsibilities: This demand assessment was composed of two tasks. First, data was collected to meet the requirements of the RES, which is an analytical tool designed to evaluate end-use sectoral energy demands with respect to their implications for future required energy resources--both domestic and imported, (see Appendix C). The second task was the qualitative and quantitative assessment of alternative end-use process and associated fuel type options which will satisfy the end-use sectoral demands. The initial step in both of these was to evaluate all existing Egyptian plans for sectoral growth through the year 2000.

To attain the data necessary for the RES, the following input was developed by the Demand Team:

1. Measure of Demand Activity: the demand level specified in units of activity, or another determinant of demand, e.g., passenger car kilometers, tons of steel produced, number of rural households (for cooking), number of irrigation pumps in operation, etc.

2. Direct Fuel Consumption: the amount of fuel (in joules) of various kinds ("fuel" includes electricity) delivered to a particular end-use category.

3. Relative Effectiveness: the relative efficiency with which various fuels provide energy to satisfy a specific activity. Relative effectiveness is distinguished from efficiency in that it reflects differences in utilization practice as well as device efficiency.

This data was collected by the Demand Team for each of the sectors studies to provide input to the RES.

2.4.2 Sectoral breakdown: To evaluate the current and projected energy demand for Egypt, the Demand Team collected and analyzed data for the industrial/agricultural, residential/commercial, and transportation sectors. These sectors are discussed below.

2.4.2.1 Industry/agriculture sectors: To carry out this segment of the demand section of the Egyptian energy study, the team examined energy use, present and projected, in the Egyptian industrial and agricultural sectors. This part of the study attempted to: (1) assess the energy use implications of continuing Egyptian economic development; and (2) identify options for improving energy efficiencies or for substituting readily available Egyptian fuels for fuels which either are imported or are especially valuable as export foreign exchange earners.

This section of the study had the following two objectives:

1. developed Egyptian industrial/agricultural energy use data including levels of output in each sector, energy use coefficients by fuel and total fuel consumption for major subsectors of industry, utilities, and agriculture; and

2. identified opportunities for improved energy use efficiencies or fuel switching in major industrial subsectors and major agricultural energy uses.

2.4.2.2 Residential/commercial sectors: An examination was made of the residential and commercial sectors to determine how much energy, (i.e., how many barrels of oil, how many litres of kerosene, how many kilowatt hours of electricity, etc.) each sector consumes.

The residential sector consisted of all dwellings from simple rural houses to multi-story Cairo apartment houses. The commercial sector was a very broad classification that included all non-residential, non-industrial buildings--such as hospitals, schools, offices, government buildings, shops, restaurants, bazaars, theaters and mosques. "Community systems," which are the water supply, sewage disposal, trash removal, and street lighting systems that support the residential and commercial buildings, were also examined.

2.4.2.3 Transportation sector: Energy demand within the Transportation Sector was assessed for major national and regional transportation developmental options as part of the overall Egyptian energy demand analysis. The objective was to measure total energy requirements for each option, by mode of transport, by region, and for entire networks.

The sectoral projections of consumption of each fuel type developed for the industry/agricultural, residential/commercial, and transportation sectors were summed together to draw up the total energy demand picture of Egypt in the years 1985 and 2000. The Reference Energy System, using input from the several supply team groups, was then used to see how this projected energy demand could be satisfied.

2.5 Role of the Supply/Demand Analysis Team

The Supply/Demand Team was responsible for analyzing the relationship between energy demand and resource utilization. This analysis was conducted using the Reference Energy System (RES) which outputs "a network diagram indicating energy flows and the associated conversion efficiencies of the reference technologies employed in various stages of the energy production/transmission/distribution/end-use system." This computerized technique is discussed in Appendix C.

The Supply and Demand Teams provided data directly to the Supply/Demand Analysis Team. For each fuel cycle included in the options analysis, the RES required data input for fuel use and the associated conversion efficiencies for technologies employed in the following activities:

1. Extraction

2. Refining and/or conversion

3. Transport of primary energy source

4. Centralized conversion (e.g., electricity generation)

5. Transport or transmission and storage of secondary energy form

6. Decentralized conversion

7. Utilization in an end-use device

The Supply and Demand Teams profiled data for all of the above activities.

3.0 DEVELOPMENT SPECIALIST CONCEPT

The concept of the development specialist is based on the need to address the social, economic, institutional, and political factors in Egypt which are related or might interact with prospective energy development plans.

Their approach enlarges the scope of the assessment beyond that of a technically oriented supply/demand analysis to one that incorporates the non-technical aspects of the options under consideration as well.

The role of the development specialists were divided into three categories:

1. Direct, in-country development support to team members.

2. Inputs to technical reports and annexes of the Supply and Demand team in defining selected possible social, political

and economic constraints, penetrations, and impacts to assist in the definition of energy options.

3. Brief overviews of the policy objectives, socio-economic, and financing considerations in Egypt related to the assessment strategies.

4.0 SPECIALIST/COUNTERPART INPUT

The Egypt/U.S. Cooperative Energy Assessment was based on a mutually collaborative effort between the U.S. Team and designated Egyptian counterparts. The three primary objectives of the close counterpart relationship were to:

- obtain better insight and quality information as to energy resource, production, planning and utilization capabilities of Egypt;
- establish a functional means for Egyptian officials to become knowledgeable about the information collection, analysis and evaluation methods being employed by the U.S. team so that these methods could, if appropriate and desirable, continue to be applied in on-going Egyptian energy analysis and planning activities; and
- acquire from participating Egyptian officials a better insight into energy analysis and planning factors that must be considered or emphasized in developing countries as compared to those which are most applicable in developed countries.

In Egypt, data collection activities were conducted jointly by the U.S. Team and Egyptian expert counterparts through an organizational structure consisting of an Executive Committee reporting to the Chairman of the Supreme Committee (Figures A.5 and A.6) which supervised and coordinated the work of three subcommittees. The three subcommittees were: (1) Conventional Energy Systems; (2) Energy Demands; and (3) Advanced Technology and Supply Systems, each of which consisted of several specialized working groups. The intent of this structure was to allow each specialty area to be addressed as efficiently as possible to save time and burden on Egyptian officials yet to allow communication among the groups, to reduce redundancy and to facilitate the cross-cutting analysis.

Fig. A.5

SUPREME COMMITTEE EGYPT/U.S. COOPERATIVE ENERGY ASSESSMENT
EGYPTIAN DELEGATES

ENG. MOHAMED KAMEL HAMED, Chairman, Egyptian Electricity Authority

*DR. ABDEL RAHMAN, Counselor to the Prime Minister

DR. FOUAD HUSSEIN, Deputy Minister & Counselor to the Deputy Prime Minister for Economic Affair, Ministry of Economy

ENG. MAHER ABAZA, First Undersecretary, Ministry of Electricity and Energy

ENG. IBRAHIM SHARKASS, Deputy Chairman, General Organization for Industrialization (GOFI)

DR. MUSTAFA K. AYOUTY, Deputy Chairman, Egyptian General Petroleum Authority

DR. GALAL MOUSTAFA, Chairman, Egyptian Geological Survey and Mining Authority

DR. MOHAMED KAMEL, Chairman, National Research Center

DR. EL-WALID EL-SHAFIE, Principal, National Planning Institute

ENG. ADLY KAMEL YAKAN, Executive Chairman, Qattarra Depression Authority

ENG. HUSSEIN SIRRY, Chairman, Nuclear Power Authority

DR. SHAZLY MOHAMED EL SHAZLY, Chairman, Nuclear Materials Authority

DR. MAHMOUD EL-KOSHAIRY, President, Solar Energy Commission

DR. EMAD EL-SHARKAWI, Egyptian Electricity Authority (Principal Liaison Official)

DR. MOUSTAFA SWIDAN, Egyptian Electricity Authority (Liaison Official)

*Appointed by Deputy Prime Minister Sultan as head of the Egyptian Delegation to the United States

FIG. A.6

SUPREME COMMITTEE EGYPT/U.S. COOPERATIVE ENERGY ASSESSMENT

UNITED STATE DELEGATES

DR. ADDISON RICHMOND, Science Attache, U.S. Embassy, Department of State

MR. ROBERT MCFARREN, Team Leader, U.S. Department of Energy

DR. PHILIP PALMEDO, Brookhaven National Laboratory, Energy Systems Manager

DR. RICHARD CIRILLO, Argonne National Laboratory, Supply Technology Assessments

DR. PETER TEAGAN, Solar Technologist

MS. KARLA KING, Executive Officer, U.S. Department of Energy
(Principal Liaison Official)

APPENDIX B - PARTICIPATION OF EGYPTIAN OFFICIALS

1.0 EGYPTIAN PARTICIPATION

Egyptian participation in the Egypt/U.S. Cooperative Assessment occurred in two phases. The first phase involved data collection through jointly conducted in-depth meetings and site visits by the U.S. team and Egyptian counterparts. These counterparts were designated by a Supreme Committee established in Egypt. The second phase of Egyptian participation occurred in the analysis phase.

1.1 Phase I - Data Collection

Data collection activities were conducted jointly by the U.S. Team and Egyptian expert counterparts under the auspices of a Supreme Committee established in Egypt through the issuance of a Ministerial Decree under the direction of Prime Minister A. Sultan (as noted in Appendix A). The purpose of the decree was to initiate cooperative activity with the U.S. in assessing the energy demand and supply options available to Egypt. Under the direction of the Supreme Committee, Egyptian counterparts were designated to work with each of the specialists of the U.S. team in one of the three subcommittees cited below. Note that each subcommittee consisted of specialized work groups.

1. Subcommittee on Conventional Energy Systems
   - o Work Group on Fossil Resources and Supply Systems
   - o Work Group on Hydroelectric Power Generation
   - o Work Group on Nuclear Electric Power Generation
2. Subcommittee on Energy Demands
   - o Work Group on Energy Demand Projections
   - o Work Group on Energy Demand Options
   - o Work Group on System Integration Methods
3. Subcommittee on Advanced Technology and Supply Systems
   - o Work Group on Solar and New Energy
   - o Work Group on Geothermal Energy

Subcommittee participants are identified in Figures B. 1 through B. 3.

Summary of the activities of each work group including people contacted and documents exchanged appear in sections 2.0 through 5.0 of this Appendix.

Fig. B. 1

EGYPT-U.S. COOPERATIVE ENERGY ASSESSMENT

SUBCOMMITTEE ON CONVENTIONAL ENERGY SYSTEMS

Egypt	U.S.
DR. MUSTAFA K. AYOUTY, Leader Deputy Chairman, Egyptian General Petroleum Authority	DR. RICHARD CIRILLO, Leader Supply Technology Assessments

WORK GROUP ON FOSSIL RESOURCES AND SUPPLY SYSTEMS

Egypt	U.S.
DR. MUSTAFA K. AYOUTY, Principal	DR. CHARLES BLISS, Principal Fossil Technologist
DR. GALAL MOUSTAFA, Chairman Egyptan Geological Survey and Mining Authority	DR. WILDS OLIVE Fuels Resource Assessments

WORK GROUP ON HYDROELECTRIC POWER GENERATION

Egypt	U.S.
ENG. ADLY KAMEL YAKAN, Principal Executive Chairman, Qatarra Depression Authority	MR. WILLIAM GRAHAM, Principal Hydro Technologist
	DR. FRANK CLARK Water Resources Specialist

WORK GROUP ON NUCLEAR ELECTRIC POWER GENERATION

Egypt	U.S.
ENG. HUSSEIN SIRRY, Principal Chairman, Nuclear Power Authority	MR. EDWARD PURVIS, Principal Nuclear Technologist
DR. SHAZLY MOHAMED EL SHAZLY Chairman, Nuclear Materials Authority	DR. LINCOLN PAGE Nuclear Materials Specialist

Fig. B. 2

COMMITTEE FOR EGYPT-U.S. COOPERATIVE ENERGY ASSESSMENTS

SUBCOMMITTEE ON ENERGY DEMANDS

Egypt

ENG. IBRAHIM SHARKUS, Deputy Chairman
General Industrial Organization
(Egyptian Leader)

U.S.

MR. ROBERT McFARREN
U.S. Team Leader

DR. PHILIP PALMEDO
BNL Energy System
Manager

WORK GROUP ON ENERGY DEMAND PROJECTIONS

DR. EL-WALID EL-SHAFIE, Principal
National Planning Institute

DR. ALI EZZATTI, Principal
Systems Analyst

WORK GROUP ON ENERGY DEMAND OPTIONS

ENG. KAMEL MAKSOUD, Principal
General Industrial Organization

MS. JENNINE ANDERSON, Principal
Development Analyst

WORK GROUP ON SYSTEM INTEGRATION METHODS

DR. MAKHOUD EL-KOSHAIRY, Principal

DR. EMAD EL SHARKAWI

DR. EL-WALID EL-SHAFIE

ENG. HAMAD EL-SHAER

ENG. AHMED GANEM

DR. PHILIP PALMEDO, Principal

Fig. B. 3

EGYPT-U.S. COOPERATIVE ENERGY ASSESSMENT

SUBCOMMITTEE ON ADVANCED TECHNOLOGY SUPPLY SYSTEMS

Egypt

DR. MAHMOUD EL-KOSHAIRY
President, Solar Energy Commission
(Egyptian Leader)

U.S.

DR. PETER TEAGAN, Solar Technologist
DR. RICHARD CIRILLO, Environmental Specialist

(Co-Leaders)

WORK GROUP ON SOLAR AND NEW ENERGY

Egypt

DR. MAHMOUD EL-KOSHAIRY, Principal

DR. MOHAMED KAMEL
Chairman, National Research Center

DR. IBRAHIM SAKR
Director, Solar Energy Applications

DR. MAHMOUD HEGAZI
Wind Energy

U.S.

DR. PETER TEAGAN, Principal
Solar Technologist

DR. GEORGE KAPLAN
Solar Technologist

WORK GROUP ON GEOTHERMAL ENERGY

Egypt

DR. SHAZLY MOHAMED EL-SHAZLY, Principal
Chairman, Nuclear Materials Authority

DR. MAHMOUD EL-KOSHAIRY

U.S.

DR. ADEL ZHODY, Principal
Geothermal Resource Specialist

The Supreme Committee was responsible for supervision and coordination of the work of the three subcommittees. An Executive Committee was formed to report the weekly progress of the subcommittees to the Chairman of the Supreme Committee.

1.2 <u>Phase II - Analysis and Integration</u>

Phase II of the assessment was conducted in the U.S. During this phase data was organized and evaluated using the Reference Energy System methodology as a tool to test various demand and supply scenarios and assumptions. From this integration and analysis a set of strategies and several options established under various energy supply and demand conditions were determined. The resultant options and strategies were then incorporated into the draft assessment report.

Egyptian participation in this analysis phase involved two engineering analysts and five senior level Egyptian officials.

<u>1.2.1 Engineering/analyst participation May 2 - June 9</u>: Two professional level engineering analysts, Mahmoud Auf and Ahmed Ghanem, attended a six-week training session at BNL. The purpose of the trip was to attain a better understanding of the analytic approach employed in this assessment. This approach was based on the BNL Reference Energy System analysis combined with the Bechtel Corporation cost, manpower, and equipment data base. Aside from the training preparation, Engineers Auf and Ghanem also contributed to the formulation of the strategy and options used in the assessment.

<u>1.2.2 Executive level participation May 31 - June 9</u>: An Egyptian delegation consisting of five senior level Egyptian officials worked with the Integration Team in the U.S. for the period May 31 - June 9. The purpose of the visit was to review the analysis, contribute observations derived from the analysis, and provide input for the assessment report. The Egyptian officials involved were: (1) Dr. Abdel Rahman, Planning Counselor to the Prime Minister, who was appointed by Deputy Prime Minister Sultan to head the Egyptian Delegation to the U.S., (2) Mr. Fouad Hussein, Deputy Minister, Ministry of Finance, (3) Dr. El Walid El Shafie, Institute of National Plannning, (4) Dr. Moustafa Swidan, Egyptian Electricity Authority and (5) Engineer Samir Habib, Egyptian General Petroleum Authority.

The Egyptian delegation spent the majority of their time in work sessions with the Integration Team at BNL. The officials were also involved in a session of meetings in Washington, D.C. with the Department of State, Agency for International Development (AID), and Energy officials, relating to the scope and value of the assessment. Upon their return to Egypt, these officials will guide the review of the draft assessment report by their respective ministries and initiate, as appropriate, the continued use of the assessment or the analysis methods in the planning and evaluation functions of those ministries.

1.3 Next Steps

As mentioned above, the draft report will be delivered to Cairo for Egyptian review. The Egyptian officials who participated in the preparation of the report in the U.S. will subsequently be involved to guide its review and evaluation by the various Egyptian governments and ministries. They will also be responsible for the preparation of Egyptian comments, corrections and additions. A more formalized review by the Supreme Committee took place in late September. This resulted in the preparation of a revised report to be submitted in final form to the two governments in late November.

2.0 SUBCOMMITTEE ON CONVENTIONAL ENERGY SYSTEMS REPORT ON DATA COLLECTION BASE

The Egyptian leader on the subcommittee was Dr. Mustafa K. Ayouty of the Egyptian General Petroleum Corp., the U.S. leader was Dr. Richard Cirillo. The subcommittee was comprised of a Work Group on Fossil Resources and Supply Systems, a Work Group on Hydroelectric Power Generation and a Work Group on Nuclear Electric Power Generation. In addition, several U.S. team members provided input to each of the Work Groups. The entire subcommittee convened for the first time on March 28 to set up the procedures for detailed counterpart activities. Dr. Ayouty and Dr. Cirillo met again on April 5 to discuss the progress of the individual work groups. In general, all of the work groups functioned smoothly with excellent cooperation being received from the Egyptian staff members. The following activities were undertaken by each of the work groups.

2.1 Work Group on Fossil Resources and Supply Systems

The leaders of this work group were Mr. Mustafa K. Ayouty of the Egyptian General Petroleum Corp., Mr. Galal Moustafa of the Egyptian Geological Survey and Mining Authority, Dr. Charles Bliss, and Mr. Wilds Olive. In addition, Mr. Wade Watkins, Mr. John Maher, and Mr. Ahmed Fouda of the U.S. Team participated in the activities of this group.

2.1.1 Overview of work group activities: The group completed their data collection on schedule. Some difficulties were encountered in the release of confidential oil and gas information but this was resolved prior to team departure. One problem encountered in evaluating resources was the large volume of information available with little aggregation into regional summaries. This necessitated a selective gathering of representative data.

A number of site visits were made to oil fields, refineries, power plants, and industrial facilities. These were very helpful in identifying alternative fossil fuel uses. Hospitality and excellent cooperation were received at all locations.

2.1.2 Principal contacts:

1. Egyptian General Petroleum Corporation:

- Eng. Sami Andrawis, Deputy Chairman, Planning and Projects
- Eng. Samir Habib, General Manager, Planning & Economics of Projects
- Eng. Abdel Hamid Hedawi, Operations Manager for Exploration
- Dr. N.H. Gezerry, Director, Exploration

2. Egyptian Electricity Authority
   - Dr. Moustafa Swidan, Director General, Power System Planning
3. Geological Survey of Egypt
   - Mr. Maurice Hermina
   - Mr. Ahmed C. Mansour
4. Gulf of Suez Petroleum Corp.
   - Mr. El Shawy Abdine
5. Union Oil Co. of Egypt
   - Mr. Nazile Tevfik
6. Cairo University
   - Dr. Amin Abdullah
7. Ein Shams University
   - Dr. Amin Basoury
8. Nuclear Materials Authority
   - Dr. Shazly El Shazly, Chairman
9. Government Organization for Industry
   - Eng. Kamel Maksoud, Director of Planning and Technical Research
10. WEPCO - Alexandria
    - Dr. Saad El Ansary
11. Transworld Egypt Petroleum Group
    - Mr. Ramzy T. El Adl, Director General, Power System

12. Desert Irrigation Authority

    - o Dr. Mohammed Ezzat, Undersecretary
    - o Mr. Saleh Nour, Chief, Technical Division

13. Ministry of Irrigation

    - o Mr. Gamil Mahmoud

14. Remote Sensing

    - o Dr. M. A. Abdel Hady, Director

2.2 Work Group on Hydroelectric Power Generation

The leaders of this work group were Eng. Adly Kamel Yakan from the Qattara Depression Authority, Dr. Frank Clarke and Mr. William Graham.

2.2.1 Overview of work group activities: The activities of this work group were extremely successful. All of the existing and potential hydroelectric power sites were identified and virtually all of the required information was collected. In addition, all of the required information on water resource availability was collected.

2.2.2 Principal contacts:

1. Qattara Depression Authority

    - o Eng. Haguib Ibrahim Rizk, Undersecretary of State
    - o Mohamed Taha El-Fafety, Undersecretary of State

2. Harza Engineering

    - o Mr. Vaughn Andres, Director of World Bank Projects, Rural Electrification Authority

3. Ministry of Electricity

    - o Dr. Moustafa Swidan, Director General, Power System Planning

2.3 Work Group on Nuclear Electric Power Generation

The leaders of this group were Eng. Hussein Sirry of the Nuclear Power Plant Authority, Dr. Shazly Mohamed El Shazly of the Nuclear Materials Authority, Dr. Lincoln Page and Mr. Edward Purvis.

2.3.1 Overview of work group activities: The team was able to complete its work on schedule. One difficulty encountered in the assessment is the lack of a thorough resource survey for uranium and thorium reserves. Although preliminary information indicates a good potential for substantial uranium finds, the data were too sketchy to make definitive statements. Surveys currently under way will hopefully remedy this. The assessment will, therefore, address the potential for development of Egyptian capability in all stages of the fuel cycle pending the availability of better resource data.

2.3.2 Principal contacts:

1. Nuclear Power Plant Authority
   - Dr. Kamel Effat, Counselor for NPPA
   - Dr. Mohammed F. El Fooley, Vice Chairman
   - Dr. Ali F. El Saiddi, Undersecretary of State
2. Government Organization for Industry
   - Dr. Mahrous El Amin
3. Nuclear Materials Authority
   - Dr. Morsy M. Morsy
4. Geological Survey of Egypt
   - Dr. Jalal Moustafa
   - Dr. Maurice Hermina, Director
   - Dr. Anwar Beshay
5. Academy of Scientific Research and Technology
   - Dr. M.A. Abdel Hady, Director of Remote Sensing
6. Transworld Petroleum Co.
   - Dr. Ramzy El Adl
7. Ministry of Irrigation
   - Dr. Mohammed Ezzat, Undersecretary for Desert Irrigation
8. Egyptian Electricity Authority
   - Dr. Emad El-Sharkawi, Managing Director

- o Dr. Moustafa Swidan, Director General, Power System Planning

9. Sanderson and Porter Consulting Engineers

- o Dr. John Shumaker, Planning Consulting Engineer

3.0 SUBCOMMITTEE ON ENERGY DEMANDS-REPORT ON DATA COLLECTION

The Egyptian Leader on the subcommittee was Eng. Ibrahim Sharkus of the General Organization for Industrialization. Early in the study Eng. Sharkus was called out of the country on business, and Dr. Mahmoud El-Koshairy of the Ministry of Electricity assumed temporary leadership responsibility until Dr. Sharkus returns. The U.S. leaders were Mr. Robert McFarren and Dr. Philip Palmedo. The subcommittee was comprised of a Work Group on Energy Demand Projections, a Work Group on Energy Demand Options, and a Work Group on System Integration Methods. The subcommittee convened for the first time on March 28 to set up detailed procedures for data collection. It reconvened on April 5 to review progress of individual work groups and the status report to be submitted to the Supreme Committee. All of the work groups functioned smoothly and excellent cooperation was received from all Egyptian staff members. Eng. Kamel Maksoud of the General Organization for Industrialization was especially helpful in arranging contacts and serving as liaison with other ministries. The following activities were undertaken by each of the work groups:

3.1 Work Group on Energy Demand Projections

The Egyptian principal of the Energy Demand work group was Dr. El-Walid El-Shafie; the U.S. principal was Dr. Ali Ezzati.

The principal objective of the Work Group was to prepare an internally consistent and reasonable projection of future energy demands adequate for the analysis of energy demand and supply options. This requires that the projection be broken down into activity sectors and that the energy demands associated with those numerous activity or subactivity sectors were individually projected.

3.1.1 Overview of work group activities: In two initial Work Group meetings on March 29 and 30, 1978, two substantive issues were identified for review with the Executive Committee of the Supreme Committee on April 1, 1978. The two issues were:

1. Whether a "real" energy demand projection (i.e., an internally consistent projection representing expected Egyptian economic and planning targets or a "hypothetical" energy demand projection (i.e., a projection formulated for this assessment but not necessarily representing Egyptian approved planning objectives) was to be used for this energy options assessment.

2. The extent to which energy consumption information considered sensitive by Egypt would be made available for purposes of the energy options assessment.

The plan agreed upon for proceeding was as follows: The Egyptian Institute of National Planning, with the assistance of several ministries, would prepare an internally consistent projection of energy demands for the years 1985 and 2000. This projection would be disaggregated only to the level of the following sectors:

- o Industry
- o Agriculture
- o Transportation
- o Households
- o Public Utilities
- o Miscellaneous

In parallel with this effort the U.S. team would prepare a methodology for further disaggregating this energy demand projection sufficiently to allow the assessment of the impact of the various energy demand and supply options being investigated in the course of the cooperative assessment. This disaggregation method and the specific assumptions which it involves will be reviewed with the Egyptian counterparts.

Information needed for the preparation and disaggregation of the projection to necessary sub-sector levels would be made available, where necessary, with the approval of the First Undersecretary of the Ministry of Electricity and Energy.

The remainder of the work proceeded on this basis. Two separate projections were provided to the U.S. Team on April 12, 1978. The one for electricity demand was a joint effort of the Institute of National Planning (INP), the Egyptian Electricity Authority (EEA) and the Ministry of Planning (MinPlan).

The second, a projection of future petroleum fuels consumption, was prepared by the Egyptian General Petroleum Authority (EGPA). Inclusion in the projection of future demand for energy in the form of animal wastes, agricultural waste and agricultural product converted into animal motive power is yet to be decided by Egypt.

Several meetings have been held to resolve differences in these two projections. Major inconsistencies between the two projections have been resolved. Extensive back-up information to the projections has been made available to the U.S. Team including two packages of information from the EGPA made available on April 19 and April 20, 1978.

A method for disaggregating the Egyptian projection to more detailed levels of sub-sector activities has been prepared by the U.S. Team. The structure for this disaggregation and the involved energy allocation ratios have been reviewed with the Work Group and adjusted, as necessary, to be acceptable.

Continuing communications will be conducted as needed after the U.S. Team departure to clarify further questions that could arise regarding the energy demand projection or its disaggregation.

3.1.2 Principal contacts:

March 28: Meeting of Dr. Ali Nassar, INP, with Dr. A. Ezzati of U.S. Team to discuss macro-economic models and forecasts of the INP for the year 2000 and their related assumptions.

March 29: Demand Projection Work Group Meeting to discuss macro-economic models and forecasts of the INP for the year 2000 and their related assumptions.

March 30: Demand Projection Work Group Meeting to continue discussion of projection methods and availability of data. Egyptian attendance was the same as for March 29 plus Eng. S. Habib, EGPA. U.S. Team attendance was the same as March 29 less V. Kumar.

April 3: Demand Projection Work Group to plan demand projection activities taking into account decisions by Executive Committee.

April 8: Demand Projection Work Group Meeting to explain status of electricity and fuels projection to U.S. Team and describe certain of the basis of this projection. U.S. questioned whether energy consumption in terms of animal waste, agricultural waste and animal motive power would be included. Egyptian attendance included: M. El Koshairy, W. El Shafie, K. Maksoud, M. Swidan, R. Abin, A. Elbihery, M. A. Barakat, M. El Ewin, M. Ghanem. U.S. team attendees included: R. McFarren, A. Ezzati, J. Davidoff, J. Anderson, A. Tomazinis.

April 9: Meeting of Dr. A. Ezzati of U.S. Team with the Egyptian Ministry of Planning to discuss the Egyptian Five-Year Plan, projections of industrial output, and the input/output tables of the Egyptian economy. The Egyptian Ministry of Planning attendees included Dr. Mahmoud Saleh (Input-Output Sector), Dr. Morris Farid and Dr. Atef Dabour.

April 12: Meeting of Dr. A. Ezzati with Eng. Mahrous El Amin, GOFI, to discuss industrial sector breakdown structure and projections of industrial subsector activity levels.

April 13: Demand Projection Work Group Meeting to review U.S. Team questions on electricity demand projection. Egyptian attendees: W. Shafie and A. Elbihery. U.S. attendees: R. McFarren, A. Ezzati, J. Anderson, J. Davidoff.

April 15: Meeting of Dr. A. Ezzati with The Egyptian Ministry of Planning to discuss assumptions and inconsistencies in the electricity and fuels demand projections. Egyptian MinPlan attendees: A. Albihery, A. Ibrahim, M.K.M. Jorihim and Eng. Fawzi.

April 16: Meeting with Mr. John Shumaker, Sanderson and Porter Corp., to discuss underlying assumptions of electricity demand projection and break down by type of industry and the historical and projected electricity demand of industrial sector. U.S. Team Attendees: R. Cirillo, E. Purvis and A. Ezzati.

April 18: Meeting with Dr. K. Maksoud and Eng. M. El Amin of GOFI to obtain their input on industry sector disaggregation ratios. U.S. Team Attendees: R. McFarren, A. Ezzati, J. Davidoff and W. Porter.

April 19: Demand Projections Work Group Meeting to review assumptions to EGPA fuels and discuss U.S. Team suggested disaggretation ratios. Egyptian attendees; W. El Shafie, M. Elbihery, S. Habib, R. Abdin. U.S. Attendees: A. Ezzati, J. Davidoff, G. Berstell and J. Anderson.

3.2 Work Group on Demand Options

This report summarizes the status of the activities of the Work Group on Energy Demand Options.

Overall, the activities of the work group have been fruitful leading to many informative counterpart meetings.

The work group has met twice. The first meeting on March 28, 1978, was primarily an introductory planning meeting. The second meeting on March 29 was held so that information might be exchanged. Specifically, the U.S. members submitted to the work group detailed information lists, bibliographies and demand team guidance documents. The Egyptian members submitted a list of counterparts for each of the energy end-use sectors. It was agreed that the U.S. members could make their own appointments with the understanding that Egypt be kept advised.

3.2.1 Overview of work group activities:

3.2.1.1 Demand sector activities: All counterpart meetings were completed by April 17, 1978. Several site visits were made and much data collected including plant diagrams.

3.2.1.2 Agriculture: Counterpart meetings were completed by April 13, 1978.

3.2.1.3 Residential and commercial: Counterpart meetings were completed by April 13, 1978. Major gaps still exist in data on fuel consumption by households, current and projected.

3.2.1.4 Transportation: Counterpart meetings completed April 18, 1978. Major gaps still exist in the definition of transportation plans.

3.2.2 Principal contacts:

March 19, 1978: Meeting with Robb Smith, Middle East Advisory Group, to discuss wage survey. U.S. Attendee: Jennine Anderson

March 22, 1978: Meeting with AID/UN participants in rural development seminar. U.S. Attendee: Jennine Anderson.

Meeting with Jerry Edwards, AID Agriculture Officer, to discuss agricultural development projects. U.S. Attendee: Jennine Anderson.

March 23: Meeting with Mr. Shope, AID Capital Resources Officer, to discuss AID industry projects in cement and textiles. U.S. Attendee: Jennine Anderson.

March 25: Meeting with Harza Engineering to discuss AID and IBRD projects in urban/rural electricity demand. U.S. Attendees: Jennine Anderson, Ted Kapus, Bill Graham and Ed Warchol.

March 28: Meeting with Harza Engineering to discuss residential electricity demand. U.S. Attendees: Gerald Berstell and Ted Kapus.

March 29: Meeting with TAMS to discuss residential energy demand. U.S. Attendees: Gerald Berstell and Ted Kapus.

March 30: Meeting with Eng. Kamel Maksoud, Head of Central Administration for Industrial Planning and Technical Research, General Organization for Industrialization, to discuss iron and steel. U.S. Attendees: Chris Moore, Charles Bliss and Mike Gallagher.

March 30: Meeting with A.M. Barakat, Head of Research Group, Transport Planning Authority, to discuss transportation.* U.S. Attendee: Jennine Anderson.

April 1: Meeting with Aly F.El Daghestany, Vice-Chairman of the Transport Planning Authority, to discuss transportation planning.* U.S. Attendees: Jennine Anderson and Mike Gallagher.

Meeting with Bill Spoolberk of the Ford Foundation to discuss residential energy demand. U.S. Attendees: Gerald Berstell and Ted Kapus.

April 2: Meeting with Eng. Sarwat Fahamy of the Water Resources Department of the Ministry of Irrigation to discuss irrigation and land reclamation. U.S. Attendee: Victor Kumar.

---

* Meeting set up through the Demand Projections Work Group

Meeting with Eng. Abdul Ghani Hassan of the Mechanical Department of the Ministry of Irrigation to discuss pumps. U.S. Attendee: Victor Kumar.

April 3: Meeting with Ministry of Housing and Reconstruction to discuss residential and commercial buildings. Attendees: Mr. A. I. El Kashif, President of Central Agency for Reconstruction; Mr. Salah El-Bendary, Deputy of Central Agency for Reconstruction; Mr. Samy Behery, Chairman of the Research and Study Agency for Reconstruction; Mr. A. Labib, Chairman, Board of Directors, Housing and Building Cooperative; Mr. Mohyie El-Nagar, Undersecretary for Planning; and Mr. Hassan Abdel Kader, Chairman of Board of Directors, Cement Asbestos Pipes Producing Co.

Complete set of volumes entitled "The Planning of Sadat City" provided by Mr. Samy Behery.

Meeting with Engineer Abd El-Mohsen Azmy, First Undersecretary for the Ministry of Irrigation and Land Reclamation, to discuss mechanization of irrigation. Attendees: Jennine Anderson and Chris Moore.

April 4: Meeting with Dr. Moustafa Swidan, Director of Power Systems Planning, Egyptian Electricity Authority, to discuss residential energy demand. U.S. Attendees: Ted Kapus, Gerald Berstell.

Meeting with A.M. Barakat, Transportation Planning Authority, to discuss further transportation fuel use data. U.S. Attendees: Jennine Anderson, Ali Ezzati and Robert McFarren.

Meeting with Eng. Hassan M. Sallan, Chairman, Executive Secretariat to the Industrial Sectorial Higher Council, to discuss textiles. U.S. Attendees: Chris Moore, Victor Kumar and Henry Cole.

Meeting with Abdel Megid El Ghish of the Egyptian Sugar Company to discuss industry and arrange sugar refinery visit. U.S. Attendee: Victor Kumar.

Meeting with R.J. Edwards, AID Agricultural Officer, to discuss agriculture and energy use. U.S. Attendee: Victor Kumar.

April 5: Meeting with A.M. Barakat, Head of Economic Research Group, Transport Planning Authority, to discuss railroad rolling stock statistics.

Meeting with Samir Toubar of Iran-Misr Development Bank to discuss data from household surveys. U.S. Attendee: Gerald Berstell.

Meeting with Dr. El Hami and Mounir Abdel Malek to discuss chemicals. U.S. Attendee: Christopher Moore.

April 6: Meeting with Eng. Mahmoud Khalil Meligny, Director General for Power, Electric and Electronic Industries of GOFI, to discuss production and energy consumption by electrical devices. U.S. Attendees: Gerald Berstell and Peter Teagan.

Meeting with Samir Toubar of Iran-Misr Development Bank to complete household data collection. U.S. Attendee: Gerald Berstell.

Meeting with Hassan Abdullah, Ministry of Agriculture, to discuss power consumption in agriculture. U.S. Attendee: Victor Kumar.

Meeting with Eng. F. Nashat and Dr. Hamed Amer to discuss petrochemicals and sector plans for the future.

April 8: Meeting with M. A. Barakat and Mrs. Effat of Transport Planning Authority. Viewed Louis Berger Report. U.S. Attendees: Anthony Tomazinis and Jennine Anderson.

Meeting with Eng. Ali Hasdairy of Statistic/Mechanization Department in the Ministry of Agriculture to discuss mechanization of agriculture. U.S. Attendee: Victor Kumar.

April 9: Meeting with Hosni Shaker, Director General Engineering Industries, GOFI, to discuss energy consumption by electrical appliances. U.S. Attendee: Gerald Berstell.

April 10: Meeting with Dr. Moustafa Swidan, Egyptain Electricity Authority, to discuss power consumption in industry sectors. U.S. Attendee: Victor Kumar.

Meeting with Mr. Ali Ben Abidin, General Organization for Food Industries, to discuss food processing industry statistics. U.S. Attendee: Victor Kumar.

Meeting with Jim Norris, AID, to discuss transport. U.S. Attendee: Anthony Tomazinis.

Meeting with David Crane and Paul Byrne of David Crane Assoc. to discuss transport. U.S. Attendee: Anthony Tomazinis.

April 11: Meeting with Eng. Kamel Maksoud, GOFI, to discuss implication of the Open Door Policy. U.S. Attendees: Robert McFarren, Henry Cole, Richard Cirillo, Norman Walpole and Jennine Anderson.

Meeting with Mr. Suleyman Haie, Vice Chairman of the Committee for Reconstruction of the Country; Dr. Hasan Marei, Chairman of the Committee, and Mr. Nahib Younis, Member of the Committee, both of the Ministry of Housing and Reclamation on the coordination of policies for development and transportation. U.S. Attendees: Anthony Tomazinis, Jennine Anderson and Robert McFarren.

April 12: Meeting with Eng. Mahmoud Khalil Meligny, GOFI, to finish discussions on data on air conditioning, lighting and television. U.S. Attendees: Gerald Berstell and Kurt Mead.

Meeting with Salah Arafa and Cynthia Nelson of American University in Cairo to discuss solar project in village near Zagazig. U.S. Attendees: Jennine Anderson, Gerald Berstell and George Kaplan.

Meeting with Dr. Ali Maasawi, Transport Planning Authority, to discuss transport planning. U.S. Attendee: Anthony Tomazinis.

Meeting with Eng. Khattab, Egyptian Copper Works, to collect data and discuss plant operations. U.S. Attendees: Paul Thorne and Victor Kumar.

Meeting with Eng. Shokri ElKarza, Misr Rayon Co. in Kafr El Dawar, to collect data and discuss operations. U.S. Attendees: Paul Thorne and Victor Kumar.

April 13: Meeting with Eng. Abdel Salam El Massawi, Deputy Chairman, Executive Org. for Iron and Steel Complex. Viewed Tender Document for Iron Ore Benefication Study. U.S. Attendee: Chris Moore.

Meeting with Dr. Ali Hosshiry, Ministry of Agriculture. Acquired data and general paper on agricultural mechanization. U.S. Attendee: Victor Kumar.

Meeting with Eng. Salam Salmawi, Technical Director of Transport Planning Authority. U.S. Attendee: Anthony Tomazinis.

April 15: Meeting with Gamal El Nazer, Deputy Minister for Economic Development, General Organization for Arabic Investment, to discuss Open Door Policy. U.S. Attendees: Henry Cole, Robert McFarren, Norman Walpole and Jennine Anderson.

Meeting with Eng. Zaki at NASCO to discuss auto industry. U.S. Attendee: Paul Thorne.

Meeting with Eng. El Hami to review chemicals industry. U.S. Attendee: Victor Kumar.

Meeting with Salam Salmawi and Abdel Kader Fathy Lashine, Transport Planning Authority. U.S. Attendee: Anthony Tomazinis.

Meeting with Mohamed El-Mezawie to discuss transport planning in Egypt. U.S. Attendee: Anthony Tomazinis.

April 17: Meeting with Hussein F. Sabbour, Chairman, and Dr. M. El Hawary of Sabbour Associates. U.S. Attendee: Anthony Tomazinis.

3.3 Work Group on System Integration Methods

The Egyptian principal for the Work Group was Dr. Mahmoud El-Koshairy. The U.S. Team principal was Dr. Philip Palmedo, with U.S. Team Leader, R. McFarren, substituting for Dr. Palmedo after his departure for the U.S.

The objective of this Work Group was to suggest measures for Egyptian participation in the continuing analysis activities to be conducted in the U.S. The purpose of this participation was to:

1. provide Egypt with continuity of input and insight with respect to the analysis activities;

2. guide the Egyptian review of the draft assessment report; and

3. enhance the effective transfer of the analysis methodology to Egypt for continued use and development.

3.3.1 Overview of work group activities: The System Integration Methods Work Group met twice, using a guidance document prepared by the U.S. Team. Alternative means of providing effective Egyptian participation in the continuing analysis activities were considered. The ability of the U.S. Government to provide financial assistance toward the cost of such Egyptian participation was clarified. The U.S. Team representatives stated that the U.S. would pay the travel cost to and from the U.S. and a daily living expense allowance while in the U.S. for up to six Egyptian representatives to participate in the analysis activities. (Costs related to other business while in the U.S. would be at the expense of Egypt.)

It was agreed that two types of participation were advisable:

First, have two intermediate level engineer/analysts participate in the analysis activities beginning on about May 1, 1978, and continuing to early June and possibly until the draft assessment report is prepared for transmittal to Egypt. These two engineer/analysts should then be available to: (a) assist in the Egyptian review of the draft assessment report; (b) work to establish the analysis methods as a functional system in Egypt; and (c) train other Egyptian engineer/analysts in the use of the analysis methods.

Second, have a group of four executive level Egyptian officials be available in the U.S. for a period of a week to 10 days at the time the analysis is about to be completed. These officials should be generally representative of four functions: (a) electricity supply; (b) fossil fuels supply; (c) long-range energy planning; and (d) financial and economic factors. During their stay in the U.S., these officials would review the results of the analysis and work with the U.S. Team to: (a) develop the observations to be drawn from the analysis; and (b) write the observations section of the draft assessment report. Upon their return to Egypt, these officials would (a) guide the review of the draft assessment report by their respective ministries; and (b) initiate, as appropriate, the continued use of the assessment or the analysis methods in the planning and evaluation functions of those ministries.

These suggestions were reviewed with the Executive Committee in its meeting on April 17, 1978 and plans for further action in this matter formulated. In the discussions with the Executive Committee, the following possible candidates for these assignments were noted:

Task No. 1. Intermediate Level Engineer/Analysts:

Engineer Ahmed Ghanem, EEA
Engineer Mahmoud Ouf, EEA

Task No. 2 Executive Level Officials:

Finance and Economics: Deputy Minister Fouad Hussein or an Alternate Appointee of Deputy Prime Minister Quasouni
Electricity Supply: Dr. Moustafa Swidan, EEA
Fossil Fuels Supply: Engineer Samir Habib, EGPA
or
Planning: Dr. El Walid El Shafie, INP

In addition, U.S. Team Leader McFarren suggested that consideration be given to participation in this task by Dr. J. H. Abdel Rahman, Planning Advisor to the Prime Minister, who is currently teaching in the U.S. This suggestion was favorably received. Mr. McFarren indicated the U.S. would be willing to pay Dr. Rahman's travel expenses if this was desired. Mr. McFarren also offered to brief Dr. Rahman on the assessment activities if Egypt decided he would be asked to participate. Mr. McFarren also noted in the course of the Work Group discussions that the U.S. was planning to provide: (a) descriptive and operating documentation or any analysis methods using computer programs; and (b) magnetic tapes, computer programs and data for continuation of the analysis.

3.3.2 Principal contacts:

April 12: To review U.S. guidance documents and consider alternative means to achieve effective Egyptian participation. Egyptian attendees: Dr. M. El Koshairy, Dr. W. El Shafie, Dr. M. Swidan and Eng. A. Ghanem. U.S. Attendees: R. McFarren and A. Ezzati.

April 17: To review Egyptian concepts for participation and finalize suggestions to the Executive Committee. Egyptian attendees: Dr. M. El Koshairy, Dr. W. El Shafie, Dr. E. Sharkawi, Dr. M. Swidan and Eng. A. Ghanem, U.S. Attendees: R. McFarren, A. Ezzati and K. King.

4.0 SUBCOMMITTEE ON ADVANCED TECHNOLOGY SUPPLY SYSTEMS REPORT ON DATA COLLECTION BASE

The Egyptian Leader on the subcommittee was Dr. Mahmoud El-Koshairy of the Ministry of Electricity; the U.S. leaders were Dr. Peter Teagan and Dr. Richard R. Cirillo. The subcommittee was comprised of a Work Group on Solar and New Energy and a Work Group on Geothermal Energy. The Work Group on Geothermal Energy convened on March 29 to discuss previous resource investigations and the Work Group on Solar and New Energy convened on April 3 to set up detailed counterpart activities. Both of the work groups functioned smoothly with excellent cooperation being received from the Egyptian staff members. The following activities were undertaken by the work groups.

4.1 Work Group On Solar And New Energy

The leaders of this group were Dr. Mahmoud El-Koshairy of the Ministry of Electricity, Dr. Mohamed Kamel and Dr. Ibrahim Sakr of the National Research Center, Dr. Mahmoud Hegazi of the Egyptian Electricity Authority, Dr. Peter Teagan, and Dr. George Kaplan.

4.1.1 Overview of work group activities: The U.S. team received excellent cooperation from the Egyptian officials and a great deal of insight into the applicability of various solar energy technologies had been gained. Discussions on solar, thermal, photovoltaic, wind energy and biomass utilization were held. Applications of solar energy to water heating, air conditioning and refrigeration, electric power generation, desalination, water pumping and biogas generation were discussed in the context of ongoing research programs and potential future commercialization possibilities. Special emphasis was placed on determining the capability of Egyptian industry to manufacture solar equipment locally. In a separate but related activity, the U.S. has arranged for two solar experts to visit Egypt April 25 to May 5 to provide technical assistance in the preparation of an international tender to procure 1,000 solar water heaters.

4.1.2 Principal contacts:

1. National Research Center

   - Prof. Mohammed Mokhtar El-Halwagi

   - Prof. El-Din Abdel Samir

2. Egyptian Electricity Authority

- o Dr. Mahmoud Hegazy, Director General for Research and Testing

4.2 Work Group On Geothermal Energy

The leaders of this work group were Dr. Shazly Mohamed El-Shazly of the Nuclear Materials Authority and Dr. Adel Zhody of the U.S. team.

4.2.1 Overview of work group activities: Dr. Zohdy was given excellent cooperation in his assessments. The principal difficulty was that, although the potential for geothermal appears to be good, an adequate survey of resources is not currently available. On this basis it was decided that Dr. Zhody's report will include a discussion of an exploration program indicating information objectives, program scope, and resource requirements. In addition, a description of alternative geothermal technology configurations will be prepared in the U.S. based on the data available. This will provide some preliminary indications of the applicability of the various systems to Egyptian needs, and can be revised as resource information becomes available. It was agreed that it would not be necessary to have a geothermal specialist visit Egypt at this time.

4.2.2 Principal contacts:

1. Nuclear Materials Authority
   - o Dr. F.T. El Adl
   - o Dr Abdel Hady
2. Geological Survey of Egypt
   - o Dr. Galal Moustafa
   - o Dr. Swanberg
   - o Dr. F. K. Boulos
3. Desert Institute
   - o Dr. Abu Shata

5.0 CROSS-CUT ACTIVITIES

Several of the U.S. Team members were involved in assembling data to be used in the reports of each of the work groups. These activities, known as "cross-cutting activities," are as follows:

5.1 Environmental Considerations

Dr. Raymond Cooper and Dr. Ronald Zussman collected information on current environmental quality to identify potential impacts of future energy developments.

5.1.1 Overview of work group activities: The data collection was difficult since there is no central environment agency in Egypt. Excellent cooperation was received by all those contacted and the available information provided. Dr. Cooper contacted some U.S. agencies that have worked on environmental problems in Egypt to assemble their data.

5.1.2 Principal contacts:

1. National Academy of Science and Technology
   - Dr. Moustafa Hafez, Head, Environmental Research Council
   - Dr. Mohammed Younis, Research Associate Professor
2. University of Alexandria
   - Dr. Ahmed Hamza
   - Dr. Samia G. Saad
3. YMCA
   - Mr. Roushdy Melek
4. UNESCO
   - Dr. Christine Gishler, Hydrologist
5. National Research Center
   - Dr. Fatma El Gohari, Professor
   - Dr. Sami Abdel Salem, Head of Air Pollution and Environmental Health
6. High Institute of Public Health, Alexandria
   - Dr. Ragas El Gazzar

5.2 Facility Cost

5.2.1 Overview of work group activities: Dr. Michael Gallagher collected data on the cost of construction of energy-related facilities. Mr. Gallagher's work was completed on time. The data he collected was used to provide estimates of construction costs, manpower requirements, and materials requirements of energy facilities. The Egyptian data assisted in the adjusting of U.S. information to reflect Egyptian conditions. The cost estimates were provided to each fuel cycle team for use in their reports.

5.2.2 Principal contacts:

1. Ministry of Industry (Government Organization for Industry)
   - Eng. Kamel Maksoud, Director of Planning and Technical Research
   - Eng. Mahrous El Amin
2. Ministry of Transportation
   - Mr. Ali F. El-Daghestany, Vice Chairman of Transport Planning Authority
   - Mr. A. M. Barakat, Head of Research Group, TPA
3. Egyptian General Petroleum Corp.
   - Mr. Sami Andrawis, Deputy Chairman, Planning & Projects
   - Eng. Samir Habib, General Manager, Planning & Economics of Projects
4. Ministry of Housing and Reconstruction
   - Eng. Wagdi Shoban, Undersecretary of State
5. MISR Consultant Engineers
   - Dr. Hassan H. El-Shafie, Managing Director
6. Tippets-Abbott-McCarthy-Stratton Consulting Engineers
   - Mr. A. Kramer
   - Mr. Ralph J. Watkins
7. Westinghouse
   - Mr. Salah Afifi, Regional Director

5.3 Manpower Requirements

5.3.1 Overview of work group activities: Dr. Richard Roman collected data on manpower availability for energy projects and on the need for additional training programs. The work was slowed by the unavailability of centrally located manpower data. Information was collected from individual ministries and other organizations. Nevertheless, Dr. Roman was provided with sufficient information to draw some conclusion on manpower availability.

5.3.2 Principal contacts:

1. Ministry of Higher Education
   - Eng. Gindy, Secretary General
   - Mr. Muttah, Consultant
2. Higher Education Council of Universities
   - Mr. Shafik Balban, Secretary General
3. National Institute of Planning
   - Dr. Mohammed Mungi, Head, Department of Manpower Planning
4. Egyptian Electricity Authority
   - Dr. Emad El-Sharkawi, Managing Director
   - Dr. Moustafa Swidan, Director General, Power System Planning
   - Mr. Hassan Said, Research and Testing Department
5. Nuclear Power Plant Authority
   - Eng. Hussein Sirry, Executive Chairman
   - Dr. Fouad Fooley, Vice Chairman
   - Dr. Ali El-Saidi, Undersecretary
6. Cairo University
   - Dr. Hassan Ismael, Professor of Engineering
7. Ministry of Manpower and Training
   - Mr. Ahmid Fahim, Undersecretary
   - Mr. Ahmed Kassab, Undersecretary
   - Mr. Kamel R. Mazloun, Statistician

8. League of Arab Engineers

   o Dr. Ibrahim Kinawy, Senior Consultant

9. National Research Center

   o Dr. Mohammed Younis

10. Academy of Scientific Research and Technology

   o Prof. Mohammed Sahea El-Dien Fayez, Vice President

11. Sahafa Institute

   o Eng. Mohammed Morsey, Director

   o Eng. Abdel-Hamid Graco, Curriculum Supervisor

5.4 Transmission Facilities

Mr. Edward Warchol collected data on transmission line capabilities and planned expansions. He has interacted closely with the fossil, hydroelectric and nuclear teams.

5.4.1 Overview of work group activities: Mr. Warchol received data on electrical transmission expansion plans up through 1985. He was advised that a study on needs beyond 1985 was under way and would be ready in 4-5 months. He worked with the supply teams to identify possible alternative configurations.

5.4.2 Principal contacts:

1. Egyptian Electricity Authority

   o Dr. Moustafa Swidan, Director General, Power Planning Authority

   o Dr. Hamdi El-Shaer, Director General for System Operations

2. Harza Engineering Co.

   o Mr. V.J. Andres, World Bank Manager for REA

   o Mr. T.E. Horkay, AID Manager for EEA

   o Dr. Zahedani, Computer Specialist

5.5 Water Resources

5.5.1 Overview of work group activities: Dr. Frank Clarke of the U.S. Geological Survey has collected information on water resources to identify any constraints that water availability may have on energy development. Dr. Clarke's work was completed and the data required was assembled on schedule.

5.5.2 Principal contacts:

1. Geological Survey of Egypt
   - Dr. Mohamed Youssef
   - Dr. Mohamed El Ramly
2. Ministry of Irrigation
   - Tharwat Fahmy, Co-Manager, Water Planning
   - Dr. K. Hefney, Director, Research Institute for Irrigation
   - Dr. Saleh Nour, Chief, Technical Office, Desert Irrigation Dept.
3. Ministry of Agriculture
   - Mr. Rifky Anwar
4. Ministry of Industry
   - Mr. Kamel Maksoud, Director for Planning and Technical Research, GOFI
5. Ministry of Housing
   - Mr. Wagdi Shaaban, Undersecretary of State
6. Academy of Sciences
   - Dr. Moustafa Hafez, Vice Chairman
7. Desert Institute
   - Dr. Shatta
8. Reclamation Company
   - Dr. Zaky Arnaout, Chairman
9. Egyptian General Petroleum Corp.
   - Dr. Moustafa El-Ayouty, Director General

10. Nuclear Materials Authority

    - Dr. Shazley El-Shazley, Chairman

5.6 Energy-Related Minerals

5.6.1 Overview of work group activities: Dr. Eugene Tolbert of the U.S. Geological Survey collected data regarding the availability of energy related mineral resources. Dr. Tolbert's visit was completed ahead of schedule and all the necessary data were collected.

5.6.2 Principal contacts:

1. Geological Survey of Egypt

    - Dr. Galal Moustafa, Chairman
    - Dr. Maurice Hermina, Director
    - Dr. Anwar Bishay
    - Dr. Mohammed El Ramly

2. Ain Shams University

    - Dr. Hassan El Etr

3. Egyptian General Petroleum Corp.

    - Dr. Moustafa El-Ayouty, Director General

4. Nuclear Materials Authority

    - Dr. Shazley Mohammed El-Shazley, Chairman

5.7 Development Issues

5.7.1 Overview of work group activities: Mr. Henry Cole and Mr. Norman Walpole collected information that would be useful in determining the social, economic and institutional impacts of various energy options.

Mr. Cole and Mr. Walpole worked with each of the supply teams after the options were identified. Additional information was requested from consultants at American University in Cairo.

5.7.2 Principal contacts:

1. Institute of National Planning

    - Dr. Walid El Shafie
    - Dr. A. Mongi

2. Government Organization for Industry

   o Eng. Kamel Maksoud, Director of Planning and Technology

   o Eng. Mahrous El Abin

3. American University in Cairo

   o Dr. Nazih Deif, Former Minister of Finance

   o Dr. Saad Ibrahim, Professor, Institute of Politics & Strategic Studies

4. Cairo University

   o Dr. Hussein Aziz

5. Ministry of Health

   o Dr. Samir Guiges

   o Dr. Abu Gamia

6. Ministry of Planning

   o Dr. Mohammed Osman

   o Dr. Hassan El Hagi

APPENDIX C - PROJECTION OF ENERGY DEMANDS

1.0 THE PROJECTION OF ENERGY DEMANDS

This Appendix provides supporting details to section 2.2, Energy Demand Projection, of the Main Report. Section 1.0 first describes in more detail how the projection of energy demands was developed and how the means to theoretically disaggregate it to subactivity levels was formulated. Section 2.0 summarizes some of the energy demand growth patterns that result from the projection. Section 3.0 provides some observations on these relative growth patterns. The attachment to this appendix provides the worksheets used in the theoretical disaggregation process so that the source of the disaggregation and any reference sources used as a basis for that theoretical disaggregation are available to the reader.

1.1 The Projection and Methodology

1.1.1 The projection approach: As described in section 2.1 of the Main Report, the Reference Energy System approach is normally based on the development of projections of physical activity levels. It became apparent early in the collaborative assessment that there was very little data available on which to base this bottom-up approach to preparing the demand projection. There existed neither a consistent set of activity levels nor a set of energy efficiencies or intensities to develop fuel requirements or activity levels. The Egyptian participants indicated that there were significant differences of opinion regarding the Five-Year Plan (ending in 1982) and the projections of sectoral growth contained therein. It was agreed, therefore, that the demand projections would be based on the Egyptian Electricity Authority (EEA) projections of electricity demand in major economic sectors, and projections of natural gas and petroleum demands by the Egyptian General Petroleum Corporation (EGPC). Even these projections required considerable work on the part of special task forces mobilized under the leadership of the Institute of National Planning. The U.S. team agreed to be responsible for disaggregating the sectoral demand projections by activities. These were then to be reviewed by the Egyptian participants.

During the information exchanges in March and April, it was made clear there had been insufficient time available to correlate the two projections to a consistent set of demographic and economic growth assumptions. Nor were they tied to a totally consistent sectoral structure for representing national economic development. Also, many U.S. and Egyptian team members realized the importance of having energy demand projections developed within a macroeconomic framework, but it was recognized that this could not be accomplished in the time available for this initial assessment.

1.1.2 Electricity demand projections: The EEA projected the demand for electricity for the following economic sectors:

1. Industry: urban and rural industry.

2. Agriculture: irrigation, drainage, farm work, and animal feedings.

3. Transportation: communication and storage, personnel, petroleum pipelines, energy needed for ports and airports, warehouses, large refrigeration plants, telephone-telex and wireless.

4. Public Utilities: drinking water plants and facilities, sewage facilities, public lighting, government housing.

5. Residential: urban and rural dwellings.

6. Miscellaneous: military, government and non-profit organizations.

These projections of electricity demand are presented in Table C.1. They are based on the aggregate electricity load projections made by Sanderson and Porter in collaboration with the EEA. A fifth degree polynomial approximation to historical aggregate electricity load projection compares favorably with the projection of the Aoki Consultants (to the EEA) which used assumed and achievable energy/GNP ratios as a basis for its electricity load projection. The final disaggregation of total electricity demand to its sectoral components was carried out by the Institute of National Planning (INP) and the Ministry of Planning using the historical and expected industrial electricity demand growth ratios and taking into account the relative and absolute growth rates of other economic sectors. The Sanderson and Porter electric load projection for major industrial complexes was also used as a major input into the analysis. The electricity demand projections, particularly for the industrial activities, were coordinated with the General Organization for Industrialization (GOFI).

<u>1.1.3 Petroleum product demand projection</u>: The Egyptian General Petroleum Corporation (EGPC) projected demand for natural gas and petroleum products for the following sectors and products:

1. Economic Sectors

   - Industry
   - Agriculture
   - Transport
   - Electricity
   - Domestic (Residential)
   - Others

TABLE C.1

PROJECTED ANNUAL DEMAND FOR ELECTRICITY

(COMPARISON CASE)

	1975			1985			2000		
	10^6kwh	10^{15}Joules	Percent	10^6kwh	10^{15}Joules	Percent	10^6kwh	10^{15}Joules	Percent
Industry	4822	17.36	58.1	16000	57.60	58.1	47170	169.81	53.6
Agriculture	666	2.40	8.0	2750	9.90	10.0	5550	19.98	6.3
Transportation & Storage	187	0.67	2.3	1545	5.56	5.6	6425	23.13	7.3
Public Util-ities	545	1.96	6.6	1500	5.40	5.5	5985	21.55	6.8
Residential	1692	6.09	20.4	4900	17.64	17.8	19350	69.66	22.0
Others	382	1.38	4.6	825	2.97	3.0	3520	12.67	4.0
Total Demand	8294	29.86	100%	27520	99.07	100%	88000	316.80	100%

Source: Ministry of Energy and Electricity, Egypt.

Note: The Total Demand is actual consumption excluding line loss

2. Petroleum Products

Egyptian Nomenclature	U.S. Nomenclature
Butagas	LPG
Benzene	Gasoline
Kerosene	Kerosene
Gas Oil (Sular*)	Gas Oil
Diesel Oil	Diesel Oil
Fuel Oil (Mazout*)	Residual Fuel Oil

The sectoral petroleum products demand projections provided to the analysis by EGPC is based on historical trends and implicit assumptions on expected relative and absolute growth rate in demand for petroleum products in various economic sectors. The projections are reported in Tables C.2 and C.3.

The projected demands for natural and associated gases for the years 1985 and 2000 were also provided by EGPC. The total and sectoral demand projection for natural gas is heavily influenced by resource availability and supply of natural gas as well as the capability to control flaring associated gases and construction of gas gathering and distribution systems for marketing previously flared natural gas. In the EGPC projection, it was assumed that 65 percent of associated gas is committed to be used in electricity generation in 1985 and 2000, 17 percent assigned to fertilizer and 17 percent to the cement industry. It is further assumed that 55 percent of non-associated gases will be used for generation of electricity and 44 percent in the industrial sector (see Table C. 4).

Table C.5 presents projected demand for total commercial energy for 1975, 1985 and 2000. These projections do include consumption of coal in the form of coke in the iron and steel industry. This estimate of coal consumption was prepared by the U.S. team on the basis of indicated targets of iron and steel production using the blast furnace process.

1.2 The Disaggregation Methodology

1.2.1 Disaggregation of sectoral energy demands: Sectoral electricity and fuel demand reported by the Egyptian counterparts were disaggregated using apportionment ratios developed for planning activities of interest within each economic sector. These ratios were developed by the U.S. team in collaboration with Egyptian officials for the industrial, transportation, agricultural, residential (urban and rural), and commercial sectors.

*Idiomatic expression

TABLE C.2

EGYPT

PROJECTED ANNUAL DEMAND FOR PETROLEUM PRODUCTS

(COMPARISON CASE)

	1975			1985			2000		
	10^3Mt	10^{15}Joules	Percent	10^3Mt	10^{15}Joules	Percent	10^3Mt	10^{15}Joules	Percent
Industry[1]	1548.7	61.9	19.9	3046.3	126.6	21.5	7250.3	302.2	36.6
Agriculture	345.8	15.3	4.9	578.6	25.5	4.3	1317.2	57.5	7.0
Transportation[2]	1250.6	64.80	20.8	2062.7	106.6	18.1	4123.8	204.5	24.8
Electricity[3]	1150.8	46.9	15.1	3986.1	163.4	27.7	26.3	1.0	.1
Domestic	1254.7	55.9	18.0	2243.7	100.6	17.1	3995.9	182.2	21.8
Others	1569.5	66.1	21.3	1575.7	66.3	11.3	1908.2	79.5	9.7
Total Demand	7120.1	310.9	100%	13493.1	589.0	100%	186121.7	824.9	100%

Source: Egyptian General Petroleum Corporation (EGPC)

1 This sector includes housing construction

2 This includes jet fuel provided by BNL.

3 The demand for mazout is modifed by the U.S. team based on the additional information provided by Egypt.

Table C.3

EGYPT

DEMAND OF PETROLEUM PRODUCTS, 1975, 1985, 2000

10^3 Metric Tons

SECTOR	BUTAGAS			BENZENE			KEROSENE			GAS OIL (H.S.D)			DIESEL			MAZOUT		
	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000
Industry[1]	16.1	85.5	412.5	--	--	--	7.1	13.8	32.0	94.4	361.0	955.8	--	--	--	1259.1	2166.0	5400.0
Agriculture	--	--	--	--	--	--	77.2	157.6	320.0	165.1	304.0	637.2	78.0	60.0	60.0	25.5	57.0	300.0
Transport[3]	--	--	--	656.0	1040.0	1980.0	184.8	300.9	429.9	436.2	741.0	1486.8	--	--	--	36.4	62.7	180.0
Electricty[2]	--	--	--	--	--	--	--	--	--	208.8	286.8	--	--	--	--	942.0	3699.3	26.3
Domestic	162.9	484.5	1237.5	--	--	--	1091.8	1759.2	2758.4	--	--	--	--	--	--	--	--	--
Others	--	--	--	--	--	--	11.9	39.4	89.6	471.6	456.0	318.6	78.0	60.0	60.0	1008.0	1020.3	1440.0
TOTAL DEMAND	179.0	570.0	1650.0	656.0	1040.0	1980.0	1372.7	2270.9	3629.9	1376.1	2148.8	3398.4	156.0	120.0	120.0	3271.0	7005.3	7346.3

[1] This sector includes housing construction
Source: Egyptian General Petroleum Corporation, A.R.E.
[2] Electric demand provided by the Ministry of Energy and Electricity
[3] This entry includes jet fuel under the kerosene column which was provided by BNL.

Table C.4

Egypt

PROJECTED ANNUAL DEMAND FOR NATURAL AND ASSOCIATED GASES

(COMPARISON CASE)

	Natural Gas						Associated Gas					
	1985			2000			1985			2000		
	10^3 tons	10^{15} joules	Percent	10^3 tons	10^{15} joules	Percent	10^3 tons	10^{15} joules	Percent	10^3 tons	10^{15} joules	Percent
Industrial	1122	52	44	1122	52	44	235.2	11	35	235.2	11	35
Electricity	1402	65	55	1402	65	55	440.8	20	65	440.8	20	65
Residential	26	1	1	26	1	1	—	—	—	—	—	—
Total	2550	118	100%	2550	118	100%	676	31	100%	676	31	100%

Source: Egyptian General Petroleum Corporation (EGPC)

Table C.5

DIRECT FUEL AND ELECTRICITY DEMAND

	1975		1985		2000	
	Natural Units	10^{15} Joules	Natural Units	10^{15} Joules	Natural Units	10^{15} Joules
Electricity (10^6 Kwh)	8294	29.86	27520	99.07	88000	316.80
Petroleum Products* (10^3 Mt)	5869	264.12	9507	425.69	18595	823.62
Natural Gas (10^3 Mt)	294	13.67	1455	64.44	1455	64.44
Coke (1^3 Mt)	1070	30.00	1965	55.00	8035	225.00
Total	15527	337.65	40447	644.20	116085	1429.86

* Excludes petroleum products consumed for electricity generation

The electricity and fuel consumption by each activity (generated by multiplying each activity ratio by the sectoral total of electricity and fuel demand) were then scrutinized through examination of penetration trends by various energy end-use devices, fuel consumption and substitution pattern, transportation mode shifts, etc. It was also attempted to examine the changes in mixes of fuels used as well as the trends of energy and fuel demand for 1975, 1985, and 2000. These ratios are presented in Tables C.6 to C.9 and documentation for these ratios are reported in the attachment to this. The corresponding energy demand by activities in quadrillion joules (QJ's) and by fuels for the major economic sectors are presented in Table C.10 to C. 13.

1.2.2 Non commercial energy demand: No estimates had been made by the INP or other Egyptian ministries as to the current demand for or utilization of noncommercial energy forms (i.e., crop residues, animal dung and firewood). Nor was there any ready means to estimate how the demand for these energy forms might change in the future. Therefore, it was agreed that the U.S. team could, if it wished, address the prospective role of noncommercial energy forms in the preparation of a set of comprehensive energy system diagrams. However, the basis for the treatment should be clearly stated and it should be noted that this matter was not addressed in the demand projections provided by the EEA or the EGPC.

The method employed by the U.S. team for estimating the potential role of noncommercial energy forms is basically to estimate what quantity of non-commercial energy materials would be available. It is then assumed that what is available will be used in a similar fashion to historical use. Accordingly, the further discussion of noncommercial energy utilization is provided in section 2.4 of the Main Report, Comparison Case Supply/Demand Balance.

2.0 SUMMARY OF DEMAND GROWTH PATTERNS

This section briefly analyzes the growth in various fuel demand projections, changes in fuels consumption patterns, and respective fuel shares of each activity in a particular end-use sector. The information presented here covers only the energy demand projection as developed with the collaboration of Egyptian counterparts.

The growth and changes in patterns of direct fuels, electricity, feedstocks and noncommercial energy usage reflect the degree of substitutions among various fuels and intensity of utilization of particular energy forms in sustaining the growth of end-use activities.

Figure C.1 and Tables C.14 and C.15 summarize the comparative growth of noncommercial energy, direct fuels, electricity, and feedstocks between 1975 and 2000. The growth in non-commercial energy consumption will remain fairly stable at about 1.4 percent per year in the 1975 to 2000 period. The demand for direct fuels will grow at 5.1 percent per year between 1975 and 85 and 4.3 percent per year between 1985 and 2000. The annual growth rates for electricity for the respective periods are 12.7 and 8.1

Table C.6 - 1975

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE INDUSTRIAL SECTOR - 1975

Activities	Electricity	Butagas	Kerosene	Gas Oil (H.S.D.)	Mazout	Natural Gas	Coal
Cotton Gin & Press	.01	--	--	--	--	--	--
Extraction Ind.	.05	--	--	--	--	--	--
Food	.05	--	--	--	--	--	--
Chemical	.32	--	--	--	--	.60	--
Small Scale Ind.	.06	.20	.20	.20	--	--	--
Build Mat.	.08	.05	.10	.50	.28	--	--
Metals	.08	.05	--	--	.20	--	1.00
Engineering Ind.	.02	.05	.10	.05	.10	--	--
Other	.28	.60	.60	.20	.42	--	--
Military	.04	.05	--	.05	--	--	--

Table C.6 - 1985

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE INDUSTRIAL SECTOR 1985

Activities	Electricity	Butagas	Kerosene	Gas Oil (H.S.D.)	Mazout	Natural Gas	Coal
Cotton Gin & Press	.02	--	--	--	--	--	--
Extraction Ind.	.05	--	--	.05	--	--	--
Food	.05	--	--	--	--	--	--
Textile	.05	--	--	--	--	.10	--
Chemical	.20	--	--	--	--	.41	--
Small Scale Ind.	.02	.20	.20	.27	--	--	--
Build Mat.	.06	.05	.10	.35	.30	.08	--
Metals	.40	.05	--	.05	.30	.26	1.00
Engineering Ind.	.10	.05	.10	.05	--	.05	--
Other	.01	.55	.60	.18	.40	.10	--
Military	.04	.10	--	.05	--	--	--

Table C.6

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE INDUSTRIAL SECTOR - 2000

Activities	Electricity	Butagas	Kerosene	Gas Oil (H.S.D.)	Mazout	Natural Gas	Coal
Cotton Gin & Press	.02	--	--	--	--	--	--
Extraction Ind.	.05	--	--	.05	--	--	--
Food	.05	--	--	--	--	--	--
Textile	.05	--	--	--	--	.10	--
Chemical	.15	--	--	--	--	.28	--
Small Scale Ind.	.02	.20	.20	.25	--	--	--
Build. Mat.	.06	--	.10	.40	.30	.13	--
Metals	.35	.10	--	.05	.20	.40	1.00
Engineering Ind.	.15	.05	.10	.05	--	.05	--
Other	.06	.60	.60	.10	.50	.04	--
Military	.04	.05	--	.10	--	--	--

Table C.7 - 1975

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE TRANSPORTATION SECTOR - 1975

Activities	Electricity	Benzene	Jet Fuel	Gas Oil (H.S.D.)	Mazout
Automobile	--	.51	--	.002	--
Bus	.07	.001	--	.05	--
Railway	.65	--	--	.25	--
Air	--	--	1.00	--	--
Ship	--	--	--	--	1.00
Truck	--	.489	--	.678	--
Pipeline, Storage	.28	--	--	.02	--
Lubrication	--	--	--	--	--

Table C.7 - 1985

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE TRANSPORTATION SECTOR - 1985

Activities	Electricity	Benzene	Jet Fuel	Gas Oil (H.S.D.)	Mazout
Automobile	--	.70	--	.01	--
Bus	.03	.001	--	.03	--
Railway	.85	--	--	.24	--
Air	--	--	1.00	--	--
Ship	--	--	--	--	1.00
Truck	--	.299	--	.72	--
Pipeline, Storage	.12	--	--	--	--
Lubrication	--	--	--	--	--

Table C.7 - 2000

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE TRANSPORTATION SECTOR - 2000

Activities	Electricity	Benzene	Jet Fuel	Gas Oil (H.S.D.)	Mazout
Automobile	--	.72	--	.01	--
Bus	.01	--	--	.03	--
Railway	.93	--	--	.06	--
Air	--	--	1.00	--	--
Ship	--	--	--	--	1.00
Truck	--	.28	--	.90	--
Pipeline, Storage	.06	--	--	--	--
Lubrication	--	--	--	--	--

Table C.8 - 1975

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE URBAN AND RURAL RESIDENTIAL SECTOR - 1975

Urban-Residential	Electricity	Butagas	Kerosene	Natural Gas	Solar
Activities					
Cooking	--	.73	.25	N	N
Air Conditioning	.014	--	--	O	O
Refrigeration	.14	--	--	N	N
Light	.44	--	.08	E	E
Hot Water	--	.20	.05		
Space Heat	--	.01	--		
Misc. Appliances	.06	--	--		
Television	.19	--	--		
Rural-Residential					
Activities					
Cooking	--	.05	.22		
Air Conditioning	--	--	--		
Refrigeration	.01	--	--		
Light	.064	--	.36		
Hot Water	--	.01	.04		
Space Heat	--	--	--		
Misc. Appliances	.002	--	--		
Television	.08	--	--		

Table C.8 - 1985

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE URBAN AND RURAL RESIDENTIAL SECTOR - 1985

Urban-Residential	Electricity	Butagas	Kerosene	Natural Gas	Solar
Activities					
Cooking	.02	.58	.18	.71	--
Air Conditioning	.03	--	--	--	--
Refrigeration	.12	--		--	--
Light	.33	--	.04	--	--
Hot Water	.06	.28	.05	.29	1.0
Space Heat	--	.01	--	--	--
Misc. Appliances	.08	--	--	--	--
Television	.21	--	--	--	--
Rural-Residential					
Activities					
Cooking	--	.10	.34		
Air Conditioning	--	--	--		
Refrigeration	.02	--	--		
Light	.06	--	.31		
Hot Water	--	.03	.08		
Space Heat	--	--	--		
Misc. Appliances	.01	--	--		
Television	.06	--	--		

Table C.8 - 2000

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE URBAN AND RURAL RESIDENTIAL SECTOR - 2000

Urban-Residential	Electricity	Butagas	Kerosene	Natural Gas	Solar
Activities					
Cooking	.04	.49	.09	.57	--
Air Conditioning	.05	--	--	--	--
Refrigeration	.14	--	--	--	--
Light	.22	--	--	--	--
Hot Water	.14	.29	.04	.43	1.00
Space Heat	--	.015	--	--	--
Misc. Appliances	.10	--	--	--	--
Television	.14	--	--	--	--
Rural-Residential					
Activities					
Cooking	--	.13	.46		
Air Conditioning	.01	--	--		
Refrigeration	.03	--	--		
Light	.06	--	.27		
Hot Water	.01	.07	.14		
Space Heat	--	.005	--		
Misc. Appliances	.02	--	--		
Television	.04	--	--		

Table C.9 - 1975

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE AGRICULTURE, PUBLIC UTILITIES, OTHER SECTORS - 1975

Agriculture	Electricity	Diesel	Kerosene	Gas Oil (H.S.D.)	Mazout
Activities					
Irrig. & Drainage	1.00	1.00			
Soil Preparation			1.00	1.00	
Food Preparation					1.00
Public Utilities					
Activities					
Lighting	.14				
Drinking Water, Sewage	.86				
Other					
Activities					
Commercial	1.00	1.00	1.00	1.00	1.00

Table C.9 - 1985

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE AGRICULTURE, PUBLIC UTILITIES, OTHER SECTORS - 1985

Agriculture	Electricity	Diesel	Kerosene	Gas Oil (H.S.D.)	Mazout
Activities					
Irrig. & Drainage	1.00	1.00	--	--	--
Soil Preparation	--	--	1.00	1.00	--
Food Preparation	--	--		--	1.00
Public Utilities					
Activities					
Lighting	.14				
Drinking Water, Sewage	.86				
Other					
Activities					
Commercial	1.00	1.00	1.00	1.00	1.00

Table C.9 - 2000

FUEL APPORTIONMENT RATIOS BY ACTIVITY IN THE AGRICULTURE, PUBLIC UTILITIES, OTHER SECTORS - 2000

Agriculture	Electricity	Diesel	Kerosene	Gas Oil (H.S.D.)	Mazout
Activities					
Irrig. & Drainage	1.00	--	--	--	--
Soil Preparation	--	1.00	1.00	1.00	--
Food Preparation	--	--		--	1.00
Public Utilities					
Activities					
Lighting	.14				
Drinking Water, Sewage	.86				
Other					
Activities					
Commercial	1.00	1.00	1.00	1.00	1.00

Table C.10

COMMERCIAL ENERGY DEMAND--INDUSTRY

(10^{15} JOULES)

Industry	Electricity			Butagas			Kerosene			Gas Oil (H.S.D.)			Mazout		
Activities	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000
Cotton Gin & Press	0.17	1.15	3.40	--	--	--	--	--	--	--	--	--	--	--	--
Extraction Ind.	0.87	2.88	8.49	--	--	--	--	--	--	--	0.81	2.13	--	--	--
Food	0.87	2.88	8.49	--	--	--	--	--	--	--	--	--	--	--	--
Textile	0.17	2.88	8.49	--	--	--	--	--	--	--	--	--	--	--	--
Chemical	5.56	11.52	25.47	--	--	--	--	--	--	--	--	--	--	--	--
Small Scale Ind.	1.00	1.15	3.40	0.15	0.81	3.88	0.06	0.12	0.28	0.84	4.35	10.67	--	--	--
Building Mat.	1.36	3.46	10.19	0.04	0.20	--	0.03	0.06	0.14	2.11	5.64	17.06	14.36	26.46	65.95
Metals	1.39	23.04	59.43	0.04	0.20	1.94	--	--	--	--	0.81	2.13	10.26	26.46	43.97
Engineering Ind.	0.35	5.76	25.47	0.04	0.20	0.97	0.03	0.06	0.14	0.21	0.81	2.13	5.13	--	--
Other	4.93	0.58	10.19	0.45	2.22	11.66	0.19	0.37	0.85	0.84	2.88	4.27	21.51	35.26	109.91
Military	0.69	2.30	6.79	0.04	0.40	0.97	--	--	--	0.21	0.81	4.27	--	--	--
Total	17.36	57.60	169.81	0.76	4.03	19.42	0.31	0.61	1.41	4.21	16.11	42.66	51.26	88.18	219.83

Industry	Natural Gas			Coal			Asphalt			Naptha		
Activities	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000
Cotton Gin & Press	--	--	--									
Extraction Ind.	--	--	--									
Food	--	--	--									
Textile	5.47	6.31	6.13									
Small Scale Ind.	8.20	25.88	17.67									
Build. Materials	--	5.05	8.20									
Metals	--	16.41	25.24	30.00	55.00	225.00						
Engineering Ind.	--	3.16	3.16									
Other	--	6.31	2.52									
Military	--	--	--									
Total	13.67	63.11	63.11	30.00	55.00	225.00	4.37	10.18	11.31	1.01	7.6	7.6

Table C.11

COMMERCIAL ENERGY DEMAND--URBAN AND RURAL RESIDENTIAL

(10^{15} JOULES)

Urban - Residential	Electricity			Butagas			Kerosene			Solar			Natural Gas		
Activities	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000
Cooking	—	0.34	2.93	5.60	13.23	28.55	12.07	14.00	10.97	--	--	--	--	0.84	0.67
Air Conditioning	0.09	0.55	3.62	--	--	--	--	--	--	--	--	--	--	--	--
Refrigeration	0.86	2.17	9.47	--	--	--	--	--	--	--	--	--	--	--	--
Light	2.67	5.86	16.37	--	--	--	3.86	3.11	--	--	--	--	--	--	--
Hot Water	--	1.08	9.68	1.53	6.39	16.90	2.41	3.89	4.88	--	0.21	10.00	--	0.34	0.51
Space Heat	--	--	—	0.08	0.23	1.16	--	--	--	--	--	--	--	--	--
Misc. Appliances	0.37	1.36	6.97	--	--	--	--	--	--	--	--	--	--	--	--
Television	1.14	3.62	10.17	--	--	--	--	--	--	--	--	--	--	--	--
Total	5.13	14.98	59.21	7.21	19.85	46.61	18.34	21.00	15.85		0.21	10.00	--	1.18	1.18
Rural - Residential															
Activities															
Cooking	—	--	—	0.38	2.28	7.57	10.62	26.44	56.08						
Refrigeration	0.07	0.39	1.81	--	--	--	--	--	--	--	--	--			
Light	0.39	1.04	3.90	--	--	--	17.37	24.10	32.92	--	--	--			
Hot Water	--	--	0.35	0.08	0.68	3.79	1.93	6.22	17.07						
Space Heat	--	--	--	--	--	0.29	--	--	--	--	--	--			
Misc. Appliances	0.01	0.14	1.60	--	--	--	--	--	--	--	--	--			
Air Conditioning	—	--	0.35	--	--	--	--	--	--	--	--	--			
Television	0.49	1.09	2.44	--	--	--	--	--	--	--	--	--			
Total	0.96	2.66	10.45	0.46	2.96	11.65	29.92	56.76	106.07						
Grand Total	6.09	17.64	69.66	7.67	22.81	58.26	48.26	77.76	121.92						

Table C.12

COMMERCIAL ENERGY DEMAND - TRANSPORTATION

(10^{15} JOULES)

Transportation	Electricity			Benzene			Jet Fuel			Gas Oil (H.S.D.)			Mazout			Lube Oils		
Activities	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000
Automobile	—	--	--	15.31	33.79	66.21	--	--	--	0.04	0.26	0.65						
Bus	0.05	0.19	0.19	0.04	0.03					0.89	0.89	2.32						
Railway	0.43	4.70	21.64							4.89	7.81	3.67						
Air							8.6	14.0	20.0									
Ship										13.28	24.11	59.72	1.48	2.55	7.33			
Truck				14.94	14.20	25.21				0.37								
Pipes, Storage	0.19	0.67	1.30															
Total	0.67	5.56	23.13	30.29	48.02	91.42	8.6	14.0	20.0	19.47	33.07	66.36	1.48	2.55	7.33	4.97	8.92	19.42

Table C.13

COMMERCIAL ENERGY DEMAND--AGRICULTURE, PUBLIC UTILITIES, OTHER

(10^{15} JOULES)

Agriculture	Electricity			Diesel			Kerosene			Gas Oil (H.S.D.)			Mazout		
Activities	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000	1975	1985	2000
Irrig & Drainage	2.40	9.90	19.98	3.48	2.68										
Soil Preparation						2.68	3.41	6.97	14.14	7.37	13.57	28.44			
Food Preparation													1.04	2.32	12.21
Total	2.40	9.90	19.98	3.48	2.68	2.68	3.41	6.97	14.14	7.37	13.57	28.44	1.04	2.32	12.21
Public Activities															
Activities															
Lighting	0.27	0.76	3.02												
Drinking Water, Sewage	1.69	4.64	18.53												
Total	1.96	5.40	21.55												
Other															
Activities															
Commercial	1.38	2.97	12.67	3.48	2.68	2.68	0.53	1.74	3.96	21.05	20.35	14.22	41.04	41.54	58.62

EGYPT

COMPARISON – CASE

DIRECT FUEL, ELECTRICITY, FEEDSTOCK AND NON-COMMERCIAL ENERGY DEMAND

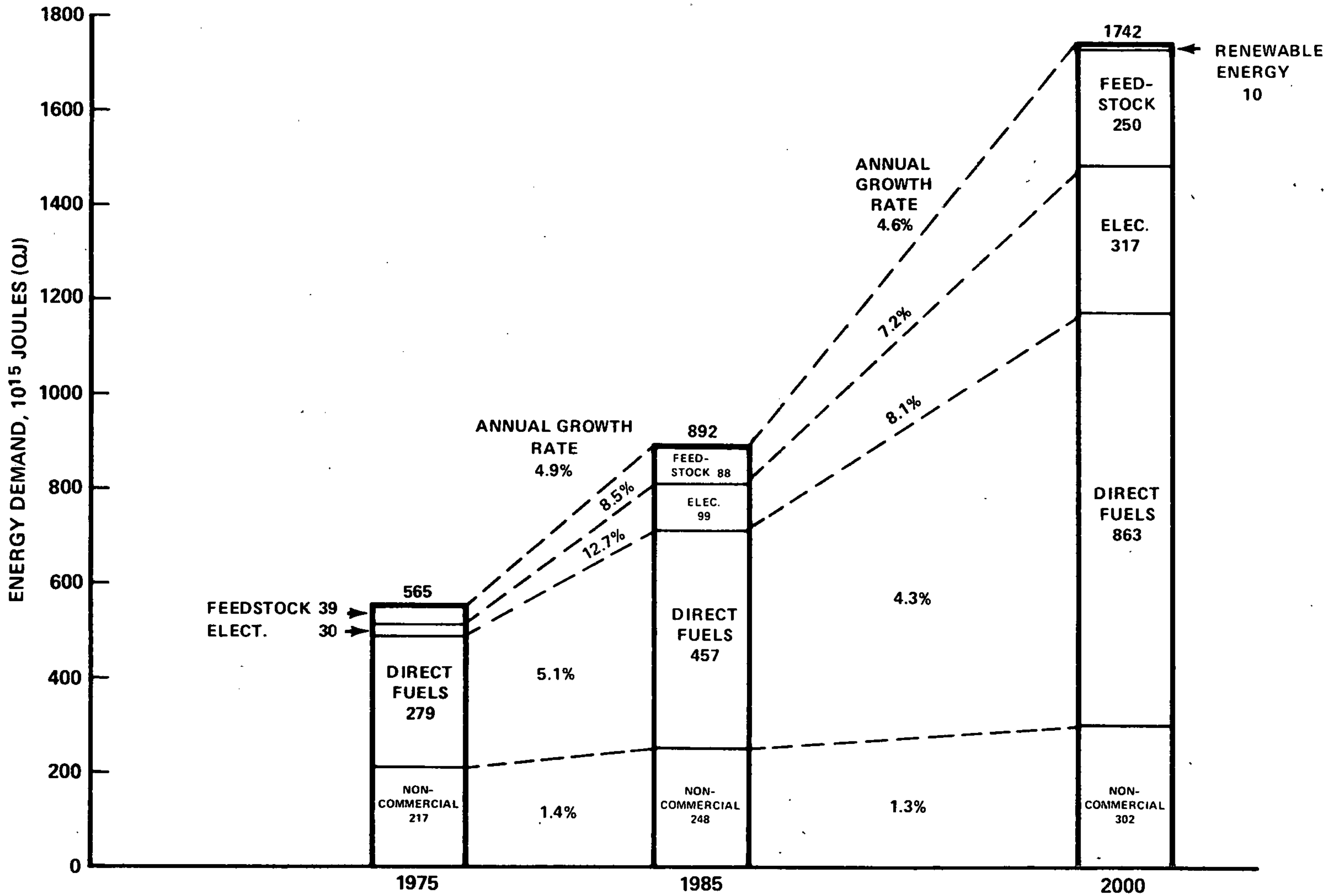


FIGURE C.1 COMPARISON CASE
DIRECT FUEL, ELECTRICITY, FEEDSTOCK AND NON-COMMERCIAL ENERGY DEMAND

Table C.14

DIRECT FUEL, ELECTRICITY AND NONCOMMERCIAL DEMAND

	1975		1985		2000	
	Natural Units	10^{15} Joules	Natural Units	10^{15} Joules	Natural Units	10^{15} Joules
Electricity (10^6 Kwh)	8294	29.86	27520	99.07	88000	316.20
Petroleum Products* (10^3 Mt)	5869	264.12	9507	425.69	18595	64.44
Natural Gas (10^3 Mt)	294	13.67	1455	64.44	1455	64.44
Coke (10^3 Mt)	1070	30.00	1965	55.00	8035	225.00
Renewable Energy (10^{15} joules)	--	--	--	0.21	--	10.00
Total Commercial Energy		337.65		664.41		1439.86
Noncommercial Energy**		216.50		247.50		301.50
Total Energy		554.15		891.91		1741.86
Commercial Energy per Capita (10^9 joules)		9.00		13.65		22.32
Noncommercial per Capita (10^9 joules)		5.77		5.08		4.67
Total Energy per Capita (10^{9d} joules)		14.78		18.87		27.00

*Excludes petroleum products consumed for electricity generation

**Estimated as discussed in Section 2.4.1

Table C.15

ANNUAL GROWTH RATES IN END-USE ENERGY DEMAND
(PERCENT)

	1975-1985	1985-2000	1975-2000
Electricity	12.7	8.1	9.9
Petroleum	6.6	2.3	4.0
Natural Gas	27.1	0.0	10.1
Coke	6.3	9.9	8.4
Renewable Energy	*	29.4	*
Total Commercial Energy	6.7	5.5	6.0
Noncommercial	1.4	1.3	1.3
Total Energy	4.9	4.5	4.7
Commercial Energy per Capita	4.3	3.3	3.7
Total Energy per Capita	2.5	2.4	2.4

* No basis for calculating percent growth rate

percents, while for the feedstocks, demands are 8.5 and 7.2 percents per year. It should be noted that based on these projections, the total energy demand will grow at a rate of 4.9 and 4.6 percents for the 1975 to 1985 and 1985 to 2000 periods.

Figures C.2 to C.4 and Tables C-16 and C-17 present the consumption and growth patterns in relation to the total commercial energy, petroleum products and electricity for the industrial, residential, transport and other sectors for 1975, 1985 and 2000. The demand for commercial energy in the industrial sector has the highest growth rate and also is the largest among the end-use sectors. The transportation and residential sectors will have similar growth, between 5 and 6 percents per year during 1975 to 2000, and shares of each sector as a percent of the total commercial energy consumption will also be similar, about 16 to 18 percent in the year 2000.

Tables C.18, 19, and 20 present the percent of energy demand by each activity within an end-use sector. In the residential sector in the year 2000, cooking will constitute about 41 percent of commercial energy demand followed by the water heating and lighting at 24 and 20 percents. In the year 2000, the demand for commercial energy by the metals industry will constitute about 47 percent of total industrial use of commercial energy followed by the demand in the building material industry of 15 percent. The transportation modes by truck and automobile will consume 37 and 30 percents of the total commercial energy used in the transportation sector in the year 2000.

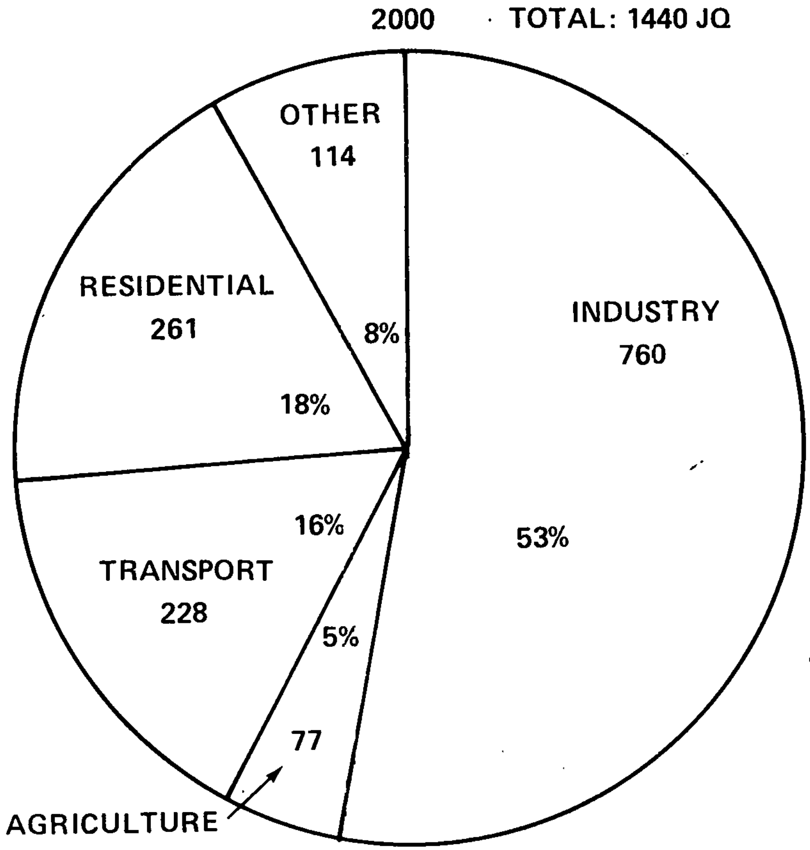
3.0 SOME OBSERVATIONS ON THE COMPARISON CASE

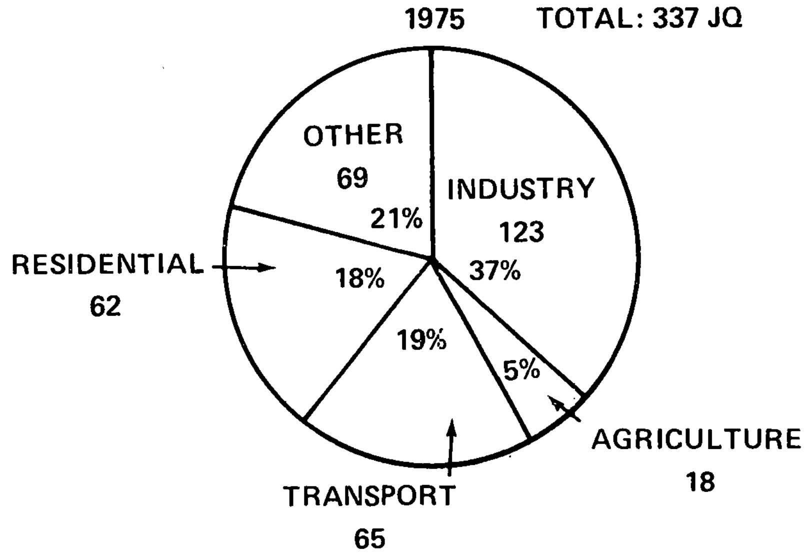
3.1 Introduction

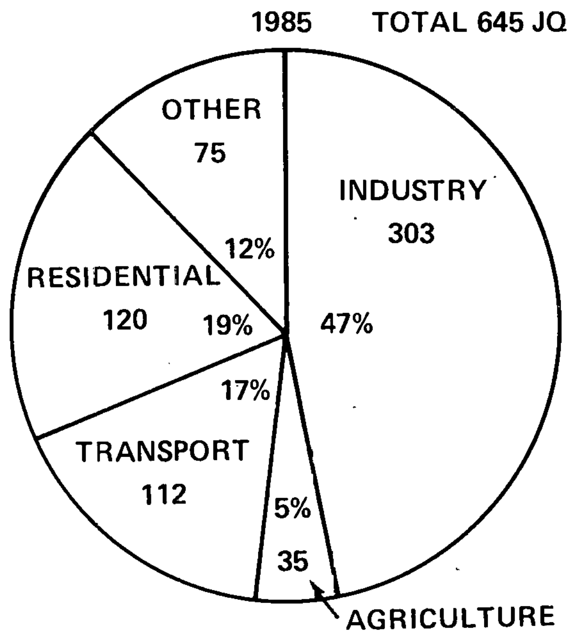
As was stressed on the preceding page, the Comparison Case is not to be viewed as a prediction of the future, but rather as a point of departure for the analysis of options. Nevertheless, it is important that it reflects a certain degree of internal consistency and that it be consistent with other aspects of Egyptian economic development. We make some preliminary observations regarding consistency in this section. It is important to return to such questions, however, as options are analyzed. For any major conclusion of an analysis such as this, one should examine the assumptions and look through the analytical process that were critical to that conclusion.

3.2 Overall Energy Growth

In the Comparison Case (as shown in Table C.14) commercial energy demand will grow at one rate e.g., 6.7 percent per year between 1975 and 1985 and 5.5 percent per year between 1985 and 2000. It should be noted that over the 1975 to 2000 period, per capita consumption of all energy forms grows at a rate of only 2.4 percent per year compared with a growth rate of total commercial energy of 6.0 percent in the same period. The



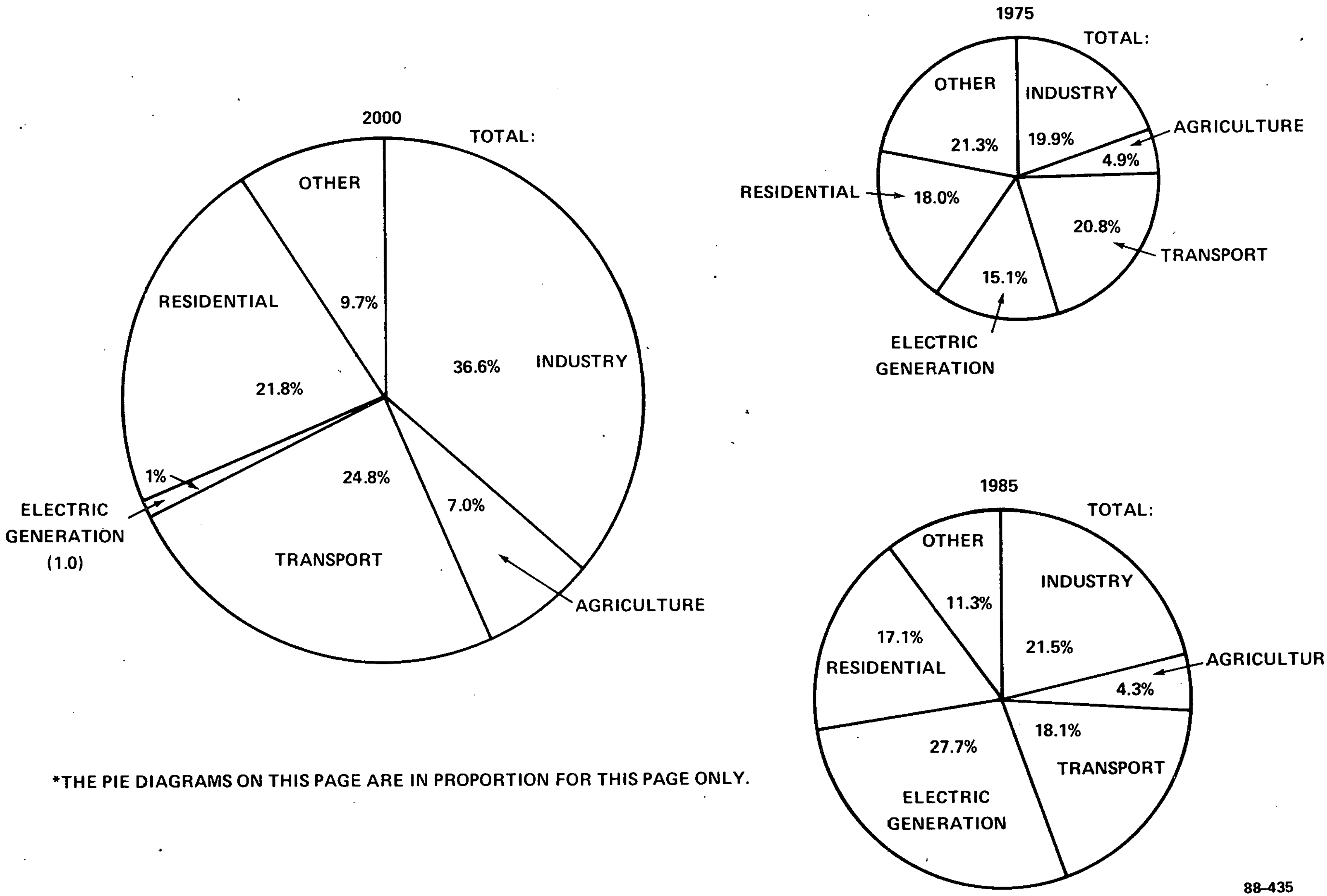




*THE PIE DIAGRAMS ON THIS PAGE ARE IN PROPORTION FOR THIS PAGE ONLY.

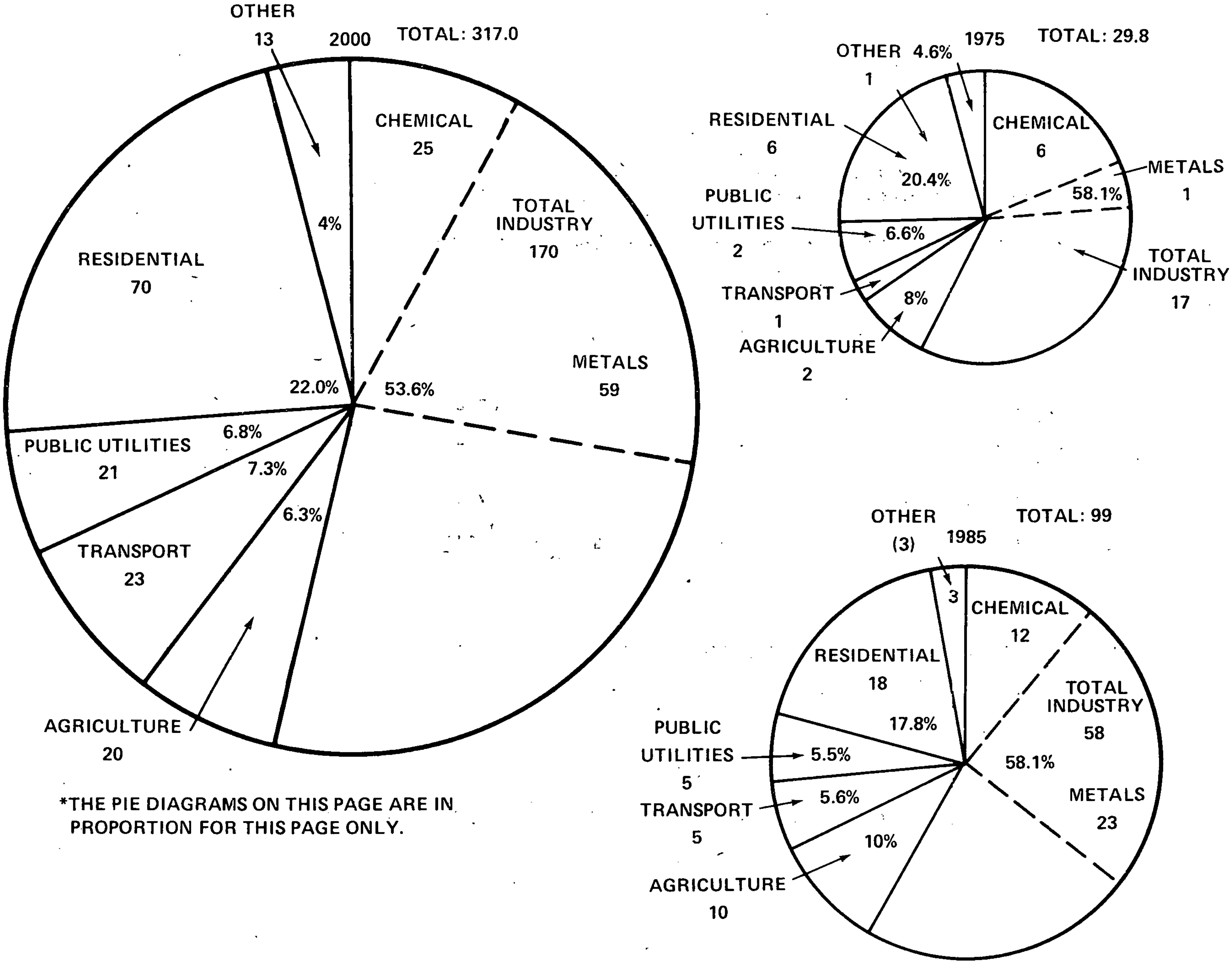
NOTE: COMMERCIAL ENERGY INCLUDES ELECTRICITY, PETROLEUM PRODUCTS, NATURAL GAS, COAL, AND SOLAR.

FIGURE C.2 PROJECTED ANNUAL DEMAND FOR TOTAL COMMERCIAL ENERGY (COMPARISON CASE) (10^{15} JOULES)



*THE PIE DIAGRAMS ON THIS PAGE ARE IN PROPORTION FOR THIS PAGE ONLY.

FIGURE C.3 EGYPT PROJECTED ANNUAL DEMAND FOR PETROLEUM PRODUCTS*
(10^{15} JOULES)



*THE PIE DIAGRAMS ON THIS PAGE ARE IN PROPORTION FOR THIS PAGE ONLY.

FIGURE C.4 EGYPT DEMAND FOR ELECTRICITY (10^{15} JOULES)

Table C.16

PROJECTED ANNUAL DEMAND FOR TOTAL COMMERCIAL ENERGY (COMPARISON-CASE)

(10^{15} JOULES)

	1975		1985		2000	
	Amount	Percent	Amount	Percent	Amount	Percent
Industry	122.95	37	302.57	47	760.30	53
Agriculture	17.80	5	35.44	5	77.45	5
Transport	65.45	19	112.12	17	227.66	16
Residential	62.02	18	119.60	19	260.75	18
Others	69.43	21	74.68	12	113.70	8
Total	337.65	100	644.41	100	1439.86	100

Includes petroleum products, natural gas, coal, electricity

Source: Egyptian General Petroleum Corporation (EGPC)
Ministry of Energy and Electricity

Table C.17

ANNUAL GROWTH RATE OF COMMERCIAL
ENERGY DEMAND

Sector	1975-1985	1985-2000	1975-2000
Industry	.09	.06	.08
Agriculture	.07	.05	.06
Transport	.06	.05	.05
Public Utilities	.11	.10	.10
Residential	.07	.05	.06
Others	.003	.02	.01

Table C.18

TOTAL COMMERCIAL ENERGY DEMAND AND SHARE OF EACH ACTIVITY IN RESIDENTIAL SECTOR

	1975		1985		2000	
	10^{15} Joules	Percent	10^{15} Joules	Percent	10^{15} Joules	Percent
Cooking	28.67	46.0	57.13	47.8	106.77	41.0
Air Conditioning	0.09	0.1	0.55	0.5	3.97	1.5
Refrigeration	0.93	1.5	2.56	2.0	11.28	4.3
Light	24.29	39.1	34.11	28.5	53.19	20.4
Hot Water	5.95	10.0	18.81	15.7	63.18	24.2
Space Heat	0.08	0.1	0.23	0.2	1.45	0.6
Miscellaneous Appliances	0.38	0.6	1.50	1.3	8.57	3.2
Television	1.63	2.6	4.71	4.0	12.61	4.8
	62.02	100.0	119.6	100.0	261.02	100.0

Table C.19

TOTAL COMMERCIAL ENERGY DEMAND AND SHARE
OF EACH ACTIVITY IN INDUSTRIAL SECTOR

	1975		1985		2000	
	10^{15} Joules	Percent	10^{15} Joules	Percent	10^{15} Joules	Percent
Cotton Gin & Press	0.17	0.1	1.5	0.4	3.40	0.5
Extraction	0.87	0.7	3.69	1.0	10.62	1.4
Food	0.87	0.7	2.88	1.0	8.49	1.1
Textile	5.64	4.6	9.19	3.0	14.80	2.0
Chemical	14.77	12.0	45.00	15.0	50.74	7.0
Small Scale Ind.	2.05	1.7	6.43	2.0	18.23	2.0
Build. Mat.	22.27	18.0	51.05	17.0	112.85	15.0
Metals	41.69	34.0	121.92	40.3	357.71	47.0
Other	27.92	22.7	47.62	16.0	139.40	18.0
Military	0.94	0.8	3.51	1.0	12.03	2.0
Engineering Ind.	5.76	4.7	9.99	3.3	31.87	4.0
Total	122.95	100.0	302.43	100.0	760.14	100.0

Table C.20

Total Commercial Energy Consumption and Share of Each Activity in the Transportation Sector

	1975		1985		2000	
	10^{15} Joules	Percent	10^{15} Joules	Percent	10^{15} Joules	Percent
Automobile	15.35	24	34.05	30	66.86	30
Bus	0.98	1	1.11	1	2.51	1
Rail	5.32	8	12.51	11	25.31	11
Air	8.6	13	14.00	13	20.00	9
Ship	1.48	2	2.55	2	7.33	3
Truck	28.22	43	38.31	34	84.93	37
Pipeline	5.53	9	9.59	9	20.72	9
	65.48	100	112.12	100	227.66	100
Total Commercial Energy Consumption and Share of Each Activity in Agricultural Sector						
Irrigation & Drainage	5.88	33	12.58	35	19.98	26
Soil Preparation	10.78	61	20.54	58	45.26	58
Food Preparation	1.04	6	2.32	7	12.21	16
	17.10	100	35.44	100	77.45	100
Total Commercial Energy Consumption and Share of Each Activity in the "Other" Sector						
Commercial	64.48	97	69.28	93	92.15	81
Public Utilities	1.96	3	5.40	7	21.55	19
	66.44	100	74.68	100	113.60	100

difference is explained in part by the low growth rate anticipated in noncommercial energy, and, more strongly, by the high rate of population growth (2.5 percent per year).

The relationship between energy growth and economic growth is discussed in a separate Appendix, but it can be noted here that the growth in commercial energy consumption in the Comparison Case between 1975 and 2000 is consistent with an average rate of growth in real gross domestic product of 4.5 to 6.0 percent per year over the same period. Commercial energy growth is also consistent with historical trends during the period between 1955 and 1975 (or between 1955 and 1964).

3.3 Electricity Growth

The growth of total commercial energy demand in the Comparison Case appears reasonable on historic and economic grounds. However, the growth of electricity consumption appears somewhat inconsistent with the growth of total energy consumption. The ratios of electricity consumption to total commercial energy consumption for the three years considered in one study are as follows: 1975 - 0.088; 1985 - 0.149; 2000 - 0.220. In Figure C.5, we compare these ratios with the ratio for other countries at GNP levels comparable to those expected in Egypt in 1985 and 2000.[1] For purposes of this figure, the GNP growth rate was taken to range from 5.5 to 7.5 percent per year to 1985 and from 4.5 to 5.7 percent between 1985 and 2000. The figure makes clear how the ratio of electricity demand projected from the year 2000 seems unreasonably high. The ratio of electricity growth to total energy growth anticipated for the 1985 to 2000 period is 1.5. This ratio would be highly unusual for a country at the stage of economic development expected for Egypt in 1985.*

In summary, although the overall energy growth contained in the Comparison Case appears consistent with anticipated economic growth, the rate of growth of electricity consumption appears unreasonably high. The entire demand picture warrants more detailed analysis on a consistent base.

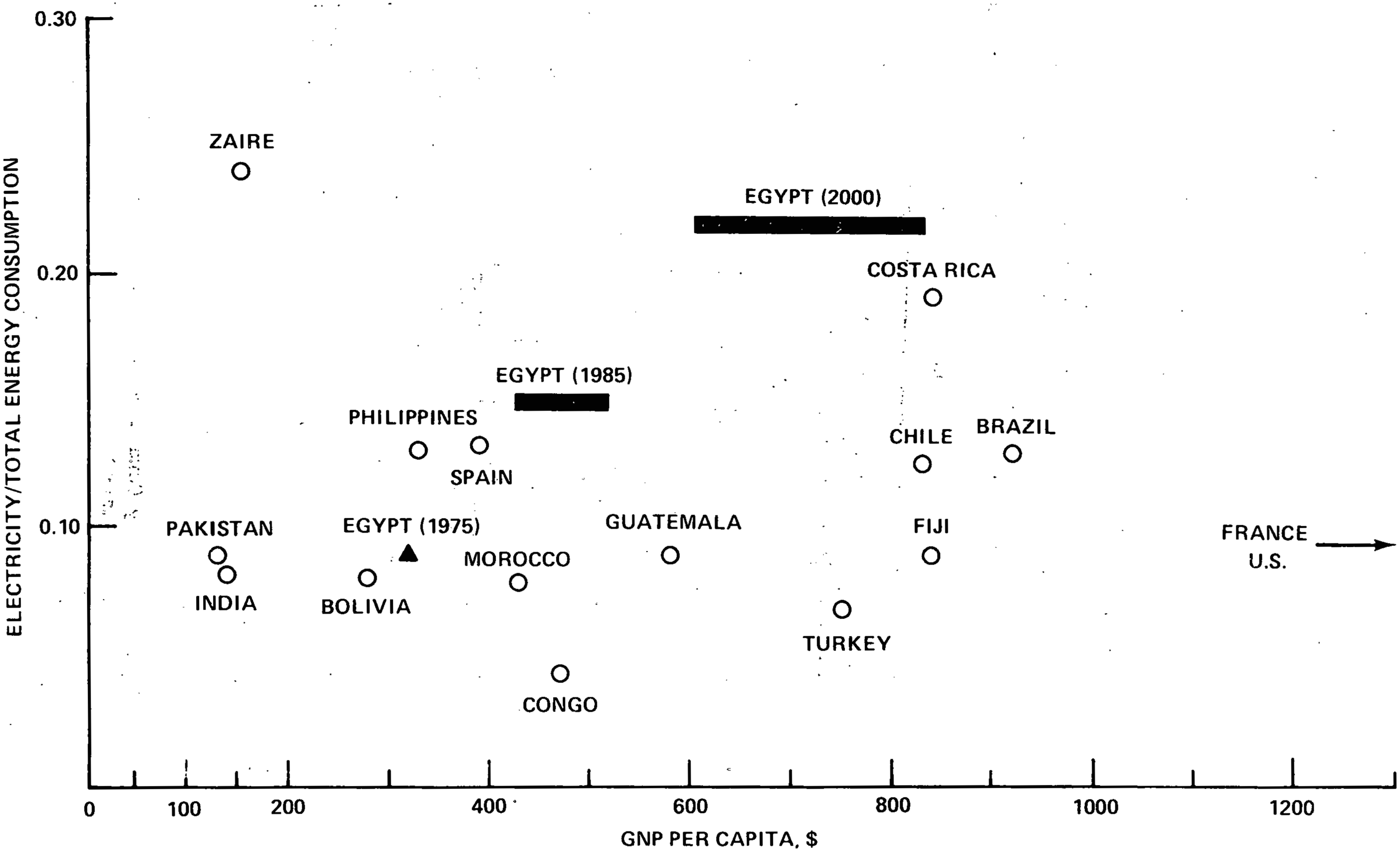
---

[1] Data source for Figure C.5 are:
- United Nations, 1975 Statistical Yearbook UN, NY 1976.
- Energy Needs, Uses and Resources in Developing Countries BNL - 50784, BNL, 1978.

* An analysis has been performed of several countries starting at the point at which they consumed energy on a per capita basis equivalent to that expected in Egypt in 1985. The average ratio of electricity growth to total energy growth was 1.2 with a standard deviation of +/- 0.115.

FIGURE C.5

RELATIONSHIP OF ELECTRICITY TO TOTAL ENERGY CONSUMPTION AS A FUNCTION OF GNP PER CAPITA



3.4 Illustration of Possible Effects of Change in Intensity of Electricity Use by Industrial Sector.

Over the period 1975 to 2000 the Comparison Case suggests that the proportion of electricity to total commercial fuels consumption (including electricity) by Egypt's planned expansion of industrial activities rises from 14 percent in 1975 to 22.3 percent in 2000. Over that period, use of electricity by industry is projected at 9.55 percent per year compared to 7.13 percent per year growth rate in the use of direct fuels. (See Table C.21). This table also presents for comparison the projected total demand for electricity and direct use of commercial fuels and the related rates of growth in total use of these energy forms.

To illustrate the potential importance of this relatively electric intensive choice for industrial development, a hypothetical analysis was carried out assuming it is possible to alter the composition of energy use within the industrial sector while maintaining the projected total demand for energy by industry. For analysis purposes, it was arbitrarily assumed that the annual rate of growth of industrial use of direct fuels over the period 1985 to 2000 would be 0.5 percent per year higher than that of the Comparison Case with a compensating reduction in industrial electricity demand. This leaves unchanged the total projected energy consumption by the industrial sector. Table C.22 shows the hypothesized changes. The resulting shift by 2000 of 43 QJ in the industrial use of electricity to direct fuels lowers the ratio of total electricity to total commercial energy demand by industry from 22 percent in the Comparison Case to 17 percent in the hypothesized example. This reduction, in turn, reduces the ratio of total electricity use to total commercial energy use from 22 percent in the Comparison Case to 19 percent in the hypothesized example.

To estimate the energy supply cost effect of this shift, it is assumed that: (a) the reduction in electricity use is reflected in reduced requirements for nuclear facilities and corresponding nuclear fuel cycle costs; and (b) that the increase in direct fuels is supplied by increases in fuel imports or reduction in exports. The calculation is indicated below:

NUCLEAR FACILITY SAVINGS:

1978-2000 Comparison Case Cost for Completed Nuclear Facility
= LE 5893 x 10^6

Reduction in Nuclear Capacity Due to Hypothetical Shift to Direct Fuels
= 43 QJ/286QJ

Nuclear Facility Cost Reduction (43/286 x LE 5893 x 10^6)

= LE 888 Million

TABLE C.21

RATE IN ENERGY CONSUMPTION GROWTH: COMPARISON CASE

(In 10^{15} Joules, or QJ)

	YEARS			GROWTH RATE IN PERCENTS		
	1975	1985	2000	75-85	85-2000	75-2000
1. INDUSTRIAL ELECTRIC	17.4	58.1	169.8	12.74	7.45	9.55
2. INDUSTRIAL DIRECT FUELS	105.6	244.5	590.5	8.78	6.04	7.13
3. INDUSTRIAL ENERGY USE	123.0	302.6	760.3	9.42	6.34	7.56
4. TOTAL ELECTRIC USE	39.86	99.1	316.8	12.74	8.06	9.91
5. TOTAL DIRECT FUELS USE	307.8	545.1	1122.1	5.88	4.93	5.31
6. TOTAL ENERGY USE	347.66	644.2	1438.9	6.36	5.5	5.85

TABLE C.22

RATE OF ENERGY CONSUMPTION: HYPOTHETICAL EXAMPLE

SHIFT IN INDUSTRIAL ENERGY USE COMPOSITION

(In 10^{15} Joules, or QJ)

	YEARS		GROWTH RATE IN PERCENTS
	2000	85-2000	75-2000
1. INDUSTRIAL ELECTRIC	126.72	5.34	8.27
2. INDUSTRIAL DIRECT FUELS	633.58	6.55	7.43
3. INDUSTRIAL ENERGY USE	760.3	6.34	7.56
4. TOTAL ELECTRIC USE	273.71	7.01	9.72
5. TOTAL DIRECT FUELS USE	1165.25	5.19	5.47
6. TOTAL ENERGY USE	1438.9	5.5	5.85

	YEAR 1975 COMPARISON CASE	YEAR 2000 COMPARISON CASE	YEAR 2000 WITH HYPOTHETICAL EXAMPLE SHIFT FROM INDUSTRIAL ELECTRIC TO INDUSTRIAL DIRECT FUELS USE
TOTAL ELECTRICITY DEMAND / TOTAL COMMERCIAL DEMAND	11.5%	22.0%	19.0%

DIRECT FUEL COSTS:

1985-2000 Accumulated Annual Net Increases in Direct Fuel (Hypothetical Example Industrial Direct Fuel Use Growing at 6.553 Percent Minus Comparison Case Industrial Direct Fuel Use Growing at 6.054 Percent)
= 222.16 QJ

Assume Direct Fuel is in the Form of Mazout and is Valued at its Export Value, $13.50 Per Barrel.

1985-2000 Increased Barrels of Mazout is (222.16 QJ x 1.7023 x 10^{-10} bbl/Joule)
= 3.78 x ^{7} bbl

Cost of Direct Fuel Increase is (3.78 x 10^{7} bbl x $13.50 $/bbl x 0.7 LE/$)
= LE 357.4 Million

NUCLEAR FUEL CYCLE SAVINGS:

1985-2000 Accumulated Decreases in Nuclear Electric Use in Hypothetical Example (Equal to Direct Fuel Increases)
= 222.16 QJ

Saving From Reduction in Nuclear Fuel Cycle at 19.5 x 10^{-10} $/Joule (Approximately 7 Mils Per Kilowatt Hour) and at 0.7 LE/$ is (222.15 QJ x 19.5 x 10^{-10} $/Joule x 0.7 LE/$)
= LE 304.3 Million

NET FUEL COST INCREASE:

357.4 Million Increased Oil Cost - 304.3 Million Nuclear Fuel Saving
= LE 53.1 Million

NET SAVINGS:

888 Million Nuclear Facility Saving - 53.1 Million Net Fuel Cost Increase
= LE 835 Million

Thus, if it were possible to implement measures to shift away from electrical intensive industrial development toward industrial use of direct fuels, and if industrial facility capital costs and energy efficiencies were not significantly different from such measures, then net savings for the same delivered energy to the industrial sector would be approximately LE 835 million.

SUMMARY

The fuel mix tables presented in this Appendix exhibit the percent by type and quantity (in 10^{15} Joules) of energy used to supply a particular activity in the Comparison Case. Furthermore, data sources and bases of projections are enumerated. Additionally, the industrial sector contains an alternative activity level projection based on more complete information.

NOTES AND REFERENCES

1. The Reference Energy Systems approach as applied to the United States is described in M. Beller, Ed., Sourcebook for Energy Assessment, BNL-50493 (Dec. 1975), Brookhaven National Laboratory. Its application to developing countries is described in An Analytical Framework for the Assessment of Energy Resource and Technology Options for Developing Countries, BNL-50800 (Feb. 1978), Brookhaven National Laboratory.

2. By noncommercial fuels we mean wood, crop residues, animal waste and other traditional fuels. It is recognized that these fuels are, to some degree, traded in commercial markets.

ATTACHMENT A

WORKSHEETS FOR THE DISAGGREGATION OF ENERGY DEMAND

FUEL MIX TABLE

Sector: Industry
End Use: Cotton

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	1.00		.17	1.00		1.15			3.40
TOTAL FUEL DEMAND, D, 10^{15} Joules			.17			1.15			3.40
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Industry
End Use: Extraction

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene				.22		.81	.20		2.13
Butagas									
Natural Gas									
Other									
ELECTRICITY	1.00		.87	.78		2.88	.80		8.49
TOTAL FUEL DEMAND, D, 10^{15} Joules			.87			3.69			10.62
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Industry
End Use: Food

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	1.00		.87	1.00		2.88	1.00		8.49
TOTAL FUEL DEMAND, D, 10^{15} Joules			.87			2.88			8.49
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES: Usage of fuel in food preparation is included in the agricultural sector.

FUEL MIX TABLE

Sector: Industry
End Use: Textile

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas	.97		5.47	.69		6.31	.43		6.31
Other									
ELECTRICITY	.03		.17	.31		2.88	.57		8.49
TOTAL FUEL DEMAND, D, 10^{15} Joules			5.64			9.19			14.80
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Industry
End Use: Small Scale Industry

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular	.41		.84	.67		4.35	.59		10.67
Kerosene	.03		.06	.02		.12	.01		.28
Butagas	.07		.15	.13		.81	.21		3.88
Natural Gas									
Other									
ELECTRICITY	.49		1.00	.18		1.15	.19		3.40
TOTAL FUEL DEMAND, D, 10^{15} Joules			2.05			6.43			18.23
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Industry
End Use: Chemical

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas	.60		8.20	.69		25.88	.41		17.67
Other									
ELECTRICITY	.40		5.56	.31		11.52	.59		25.47
TOTAL FUEL DEMAND, D, 10^{15} Joules			13.76			37.40			43.14
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES: The chemical industry entry includes fertilizer and petrochemical industries.

FUEL MIX TABLE

Sector: Industry
End Use: Building Materials

	1975			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout	.802		14.36	.65		26.46	.649		65.95
Sular	.118		2.11	.14		5.64	.17		17.06
Kerosene	.002		.03	.001		.06	.001		.14
Butagas	.002		.04	.005		.20			--
Natural Gas				.12		5.05	.08		8.20
Other									
ELECTRICITY	.076		1.36	.084		3.46	.10		10.19
TOTAL FUEL DEMAND, D, 10^{15} Joules			17.90			40.87			101.54
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES: This end use includes the "Housing Construction" sector from Ministry of Planning, Egypt.

FUEL MIX TABLE

Sector: Industry
End Use: Metals

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout	.25		10.26	.217		26.46	.12		43.97
Sular				.01		.81	.006		2.13
Kerosene									
Butagas	.001		.04	.002		.20	.005		1.94
Natural Gas				.13		16.41	.07		25.24
Coal	.719		30.00	.451		55.00	.629		225.00
Other									
ELECTRICITY	.03		1.39	.19		23.04	.17		59.43
TOTAL FUEL DEMAND, D, 10^{15} Joules			41.69			121.92			357.71
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Industry
End Use: Engineering

	1975			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout	.89		5.13						
Sular	.04		.21	.08		.81	.066		2.13
Kerosene	.005		.03	.01		.06	.004		.14
Butagas	.005		.04	.02		.20	.03		.97
Natural Gas				.315		3.16	.10		3.16
Other									
ELECTRICITY	.06		.35	.575		5.76	.80		25.47
TOTAL FUEL DEMAND, D, 10^{15} Joules			5.76			9.99			31.87
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Industry
End Use: Other

	1975			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout	.746		21.51	.79		35.26	.74		109.91
Sular	.04		1.05	.08		3.69	.06		8.54
Kerosene	.007		.19	.01		.37	.006		.85
Butagas	.017		.49	.06		2.62	.084		12.63
Natural Gas									
Other									
ELECTRICITY	.19		5.62	.106		2.88	.11		16.98
TOTAL FUEL DEMAND, D, 10^{15} Joules			28.86			44.82			148.91
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and an internal report, revealing actual electric sold to various industries as well as projected electric demand by industry, from the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of S. Habib (Egyptian General Petroleum Authority) and El Behiry (Ministry of Planning)

ILLUSTRATIVE VARIABLES: Other end-use includes military industrial fuel usage.

EGYPTIAN DEMOGRAPHICS

	1975	1985	2000
Total population	38×10^6	47×10^6	66×10^6
Average household size (both urban and rural)	5.2	5.2	5.2
% of population in urban areas	44%	46.5%	50%
% of population in rural areas	56%	53.5%	50%
Number of urban households	3.215×10^6	4.203×10^6	6.36×10^6
Number of rural households	4.093×10^6	4.835×10^6	6.36×10^6
% of urban households electrified (1975 from census)	77%	90%	100%
% of rural households electrified (1975 from census)	18%	30%	50%

Source: Gerald Berstell, Annex 3 - Residential/Commercial.

Further explanation of the assumptions that went into the creation of this table may be found within Annex 3 - Residential/Commercial.

PERCENT SATURATION OF ENERGY-USING DEVICES
IN EGYPTIAN RESIDENCES

	1975		1985		2000	
	Urban	Rural	Urban	Rural	Urban	Rural
	%		%		%	
Cooking						
(1) Electric ovens	0	0	2	0	10	0
(2) Butagas stoves	35	2	55	8	75	20
(3) Kerosene stoves	65	43	43	68	15	75
(4) Wood/noncommercial stoves	0	55	0	24	0	5
	(100)	(100)	(100)	(100)	(100)	(100)
Lighting						
(5) Electric	77	18	90	30	100	50
(6) Kerosene	23	82	10	70	0	50
	(100)	(100)	(100)	(100)	(100)	(100)
Hot Water						
(7) Electric	0	0	5	0	20	1
(8) Butagas water heater	5	0	20	2	45	10
(9) Kerosene (on stove)	65	43	43	68	15	75
(10) Butagas (on stove)	30	2	32	6	20	9
	(100)	(45)	(100)	(76)	(100)	(95)
Refrigeration						
(11) Electric	15	1	25	5	60	15
(12) Ice box	30	5	35	10	30	20
	(45)	(6)	(60)	(15)	(90)	(35)
Space conditioning						
(13) Air conditioner/ compressor	1	0	5	0	20	2
(14) Butagas heater	1	0	5	0	10	2
(15) Fans	35	2	50	10	90	25
Others						
(16) TV	30	10	65	20	95	30
(17) Iron	10	0	25	2	70	25
(18) Washing machine	1	0	5	0	25	5
(19) Vacuum cleaner	10	0	20	0	50	10
(29) Dishwasher	0	0	2	0	15	0
(21) Blender, razor, hairdryer, etc.	-	-	-	-	-	-

Source: Gerald Berstell, Annex 3 - Residential/Commercial.

Further explanation of the assumptions that went into the creation of this table may be found within Annex 3 - Residential/Commercial.

FUEL MIX TABLE

Sector: Residential - Urban
End Use: Cooking

	1975			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene	.68		12.07	.49		14.00	.25		10.97
Butagas	.32		5.60	.47		13.23	.66		28.55
Natural Gas				.03		.84	.02		.67
Other									
ELECTRICITY				.01		0.34	.07		2.93
TOTAL FUEL DEMAND, D, 10^{15} Joules			17.67			28.41			43.12
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity.

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Urban
End Use: Air Conditioning

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	1.00		.09	1.00		.55	1.00		3.62
TOTAL FUEL DEMAND, D, 10^{15} Joules			.09			.55			3.62
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Urban
End Use: Refrigeration

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	1.00		.86	1.00		2.17	1.00		9.47
TOTAL FUEL DEMAND, D, 10^{15} Joules			.86			2.17			9.47
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Urban
End Use: Lighting

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene	.59		3.86	.35		3.11			
Butagas									
Natural Gas									
Other									
ELECTRICITY	.41		2.67	.65		5.86	1.00		16.37
TOTAL FUEL DEMAND, D, 10^{15} Joules			6.53			8.97			16.37
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Urban
End Use: Water Heating

	1975			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene	.61		2.41	.33		3.89	.12		4.88
Butagas	.39		1.53	.53		6.39	.40		16.90
Natural Gas				.03		.34	.01		.51
Other				.02		.21	.24		10.00
ELECTRICITY				.09		1.08	.23		9.68
TOTAL FUEL DEMAND, D, 10^{15} Joules			3.94			11.91			41.97
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Urban
End Use: Space Heat

	1975			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas	1.00		.08	1.00		.23	1.00		1.16
Natural Gas									
Other									
ELECTRICITY									
TOTAL FUEL DEMAND, D, 10^{15} Joules			.08			.23			1.16
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt.

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Urban
End Use: Miscellaneous Appliances and Television

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	1.00		1.51	1.00		4.98	1.00		17.14
TOTAL FUEL DEMAND, D, 10^{15} Joules			1.51			4.98			17.14
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Rural
End Use: Cooking

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene	.97		10.62	.92		26.44	.88		56.08
Butagas	.03		.38	.08		2.28	.12		7.57
Natural Gas									
Other									
ELECTRICITY									
TOTAL FUEL DEMAND, D, 10^{15} Joules			11.00			28.72			63.65
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt.

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member.

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Rural
End Use: Refrigeration

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	1.00		.07	1.00		.39	1.00		1.81
TOTAL FUEL DEMAND, D, 10^{15} Joules			.07			.39			1.81
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Rural
End Use: Lighting

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene	.98		17.37	.96		24.10	.89		32.92
Butagas									
Natural Gas									
Other									
ELECTRICITY	.02		.39	.04		1.04	.11		3.90
TOTAL FUEL DEMAND, D, 10^{15} Joules			17.76			25.14			36.82
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Rural
End Use: Water Heating

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene	.96		1.93	.90		6.22	.80		17.07
Butagas	.04		.08	.10		.68	.18		3.79
Natural Gas									
Other									
ELECTRICITY							.02		.35
TOTAL FUEL DEMAND, D, 10^{15} Joules			2.01			6.90			21.21
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Rural
End Use: Space Heating

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas							1.00		.29
Natural Gas									
Other									
ELECTRICITY									
TOTAL FUEL DEMAND, D, 10^{15} Joules									.29
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt.

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Residential - Rural
End Use: Miscellaneous Appliances Air Conditioning, Television

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	1.00		.50	1.00		1.23	1.00		4.39
TOTAL FUEL DEMAND, D, 10^{15} Joules			.50			1.23			4.39
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Apportionment by Gerald Berstell (Resource Planning Associates) U.S. team member

ILLUSTRATIVE VARIABLES:

Transportation Activities
Egypt--1975

	Passengers	Passenger Klm.	Freight Tons	% of Total	Freight Ton Klm.	% Total
Highways	161×10^6	21.2×10^9	58.3×10^6	82.9	12.2×10^9	75.0
Railroads	126×10^6	7.0×10^9	7.8×10^6	11.1	2.2×10^9	13.4
Waterways	---	---	4.2×10^6	6.0	1.9×10^9	11.6
Airways	$(0,5+2,3) \times 10^6$	n.a.	minor		---	
Pipelines	---	---	13.40×10^6		n.a	
Shipping	minor	---	13.5×10^6		---	
Urban Transit	1.7×10^9	11.9×10^9			---	
Urban Hwy	1.28×10^9	7.68×10^9	130×10^6		1.04×10^9	

Activity Levels--1985

Activities	Comparison Case Activity Levels
Total Tons	135×10^6
Water Transport	7.000.000
% of Total	5.2%
Railroad Freight	17.5×10^6
% of Total	12.96%
Highway Freight	110.5×10^6
% of Total	81.85%
Water Ton Kilometers	3.1×10^9 ton kilometers
Railroad Ton Kilometers	4.90×10^9 ton kilometers
Highway Ton Kilometers	22.10×10^9 ton kilometers
Vehicle Truck Kilometers	7.54×10^9 vehicle kilometers
Restricted to	
% of Water Ton Kilometers	10%
% of Railroad Ton Kilometers	16.3%
% of Highway Ton Kilometers	73.7%

Source: Anthony Tomazinis (University of Pennsylvania): Annex 4 - Transportation.

Activities	Activity Levels: 2000 Comparison Case Activity Levels
Total Urban Person Trips	24 x 365 x 1.0 = 7.20
Transit Trips Total	= 2.55
Buses	= 1.00
Streetcar Trolleys	= 0.55
Subway	---
Suburban Railroad	= 1.00
Pedestrian Trips	20% = 1.44 x 10^9
Auto Trips (Cars and Taxi)	3.21 x 10^9
Freight Total	234.000.000
Increase over 75	75%
Auto Passenger Kilometers	3.21 x 7 = 22.47 x 10^9
% of Highway Freight	96%
Highway Freight	225. x 10^6
Ton Kilometers	936. x 10^6
Urban Auto Vehicle Kilometers	12.84 x 10^9
Urban Truck Kilometers	2.25 x 10^9
Urban Auto Vehicle Kilometer Increase	1.76
Urban Truck Kilometer Increase	1.47%
Total Person Trips	520.2 x 10^6
Car Person Trips	230.88 x 10^6
Railroad Trips	= 126 x 10^6
Bus Trips	= 161 x 10^6
Airways	= 3.20 x 10^6
Car Vehicle Kilometers	69.26 x 10^9
Bus Passenger Kilometers	21.3 x 10^6
Railroad Passenger Kilometers	7.000 x 10
Bus Vehicle Kilometers	175. x 10^6

	Activity Levels: 2000 Comparison Case
Total Urban Trips	41 x 1.20 x 300 = 14.76 x 10^9
Transit Total	5.95 x 10^9
Buses and Trolleys	2.55 x 10^9
Subway	3.40 x 10^9
Highway Trips (Auto & Taxi)	= 5.86 x 10^9
Pedestrians	20% = 2.95 x 10^9
Freight Total	404 x 10^9
Increase over 75	315%
% Highway	97%
Highway Tons	392.0
Total Person Trips	= 778.2 x 10^6
Car Trips	1400 x 24 x 2 x 4 = 291.2
Railroad Trips	= 200 x 10^6
Bus Trips	= 287 x 10^6
Airways	10.80 x 10^6
Total Tons	342 x 10^6
Waterways	35 x 10^6
% of Total	10.2%
Railroads	23. x 10^6
% of Total	6.7%
Highway	284 x 10^6
Total Ton Kilometers	69.3 x 10^9
% Increase over 1975 (total)	875%
% Increase over 1975 (hwy.)	349%
Water Ton Kilometer	14.00 x 10^9
Railroad Ton Kilometer	8.05 x 10^9
Highway Ton Kilometer	42.60 x 10^9
% Water Ton Kilometer	21.65%
% Railroad Ton Kilometer	12.45%
% Highway Ton Kilometer	65.99%

Source: Anthony Tomazinis (University of Pennsylvania): Annex 4 - Transportation.

FUEL MIX TABLE

Sector: Transportation
End Use: Automobile

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene	.997		15.31	.99		33.79	.99		66.21
Diesel	.003		0.04	.01		0.26	.01		0.65
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY									
TOTAL FUEL DEMAND, D, 10^{15} Joules			15.35			34.05			66.86
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt.

BASIS OF PROJECTIONS: Anthony Tomazinis (U. of Pennsylvania) transportation specialist of the U.S. team

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Transportation
End Use: Buses

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene	.04		.04	.03		.03	.		--
Diesel									
Mazout									
Sular	.91		.89	.88		.89	.92		2.32
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	.05		.05	.19		.19	.08		.19
TOTAL FUEL DEMAND, D, 10^{15} Joules			.98			1.01			2.51
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt.

BASIS OF PROJECTIONS: Anthony Tomazinis (U. of Pennsylvania) U.S. team member

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Transportation
End Use: Railway

	1975			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE									
Benzene									
Diesel	.92		4.89	.62		7.81	.15		3.67
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	.08		.43	.38		4.70	.85		21.64
TOTAL FUEL DEMAND, D, 10^{15} Joules			5.32			12.51			23.31
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt.

BASIS OF PROJECTIONS: Anthony Tomazinis (U. of Pennsylvania) U.S. team member transportation specialist

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Transportation
End Use: Trucks

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene	.53		14.94	.37		14.20	.30		25.21
Diesel									
Mazout									
Sular	.47		13.28	.63		24.11	.70		59.72
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY									
TOTAL FUEL DEMAND, D, 10^{15} Joules			28.22			38.31			84.93
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt.

BASIS OF PROJECTIONS: Apportionment by Anthony Tomazinis (U. of Pennsylvania) U.S. team member transportation specialist

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Transportation
End Use: Airways, Pipeline and Storage, Waterways

	1975			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout	.14		1.48	.15		2.55	.26		7.33
Sular	.03		.37	•					
Kerosene									
Butagas									
Natural Gas									
Jet Fuel	.81		8.60	.81		14.00	.70		20.00
Other									
ELECTRICITY	.02		.19	.04		.67	.04		1.30
TOTAL FUEL DEMAND, D, 10^{15} Joules			10.64			17.22			28.63
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Apportionment by Anthony Tomazinis (U. of Pennsylvania) U.S. team member transportation specialist

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Commercial
End Use:

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel	.05		3.48	.04		2.68	.03		2.68
Mazout	.61		41.04	.60		41.54	.64		58.62
Sular	.31		21.05	.29		20.35	.15		14.22
Kerosene	.01		0.53	.03		1.74	.04		3.96
Butagas									
Natural Gas									
Other									
ELECTRICITY	.02		1.38	.04		2.97	.14		12.67
TOTAL FUEL DEMAND, D, 10^{15} Joules			67.48			69.28			92.15
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Information exchanged 4/19/78 with Samir Habib.

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Agriculture
End Use: Irrigation & Drainage

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel	.59		3.48	.21		2.68			
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	.41		2.40	.79		9.90	1.00		19.98
TOTAL FUEL DEMAND, D, 10^{15} Joules			5.88			12.58			19.98
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt, and the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of El Behiry at the Institute of National Planning meeting of 4/15/78.

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Agriculture
End Use: Soil Preparation

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel							.09		2.68
Mazout									
Sular	1.00		7.37	1.00		13.57	.91		28.44
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY									
TOTAL FUEL DEMAND, D, 10^{15} Joules			7.37			13.57			31.12
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt.

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of El Behiry at the Institute of National Planning meeting of 4/15/78.

ILLUSTRATIVE VARIABLES:

FUEL MIX TABLE

Sector: Agriculture
End Use: Food Preparation

	1975			1985			2000		
	f_i	e_i	D_i	f_i	e_i	D_i	f_i	e_i	D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout	.23		1.04	.25		2.32	.46		12.21
Sular									
Kerosene	.77		3.41	.75		6.97	.54		14.14
Butagas									
Natural Gas									
Other									
ELECTRICITY									
TOTAL FUEL DEMAND, D, 10^{15} Joules			4.45			9.29			26.35
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Egyptian General Petroleum Corp., Egypt

BASIS OF PROJECTIONS: Apportionment by Jack Davidoff (Brookhaven National Laboratory) U.S. team member with the consultation of El Behiry at the Institute of National Planning meeting of 4/15/78.

ILLUSTRATIVE VARIABLES: Food Preparation also includes "other" uses in agriculture.

FUEL MIX TABLE

Sector: Public Utilities
End Use: Lighting and Water

	1975 f_i	1975 e_i	1975 D_i	1985 f_i	1985 e_i	1985 D_i	2000 f_i	2000 e_i	2000 D_i
DIRECT FUEL USE									
Benzene									
Diesel									
Mazout									
Sular									
Kerosene									
Butagas									
Natural Gas									
Other									
ELECTRICITY	1.00		1.96	1.00		5.40	1.00		21.55
TOTAL FUEL DEMAND, D, 10^{15} Joules			1.96			5.40			21.55
BASIS:									
SATURATION, S,									
BASIC ENERGY DEMAND, E 10^{15} Joules									
UNIT BASIC DEMAND, E_u									

REFERENCE TECHNOLOGIES:

DATA SOURCES: Internal report from the Ministry of Energy and Electricity

BASIS OF PROJECTIONS: Market allocation between end uses was extrapolated from present usage pattern.

ILLUSTRATIVE VARIABLES: Food Preparation also includes "other" uses in agriculture.

APPENDIX D - DETAILS OF THE COMPARISON CASE ENERGY SUPPLY

1.0 INTRODUCTION

This Appendix will describe the details of the Comparison Case energy supply system and document the assumptions used in developing it.

The Comparison Case for the energy assessment was established as a point of comparison against which to evaluate the impact of alternatives. It does not represent a prediction of the future development of Egypt, nor does it reflect a desired, recommended or optimum condition. Its use is solely for the purpose of establishing a point of reference for the analysis.

The fundamental data that has been used for the analysis are the projections of the demand for petroleum products and natural gas, and the demand for electricity that were supplied by the Egyptian General Petroleum (EGPC) and the Egyptian Electricity Authority (EEA) respectively. These have already been discussed in Appendix C. The energy supply system in the Comparison Case was constructed to match the demand projection.

In addition to the projections provided by EGPC and EEA, data accumulated by the assessment team in the course of the visit to Egypt were used to develop projections of energy supply capabilities. Detailed evaluations of these data are provided in the technical annexes accompanying this report. This section will outline how that information, combined with some additional assumptions, was used to develop the Comparison Case.

2.0 OIL

2.1 Reserves

As discussed in Annex 1-Energy Resources, Egypt has oil reserves in the Gulf of Suez and Western Desert with promising areas in the Nile Delta, Nile Basin, northern Sinai, and off-shore tracts. Current known reserves are estimated at 2.1-5.1 x 10^9 bbls. Although exploration activity has not grown significantly in recent years, the Comparison Case assumes that an adequate level of exploration will be maintained to sustain oil production levels to the year 2000. This may require some changes from current practice.

2.2 Production

EGPC projections for crude oil production out to 1982 were given in Annex 1-Energy Resources. The 1977 production rate was 420,000 bbls/day with a plan to achieve 880,000 bbls/day by 1982. The ultimate objective is to achieve 1 million bbls/day before 1985. It is evident that the achievement of this production rate will involve the discovery of new and significant reserves.

For the Comparison Case it is assumed that the 1 million barrel per day production will be achieved as planned and that this will be maintained through the year 2000. This is done in recognition of the speculative nature of predicting the rate of success at discovering new oil reserves.

On the basis of current oil concession agreements, the Egyptian share of oil production is 75 percent. To increase the incentives for oil companies, EGPC projects this to decrease to 70.3 percent by 1982. For the Comparison Case, this apportionment is assumed to remain constant through 2000.

Egypt currently exports 32 percent of its share of the oil production. Combined with the partners' share, this amounts to 47 percent of total production being exported. This is expected to increase to 65 percent of production in 1982.

Based on the Comparison Case demand projections, the exports will be 69 percent of total production in 1985 and 51 percent in 2000. This decrease in exports is a result of the constant value of 1 million bbls/day of production matched against an increasing local demand.

2.3 Refining

As discussed in Annex 5-Fossil Fuels, there are currently six refineries in Egypt with a total capacity of 219,000 bbls/day. All are of the low gasoline configuration; no catalytic cracking capacity is in place. Current plans call for the addition of another 100,000 bbls/day refinery at Suez to be in operation by 1982 for a total capacity of 319,000 bbls/day.

For the Comparison Case it is assumed that the refinery capacity in 1985 will be 319,000 bbls/day and that additional refineries will be built between 1985 and 2000 to satisfy the local demand for petroleum products. It is further assumed that the output product mix will not change and all new refineries will be of the low gasoline configuration.

Based on the Comparison Case demand projections there will be a need for two additional refineries of 100,000 bbls/day capacity each between 1985 and 2000. Figure D.1 gives the product mix projections.

Egypt will continue to require imports of butane and kerosene to meet the projected demand. In 1985 imports of fuel oil will also be required; and Egypt will have surplus gasoline and naptha, gasoil and diesel fuel, and asphalt available for export. In 2000 fuel oil will also be available for export.

3.0 GAS

3.1 Reserves

In Annex 1-Energy Resources, natural gas reserves are estimated to be

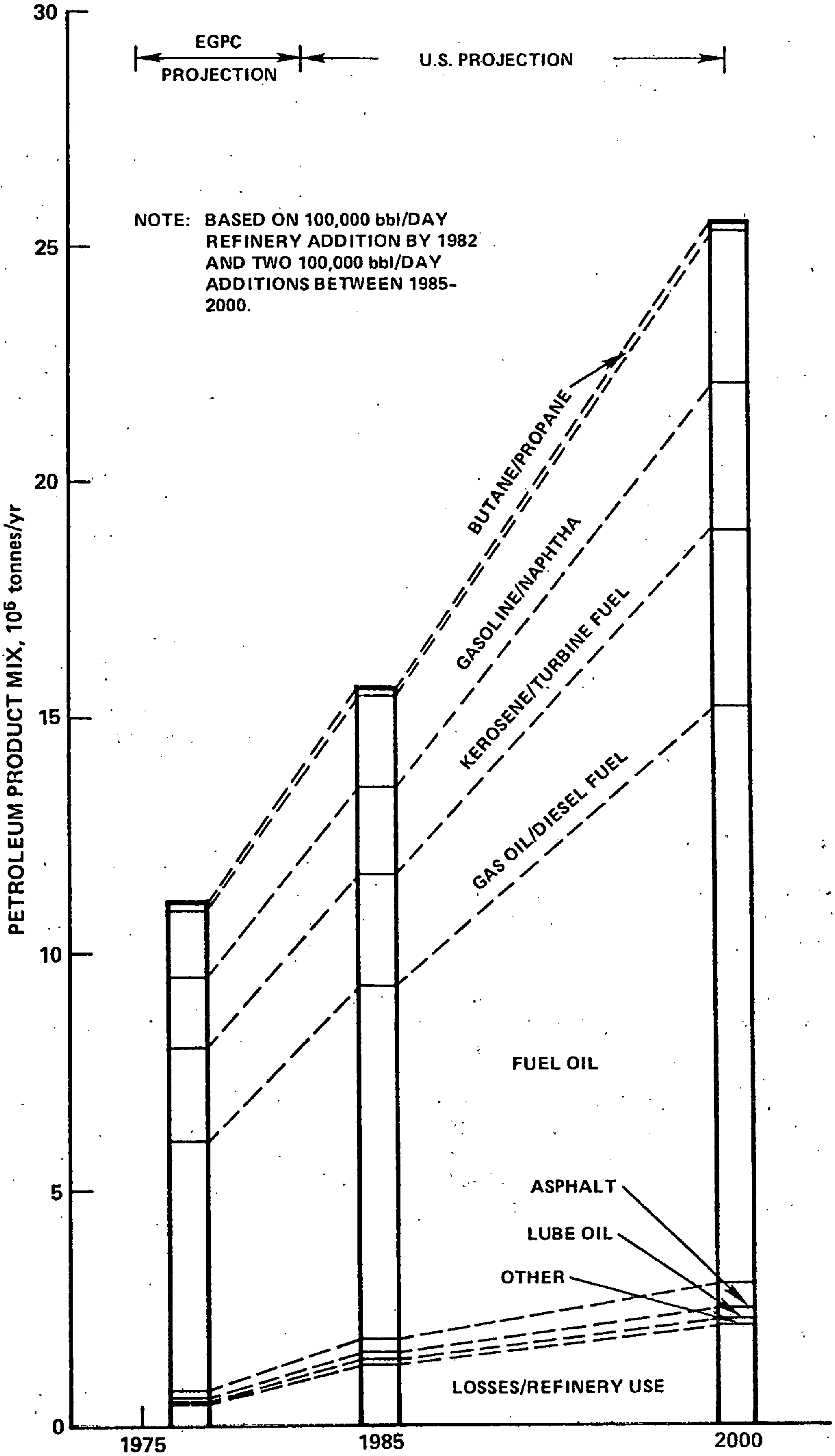


FIGURE D.1 REFINERY OUTPUT PRODUCT MIX

71-113 x $10^9 m^3$. It is assumed that this is in the form of nonassociated gas located in the Nile Delta Basin and in the Western Desert. Additional associated gas is located in the Gulf of Suez Basin but data are limited on reserves.

3.2 Production

EGPC estimates for both associated and nonassociated gas production are given in Table D.1. Note that a substantial amount of the associated gas is currently flared. The associated gas production estimates do not, however, reflect the maximum production that could be achieved assuming the 1 million bbls/day oil production rate is achieved. To estimate the maximum production, the gas/oil ratio of the Ramaden Field is assumed to be valid for all oil fields (400 scf/bbl). This is assumed to be a conservative estimate since values as high as 1000 scf/bbl have been observed. In the Comparison Case it is assumed that the difference between the maximum associated gas production estimates and the EGPC production estimates is retained in the gas cap for pressure maintenance. In the strategies that follow it will be assumed that this gas can be recovered (possibly requiring enhanced oil recovery techniques to maintain well pressure) and used in a variety of applications.

3.3 Distribution

The Comparison Case gas distribution system includes the transport of non-associated gas from Abu Gharadi, Abu Qir, and Abu Madi to Helwan, Kafr El Dewar power plant, and Talka respectively. A pipeline to bring associated gas ashore at El Shukheir in the Gulf of Suez and transport it up to Suez for use in fertilizer, cement, and power production is also included.

4.0 COAL

4.1 Reserves

As indicated in Annex 1-Energy Resources, most significant reserves are the Maghara deposits in the Sinai with proven and probable reserves of 35.6 x 10^6 tonnes. Other deposits in the Western Desert, Ayun Musa, Wadi Thora, and Wadi Araba do not have sufficient data to be included in the assessment.

4.2 Production

As discussed in Annex 5-Fossil Fuels, Egypt planned to open a mine at Maghara prior to the 1967 war, which would produce at the rate of 300,000 tonnes/year. It is assumed in the Comparison Case that this mine could be in operation by 1985 and will produce at this rate through 2000.

Table D.1 Projections of Demand for Natural Gas

Demand Sector	% of Total Demand 1975	1985	2000
Non-Associated Gas			
Industry			
Refracteries	--	25.0	25.0
Spinning & Textiles	--	6.6	6.6
Iron & Steel	--	12.4	12.4
Electricity	--	55.0	55.0
Domestic	--	1.0	1.0
		100.0	100.0
Total Demand (10^3 tonnes)		2550.0	2550.0
(10^9 m^3)		3.17	3.17
Associated Gas			
Industry			
Fertilizer	--	17.4	17.4
Cement	--	17.4	17.4
Electricity	--	65.2	65.2
		100.0	100.0
Total Demand (10^3 tonnes)		676.0	676.0
(10^9 m^3)		0.84	0.84

Source: Egyptian General Petroleum Corp., April 1978.

4.3 Uses

From the results of Annex 5-Fossil Fuels, it is seen that the quantity of coal would not support a large power plant (approximately 150 MWe). It is assumed, therefore, that the coal will be blended with imported metallurgical coal for use in steel-making. The blend will be assumed to be limited to 20 percent of the coking coal required.

5.0 URANIUM AND THORIUM

There is only very limited information on uranium and thorium reserves as reported in Annex 1-Energy Resources. In the Comparison Case it is assumed that all nuclear fuel requirements are met by imports. No indigenous uranium or thorium production is included.

6.0 ELECTRICITY

The EEA projections for the demand for electricity have already been discussed. The Comparison Case generator mix that will satisfy these demands was developed by combining information from EEA and from the U.S. team visit. The EEA data was developed using the Wein Automatic System Planning (WASP) model, which produces a generator mix based on minimizing electricity costs while maintaining system reliability. Table D.2 gives the installed capacity of the Comparison Case. Table D.3 gives the post-1983 build schedule.

6.1 Hydroelectric

(See Annex 6-Hydroelectric Power.) The Comparison Case assumes that the hydroelectric capacity of Egypt is made up of the Aswan and High Dams and includes the electrification of the Esna, Nag Hammadi, and Assiut barrages and the addition of 160 MWe to the Aswan Dam by the year 2000. The four potential new barrage sites on the Nile are not included, nor is the Qattara depression project. The rate of water release through the hydropower facilities is assumed to be limited to the treaty restrictions between Egypt and the Sudan.

In addition to the baseloaded hydropower facilities, it is assumed in the Comparison Case that there are 2550 MWe of pumped storage capacity. This does not represent full exploitation of potential pumped storage capability (as discussed in Annex 6-Hydro) but represents the required capability based on WASP calculations for peak load demand. It is assumed that this pumped storage capacity will be located at the potential sites in the Suez area. It should be noted that the development of pumped storage capacity is integrally related to the nuclear power development program. As some of the following strategies will demonstrate, the peak load demand will be met by other than pumped storage if nuclear power is available in smaller quantities than in the Comparison Case.

Table D.2 Comparison Case Installed Electrical Capacity

Generator Type	Installed Capacity, MWe 1975	1985	2000
Hydroelectric	2445	2445	2603
Oil- and Gas-Fired Steam	1420	4068	2817
Combustion Turbine - Simple Cycle	137	437	0
Combined Cycle	0	0	0
Nuclear	0	0	12600
Renewable Resource			
Solar	0	2.5	902
Wind	0	0.65	364
Biomass	0	0.42	180
Geothermal	0	0	20
Pumped Storage	0	0	2550
	4002	6954	22036

Table D.3 Comparison Case Power Plant Build Schedule

Year	Added Capacity	Retired Capacity	Total Available Capacity	Peak Demand	Reserve (Peak Demand) After Capacity
(MWe)	(MWe)	(MWe)	(MWe)	(MWe)	(MWe) %
1983	0		5786	4028	43.6
1984	600T		6386	4518	41.3
1985	600T	36	6950	5045	37.8
1986	600N	34	7516	5527	36.0
1987	66 Aswan		7582	6066	25
1988	600N+59ESNA	40	8201	6629	23.7
1989	600N+150PS		8551	7221	24.0
1990	600N+150PS +33N.H.		9708	7834	23.9
1991	600N+150PS +175ST	47	10411	8510	22.3
1992	600N+150		111161	9208	21.2
1993	600N+300PS +150S*		112061	10032	20.2
1994	900N+300PS	100	13161	10084	220.9
1995	900N+300PS	240	14121	11826	19.4
1996	900N+300PS +250S*	24	15297	12794	19.6
1997	900N+900N	172	16926	13941	21.4
1998	900N+900N	632	18094	15015	20.5
1999	900N+300PS	166	19128	16197	18.1
2000	1200N+450PS +871S**+20G	300	20710	17395	19.5

* Doesn't count for Reserve margin

** Includes 250 MWe for Peak Demand

6.2 Fossil-Fueled Generators

The Comparison Case assumes that additional fossil-fueled generators will be built through 1987, but that all additional capacity beyond that point will be nuclear. Also, older plants will be systematically retired so that all of the steam plants and combustion turbines in operation in 1975 will be out of service by 2000, leaving only the newer plants in operation.

As noted above, the Comparison Case assumed the use off some natural gas for electricity generation. It is assumed that this will be in the form of dual-firing capability in power plants.

It is assumed that the efficiency of fossil-fired power plants will be improved in the period from the present to 1985 and will remain at a reasonable level (30 percent) through the year 2000. The fossil-fired capacity is assumed to operate in cycling and peak load conditions in 2000.

6.3 Nuclear Generators

The Comparison Case assumes the intensive nuclear power program will be achieved and that 12,600 MWe of nuclear power will be in place by 2000. All of the reactors will be of the light water configuration. It is assumed that these reactors will be operated in a base load condition.

6.4 Solar Electric

Due to the extremely good potential for solar power in Egypt, it was assumed in the Comparison Case that some of the electricity would be generated by solar-powered equipment. There are a large number of possible configurations of solar electric equipment including varieties of thermal and photovoltaic systems. No attempt was made to project the penetration of each type of system; rather, a total contribution of solar power to electricity generation was included.

The Comparison Case assumes that there is no vigorous government program to promote the use of solar electric systems and that the penetration rate of this equipment is the result of only moderate research and development programs.

It is further assumed that the solar electric equipment represents a mix of small-scale, dispersed systems that operate without any connection to a central utility grid and larger, centralized systems that can feed power into a grid as well as meet local demands. No attempt was made to estimate the distribution of each type of system.

6.5 Wind Electric

In a fashion analagous to the solar electric systems, it is assumed in the Comparison Case that wind-driven generators will meet some of the electrical demand. Again, it is assumed that there is no aggressive government program to promote wind energy development and only moderate research and development is undertaken. There is likewise a split between isolated and grid-connected systems although the emphasis would be primarily on the dispersed system configuration. Most of the wind power generated would be available for use along the Mediterranean and Red Sea coasts.

6.6 Biomass

In the Comparison Case it is assumed that some use can be made of biomass materials to generate electricity. The principal application is in the rural areas where animal wastes can be processed by anaerobic digestion to produce methane, which can then be used to fuel engine-powered generators. Direct combustion of processed agricultural wastes (e.g., bagasse, rice hulls, etc.) is also considered. The Comparison Case assumes no aggressive program of biomass utilization.

6.7 Geothermal

Very little information exists regarding the availability of geothermal power. The Comparison Case assumes that a small amount of geothermal-generated electricity (20 MWe) will be available by 2000.

7.0 SOLAR HOT WATER HEATING

As discussed in Annex 8-Potential Use of Renewable Energy Resources, solar hot heating represents significant potential applications in Egypt. As above, in the Comparison Case, it is assumed that there is no aggressive promotion of solar hot water heating and the only penetration into the market is based on relative economics. Table D.4 shows the assumed use of solar hot water heat in the Comparison Case.

Table D.4 Comparison Case Solar Hot Water Heating

Year	Installed Area ($10^6 m^2$)	Heat Delivered	
		10^{15} joules	10^{12} Btu
1975	0	0	0
1985	0.053	0.22	0.2
2000	2.5	10.00	3.7

APPENDIX E - ASSUMPTIONS IN THE COST, MANPOWER, EQUIPMENT AND MATERIAL REQUIREMENTS

1.0 INTRODUCTION

The assessment's energy strategies emphasize various energy supply and conversion options: offshore oil, associated and nonassociated gas, coal use, nuclear, hydroelectric power, solar energy, etc. The implementation of these options will require differing amounts of capital, manpower and equipment. The Energy Supply Planning Model (ESPM) has provided the assessment with a systematic way to determine the total direct resources, cost and scheduling required to build and operate the energy supply facilities that will be needed to implement a given strategy. This Appendix describes the principle assumptions embedded in these calculations, the Egypt-specific adjustments made to ESPM, and the assumptions underlying the preparation of facility build schedules that were an essential element in the ESPM calculations.

2.0 ESPM ASSUMPTIONS AND ADJUSTMENTS TO EGYPTIAN CONDITIONS

2.1 ESPM Data Base

A central feature of the Energy Supply Planning Model is its extensive engineering data base, which consists of those resources directly required to engineer, construct, startup, operate, and maintain energy supply and transportation facilities. The original data base was developed for the United States and included 101 "typical" energy extraction, processing and transportation facilities selected to give a comprehensive coverage of the energy supply industry in the United States.

The "typical" facilities are in fact "future average" facilities in the sense that their resource requirements are intended to be typical of requirements of the kind and size likely to be under construction in the 1978 to 2000 period. This choice implies that a "typical" facility may not be identical to any existing or planned facility but can yield reasonably accurate indications of cost and resource needs over a future time period. The construction requirements of these facilities are then broken down into a large number of categories of manpower, directly purchased materials and equipment, and the direct and indirect input of raw materials. Capital costs are then calculated from data base information on unit costs of these input categories.

Construction resources are expended at various rates during a construction period. To account for this effect, time-phased data on the percentage of the total resources that are required during each year of the construction project have been developed in the data base. Additionally, for operation and maintenance of the completed facilities the data base contains U.S. data on the annual costs for manpower, materials, equipment and utilities, as well as annual manpower costs by disciplines.

It is important to note that the data base and the ESPM analysis are developed in terms of direct requirements for the construction and operation of facilities. Ripple effects through the economy for indirect physical labor and material requirements are excluded. For example, the data base includes the direct engineering requirements for the design of a power plant, but not the (indirect) engineering requirements associated with the design of manufactured equipment (piping, heat exchangers, etc.) included in the power plant.

The existing data base does not contain information on costs which could be termed "owner's costs". Therefore, such factors as interest during construction, land costs, leasing fees, and taxes are not included in the ESPM data base or ESPM produced cost estimate.

2.2 Adaptation for Egypt Assessment Analysis

Although the ESPM model was developed originally for the analysis of energy options in the United States, it provides major value to the Egypt energy assessment in two ways: 1) the energy facilities data base is comprehensive, current, accessible and organized into an integrated framework amenable to analysis of policy changes; and 2) it provides a consistent set of engineering information derived under common ground rules.

In order to use the ESPM to estimate the resource requirements of Egyptian energy supply facilities, it was necessary to adopt the model to reflect conditions that apply to Egypt. Since facility cost and resource requirements data for Egypt are not readily available, it was determined that the most appropriate methodology would involve modification of existing ESPM estimates to an Egyptian basis rather than the development of entirely new estimates for Egyptian facilities. Such factors as Egyptian wage rates, project efficiency factors, expatriate labor conditions, and import surcharges on capital goods were used to transform the U.S. data to be more specific to Egypt.

Improved results could be obtained by complementing these modifications with the development of new estimates for those energy technologies with highly site-specific characteristics, e.g., hydro facilities and oil wells. This was not possible in the course of this assessment. Cost information and facility descriptions were provided by the U.S. specialists when such information was available. Such facility cost information was directly imported to ESPM and where possible a "surrogate" ESPM typical facility was used to represent potential resource needs that might be associated with such facilities.

2.2.1 General assumptions for Egypt modifications: A basic assumption for the ESPM analysis was that future energy projects in Egypt would be engineered and constructed according to worldwide standards. Such methods place a high premium on capital intensive construction equipment and techniques, with lesser dependence on unskilled labor. Additionally, this would mean that, in general, the project would adhere to U.S. design and construction practices, management, inspections and quality assurance practices.

The significance of this assumption is that the ESPM's U.S. data on the relative mixes of labor and material quantities for energy facilities can be used for Egyptian facilities. Thus, construction or operation of identical oil refineries in the United States or Egypt can be assumed to require identical quantities of capital goods and labor (as adjusted for project efficiency differences). Without this simplifying assumption, modification of the ESPM's data base would require considerably more effort than was available for the study.

Based on discussions held in Egypt, this assumption of world standards does appear to be reasonable for the major energy projects being considered (e.g., nuclear power plants, refineries and pipelines). However, this would not be as good an assumption for more routine civil construction projects such as housing, roads, waterways, etc.

Throughout the analysis all costs have been estimated in constant 1978 Egyptian pounds. Foreign exchange requirements have been calculated on the basis of a conversion rate of $1.00 U.S. equals 0.7 Egyptian pounds (LE). This ratio is presently the unofficial rate of exchange (the official rate is 0.3 LE/$). However, it is judged to better reflect future exchange conditions and is, in fact, the rate at which most commodities are now traded with government approval.

2.2.2 Modification for materials and equipment: Quantities of materials and equipment required for Egyptian facilities are also assumed to be the same as for similar facilities in the United States. Determination of the costs of these quantities requires assessment of:

- Local versus foreign source
- Costs of local sources
- Costs of imported sources

Basic materials such as wood products, cement, concrete and steel are currently available from local suppliers in Egypt, but this is generally not the case for finished heavy equipment.

Uniform national price statistics for capital goods were not available; it was assumed that locally available materials could be purchased at prices roughly equal to world prices, which were estimated by escalating ESPM prices from March 1977 to January 1978.

Despite the availability of many basic materials, the supplies tend to be marginally adequate, with slippage of project construction schedules a typical consequence of over-reliance on local industry. For this reason, importation of locally available materials may be necessary and is allowed for major projects. In practice, on the most important construction projects essentially all materials and equipment are assumed imported. Table 2.5-8 in the Main Report indicates examples of these import ratios. For these major projects, import tariffs are typically waived. Thus, materials and equipment procured from international suppliers in the United States, Europe and Japan can be obtained at the world price plus costs of overseas transportation and local handling and transportation within Egypt.

The delivered price for imports has been estimated to be 20 percent above the world price, which includes about 10 percent extra for overseas transportation and 10 percent for local handling. This 20 percent premium corresponds to procurement from Japan or Europe; another 5 percent might be added if the United States is the source.

These general guidelines were converted to detailed import fractions for about 20 equipment and materials sectors as necessary to develop the costs of materials and equipment for Egyptian facilities at the ESPM level of detail. Separate fractions were estimated for different types of facilities depending on the detailed bill-of-goods make-up of the requirements. For most facilities, items currently produced in Egypt were assumed to be procured there for construction, whereas estimates for operations and maintenance assumed additional items would be available following implementation of Egypt's Five-Year National Plan of 1978 to 1982. For a few facilities (oil and gas wells, and nuclear power plants) that were considered to be of high priority or complexity, it was assumed that essentially all materials and equipment would be imported to save time.

<u>2.2.3 Modification for labor force factors</u>: There exists in Egypt an abundance of local labor. Large numbers of semi-skilled, unskilled, administrative, clerical, and technical workers are readily available. Skilled Egyptian workers are available in moderate numbers in almost all disciplines, except for skilled craft workers such as pipe welders and millwrights.

However, there is little experience with large, complex energy projects, and the highly trained labor that does exist is frequently drawn to other higher-paying countries in the Arab region and elsewhere.

The first step in modifying the ESPM labor data base to Egyptian conditions was to derive adjusted requirements for quantities of labor. As previously stated, the quantities of labor required to build and operate Egyptian energy facilities were assumed to be identical, after adjustment for "project efficiency" factors, to similar facilities in the United States. A project efficiency factor is defined to be the ratio of the number of hours of labor required in Egypt relative to the U.S. for similar projects. Such a factor is a composite of many individual conditions, such as laborer work knowledge and ability, job-site conditions, local climate, length of workweek, management methods, general economic conditions and culture.

A project efficiency factor of 2-3 was felt to be appropriate for Egyptian projects. For expatriates working in Egypt, project efficiency factors could be expected to be somewhat reduced, to perhaps a range of 1.5 to 2.5.

Regarding the use of expatriates, it was assumed that most facilities would be operated and maintained by an entirely Egyptian work force. For the higher priority oil and gas wells and nuclear power plants, about one-fifth of the operations work force was assumed to be expatriates. A training program for local operators that is tied to the energy development program is implicitly assumed with these factors.

The engineering and construction of energy facilities is expected to see a somewhat greater use of foreign labor. For most facilities a figure of one-half of the engineering and one-sixth of the manual labor was used, and for the highest-priority facilities foreign labor is assumed to account for all of the engineering and one-third of the manual workers. It should be noted that only about one-third or less of the foreign engineering work would involve expatriates, since the bulk of the engineering work would be carried out in the home office of the foreign company.

The final step necessary to modify the Egyptian labor data was to develop adjusted labor costs, taking into account the use of local versus foreign labor and project efficiency factors developed above, and unit labor costs. Unit costs for Egyptian construction labor is estimated to range from an average of about 1 LE/hour for manual to an average of about 3.25 LE/hour for nonmanual technical labor. These figures include all benefits, including an allowance for housing and food.

In the case of operation and maintenance, the housing and food allowance is removed to give annual wages of 1725 LE to 4850 LE for the same range of manpower skills.

These unit costs are roughly 1/3 to 1/6 those prevailing in the United States. Thus, although Egyptian projects may require up to three times as many manhours, overall labor costs amount to only 50 percent to 70 percent of those in the United States.

Of course, this saving is reduced to the degree that foreign labor is used on Egyptian projects. Manual labor expatriates are likely to be sourced not from Western developed countries but rather from developing countries such as South Korea, India, Pakistan, Indonesia and the Philippines. After inclusion of incentive premiums, unit costs of these manual expatriates are expected to be about 4 to 5 LE/hour or nearly five times the cost of using local labor. However, this is still less than the equivalent U.S. labor rate for manual manpower and far less than the cost of using expatriates from Western developed countries.

The major portion of foreign engineering and field supervision manpower is expected to be provided by developed countries (e.g., United States, West Germany, France, Japan and the United Kingdom). In the case of facilities engineering, the home office portion of this work force has been costed out at U.S. rates already existing in the ESPM data base. However, certain other costs and labor burdens are applicable to expatriates in this class. For this study an average overall premium of 135 percent has been assumed to cover base salary premium, air fares, food and housing (not included for operations manpower), vehicle, and marital status allowances.

2.2.4 Other cost assumptions: Total construction costs are the sum of labor, materials, equipment, and "other," which includes contractor overhead, fee, and contingency. This "other" costs component has been assumed here to be the same percentage for Egyptian facilities as for the United States. Its exact size varies among the various facility types. It should be noted that this factor would in practice be set by the management of the contracting company. Higher rates than those assumed here would not be unreasonable, in that overhead costs and risks associated with international projects are higher than for domestic projects.

A factor has also been applied to total construction costs to cover working capital costs, as well as general plant and intangible costs. The costs of land and land rights, escalation and interest during construction have not been included.

As noted earlier, all costs are stated in constant January 1978 Egyptian pounds. A currency conversion rate of $1.00 U.S. = LE 0.7 was used to convert to Egyptian pounds from U.S. dollars when necessary.

2.2.5 Modification for smaller size of Egyptian facilities: It was recognized that facility sizes typical of energy projects in the United States would, in many cases, be larger than appropriate for developing countries such as Egypt. Within a reasonable range of facility sizes, parametric scaling was used to adjust resource requirements data. Such data were scaled down for oil and gas wells, oil refineries, coal mines, uranium wells, and electric generating facilities using oil, gas, coal, nuclear and pumped hydro storage. Separate scale coefficients were developed for manpower, basic materials, other materials and equipment, land, energy and utilities and miscellaneous costs. These varied among different facilities.

Egyptian oil and gas wells are much more productive than those in the U.S., hence a given amount of production can be obtained for correspondingly less investment. The assumption that future oil and gas wells in Egypt will continue this higher relative production rate is a major uncertainty in the cost and resource estimates. The relative assumptions on oil productivity and field size are presented in Section 2.5 of the Main Report.

2.2.6 Imports: A primary element of resource development strategy for most countries is the encouragement of the use of indigenous labor, industry, and capital in carrying out programs, thereby reducing balance of payments burdens. It was therefore decided to provide information of use in analyzing the foreign exchange implications of alternative energy strategies. Accordingly, the ESPM data base was modified by partitioning it into two data sets, the first containing total resource requirements and the second containing the imported component of the total requirements. The "Import" data set contained the costs of direct purchases of foreign labor, materials, equipment and services, as well as the quantities of foreign labor required for energy facilities. Creation of this data base required assumptions regarding the use of foreign versus local labor, materials, etc., for the various types of energy facilities as discussed in earlier sections of this Appendix.

The import component varies across input categories, but for all facilities the import component averages about 80 percent of total capital requirements, about 20 percent of operating costs, and about 25 percent of construction labor requirements (45 percent for non-manual and 20 percent for manual).

2.2.7 Facilities not covered by ESPM: The coverage of energy technologies in ESPM was restricted to those already existing in the data base. Technologies for generation of electric power via solar thermal, wind, biomass, Nile River Barrages, or the Qattara hydroelectric project were not included in ESPM. Further, technologies were excluded for which the typical size of an Egyptian facility was so much smaller than U.S. size that scaling factors were felt to be inappropriate. In this category were mine-month coal-fired power plants, crude oil and gas pipelines, and the annual costs of operating oil and gas wells. Geothermal system requirements were not estimated because of their small relative magnitude. Analyses for these technologies excluded by the ESPM were carried out by individual technology specialists on the assessment team, and the results directly added to the ESPM output.

2.2.7.1 Hydroelectric costs: Hydroelectric facility costs are either those obtained from Egyptian Electricity Authority sources or generalized estimates for pumped storage facilities. (See Annex 6-Hydro.) Estimated costs for powerhouse addition to existing barrages obtained from Egyptian sources by the hydroelectric specialist were included in the ESPM estimate. Selected portions of an ESPM "typical" 200 MWe hydroelectric dam were used as a surrogate for estimating the manpower, equipment and materials resources that could be associated with these powerhouse additions to existing barrages. Since there has been little site investigation work at potential pumped storage sites, typical pumped storage facility data was used. There is considerable uncertainty in the unit costs associated with any pumped storage facilities. Separate Qattara project costs are not included due to the large uncertainty about the scope of the project and the major effect this could have on project costs. It was assumed in the accelerated renewable resource strategy, where the Qattara project was assumed to be constructed, that the estimate for pumped storage facilities would reasonably encompass some part of the Qattara project costs.

2.2.7.2 Solar costs: Cost, equipment and manpower requirements for solar heat and solar electric systems were estimated independently by the solar specialists of the U.S. team, (see Annex 8-Potential Use of Renewable Resources). Depending on the current development status of these technologies, the capital cost (which is a dominant factor in solar energy generation costs) is expected to decrease as a result of both continuing RD&D efforts and larger production volumes. This was a key assumption in the solar specialists' estimate. It was assumed that the anticipated reductions in costs for solar heating and wind systems over the period to 2000 will be considerably less than those for solar photovoltaic or solar thermal systems, because the technical and engineering status of the latter systems is not as advanced, and greater improvements can be expected. Cost reductions on the more well-developed technologies are due primarily to savings from both volume production of the required equipment and engineering savings in equipment manufacture, installation, operation, and maintenance activities. However, cost reductions will be limited by the large portion of the cost associated with conventional equipment, such as steel support structures, piping, electrical generators and controls.

Solar heating and certain of the solar electric systems offer a significant foreign exchange advantage. Over 50 percent of installed system costs are labor-related, and the labor requirements are of a type that Egyptian labor could readily be trained to perform. Also, many of the basic materials and equipment required could be manufactured in Egypt. It appears that, with careful planning, Egypt could provide up to 85 percent of solar system materials, equipment, and labor required by the year 2000. Over the interim period, it is assumed that 30 percent of all costs support foreign exchange or imported labor. Even so, this is considerably less than the general level of 80 percent which is assumed to be applied to the imported labor and equipment requirements of other fuel refining and electrical generation systems.

It is assumed that the solar systems for commercial applications will be installed, checked out and will begin regular operations in about one year. On this basis, solar system capital costs include little interest during construction compared to that for fossil and nuclear electric generation plants or oil refineries. This assumption is optimistic but not unreasonable for small dispersed solar installations such as solar water heaters, small wind-electric generators, irrigation pumps, etc. But, it is completely unrealistic for such large-scale solar installations as would be involved in application of solar photovoltaic, solar thermal or wind-generator fields for interconnection into the electric grid or for biogas installations at central collection points for urban wastes, However, due to the inability to reasonably assign the assumed total solar energy contribution to the several types of applicable technologies, the above noted optimistic assumption was arbitrarily applied to all solar systems. This is clearly an assumption which towers the estimated cost associated with the assumed use of solar systems.

<u>2.2.8 Effluent control systems</u>: An important assumption for the cost calculation is that oil-fired electric generation plants are assumed to require no flue gas scrubbers or other effluent control systems. They also are assumed to utilize once-through cooling, on the assumption they will be located on major salt water bodies. The addition of flue gas scrubbers would increase plant capital costs by over $100 per kilowatt of installed capacity ($100/kw), in addition to increasing plant operations and maintenance costs. The installation of cooling towers would increase plant capital costs about $20/kw, and slightly increase plant operation and maintenance costs.

3.0 ASSUMPTIONS FOR THE CONSTRUCTION SCHEDULE OF ENERGY FACILITIES

To estimate total and annual average facility cost, equipment and manpower requirements, it was necessary to develop a construction schedule for the required facilities. From the 1985 and year 2000 projected end-use demands and the demand-supply balances discussed in Appendices C and D, a smoothed demand for energy forms was derived for the intervening years. The schedules for the major fossil-fuel supply and processing facilities thus could be quite reasonably developed from the information provided by the EGPC. Similarly, except for the electric generation system, the required build dates for most other energy supply facilities could be derived by the ESPM from the yearly demands for each of the various strategies taken together with the construction lead times. Table E.1 and E.2 indicate the assumed construction lead time for many of these facilities included in the assessment. Table E.3 gives the resulting supply facility "build" or construction start schedules for the Comparison Case.

3.1 Electrical Generation Construction Schedules

The preparation of construction schedules for the needed electric generation and transmission facilities poses more difficulty than the other facilities. This results from: (1) the need to maintain a generating capacity reserve margin above estimated peak electric demand; and (2) the need to utilize a wide variety of electric generation facilities (e.g., oil-fired steam turbine, combustion turbine, nuclear, pumped storage and solar electric), each with significantly different operation and cost features and construction lead times.

The results of the analyses of these factors define the time path for the electric generation system expansion and when combined with the facility construction lead times, the electric facility "build schedule." Appendix D, Figure D.3 discusses this for the Comparison Case. Similarly, Appendix F depicts the electric generation system expansion for other energy supply-demand strategies addressed in the assessment. Such schedules only provide feasible solutions to electric generation additions. Optimization of the electric system growth was not attempted in this initial assessment.

<u>Assumptions and Constraints</u>. The electric generation system through 1983 was based upon the existing Egyptian electric generation system, the facilities currently under construction, and the assumption that existing schedules and performance objectives would be met. Construction in 1984 and 1985 was based upon projections which were under consideration by Egyptian officials.

The assumption was made that the performance of electric generation facilities, with respect to thermal efficiencies and plant availability, would improve over that now being experienced to a level approaching that realized in the U.S. This should be achievable by the completion

TABLE E.1

ENERGY FACILITY CONSTRUCTION TIMES

FACILITY NAME	MONTHS CONSTRUCTION TIME
ONSHORE PRIMARY OIL RECOVERY (1.000 Mbpd)	24
ONSHORE SECONDARY OIL RECOVERY (0.913 Mbpd)	24
ONSHORE ENHANCED OIL RECOVERY (3.51 Mbpd)	24
OFFSHORE OIL RECOVERY (12.5 Mbpd)	36
HIGH-GASOLINE REFINERY (200 Mbpd EFFECTIVE)	48
LOW-GASOLINE REFINERY (100 Mbpd EFFECTIVE)	48
ONSHORE CONVENTIONAL GAS RECOVERY (100 MMcfd)	24
ONSHORE ENHANCED GAS RECOVERY (208 MMcfd)	18
OFFSHORE GAS RECOVERY (25 MMcfd)	36
LNG EXPORT (3,030 MMcfd)	72
UNDERGROUND COAL MINE (2 MMtpy)	36
SURFACE URANIUM MINE (275.4 Mtpy)	48
UNDERGROUND URANIUM MINE (114.8m Tonnes/yr.)	36
URANIUM MILL (275.4m Tonnes/yr.)	16
COMBINED CYCLE POWER PLANT (400 MWe)	48
GAS TURBINE POWER PLANT (133 MWe)	18
LIGHT WATER REACTOR (LWR) (ALL SIZES)	108
DAM AND HYDROELECTRIC POWER PLANT (200 MWe)	57
PUMPED STORAGE (500 MWe)	78

TABLE E.2

ENERGY TRANSPORTATION FACILITY CONSTRUCTION TIMES

FACILITY NAME	MONTHS CONSTRUCTION TIME
CRUDE OIL PIPELINE (800 MB/P, 241.9 KM)	27
OIL TANKER (90,000 bbl)	--
OIL BARGES (90,000 bbl)	--
OIL TANK TRUCK (226 bbl)	--
PRODUCE PIPELINE (70 Mbpd, 160.9 KM)	18
HOT OIL PIPELINE (40 Mbpd, 80.5 KM)	18
REFINED PRODUCTS BULK STATION (69 Mbpd)	20
RAIL LINE (64.4 KM, SINGLE TRACK)	33
MIXED TRAIN (6556 Tonnes)	--
COAL UNIT TRAIN (9,528 Tonnes)	--
COAL BARGES (19,098 Tonnes)	--
COAL TRUCK (22.7 Tonnes)	--
GAS DISTRIBUTION FACILITIES (50-MMscfd)	60
230 kVac TRANSMISSION LINE (250 Mwe, 500 mi)	24
500 kVac TRANSMISSION LINE (1,200 Mwe, 500 mi)	24
ELECTRICITY DISTRIBUTION - AERIAL LINES - (131.6 MWe)	26

TABLE E. 3

SCHEDULE OF ANNUAL ENERGY FACILITIES ADDITIONS TO SUPPLY FUEL MIX: EGYPT - COMPARISON CASE 1976-2010

FACILITY NAME	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
ONSHORE PRIMARY OIL RECOVERY-(1,000 MBPD)	17*	17*	17*	18*	17	18	17	17	16	16	14	13	14	13	13	14
OFFSHORE OIL RECOVERY (12.5 MBPD)	3*	3*	3*	3*	4*	3	3	3	3	3	3	2	3	2	3	2
LOW-GASOLINE REFINERY (100 MB/D EFFECTIVE)	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0
ONSHORE CONVENTIONAL GAS RECOVERY (100 MMCF/D)	1*	0	0	1*	0	0	0	1	0	0	0	0	1	0	0	0
SURFACE URANIUM MINE (275.4 M TONNES/Y)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
URANIUM MILL (275.4 M TONNES/Y)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
OIL-FIRED POWER PLANT (600 MWE)	0	0	0	0	1*	1*	0	0	1	1	0	0	0	0	0	0
OIL-FIRED POWER PLANT (450 MWE)	0	0	0	1*	0	0	0	0	0	0	0	0	0	0	0	0
GAS TURBINE POWER PLANT (133 MWE)	0	1*	1*	0	0	0	0	0	0	0	0	0	0	0	0	0
LIGHT WATER REACTOR (LWR) (1200 MWE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIGHT WATER REACTOR (LWR) (900 MWE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIGHT WATER REACTOR (LWR) (600 MWE)	0	0	0	0	0	0	0	0	0	0	1*	0	1	1	1	1
DAM & HYDROELECTRIC POWER PLANT (200 NWE)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
PUMPED STORAGE (500 MWE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

* THE CONSTRUCTION SCHEDULE FOR THIS FACILITY IS LONGER THAN THE NUMBER OF YEARS BETWEEN 1977 AND THE ON-LINE DATE.

TABLE E.3 (Continued)

SCHEDULE OF ANNUAL ENERGY FACILITIES ADDITIONS TO SUPPLY FUEL MIX: EGYPT - COMPARISON CASE 1976-2010

FACILITY NAME	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
ONSHORE PRIMARY OIL RECOVERY-(1,000 MBPD)	13	14	13	14	14	14	14	15	14	14	14	14	14	14	14	14
OFFSHORE OIL RECOVERY (12.5 MBPD)	3	2	3	2	3	3	2	3	3	3	3	3	3	3	3	3
LOW-GASOLINE REFINERY (100 MB/D EFFECTIVE)	0	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0
ONSHORE CONVENTIONAL GAS RECOVERY (100 MMCF/D)	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0
SURFACE URANIUM MINE (275.4 M TONNES/Y)	1	0	0	1	0	1	0	0	0	1	0	0	1	0	0	1
URANIUM MILL (275.4 M TONNES/Y)	1	0	0	1	0	1	0	0	0	1	0	0	1	0	0	1
OIL-FIRED POWER PLANT (600 MWE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OIL-FIRED POWER PLANT (450 MWE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GAS TURBINE POWER PLANT (133 MWE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LIGHT WATER REACTOR (LWR) (1200 MWE)	0	0	0	0	0	0	0	0	1	1	2	1	2	1	2	2
LIGHT WATER REACTOR (LWR) (900 MWE)	0	0	1	1	1	2	2	1	0	0	0	0	0	0	0	0
LIGHT WATER REACTOR (LWR) (600 MWE)	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DAM & HYDROELECTRIC POWER PLANT (200 NWE)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PUMPED STORAGE (500 MWE)	0	1	0	1	0	0	1	0	1	0	1	0	1	1	1	1

* THE CONSTRUCTION SCHEDULE FOR THIS FACILITY IS LONGER THAN THE NUMBER OF YEARS BETWEEN 1977 AND THE ON-LINE DATE.

TABLE E.3 (Concluded)

SCHEDULE OF ANNUAL ENERGY FACILITIES ADDITIONS TO SUPPLY FUEL MIX: EGYPT - COMPARISON CASE 1976-2010

FACILITY NAME	2008	2009	2010	TOTAL ADDED (1978-2010)	TOTAL ADDED (1978-2000)
ONSHORE PRIMARY OIL RECOVERY-(1,000 MBPD)	14	14	14	482	342
OFFSHORE OIL RECOVERY (12.5 MBPD)	3	3	3	94	64
LOW-GASOLINE REFINERY (100 MB/D EFFECTIVE)	0	0	0	7	5
ONSHORE CONVENTIONAL GAS RECOVERY (100 MMCF/D)	0	0	0	6	5
SURFACE URANIUM MINE (275.4 M TONNES/Y)	0	0	1	8	4
URANIUM MILL (275.4 M TONNES/Y)	0	0	1	8	4
OIL-FIRED POWER PLANT (600 MWE)	0	0	0	4	4
OIL-FIRED POWER PLANT (450 MWE)	0	0	0	1	1
GAS TURBINE POWER PLANT (133 MWE)	0	0	0	1	1
LIGHT WATER REACTOR (LWR) (1200 MWE)	2	2	3	19	1
LIGHT WATER REACTOR (LWR) (900 MWE)	0	0	0	8	8
LIGHT WATER REACTOR (LWR) (600 MWE)	0	0	0	7	7
DAM & HYDROELECTRIC POWER PLANT (200 NWE)	0	0	0	1	1
PUMPED STORAGE (500 MWE)	1	1	1	13	5

* THE CONSTRUCTION SCHEDULE FOR THIS FACILITY IS LONGER THAN THE NUMBER OF YEARS BETWEEN 1977 AND THE ON-LINE DATE.

of new plants now under construction, overhaul of some existing facilities, and maintenance activities.

No attempt was made to combine features of the various strategies except for the combined strategy of the nuclear capacity variation.

3.2 End Effects of Post 2000 Construction

To avoid distortions in capital requirements toward the end of the period (the so-called "end effect" distortion), the cumulative cost, equipment, and manpower estimates for the year 2000 must include the requirements for energy supply facilities that are under construction in that period but are not scheduled to begin operation until after 2000. To do this, construction schedules for energy supply facilities needed after 2000 are assumed in a manner consistent with overall system growth requirements. For example, solar-electric systems are expected to be added to the electric grid at a rate of 9 percent per year in the year 2000, and this growth rate is then assumed to continue in the post-2000 period.

Those post-2000 facilities with long siting and construction times and high capital costs (e.g., nuclear plants, pumped storage facilities, etc.) can make a significant contribution to the total accumulated cost, equipment, and manpower estimates up to the year 2000, while making no contribution to installed capacity in that period. To illustrate, the cumulative capital costs for energy supply facilities for the Comparison Case (17.2 billion LE) include 3.5 billion LE for nuclear power plants that would not begin operation until after 2000. Moreover, because there are large variations in the construction times assumed for various energy supply facilities (e.g., one year for solar electric facilities, nine years for nuclear power plants, five years for pumped storage hydroelectric facilities, etc.), the "costs-for-future-capacity" included in the cumulative capital costs will vary significantly when the mix of types of facilities changes. This variation bears careful scrutiny in the examination of the different strategies that are presented in Section 2.6. The presentations in Section 2.6 attempt to show the aggregate effect of these post-2000 facility requirements. Examination of the specific make-up of those end-effects cannot easily be presented without extensive discussion beyond the scope of this Appendix.

In a similar fashion, capital expenditures prior to 1978 for facilities which come into operation in the period 1978 to 1985 causes a distortion that could be termed a "beginning effect." These expenditures have not been included in the cost calculations, and the totals are somewhat underestimated, as a result. However, since almost none of the facilities that were under construction prior to 1978 will still be under construction after 1982, the effect of this distortion is small. Moreover, it is similar in all of the strategies described in Section 2.6.

4.0 FUEL CYCLE COSTS

4.1 Fossil Fuels

Fossil fuel cycle costs were determined using a world price for residual fuel oil of $75 a tonne, converting this to dollars (or Egyptian pounds [LE]) per joule, using the energy content (joules per tonne) of the residual fuel oil, and applying the resulting factor to the total joules of fuel consumed from the energy balance. (An energy content of 40.7×10^{9} joules/tonne was used for residual fuel oil, assuming it is derived from Egyptian refining of Egyptian crude oil.) Natural gas was assumed to sell at the equivalent (based on energy content) world price of residual fuel oil, so the same factor was used. This factor is 18.4×10^{-10} \$/joule or 12.9×10^{-10} LE/joule; it is the cost per joule of the fossil fuels required for the entire electrical generation process in terms of net energy output. If an average fossil plant net generation efficiency of 30 percent is assumed, the total fuel cost per joule of electric energy produced by fossil plants at the busbar is 61.33×10^{-10} \$/joule or 43×10^{-10} LE/joule. (This is equivalent to 2.2 cents per kilowatt hour (kWh) or, with about 5.76×10^{9} joules (5.5 million Btu) per barrel of oil, approximately $13.50 per barrel.)

4.2 Nuclear Fuels

Based on the assumption of a "throw-away" nuclear fuel cycle, total fuel cycle costs are 0.7 cents/kWh, in constant 1978 dollars (no escalation). The average nuclear fuel consumption rate (burnup) was assumed to be 33,000 megawatt-days per tonne, typical of that achieved in current reactors. (No other improvements in nuclear fuel technology were assumed to occur). This is equivalent to a total fuel cost of 19.5×10^{-10} \$/joule, or 13.6×10^{-10} LE/joule at the busbar for nuclear electric generation.

Neither the fossil fuel cost or nuclear fuel cycle costs considered future changes in the real cost of basic fuels, fuel's processing or transport charges. To be done properly, this would involve a comparative economic analysis which was beyond the scope of what could be accomplished in this initial assessment.

APPENDIX F - DETAILS OF OPTIONS AND STRATEGIES CONSIDERED

1.0 INTRODUCTION

As part of the assessment process, the U.S. team identified several alternatives in both the supply and demand sectors. The alternatives, referred to as options, were grouped into sets based on a common impact. These sets are referred to as strategies.

The list of alternatives presented here is not intended to be exhaustive. Rather, it is designed to reflect a set of possibilities that, at first review, appear to be promising. Further review may uncover additional possibilities or may indicate that some of those considered here are not practical.

This Appendix gives the details of how the options and strategies were constructed and gives the energy balance of each strategy.

2.0 EVALUATION OF OPTIONS AND STRATEGIES

The process by which the options and strategies were evaluated consisted of several steps. First, the effect of each individual option on energy demand and/or supply was computed and expressed in terms of joule equivalents. Second, the effect of all of the options included in a particular strategy was computed and the resultant change in the supply and/or demand for fuels and electricity was determined. Third, a modified electric system was constructed. Fourth, the energy balance of the strategy was displayed in an energy system network. Fifth, the cost, manpower needs, and materials requirements for the energy supply system were computed using the Energy Supply Planning Model. Finally, the results are examined against the Comparison Case to determine the impact of the strategy. These examinations have been presented in Section 2.6.

Four primary strategies were considered in this analysis:

(1) maximum gas use;

(2) improved efficiency;

(3) accelerated renewable resources; and

(4) nuclear capacity variations (medium nuclear, low nuclear, and combined strategies)

Two alternatives in the use of natural gas and three variations of nuclear electric generation capacity were examined within the context of these four primary strategies.

3.0 MAXIMUM GAS USE

The objective of this strategy is to make full use of the available natural gas. Current information indicates that there is not a sufficient quantity of both nonassociated and associated gas available to consider it as an export commodity (which would involve liquifaction), hence the strategy centers on identifying domestic uses for the gas.

3.1 Production

As was indicated in the description of the Comparison Case, there currently are plans to utilize 3.17 x $10^9 m^3$/yr (2.55 x 10^6 tonnes/yr) of nonassociated gas in the industrial, domestic, and electrical sectors and 0.84 x $10^9 m^3$/yr (.676 x 10^6 tonnes/yr) of associated gas in the fertilizer, cement, and electrical sectors in the Suez area. These rates apply in both 1985 and 2000. Further, the Comparison Case assumed that an additional 3.30 x $10^9 m^3$/yr of associated gas was recirculated into oil wells for gas lift or left in the gas cap for pressure maintenance. For this strategy, it is assumed that this additional gas (amounting to 123.93 x 10^{15} joules/yr) can be recovered without sacrificing oil production.

The strategy hinges on two critical assumptions: first, that the amount of associated gas that can be produced is equivalent to 400 standard cubic feet per barrel (scf/bbl of oil), which is the equivalent of the Ramadan Field; and second, that it is technically and economically feasible to recover this gas through enhanced oil recovery techniques. More detailed evaluation could prove either or both of these assumptions to be erroneous.

3.2 Collection and Distribution

The Comparison Case included gas distribution pipelines from the nonassociated gas fields to Helwan, Kafr El Dewar, and Talka and from the Gulf of Suez associated gas fields north to Suez. This strategy assumes that appropriate gas collection and distribution systems will be built to permit the distribution of all natural gas to demand centers and that there is no distinction between gas from associated and nonassociated fields in terms of potential users.

3.3 Uses

This strategy has two alternative cases. The first case gives priority to residential and industrial users. The second case assumes that all of the additional gas available will be used for electricity generation.

3.3.1 Case 1: Residential and industrial priority: In this case it is assumed that residential use of natural gas for cooking and hot water heating has the highest priority for utilization of the additional gas. This is the result of the current residential energy consumption pattern that relies on the use of imported butagas.

Supply Residential Requirements. The use of natural gas in residential areas would relieve demands for butagas, kerosene and electricity. For purposes of calculation, it was assumed that due to distribution problems natural gas use would be practical only in urban areas. Also, due to difficulties associated with retrofit, the market was defined as consisting of all new housing, both in the new cities and in existing cities. The calculations supporting the estimates of gas used and fuels saved by implementing this option appear in Annex 3-Residential and Commercial. A summary of results is presented below in Table F.1.

Table F.1

Substitution of Gas for Electricity, Butagas, and Kerosene in Residences

YEAR	GAS USED	BUTAGAS SAVED	KEROSENE SAVED	ELECTRICITY	SAVINGS
1985	$236 \times 10^6 M^3$ (8.8 JQ)	110×10^3 Tonne (5.2 JQ)	88×10^3 Tonne (3.9 JQ)	97×10^6 KWH (0.3 JQ)	0.6 JQ
2000	$925 \times 10^6 M^3$ (34.6 JQ)	559×10^3 Tonne (26.3 JQ)	105×10^3 Tonne (4.7 JQ)	1321×10^6 KWH (4.7 JQ)	1.1 JQ

This option will release imported butagas and kerosene and will result in net energy savings.

Supply Industrial Facilities. The use of gas by industry has the potential to release fuel oil, coal and electricity for other uses, including exports (or reducing imports). Three possible options were identified for utilizing natural gas in industry. These are: (1) substitute the direct reduction method of iron production for one-half of planned blast furnace expansion; (2) replace the existing Kima electrolysis method fertilizer facilities with natural gas methods; and (3) produce methanol from natural gas.

(1) Substitution of Direct Reduction for One-half Planned Blast Furnace Expansion-

Since conflicting projections were given by different sources of planned iron and steel expansion through 2000, it was decided for the purpose of options analysis to define as the base projection those expansion plans implied by the fuels projections in the Comparison Case.

Comparison Case projections of natural gas consumption by metals are:

1975	1985	2000
-	16.41×10^{15} J	25.24×10^{15} J

If natural gas consumption by metals other than iron and steel is assumed to be negligible and if direct reduction is the only iron and steel process using natural gas, then the projections imply direct reduction iron and steel production of:

1975	1985[a]	2000[1]
-	0.93×10^6 tonne/yr	1.43×10^6 tonne/yr

Current blast furnace production (all at Helwan) is 0.96×10^6 tonne/yr. It is not clear what blast furnace expansion is embedded in the Comparison Case demand projections. Therefore, it was arbitrarily decided to use as the hypothetical basis for options analysis the blast furnace expansion plans given in the Gordian Report.

These working projections are:

1975	1985	2000
0.96×10^6 Tonnes	3.75×10^6 Tonnes	7.25×10^6 Tonnes

If the per tonne energy consumption estimates given in Table F.2 are applied to these production figures, the total energy used by process is shown in Table F.3. (Table F.3 is derived from tables in Annex 2-Industrial/Agricultural Sector Options.)

As an option under the "maximum gas use" strategy the gas-utilizing direct reduction method is substituted for the proposed intensive blast furnace method. According to the hypothetical expansion plans, the increment of production capacity available for fuel switching is 0.79×10^6 tonnes in 1975, and a total of 6.29×10^6 tonnes in 1985 and 6.29×10^6 tonnes in 2000.

If one-half of this was shifted, the costs in terms of natural gas and electricity would be:

	1985	2000
Natural Gas	6.95×10^{15} J	55.35×10^{15} J
Electricity	1.0×10^{15} J	7.85×10^{15} J

The savings in terms of mazout and coal would be:

	1985	2000
Mazout	0.78×10^{15} J	6.1×10^{15} J
Coal	12.15×10^{15} J	96.75×10^{15} J

This option, therefore, results in the use of natural gas and the release of mazout and coal.

TABLE F.2

IRON AND STEEL - EXPANSION PROCESS OPTIONS[i]

Process Description	Natural Gas[a] (NM^3)	Mazout[b] (Kg)	Electricity[c] (Kwh)	Oxygen[d] (NM^3)	Total Electricity (Kwh)	Coal[e] (MT)	Total (10^9 J)
Blast Furnace		136	158.5		158.5	1.099	
TOTAL (10^9 Joules)		5.54	0.57		0.57	30.77	36.9[f]
Direct Reduction electric furnace, continuous casting, reheat furnace, finishing	469	92.8	608	12 (10.3 (Kwh)	618.3		
TOTAL (10^9 JOULES)	17.6	3.8	2.19	0.4	2.22		23.62
Direct Reduction, Oxygen lancing, open hearth w/continuous casting, reheat furnace, finishing							
Gas Process[g]	566.2	90.0	19	42 (36.4 Kwh)	55.4		
Oil Process	469	180	19	42 (36.4 Kwh)	55.4		
TOTAL (10^9 JOULES) Gas Proc.	21.3	3.7	0.07	0.13	0.2		25.2
Oil Proc.	17.6	7.4	0.07	0.13	0.2		25.2
Direct Reduction[h] Open hearth w/o oxygen lancing, continuous casting, reheat furnace, finishing							
Gas Process	566.2	90	19		19		
Oil Process	469	180	19		19		
TOTAL (10^9 Joules)							
Gas Process	21.3	3.7	0.07		0.07		25.1
Oil Process	17.6	7.4	0.07		0.07		25.1

Notes

a 3.744×10^7 J/NM^3

b 4.071×10^{10} J/Tonne

c 3.6×10^6 J/Kwh

d 0.866 Kwh/NM^3

e 28×10^9 J/MT

f If credit is given for byproducts, net energy is approximately 33.1×10^9 Joules. Fuels include blast furnace and coke oven gases, tars and pitch and light oils.

g Assumes substitution possible at 1.08 M^3 of natural gas per kilogram of mazout

h Will take almost 2x as long to produce as much steel.

i Gordian report is source of base numbers.

TABLE F.3

TOTAL ENERGY USED IN BLAST FURNACE AND DIRECT REDUCTION PRODUCTION

	10^{15} J NATURAL GAS			10^{15} J MAZOUT			10^{15} J ELECTRICITY			10^{15} J COAL			10^{15} J TOTAL		
PROCESS	75	85	2000	75	85	2000	75	85	2000	75	85	2000	75	85	2000
Direct Reduction w/electric furnace	-	16.4	25.2	-	3.5	5.4	-	2.1	3.2	-	-	-	-	22	33.8
Blast Furnace	-	-	-	5.3	20.8	40.1	0.54	2.13	4.13	29.5	115	223.1	35.3	137	267.33

(2) Replace the Existing Kima Electrolysis Facility with a Natural Gas Facility-

This option was rejected because the availability of natural gas was less than had been previously thought and because naptha process replacement is being discussed.

(3) Produce Methanol from Natural Gas-

This option was rejected because of insufficient gas, insufficient ready market for methanol and incomplete information regarding this option.

With the residential use and the conversion of one-half of the blast furnace capacity to direct reduction, there is still a small quantity of gas remaining. This amounts to $2.89 \times 10^9 m^3$ (108.18×10^{15} joules) in 1985 and $0.91 \times 19^9 m^3$ (33.98×10^{15} joules) in 2000. It was assumed that this gas would not be used since it represents a rapidly declining resource that would require significant capital expense to extract (i.e., enhanced oil recovery). Instead, it would remain in the wells for pressure maintenance. A more detailed economic evaluation might show that this gas could be profitably used in electricity generation or for other uses.

Table F.4 indicates the energy impact of the Case. Figures F.1a and b show the energy balance for the entire system.

<u>3.3.2 Case 2: Electricity generation priority</u>: This case assumes that all additional available gas is used to generate electricity. This results in a different electric system configuration than the Comparison Case. Table F.5 gives the generator mix and Table F.6 gives the post-1983 build schedule. Note that the availability of gas for electricity generation leads to a greater emphasis on combined cycle plants, which can be operated at higher efficiencies than conventional steam plants or simple cycle gas turbines. A reduction of about 14 percent in the nuclear generator capacity in the year 2000 is also possible.

Apart from the change in the structure of the electrical sector, there were no differences from the Comparison Case. Figures F.2a and b show the energy balance.

4.0 IMPROVED EFFICIENCY

The objective of this strategy was to improve the efficiency of utilization of energy in several sectors. Data was available in the residential, transportation, and industrial sectors. The strategy also had an effect on the electrical sector through a reduction in electricity demand. The reduced demand for petroleum products is reflected entirely by an increase in the export of products conserved or a reduction in import requirements.

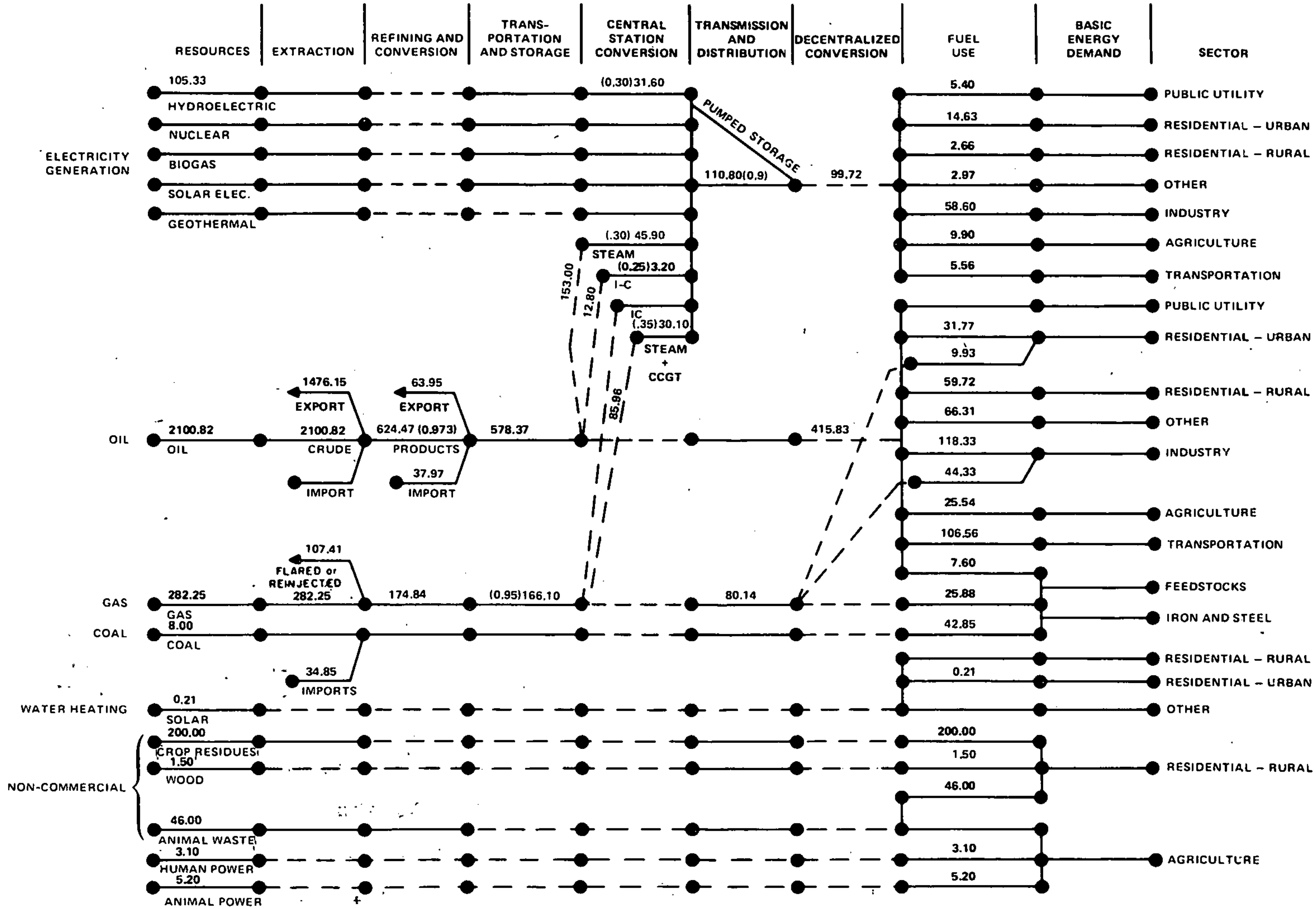
Table F.4

Impact of Maximum Gas Use Strategy: Case 1

Change from the Comparison Case, 10^{15}J

	Natural Gas		Butagas		Kerosene		Mazout		Coal		Electricity		Total	
	1985	2000	1985	2000	1985	2000	1985	2000	1985	2000	1985	2000	1985	2000
Natural Gas Production	+123.93	+123.93												
Residential	+8.8	+34.6	-5.2	-26.3	-3.9	-4.7					-0.3	-4.7		
New Cities														
New Construction														
Industrial														
1/2 Blast Furnace	+6.95	+55.35					-0.78	-6.1	-12.15	-96.75	+1.0	+7.85		
	+15.75	+89.95	-5.2	-26.3	-3.9	-4.7	-0.78	-6.1	-12.15	-96.75	+0.7	-3.15	-5.58	-47.05
Unused Gas	108.18	33.98												

REFERENCE ENERGY SYTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	921.00
NON-COMMERCIAL	247.50
HUMAN & ANIMAL	8.30
TOTAL	1176.80
NET EXPORTS	1467.28

NOTES

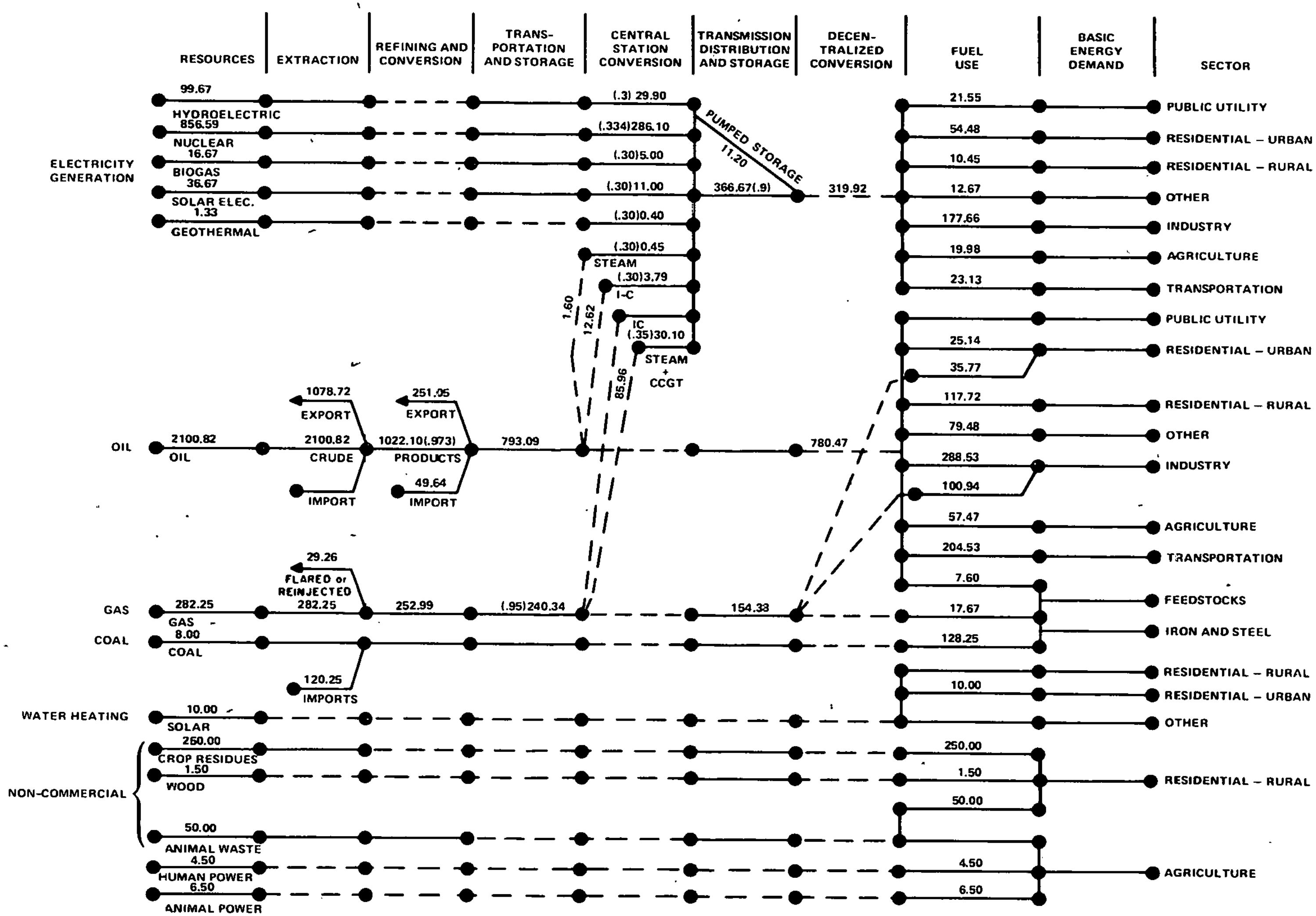
1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	638.75
NON-COMMERCIAL	247.50
HUMAN & ANIMAL	8.30
TOTAL	894.55

FIGURE F1.a
MAXIMUM GAS USE--CASE 1-1985

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	2217.27
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	2529.77
NET EXPORTS	1159.88

NOTES

1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	1393.02
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	1705.52

FIGURE F1.b
MAXIMUM GAS USE--CASE 1-2000

Table F.5. Generator Mix for Maximum

Gas Use: Case 2

Generator Type	1985 Capacity MW	1985 Change from Comparison Case, %	2000 Capacity MW	2000 Change from Comparison Case, %
Hydroelectric	2,445	0	2,603	0
Oil and Gas-Fired Steam	2,868	-29.5	1,617	-42.6
Combustion Turbine - Simple Cycle	107	-75.5	0	0
Combined Cycle	1,230	*	1,868	*
Nuclear	0	0	10,800	-14.3
Renewable Resource				
Solar	2.5	0	902	0
Wind	0.65	0	364	0
Biomass	0.42	0	240	0
Geothermal	0	0	20	0
Pumped Storage	0	0	2,550	0
Total	6,654	-4.3	20,964	-4.9

*No combined cycle was included in the Comparison Case.

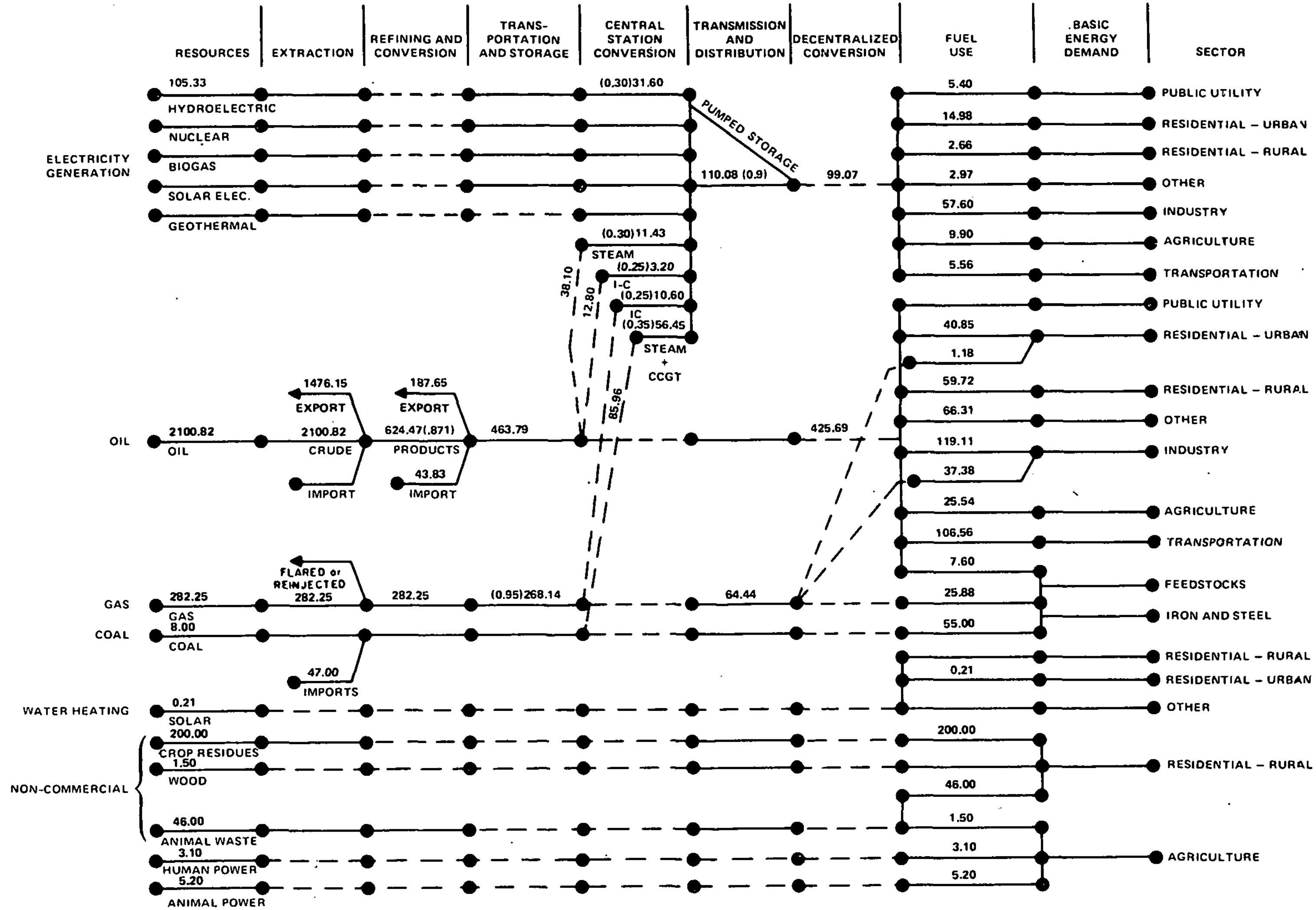
TABLE F.6

Electric Sector Build Schedule for Maximum Gas Use: Case 2.

Year	Added Capacity (MWe)	Retired Capacity (MWe)	Total Available (MWe)	Peak Demand (MWe)	Reserve Demand (MWe)	Reserve Margin %
1983	0	0	5786	4028	1758	43.6
1984	450CCGT	-	6236	4518	1718	38.0
1985	450CCGT	36	6650	5045	1605	31.8
1986	600N	34	7216	5527	1689	30.6
1987	188GT(conv) +66 ASN		7470	6066	1404	23.1
1988	600N+59ESNA	40	8089	6629	1460	22.0
1989	300PS+450CCGT		8839	7221	1618	22.4
1990	33NH+600N	26	9446	7834	1612	20.6
1991	900N+175S*	47	10299	8510	1789	21.0
1992	900N		11199	9208	1991	21.6
1993	150S* +900PS		12099	10032	2067	20.6
1994	1200N	100	13199	10884	2315	21.3
1995	1200N+300PS	240	14459	11826	2633	22.3
1996	1200N +250S*	24	15635	12794	2841	22.2
1997	1200N+300PS	172	16963	13941	3022	21.6
1998	1200N+450PS	632	17981	15015	2966	19.8
1999	1200N+300PS	166	19315	16197	3118	19.3
2000	1200N+871S** +20G		20785	17395	3390	19.5

* Does not count for reserve margin
** Includes 250 MWe for peak power

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	919.45
NON-COMMERCIAL	247.80
HUMAN & ANIMAL	8.30
TOTAL	1175.25
NET EXPORTS	1872.97

NOTES

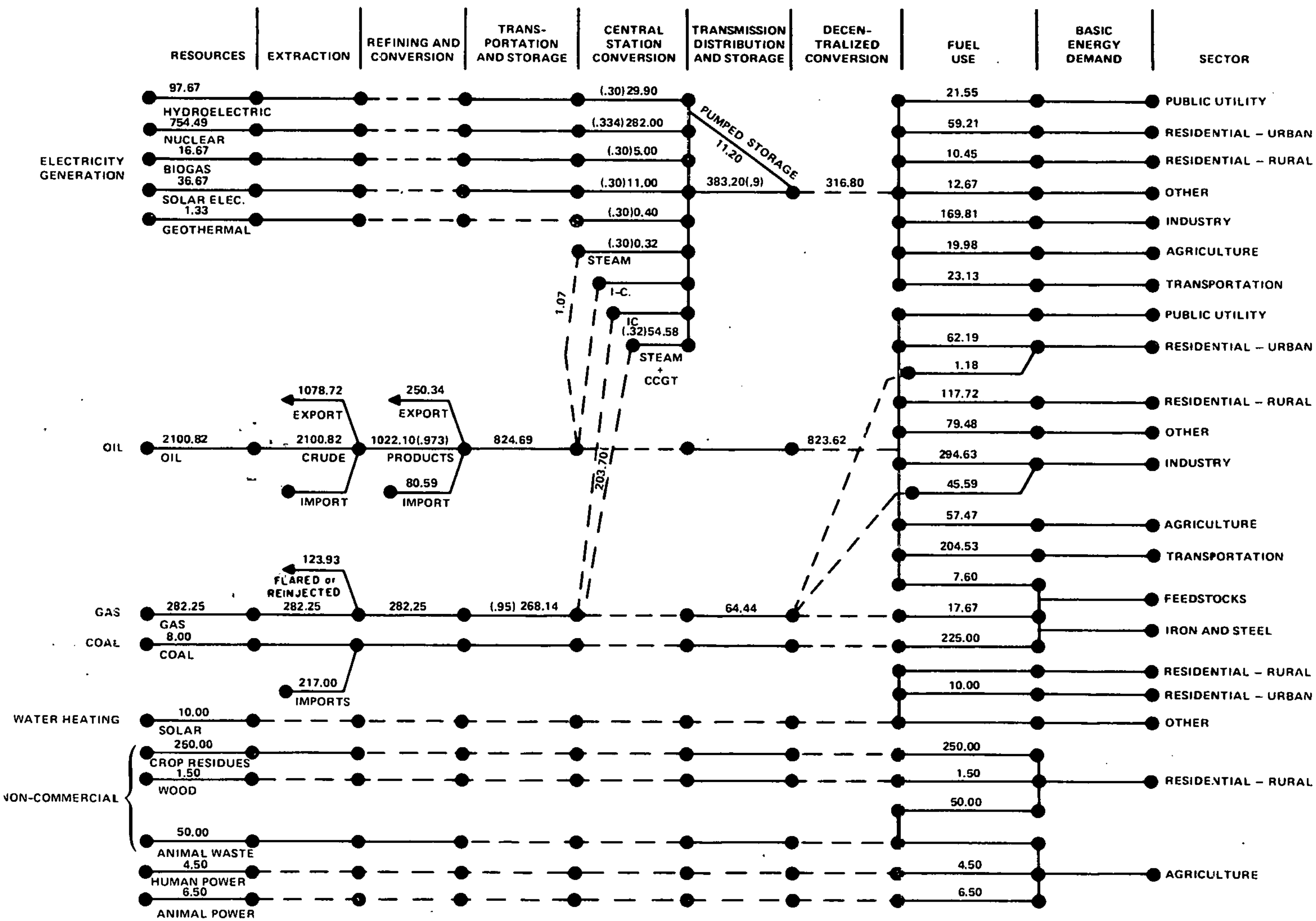
1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	644.41
NON-COMMERCIAL	247.50
HUMAN & ANIMAL	8.30
TOTAL	900.21

FIGURE F.2a
MAXIMUM GAS USE--CASE 2-1985

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	2273.15
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	2586.15
NET EXPORTS	1031.47

NOTES

1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	1439.86
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	1752.36

FIGURE F.2b
MAXIMUM GAS USE--CASE 2-2000

4.1 Residential Sector

Substitution of Fluorescent for Incandescent Light in the Residential and Commercial Sectors. The analysis of this option, based upon information contained in the Annex 3 - Residential/Commercial, assumed the following: (1) fluorescent bulbs currently comprise 15 percent of all residential and commercial lighting usage; (2) one-quarter of remaining incandescent lighting in both of these sectors could be replaced by fluorescent lighting; and (3) the fluorescent lighting consumes 40 percent of the power used by incandescent.

Given these assumptions, possible electricity savings were calculated amounting to:

1985	2000
2.1×10^{15} J	6.0×10^{15} J

Transistorization of Television Sets. The analysis of this option, also based upon calcuations and information appearing in Annex 3-Residential/Commercial, assumes that greater use of solid state circuitry in Egyptian televisions could result in a 50 percent reduction in per unit power consumption. Total potential electricity savings would be:

1985	2000
2.47×10^{15} J	6.48×10^{15} J

Placement of Light Reflectors on Bare Light Bulbs. This option was rejected for analysis at this time. Most housing units using bare light bulbs are likely to also be using minimum wattage bulbs. Therefore, even if implementation were practical, the result would be more light from existing bulbs rather than less power consumption by even lower wattage bulbs.

4.2 Transportation Sector

Improved Conservation and Planning Procedures and Increased Use of Waterways and Railroads Relative to the Highways. This option is based upon information appearing in Annex 4-Transportation. Fuel savings (-) and costs (+) associated with it are:

	Electricity	Mazout	Sular	Benzene	Net Savings
1985	$+2.40\times10^{15}$J	$+0.66\times10^{15}$J	-3.62×10^{15}J	-11.33×10^{15}J	-11.89J
2000	$+2.97\times10^{15}$J	$+1.11\times10^{15}$J	-7.37×10^{15}J	-26.03×10^{15}J	-29.32J

The increased use of electricity is due to emphasis on the electrified railway while the increase in mazout is due to its use in barges on the waterways. Decreased use of sular and benzene is due to substitution of mass transit for cars and the substitution of railway and waterway freight movement for truck freight.

It should be noted (see discussion in Annex 4 -Transportation) that the fuel savings (and costs) associated with this option are based upon a Comparison Case that displays a definite break with historical trends. If, instead, this transportation option were compared with projections based upon historical trends, increases in electricity consumption and decreases in sular and benzene use would be much larger and the net energy savings would also be considerably larger.

4.3 Industrial Sector

In Cement Production, Institute Less Fine Grinding of Clinker, Increase Fuel Switching and Use of Water, and Increase Use of Blended Cement. This option, based upon information contained in Annex 2-Industry/ Agriculture Sector Options assumes that the potential 5.3 percent energy savings in 1985 and the 14.4 percent possible in 2000 are apportioned in the following manner: (a) all of the clinker savings accrue to electricity; (b) fuel switching and waste use savings accrue to fuels; and (c) savings due to using blended cement are allocated proportionately.

Since the cement projections implied by the Comparison Case are not easily discernable, the percentage fuel savings are applied to the cement production projections reported in Annex 2 - Industry/Agriculture Sector Options. According to this method of calculation, energy savings achievable with this option are:

	Electricity	Mazout*
1985	0.41×10^{15} J	2.31×10^{15} J
2000	1.11×10^{15} J	9.49×10^{15} J

Convert the Automotive Plant to a Two or Three-Shift Operation. This option would minimize energy inefficiency resulting from frequent shut down and start-up of operations. Estimates of possible savings,

---

* It is likely that the mazout savings should be apportioned between gas and mazout if split according to the Comparison Case gas/mazout ratio for Building Materials, Insert A. The fuel savings would be:

	Gas	Mazout
1985	0.6×10^{15} J	1.71×10^{15} J
2000	1.97×10^{15} J	7.52×10^{15} J

based upon the production projections appearing in Annex 2 - Industry/ Agriculture Sector Options are shown below.

	Electricity	Mazout
1985	0.011×10^{15} J	0.015×10^{15} J
2000	0.011×10^{15} J	0.015×10^{15} J

<u>Reduce Anode Current Density in the Aluminum Process</u>. This option could feasibly improve energy efficiency 6.9 percent from 18,000 Kwh/tonne to 16,760 Kwh/tonne. The disadvantage of this option is that it reduces productivity. However, this is no real problem as long as capacity utilization does not exceed 85 percent. Estimated electricity savings based upon the production projections given in Annex 2-Industry/Agriculture Sector Options is 0.74×10^{15} joules for both 1985 and 2000.

<u>In the Textiles Industry, Capture of Waste Heat, Steam and Water During the Spinning, Weaving and Finishing Processes</u>. This option, applied to projections given in Annex 2 - Industry, would result in savings in 2000 of 0.48×10^{15} joules of electricity and 1.32×10^{15} joules of mazout.*

<u>To Replace Kima Fertilizer Electrolysis Process With Naptha Process by 2000</u>. This option, according to Annex 2 - Industry, would result in the following fuel shifts:

	Increased Use		Decreased Use
Feed Stock	3.79×10^{15} J	Electricity	6.88×10^{15} J
Naptha			
Fuel	2.05×10^{15} J	Mazout	0.6×10^{15} J

<u>Improved Housekeeping and Maintenance in the Chemicals Industries</u>. This option, taken from information appearing in Annex 2 - Industry would involve energy savings of:

	1985	2000
Electricity	0.3×10^{15} J	1.05×10^{15} J
Fuels*	0.9×10^{15} J	3.15×10^{15} J

---

* Actual fuel composition is not known but for purposes of calculation, it was all considered mazout.

Improved Housekeeping and Maintenance in the Food Procesing Industry. This option, taken from information appearing in Annex 2 - Industry, could provide savings of:

	1985	2000
Electricity	0.01×10^{15} J	0.05×10^{15} J
Mazout	0.07×10^{15} J	0.30×10^{15} J

Deferral of Construction of Low Density Polyethylene (LDPE) Plant to Take Advantage of a New Energy-Conserving Technology Which Would Use 75 percent Less Energy. This option was not included in the analysis since its inclusion would have violated the project ground rule of not altering projected activity levels, i.e., tons of LDPE.

Shift in Investment from High Energy - High Capital - Low Labor Using Industry, e.g., Petrochemicals, to Low Energy - Low Capital - High Labor Intensive Industries. This option also was not included in the analysis since it would impact projected activity levels.

Promote Phosphatic Fertilizer Process Over Nitrogen Process. Although it is known that the phosphatic process consumes one-seventh of the energy consumed by the nitrogen process for fertilizer manufacture, insufficient information was available on the mix of fertilizers appropriate to Egyptian land. Therefore, further analysis of this option was precluded.

Increase Imports of Iron and Steel Scrap. Although this option would reduce the energy used by the iron and steel industry, it was not analyzed because of its impact on activity levels.

Replacement of Planned Blast Furnace (Iron) Capacity Expansion With Direct Reduction Process. This option (which appears in the "Maximum Gas Use Strategy") was considered for and then dropped from the "Improved Efficiency Strategy" because of the unusual role of coal. In the case of Egypt, coal is only being considered for its metallurgical content, not its energy producing capability. Therefore, even though large quantities of coal are released by this option, only imports of coal are reduced and new supplies of fuel are not made available for electricity generation.

4.4 Energy Supply Sectors

As a result of the efficiency measures there is a reduction in the demand for electricity and fuels. Table F.7 summarizes the effects. Total net savings is about 21×10^{15} joules in 1985 and 58×10^{15} joules in 2000. These represent 3 percent of the 1985 commercial energy demand and 4 percent of the 2000 demand respectively.

Electricity demand is reduced 4 percent in 1985 and 6 percent in 2000. Table F.8 gives the generator mix for this strategy and Table F.9 gives the post 1983 build schedule. Capacity requirements are reduced almost 11 percent

Table F.7

Effect of Strategy to Improve Efficiency

Sector	Change in energy from Comparison Case, 10^{15} joules											
	Electricity		Mazout		Sular (Gas Oil)		Benzene (Gasoline)		Natural Gas		Naptha	
	1985	2000	1985	2000	1985	2000	1985	2000	1985	2000	1985	2000
A. Residential												
1. Fluorescent Light	-2.10	-6.00										
2. Transistorized TV	-2.47	-6.48										
B. Transportation	+2.40	+2.97	+0.66	+1.11	-3.62	-7.37	-10.77	-22.74				
C. Industry												
1. Cement	-.41	-1.11	-2.31	-9.49								
2. Automotive	-0.011	-0.011	-0.015	-0.015								
3. Aluminum	-0.74	-0.74										
4. Textiles	0	-0.48	0	-1.32								
5. Fertilizer (Kima)	0	-6.88	0	-0.60							0	+5.84
6. Chemicals	-0.30	-1.05	-0.90	-3.15								
7. Food Processing	-0.01	-0.05	-0.07	-0.30								
Total	-3.64	-19.83	-2.63	-13.76	-3.62	-7.37	-10.77	-22.74	0	0	0	+5.84

Table F.8 Generator Mix for Improved End-Use Efficiency

Generator Type	Capacity 1985 MWe	Capacity 1985 Change from Comparison Case, %	Capacity 2000 MWe	Capacity 2000 Change from Comparison Case, %
Hydroelectric	2,445	0	2,603	0
Oil and Gas-Fired Steam	2,868	-29.5	1,617	-42.6
Combustion Turbine - Simple Cycle	437	0	0	0
Combined Cycle	450	*	900	0
Nuclear	0	0	11,700	-7.1
Renewable Resource				
Solar	2.5	0	902	0
Wind	0.65	0	364	0
Biomass	0.42	0	180	0
Geothermal	0	0	20	0
Pumped Storage	0	0	2,550	0
Total	6,204	-10.8	20,678	-6.2

*No combined cycle was included in the Comparison Case.

TABLE F.9

Electric Sector Build Schedule for Improved
End-Use Efficiency

Year	Added Capacity (MWe)	Retired Capacity (MWe)	Total Available (MWe)	Peak Demand (MWe)	Reserve Demand (MWe)	Reserve Margin %
1983	0		5786	3947	1839	46.6
1984	450CCGT		6236	4382	1854	42.3
1985	—	36	6200	4843	1357	28.0
1986	600N	34	6834	5306	1528	28.8
1987	600N+66ASN		7500	5793	1701	29.5
1988	59ESNA+450CCGT	40	7969	6298	1671	26.5
1989	300PS		8269	6788	1481	21.8
1990	900N+33NH	26	9176	7403	1773	23.9
1991	900N+175S*	47	10029	7999	2030	25.4
1992	600N		10269	8609	2020	23.5
1993	900N+150S*		11529	9402	2127	22.6
1994	900N	100	12329	10200	2129	20.9
1995	900N+60PS	240	13589	11083	2606	22.6
1996	1200N +250S +300PS	24	15065	11990	3075	25.6
1997	1200N	172	16093	13065	3028	23.2
1998	1200N+450PS	32	17111	14072	3039	21.6
1999	1200N+300PS	166	18445	15180	3265	21.5
2000	1200N+871S* +20G	330	19585**	16303	3282	20.1

* Does not count for reserve margin
** Includes 250 MWe for peak power

in 1985 and slightly more than 6 percent in 2000. The principal impact of this strategy is to permit a delay in the construction of power plants.

4.5 Energy Balance

Figures F.3.a and b gives the energy balance for the strategy.

5.0 ACCELERATED RENEWABLE RESOURCES

The objective of this strategy was to make maximum use of the renewable resources available in Egypt. These included solar, wind, biomass electric and the Qattara project. Table F.10 presents the electric generator mix based on this strategy; Table F.11 presents the build schedule. Table F.12 presents the impact of a accelerated hot water heating program.

5.1 Solar Penetration Analysis

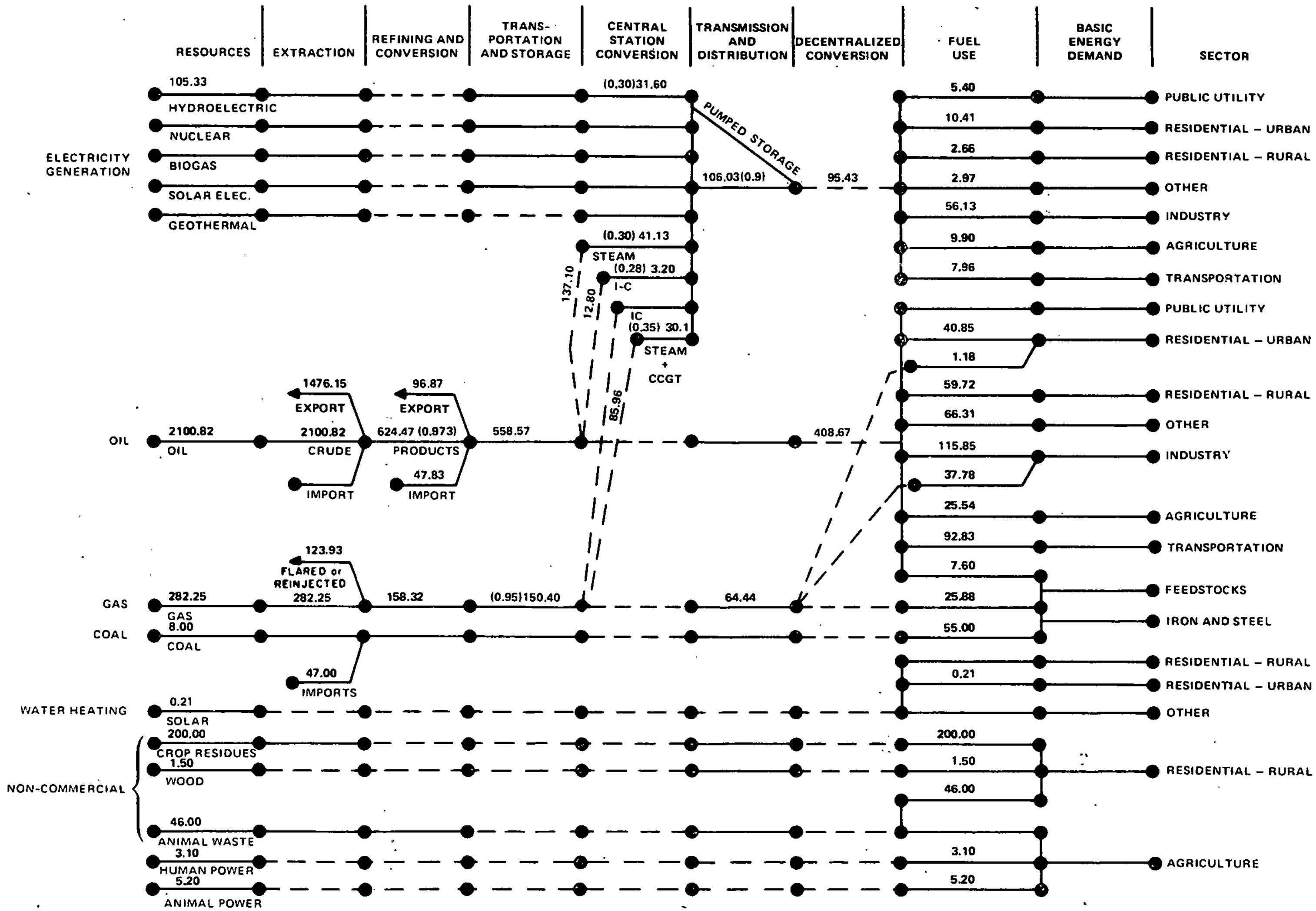
To accurately determine the extent to which advanced solar energy technologies can be employed, a detailed market survey would be needed that addressed issues of technology availability economics, consumer acceptance, manufacturing capability, and many other issues. This was not possible in the time restraints of this assessment but a simplified analysis was used to provide some estimates. More details are in Annex 8-Potential Use of Renewable Energy Resources in Egypt.

In all cases, the widespread implementation of solar heating and power systems will require positive actions on the part of the government. This in part, is due to the substantial subsidies provided to conventional energy sources which reduces the incentive of the end user to utilize solar equipment. On the other hand, it was assumed that no government incentives were provided unless the basic economics of the solar option appeared attractive when compared to more conventional options.

In the case of solar water heaters, the rate of implementation was estimated using payback period versus market penetration curves conventionally used in market analysis. The payback period estimated was based on the worldwide (unsubsidized) value of kerosene and butane fuels and on solar water heating system cost projections. For example, in this analysis, it was assumed that a 6-year payback period which would correspond to present economic conditions would result in a 1 percent penetration of new construction.

For the accelerated solar scenario, it was assumed that the beneficial foreign and job creation aspects of solar water heating would justify an additional 30 percent subsidy for the water heaters with a corresponding decrease in payback period and increases in market penetration.

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	892.93
NON-COMMERCIAL	247.80
HUMAN & ANIMAL	8.30
TOTAL	1148.73
NET EXPORTS	1470.19

NOTES

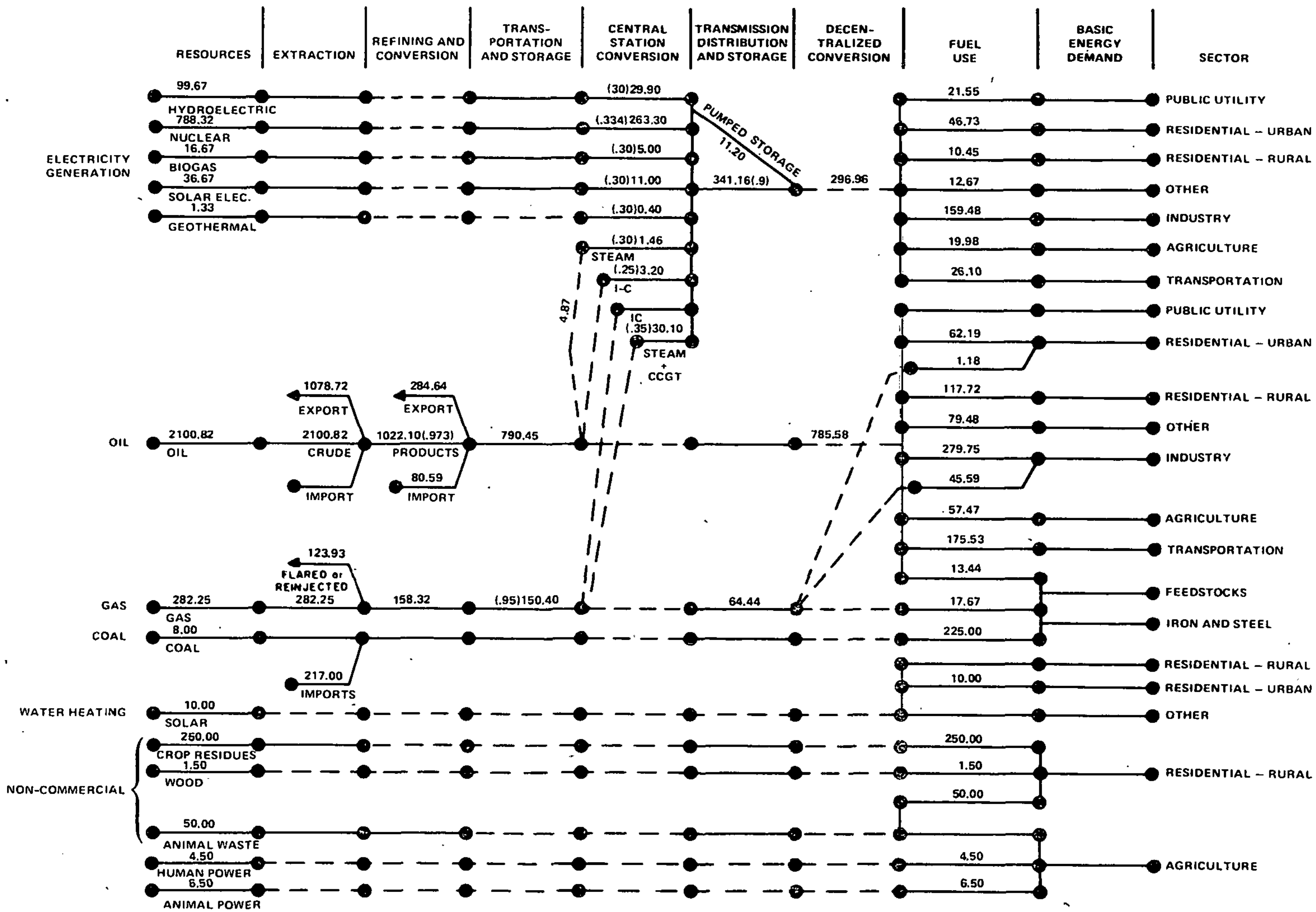
1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	623.75
NON-COMMERCIAL	247.50
HUMAN & ANIMAL	8.30
TOTAL	879.55

FIGURE F.3a
IMPROVED EFFICIENCY - 1985

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	2148.36
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	2460.86
NET EXPORTS	1065.77

NOTES

1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	1381.98
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	1694.48

FIGURE F.3b
IMPROVED EFFICIENCY - 2000

Table F.10

Generator Mix for Accelerated Renewable Resources

Generator Type	Capacity 1985 MWe	1985 Change from Comparison Case, %	2000 MWe	2000 Change from Comparison Case, %
Hydroelectric	2,445	0	3,273	+25.7
Oil and Gas-Fired Steam	2,868	-29.5	1,617	-42.6
Combustion Turbine - Simple Cycle	437	0	0	0
Combined Cycle	900	*	900	*
Nuclear	0	0	11,400	-09.5
Renewable Resource				
Solar	125	+4,900	2,625	+191
Wind	32	+4,823	1,048	+187
Biomass	21	+4,900	660	+178
Geothermal	0	0	20	0
Pumped Storage	0	0	2,550	0
Total	6,828	-1.8	23,935	+8.6

*No combined cycle was included in the Comparison Case.

TABLE F.11

Electric Sector Build Schedule for Accelerated Renewable Resources

Year	Added Capacity (MWe)	Retired Capacity (MWe)	Total Available (MWe)	Peak Demand (MWe)	Reserve Demand (MWe)	Reserve Margin %
1983	0		5786	4028	1758	43.6
1984	450CCGT		6236	4518	1718	38.0
1985	450CCGT+173S[1]	36	6650	5045	1605	31.8
1986	600N	34	7216	5527	1689	30.6
1987	66ASN		7282	6066	1216	20.0
1988	600N+59ESNA	40	7901	6629	1272	19.2
1989	600N+300PS		8801	7221	1580	21.9
1990	796S[2]+900N+ 33N.H.	26	9897	7834	2063	26.4
1991	300PS	47	10150	8510	1640	19.3
1992	900N		11050	9208	1842	20.0
1993	700S[3]+900N+ 150PS		12219	10032	2187	21.8
1994	900N+150PS	100	13169	10884	2285	21.0
1995	1200N+150PS	240	14279	11826	2453	20.7
1996	1000S[4]+1200N	24	15625	12794	2831	22.1
1997	1200N+450PS	172	17103	13941	3162	22.7
1998	1200N+600PS	632	18271	15015	3256	21.7
1999	1200N+450PS	166	19755	16197	3558	22.0
2000	1504S[5]+1200N +670Q+20G	330	21570	17395	4175	24.0

1 Does not count for reserve margin
2 Includes 189 for reserve margin
3 Includes 119 for reserve margin
4 Includes 170 for reserve margin
5 Includes 255 for reserve margin

TABLE F.12

Impact of Accelerated Solar
Hot Water Heating Program

Year	Installed Area ($10^6 m^2$)	Heat Delivered 10^{15} joules	10^{12} Btu	Change from Comparison Case, %
1985	0.77	3.1	2.9	1309
2000	10.9	44	42	340

The purchase and use of water heaters would often involve individual decisions similar to the case in the industrialized countries. In contrast, most of the solar power options would be purchased and installed by government agencies; particularly the large grid-connected systems which can make significant nationwide energy impacts.

The modest implementation rate scenarios of the Comparison Case for solar energy assumed that the government installs systems only if their economics are favorable. It was assumed, however, that the economics of internal resources (labor, materials, etc.) used in the construction of solar power units (as compared to nuclear) was taken into account. Actual installation rate assumptions are somewhat arbitrary since they would depend upon a number of government objectives relative to industrial development, employment policies, and subsidy arrangements. The scenarios utilized assumed that initial installations were non-grid connected so that relatively high cost solar could be used to supplement or replace energy conventionally produced by diesel generators and pumps which are costly to operate. Later installations were assumed to be grid connected which is consistent with an assumption of improving relative economics of solar energy systems so that they become competitive with larger scale utility generators. The implementation rates for the accelerated solar case are, however, limited by materials, financial, and labor availability constraints.

The accelerated solar case for solar power generators assumes that a series of government actions (subsidies, standards, regulations, etc.) provides the basis for a rapid build-up of manufacturing capacity in the 1985 to 1990 time period. It is also assumed that by the mid-1990's, solar technology demonstrations have either proven or shown the way to those technology, engineering, manufacturing and installation measures which will assure that solar energy systems are economically competitive with reasonable initial subsidies. The rate of increase in production capability is assumed to lessen during the 1990's to a more sustainable level. By the year 2000, solar energy systems are supplying roughly 15 percent of the electric energy needs (assuming 100 x 10^9 kw of energy are required), and additional solar generating capacity is coming on line so as to increase solar output at a rate of 9 percent per year. This rate of increase is sufficient to modestly increase solar's portion of generating capacity in the post-2000 time period assuming Egypt's electricity needs are increasing at a rate of 7 to 8 percent

Further acceleration of the solar scenario beyond that used here became increasingly difficult to justify due to several factors. First of all, the present scenario calls for utilizing a significant percentage of Egypt's available material, financial, and skilled manpower resources of the specific type required. If additional rescources were required for a greater application of solar, the resultant effort would require importing a higher percentage of basic materials (cement, steel, etc.). Also, a 15 percent contribution to the utility grid is sufficiently low that the impact of solar's variability of energy production can be accommodated by the electric grid with planned for pumped hydro storage capacity and modest variations in the operation of the conventional utility generating mix. Further increases in solar electric generating capacity could significantly impact utility operations and/or may require substantial additional energy storage capability either in pumped storage or internal to the solar power options (batteries, etc.) which would adversely affect system economics.

These factors do not limit the role of solar energy in Egypt beyond the year 2000 to the 15 percent range judged to be marginally attainable by the year 2000, but do indicate a requirement to carefully analyze these issues in the planning of a large scale solar applications program.

The solar application scenarios outlined are thought to be reasonable ones given the prospects for solar technologies, Egyptian resources, and demand projections. More detailed analysis is, however, required to better define implementation plans which fully consider those factors.

5.2 Qattara - Phase 1

As described in Annex 6-Hydroelectric Power, the Qattara Depression Project is a major undertaking that has implications beyond electricity production. In that Annex report it is noted that a feasibility study is currently underway that will provide some insight into whether or not the project is technically and economically viable. For this assessment, it was assumed that approximately ten years would be required to complete the first phase of the project once approval was received. The Comparison Case assumed that Qattara would not be in operation before 2000. In this accelerated renewables strategy, it is assumed that a concentrated effort is made to exploit all of the avail able renewable resources as quickly as possible and that acceleration of the Qattara project would be within the range of possibility. Accordingly, it was was assumed that Phase I of the Qattara program would result in 670 MWe of electric generation capacity in the form of conventional hydropower beginning operation in the year 2000. No pumped storage capacity is assumed to be operational at that time.

It should be emphasized that these assumptions do not represent an evaluation that Qattara is feasible, economic or even desirable. They are only used to illustrate the potential impact of the project on Egypt's energy balance.

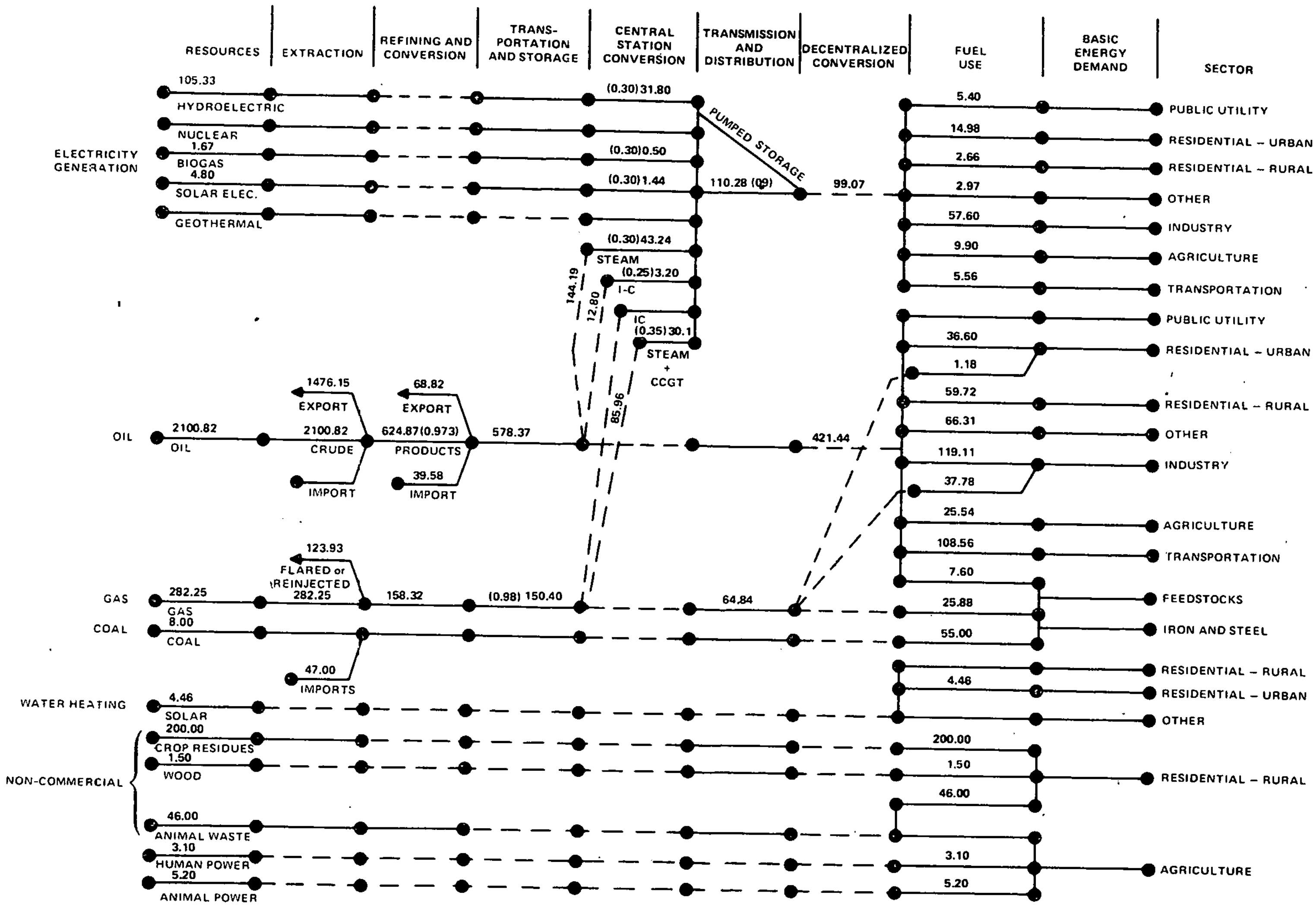
5.3 Energy Balance

Figures F.4 a and b give the energy balance of this strategy.

6.0 NUCLEAR CAPACITY VARIATION STRATEGIES

The principal objective of this strategy was to evaluate the impact of alternative means of meeting the electrical demand with less nuclear power than the 12,600 MWe considered in the Comparison Case. Three cases

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS.

COMMERCIAL	964.80
NON-COMMERCIAL	247.80
HUMAN & ANIMAL	9.30
TOTAL	1458.39
NET EXPORTS	

NOTES

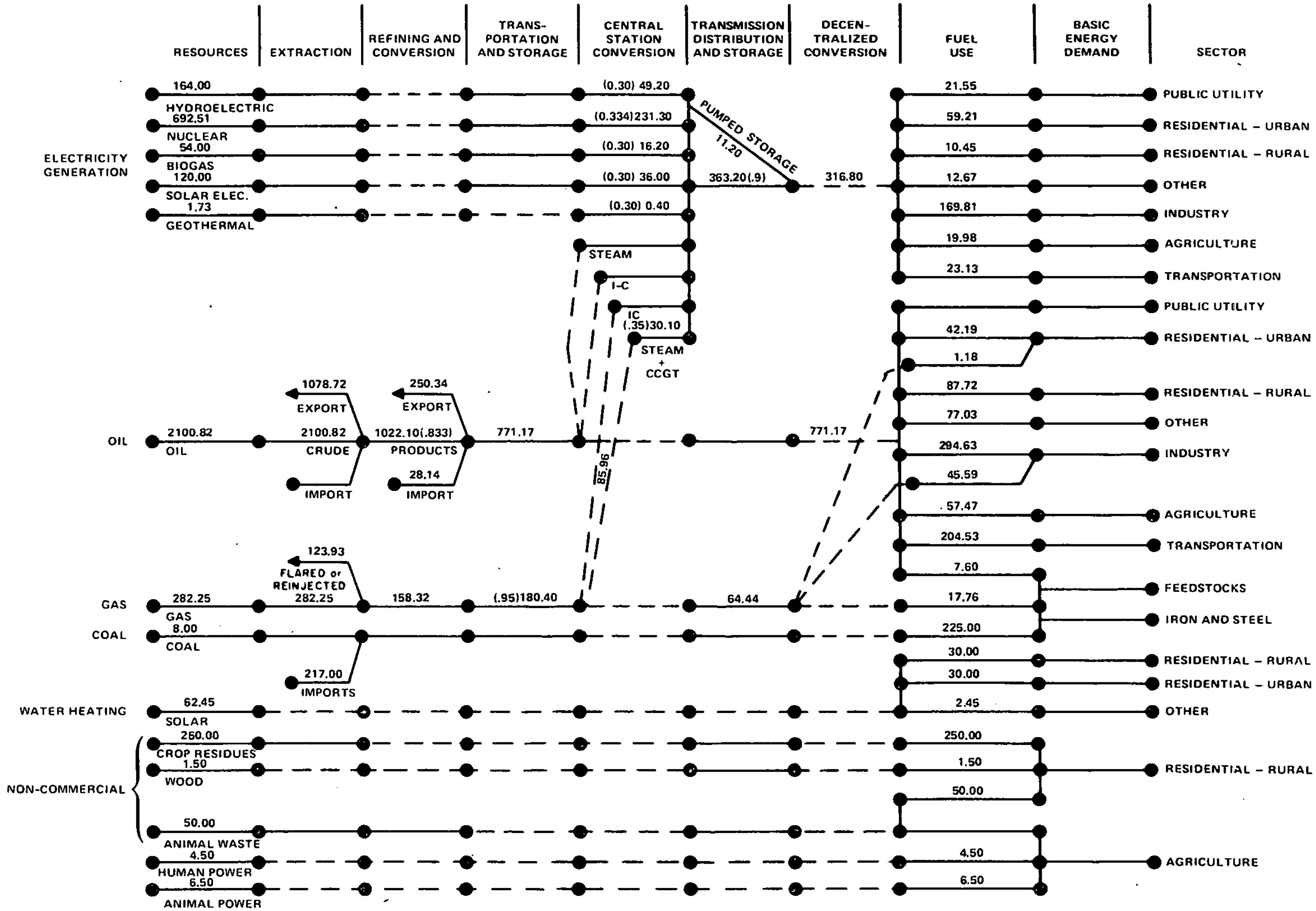
1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	648.41
NON-COMMERCIAL	247.50
HUMAN & ANIMAL	8.30
TOTAL	800.21

FIGURE F.4a
ACCELERATED RENEWABLE RESOURCES - 1985

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:	
COMMERCIAL	2270.18
NON-COMMERCIAL	701.80
HUMAN & ANIMAL	11.00
TOTAL	2582.68
NET EXPORTS	1083.92

NOTES

1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:	
COMMERCIAL	1439.86
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	1752.36

FIGURE F.4b
ACCELERATED RENEWABLE RESOURCES - 2000

were considered: (a) medium nuclear - satisfying one-half of the electricity demand with nuclear; (b) low nuclear - eliminating all nuclear power except 1900 MWe with fossil fuel capacity meeting the difference from the Comparison Case to the limit of domestic oil productive capacity; and (c) combined nuclear offset strategy - mplementing selected features of all of the previous strategies (maximum gas use, improved efficiency, and accelerated renewable resources) while using fossil-fired capacity to meet the balance of the demand to limit nuclear capacity to 1900 MWe.

In the first two cases, the demand for electricity was held constant while the structure of the electrical sector was modified to meet that demand with various generator mixes. In case (c) electricity reductions resulting from the implementation of the improved efficiency options were also considered. Table F.13 gives the generator mix for the three cases.

6.1 Case 1 - Medium Nuclear

In this case one-half of the Comparison Case electricity generation is assumed to be by nuclear power while the remainder of the nuclear capacity reduction from the Comparison Case is made up by oil- fired capacity. Table F.14 gives the build schedule for this case. Figure F-5a gives the energy balance. This case also closely approximates the full use of Egyptian produced residual fuel oil for electric generation to the limit of its availability.

6.2 Case 2 - Low Nuclear

In this case all of the nuclear capacity, with the exception of 1900 MWe, is eliminated and replaced with oil-fired capacity. The 1900 MWe is retained as representing the maximum capacity that is under negotiation between the U.S. and Egypt. The balance of the electrical demand is met by oil-fired capacity. Table F.15 is the build schedule for this case. Figure F.5b shows the energy balance for the low nuclear case.

6.3 Case 3 - Combined Strategies

In this case, options previously considered in other strategies are implemented in the interest of maximizing the electrical generation by other than nuclear power and reducing the energy consumption by improving end use efficiency. In implementing the natural gas strategy it is assumed that all the additional gas available is used for electricity generation. All of the end use efficiency options are assumed to be implemented. In the accelerated renewable resource strategy implementation it is assumed that both the accelerated solar, wind, and biomass programs; and Qattara - Phase 1, are put into operation. The balance of the electrical requirements previously provided by nuclear plants are met by new fossil-fired capacity. Table F-16 is the build schedule for this strategy; Figure F-5c shows the energy balance.

Table F.13
Generator Mix for
Nuclear Capacity Variations Cases[a]

Generator Type	Low Nuclear		Medium Nuclear		Combined Strategies	
	Capacity (MWe)	Change[b] (%)	Capacity (MWe)	Change[b] (%)	Capacity (MWe)	Change[b] (%)
Hydroelectric	2,603	0	2,603	0	3,273	+25.7
Oil- and Gas-Fired Steam	13,727	+389	6,117	+117	11,367	+304
Combustion Turbine - Simple Cycle	0	0	0	0	0	0
Combined Cycle	1,800	c	1,800	c	1, 418	c
Nuclear	1,900	-85	7,500	-41	1,900	-85
Renewable Resource						
Solar	902	0	902	0	2,625	+191
Wind	364	0	364	0	1,048	+187
Biomass	180	0	180	0	500	+178
Geothermal	20	0	20	0	20	0
Pumped Storage	300	- 88	2,400	-6	1,350	-47
Total	21,836	-0.9	21,886	-0.7	23,501	+6.6

a year 2000 only
b from Comparison Case
c No combined cycle was included in the Comparison Case

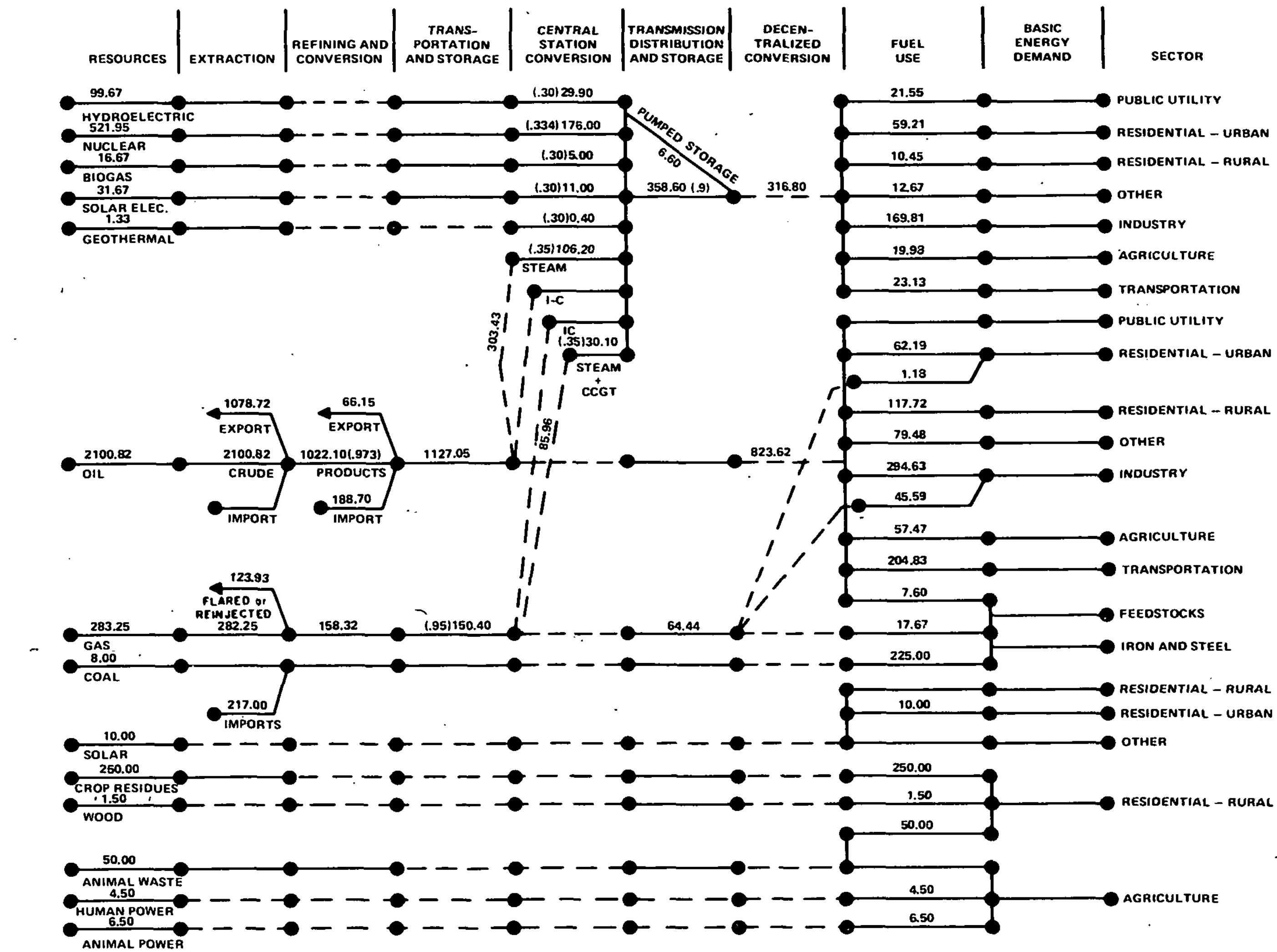
TABLE F.14

Electric Sector Build Schedule for
Medium Nuclear Case

Year	Added Capacity (MWe)	Retired Capacity (MWe)	Total Available (MWe)	Peak Demand (MWe)	Reserve Demand (MWe)	Reserve Margin %
1983	0	0	5786	4028	1758	43.6
1984	450CCGT	0	6236	4518	1718	38.0
1985	450CCGT	36	6650	5045	1605	31.8
1986	600N	34	7216	5527	1689	30.6
1987	600N+ASU66	-	7882	6066	1816	30.0
1988	600T+59ESNA	40	8502	6629	1873	28.2
1989	300PS	26	8776	7221	1555	21.5
1990	900N+175S*	-	9676	7834	1842	23.5
1991	600CCGT+300PS	-	10529	8510	2019	23.7
1992	900N	-	11429	9208	2221	24.1
1993	150S* +900N	-	12329	10032	2297	22.9
1994	600PS+900T	100	13729	10884	2845	26.1
1995	300PS+300GT	240	14089	11826	2263	19.1
1996	1200N +250S*	24	15265	12794	2471	19.3
1997	1200N+300GT	127	16638	13941	2697	19.3
1998	1200N+300PS +600T	632	18106	15015	3091	20.6
1999	900T+600GT	166	19440	16197	3243	20.0
2000	871S*+600PS+ 20G+600GT	330	20910**	17395	3505	20.2

* Does not count for Peak
** Includes 250 MWe solar for Peak

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	2217.83
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	2846.43
NET EXPORTS	739.17

NOTES

1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	1438.50
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	1752.36

FIGURE F. 5a
NUCLEAR CAPACITY VARIATION--MEDIUM NUCLEAR--2000

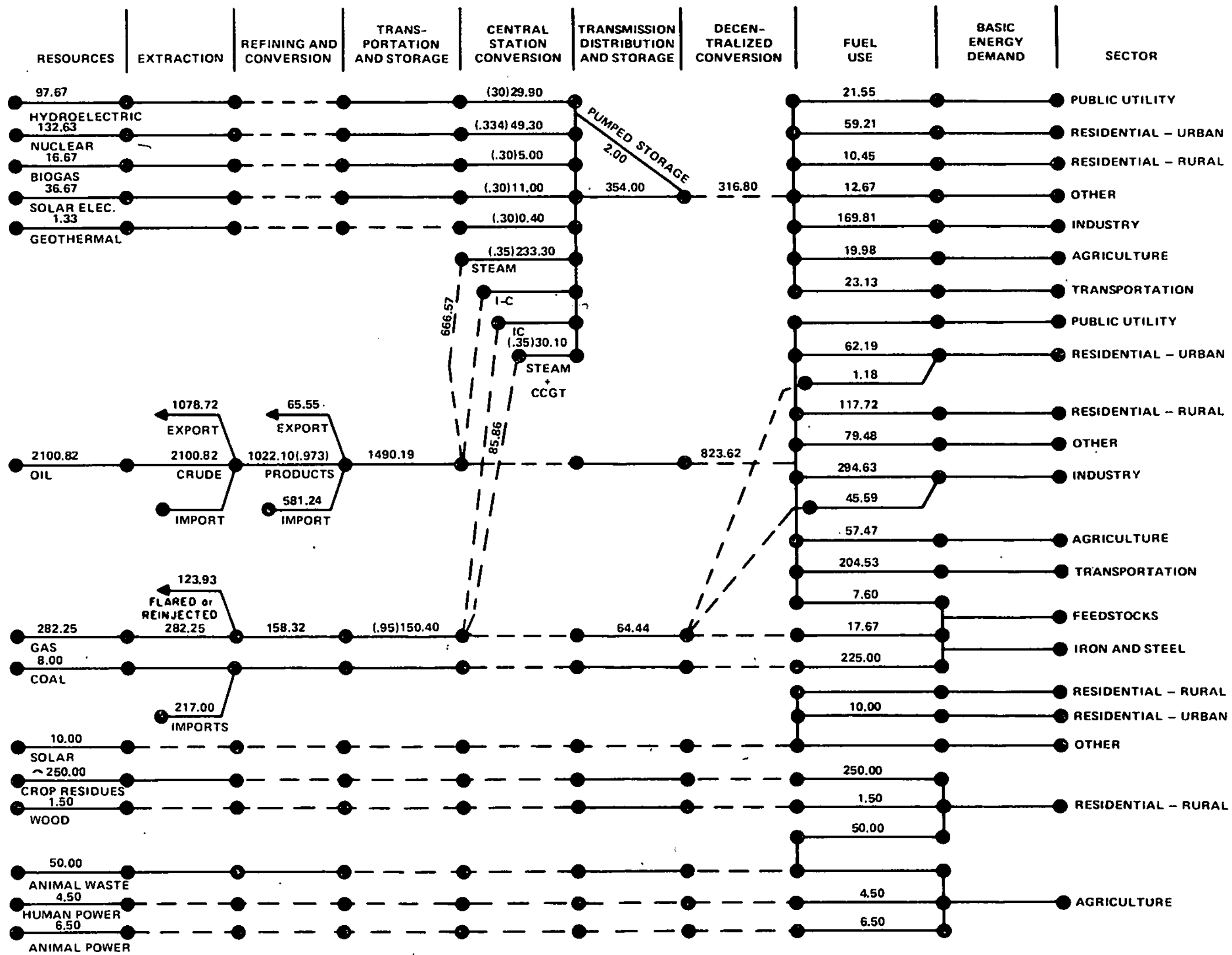
TABLE F.15

Electric Sector Build Schedule for
Low Nuclear Case

Year	Added Capacity (MWe)	Retired Capacity (MWe)	Total Available (MWe)	Peak Demand (MWe)	Reserve Demand (MWe)	Reserve Margin %
1983	0	-	5786	4028	1758	43.6
1984	450T+CCGT	-	6336	4518	1718	38.0
1985	450T	36	6840	5045	1795	35.6
1986	600N	34	7406	5527	18789	34.0
1987	66ASN		7472	6066	1406	23.2
1988	600N+59ESNA	40	8091	6629	1462	22.0
1989	700N+300PS		9091	7221	1870	25.9
1990	600CCGT+ 1755+33NH	26	9724	7834	1890	24
1991	750T	47	10521	8510	2011	23.6
1992	750T	-	11271	9208	2063	22.4
1993	750CCGT+150S*	-	12021	10032	1989	19.8
1994	1200T	100	13221	10884	2337	21.5
1995	1200T	240	14421	11826	2595	21.9
1996	1200T +250S*	24	15597	12794	2803	21.9
1997	1800T	172	17225	13941	3284	23.6
1998	2100T	632	18693	15015	3678	24.5
1999	2100T	166	19727	16197	3530	21.8
2000	1500T+871 +20G	330	21167**	17395	3772	211.7

* Does not count for Reserve
** Includes 250 MWe Solar

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:

COMMERCIAL	2211.83
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	2524.33
NET EXPORTS	-11.20

NOTES

1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:

COMMERCIAL	1439.86
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	1752.36

FIGURE F. 5b
NUCLEAR POWER CAPACITY VARIATIONS (1900 MW)--LOW NUCLEAR--2000

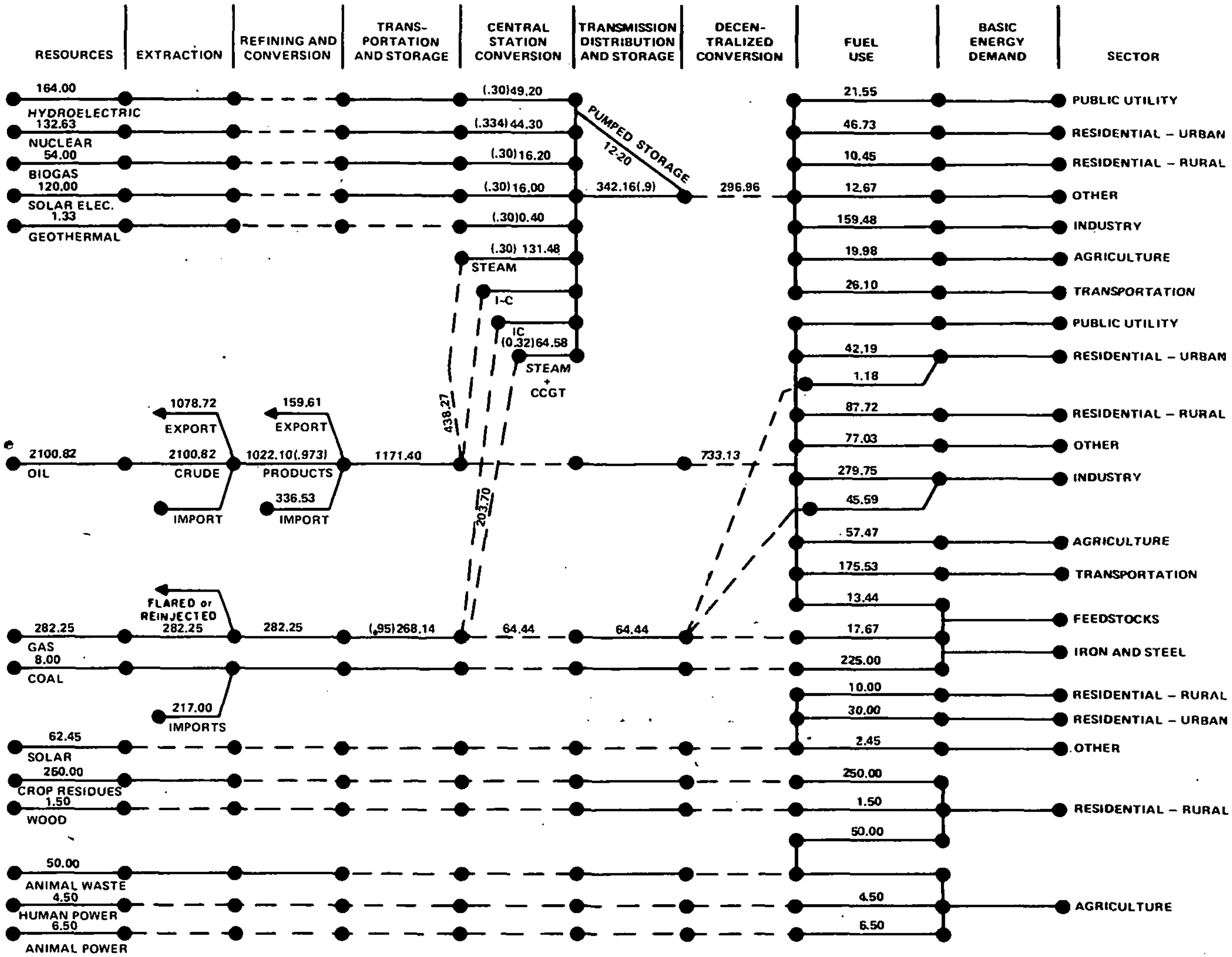
TABLE F.16

Electric Sector Build Schedule for Combined Strategies Case

Year	Added Capacity (MWe)	Retired Capacity (MWe)	Total Available (MWe)	Peak Demand (MWe)	Reserve Demand (MWe)	Reserve Margin %
1983	0	0	5786	3947	1839	46.6
1984	450CCGT	0	6236	4382	1854	42.3
1985	450CCGT+175S (1)	36	6650	4843	1807	37.3
1986	600N	34	7216	5306	1910	36.0
1987	188GT(CC)+66ASN	-	7470	5793	1677	28.9
1988	600N+59ESNA	40	8089	6298	1791	28.4
1989	300PS		8389	6788	1601	23.6
1990	796S (2)+700N+33NH	26	9285	7403	1882	25.4
1991	300PS+450T	47	9988	7999	1989	24.9
1992	750T		10738	8609	2129	24.7
1993	700S (3)+750T 150PS		11757	9402	2355	25.0
1994	600T	100	12257	10200	2057	20.0
1995	1200T+150PS	240	13367	11083	2284	20.6
1996	1000S (4) +1200T	24	13367	11083	2284	20.6
1997	900T+450PS	172	16063	13065	2998	22.9
1998	1800T	632	17231	14072	3159	22.4
1999	1500T	166	18565	15180	3385	22.3
2000	1504S (5)+600T+ +670Q+20G		20110	16303	3807	23.4

(1) Does not count for Reserve Margin
(2) Includes 189 for Reserve Margin
(3) Includes 119 for Reserve Margin
(4) Includes 170 for Reserve Margin
(5) Includes 225 for Reserve Margin

REFERENCE ENERGY SYSTEM - EGYPT



ENERGY RESOURCE REQUIREMENTS:	
COMMERCIAL	2245.57
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	2558.07
NET EXPORTS	684.80

NOTES

1. SOLID ELEMENT DENOTES A REAL ACTIVITY
2. ENERGY FLOWS ARE INDICATED IN 10^{15} JOULES ABOVE EACH ELEMENT. CONVERSION EFFICIENCIES ARE INDICATED IN PARENTHESES.

DIRECT FUELS AND ELECTRICITY DEMAND:	
COMMERCIAL	1381.98
NON-COMMERCIAL	301.50
HUMAN & ANIMAL	11.00
TOTAL	1694.48

FIGURE F.5c
NUCLEAR CAPACITY VARIATIONS (COMBINED) 2000

7.0 RELATIVE COST, RESOURCE AND FINANCING REQUIREMENTS OF STRATEGIES

7.1 Cost, Equipment and Manpower Estimates

As noted in section 2.5 of the Main Report, cost, equipment and manpower requirements were estimated for all energy supply facilities using the Energy Supply Planning Model (ESPM) and its contained data base. This data base builds upon extensive experience in the U.S. and throughout the world in the engineering and construction of a large variety of energy supply facilities. This experience is then reflected in the form of defined typical energy supply facilities. The following estimates are provided for each facility:

- facility capital cost, lead times and expenditure rates;
- facility equipment requirements;
- facility design, construction, operation and maintenance manpower requirements; and
- facility operation, maintenance costs and equipment needs.

Extensive detailed data is provided for 101 typical defined facilities. Energy supply capacity needs are then specified for certain time frames and the ESPM "builds" the necessary supply facilities. The ESPM then aggregates, in a number of different ways, the costs, equipment and manpower requirements associated with that specific energy supply capability. The ESPM can develop its own build schedule or implement in its calculations a specified "build schedule."

For the Egypt/U.S. Cooperative Assessment, less than half the available 101 defined energy supply facilities were utilized. Two special features were also added. First, cost and resource data to those work, equipment supply and construction cost situations that would generally apply in Egypt were incorporated. Second, a capability was added to the ESPM to broadly estimate foreign exchange components of capital costs and foreign or expatriate equipment and labor requirements. (These added features required many assumptions regarding labor availability, productivity, domestic supply capabilities, work and living conditions, premium pay rates, etc.).

Accordingly, although the estimates by the ESPM involve a building - up or aggregation of many detailed data elements, they are not comparable in detail or accuracy with a detailed estimate for a specified facility at a selected site. Also, site related costs and supporting infrastructure costs cannot be reasonably accounted for. Therefore, caution is urged in the use of their estimates for comparison of specific alternative facilities. Rather, the ESPM results are best applied to indicate in an aggregate sense, the relative cost and resource requirements involved in bringing into being alternative broad-scope energy supply capabilities.

Cost, equipment and manpower requirements for solar water heating and solar electric systems (including photovoltaic, wind, solar thermal or biomass) were estimated separately by the U.S. team solar specialists. Tables F.17 through F.20 summarize the cost manpower and materials requirements of the Comparison Case and the six primary strategies examined. Table F.21 illustrates the more detailed cost information available in the ESPM printouts. Table F.22 summarizes the investment for solar installations associated with the Comparison Case (Case A) and the Accelerated Renewable (Case B) Strategy.

7.2 Financial Aspects of Alternative Energy Development Strategies

The costs of the energy facilities required to implement the energy strategies defined in the assessment are substantial. Therefore, it is important to:

(a) examine the possible impacts these costs will have on the Egyptian economy,

(b) place them in the context of total Egyptian investment; and

(c) examine possible levels of Egyptian borrowing and debt service accompaning the energy strategies.

7.2.1 Energy investment levels and the national economy: The investment in energy facilities averages approximately LE 800 million per year in 1978 prices with no inflation escalator. For perspective, this includes an average of more than LE 550 million per year for electric utility investment compared to LE 875 million allocated over the entire 1978 to 1982 Five Year Plan for the Ministry of Electricity. Annual costs for the Comparison Case and alternate strategies will, in reality, be increasing with a growing Egyptian economy. For example, total electric utility investment costs in the Comparison Case increase from approximately LE 380 million in 1985 to LE 955 million in the year 2000.

A more useful comparison to help place the energy investment levels in perspective is to contrast historical levels of investment to projected levels. Tables F.23 and F.24 present some results of this. Because of the difficulty in developing data on past total energy investment, the proportion of electrical investment to total Egyptian investment has been used. In the last 20 years, except for the construction period for the High Dam, this ratio has been in the 4 to 6 percent range. Using total Egyptian economic investment levels for the GDP projection presented in Section 3 of Appendix G, electricity investment as a proportion of total Egyptian economic investment is rising for all three projections and to levels above those of the High Dam period.

While the absolute level of the ratio may in part be a product of the cost assumptions, explanations for the growth in the ratio rest with other factors as well. This growth may in part indicate electricity demand assumptions based on even higher sustained GDP growth than those projected. It also reflects the shifts to highly capital intensive

Table F.17

SUMMARY OF COSTS, MANPOWER, AND MATERIALS

STRATEGY: <u>COMPARISON</u>

COSTS (LE000,000)		
ANNUAL FUEL COST (YEAR 2000)	SOLAR	NEGLIGIBLE
	OTHER	501
	TOTAL	501
ANNUAL O & M COST (YEAR 2000)	SOLAR	42
	OTHER	271
	TOTAL	313
CUMULATIVE CAPITAL COSTS (TO YEAR 2000)	SOLAR	1400
	OTHER	16200
	TOTAL	17600
CUMULATIVE CAPITAL REQUIRED FOR IMPORTS (TO YEAR 2000)	TOTAL	13200

MANPOWER (MY)		
SOLAR	CONSTR	10900
	O & M	4800
OTHER	CONSTR	38000
	O & M	27000
TOTAL		80700

MATERIAL (TONNES)	STEEL	ALUMINUM	CEMENT
SOLAR	34000	9000	33000
OTHER	139800	12000	123000
TOTAL	173800	21000	156000

SUMMARY OF COSTS, MANPOWER, AND MATERIALS

STRATEGY: <u>IMPROVED EFFICIENCY</u>

COSTS (LE000,000)		
ANNUAL FUEL COST (YEAR 2000)	SOLAR	NEGLIGIBLE
	OTHER	475
	TOTAL	475
ANNUAL O & M COST (YEAR 2000)	SOLAR	42
	OTHER	258
	TOTAL	300
CUMULATIVE CAPITAL COSTS (TO YEAR 2000)	SOLAR	1400
	OTHER	14500
	TOTAL	15900
CUMULATIVE CAPITAL REQUIRED FOR IMPORTS (TO YEAR 2000)	TOTAL	11700

MANPOWER (MY)		
SOLAR	CONSTR	10900
	O & M	4800
OTHER	CONSTR	29500
	O & M	26400
TOTAL		71600

MATERIALS (TONNES)	STEEL	ALUMINUM	CEMENT
SOLAR	34000	9000	33000
OTHER	134600	11900	91300
TOTAL	168600	20900	124300

Table F.18

The following tables summarize the above items for the individual strategies.

SUMMARY OF COSTS, MANPOWER, AND MATERIALS

COSTS (LE000,000) — STRATEGY: MEDIUM NUCLEAR

ANNUAL FUEL COST (YEAR 2000)	SOLAR	NEGLIGIBLE
	OTHER	742
	TOTAL	742
ANNUAL O & M COST (YEAR 2000)	SOLAR	42
	OTHER	257
	TOTAL	299
CUMULATIVE CAPITAL COSTS (TO YEAR 2000)	SOLAR	1400
	OTHER	13800
	TOTAL	15200
CUMULATIVE CAPITAL REQUIRED FOR IMPORTS (TO YEAR 2000)	TOTAL	11000

MANPOWER (MY)

SOLAR	CONSTR	10900
	O & M	4800
OTHER	CONSTR	38000
	O & M	27000
TOTAL		80700

MATERIAL (TONNES)

	STEEL	ALUMINUM	CEMENT
SOLAR	34000	9000	33000
OTHER	130300	11800	82400
TOTAL	168300	20800	115400

SUMMARY OF COSTS, MANPOWER, AND MATERIALS

COSTS (LE000,000) — STRATEGY: LOW NUCLEAR

ANNUAL FUEL COST (YEAR 2000)	SOLAR	NEGLIGIBLE
	OTHER	1037
	TOTAL	1037
ANNUAL O & M COST (YEAR 2000)	SOLAR	42
	OTHER	262
	TOTAL	304
CUMULATIVE CAPITAL COSTS (TO YEAR 2000)	SOLAR	1400
	OTHER	13500
	TOTAL	14900
CUMULATIVE CAPITAL REQUIRED FOR IMPORTS (TO YEAR 2000)	TOTAL	10600

MANPOWER (MY)

SOLAR	CONSTR	10900
	O & M	4800
OTHER	CONSTR	35900
	O & M	28800
TOTAL		80400

MATERIALS (TONNES)

	STEEL	ALUMINUM	CEMENT
SOLAR	34000	9000	33000
OTHER	139200	11500	98235
TOTAL	163200	20500	131235

Table F.19

SUMMARY OF COSTS, MANPOWER, AND MATERIALS

COSTS (LE000,000 — STRATEGEY : ACCELERATED RENEWABLE RESOURCES

ANNUAL FUEL COST (YEAR 2000)	SOLAR	NEGIGICABLE
	OTHER	425
	TOTAL	425
ANNUAL O & M COST (YEAR 2000)	SOLAR	122
	OTHER	266
	TOTAL	388
CUMULATIVE CAPITAL COSTS (TO YEAR 2000)	SOLAR	4200
	OTHER	15000
	TOTAL	19200
CUMULATIVE CAPITAL REQUIRED FOR IMPORTS (TO YEAR 2000)	TOTAL	12500

SOLAR	CONSTR	27000
	O & M	16000
OTHER	CONSTR	31400
	O & M	27000
TOTAL		101400

MATERIAL (TONNES)

	STEEL	ALUMINUM	CEMENT
SOLAR	65000	11000	68000
OTHER	134100	11900	93800
TOTAL	199100	22900	161800

SUMMARY OF COSTS, MANPOWER, AND MATERIALS

COSTS (LE000,000) — STRATEGY: MAXIMUM GAS USE

ANNUAL FUEL COST (YEAR 2000)	SOLAR	NEGLIGIBLE
	OTHER	606
	TOTAL	606
ANNUAL O & M COST (YEAR 2000)	SOLAR	42
	OTHER	259
	TOTAL	301
CUMULATIVE CAPITAL COSTS (TO YEAR 2000)	SOLAR	1400
	OTHER	14700
	TOTAL	16100
CUMULATIVE PITAL REQUIRED FOR PORTS (TO YEAR 2000)	TOTAL	

MANPOWER (MY)

SOLAR	CONSTR	10900
	O & M	4800
OTHER	CONSTR	30200
	O & M	26100
TOTAL		72000

MATERIALS (TONNES)

	STEEL	ALUMINUM	CEMENT
SOLAR	34000	9000	33000
OTHER	132100	11900	92000
TOTAL	166100	20900	125000

Table F.20

SUMMARY OF COSTS, MANPOWER, AND MATERIALS

COSTS (LE000,000) STRATEGY: NUCLEAR CAPACITY VARIATIONS

ANNUAL FUEL COST (YEAR 2000)	SOLAR	NEGLIGIBLE
	OTHER	894.5
	TOTAL	894.5
ANNUAL O & M COST (YEAR 2000)	SOLAR	122
	OTHER	214
	TOTAL	336
CUMULATIVE CAPITAL COSTS (TO YEAR 2000)	SOLAR	4200
	OTHER	10600
	TOTAL	14800
CUMULATIVE CAPITAL REQUIRED FOR IMPORTS (TO YEAR 2000)	TOTAL	8700

MANPOWER (MY)

SOLAR	CONSTR	27000
	O & M	16000
OTHER	CONSTR	27100
	O & M	24400
TOTAL		94500

MATERIAL (TONNES)

	STEEL	ALUMINUM	CEMENT
SOLAR	65000	11000	68000
OTHER	96200	11400	52900
TOTAL	161200	22400	120900

TABLE F.21

CUMULATIVE CAPITAL REQUIREMENTS (MILLION POUNDS, JAN. 1978) OF THE ENERGY INDUSTRY BY FACILITY GROUPING

(1978-2000) EGYPT-Comparison Case (without solar)

FACILITY	CONSTRUCTION COSTS	OWNER'S COSTS PRIOR TO STARTUP	TOTAL
OIL			
EXPLORATION, DEVELOPMENT, & PRODUCTION	1665.8	256.2	1922.0
REFINING AND PROCESSING	1265.5	203.0	1468.4
PIPELINES	68.6	11.7	80.3
TANKERS, BARGES, TRUCKS	327.8	57.4	385.1
BULK STATIONS	21.3	3.6	24.9
OTHER	0.0	0.0	0.0
TOTAL OIL	3448.9	531.8	3880.8
OIL SHALE	0.0	0.0	0.0
GAS			
EXPLORATION, DEVELOPMENT, & PRODUCTION	20.2	3.1	23.3
GEOPRESSURED METHANE	0.0	0.0	0.0
PIPELINES	0.0	0.0	0.0
LNG TANKERS	0.0	0.0	0.0
DISTRIBUTION	39.5	6.7	46.2
OTHER	0.0	0.0	0.0
TOTAL GAS	59.7	9.8	69.5
COAL			
UNDERGROUND MINING	0.0	0.0	0.0
SURFACE MINING	0.0	0.0	0.0
RAIL	62.7	10.7	73.3
PIPELINES	0.0	0.0	0.0
BARGES, TRUCKS	8.1	1.4	9.5
TOTAL COAL	70.8	12.0	82.9
COAL SYNTHETICS			
LIQUEFACTION	0.0	0.0	0.0
METHANOL	0.0	0.0	0.0
SOLVENT REFINING	0.0	0.0	0.0
GASIFICATION (HIGH BTU)	0.0	0.0	0.0
GASIFICATION (LOW AND MEDIUM BTU)	0.0	0.0	0.0
TOTAL SYNTHETICS	0.0	0.0	0.0

TABLE F.21 (continued)

CUMULATIVE CAPITAL REQUIREMENTS (MILLION POUNDS, JAN. 1978) OF THE ENERGY INDUSTRY
BY FACILITY GROUPING

(1978-2000) EGYPT-Comparison Case (without solar)

FACILITY	CONSTRUCTION COSTS	OWNER'S COSTS PRIOR TO STARTUP	TOTAL
NUCLEAR FUEL CYCLE	93.5	14.0	107.5
SOLAR	0.0	0.0	0.0
ELECTRIC UTILITIES			
COAL-FIRED	0.0	0.0	0.0
SULFUR REMOVAL FACILITIES	0.0	0.0	0.0
COAL-FIRED (FLUID BED)	0.0	0.0	0.0
NUCLEAR	8037.6	905.0	8942.6
HYDRO AND PUMPED STORAGE	876.0	92.0	967.9
OIL AND GAS	406.4	45.9	452.3
GEOTHERMAL	0.0	0.0	0.0
TOTAL GENERATION	9319.9	1042.9	10362.9
TRANSMISSION	599.9	69.6	669.5
DISTRIBUTION	943.5	107.6	1051.1
TOTAL UTILITIES	10863.4	1220.1	12083.5
TOTAL ENERGY INDUSTRY	14436.4	1787.8	16224.2

TABLE F.22

Solar Investment Costs
(Constructor's and Owner's)

LE 10^6

	Case A	Case B
1976	0.0	0.0
1977	0.0	0.0
1978	0.0	0.0
1979	0.0	1
1980	0.5	2
1981	1.0	5
1982	1.0	10
1983	1.5	20
1984	2.0	40
1985	2.5*	93*
1986	5	115
1987	10	145
1988	20	175
1989	40	205
1990	82*	247*
1991	87	259
1992	95	271
1993	100	283
1994	105	295
1995	115	307
1996	120	319
1997	125	331
1998	130	343
1999	140	355
2000	157*	367*
TOTAL	1339.3	4188

TABLE F.23

Historical Electric Investment to Total Investment

Year	Electric Investment/Total Investment %
1965/66	13.1
1967/68	18.3
1970/71	5.6
1973	6.1
1975	3.7

Source: World Bank, ARE, Vol. VI, Statistical Appendix, PP. 22, 24. May 8, 1978.

TABLE F.24

Electricity Investment to Total Egyptian Investment

Electrical Energy Investment*/Projected Total Investment** for Various GDP Projections

Strategy	GDP Projection Level	Percent 1985	Percent 2000
Comparison	Hi	10.1	17.7
	Ref	12.7	23.1
	Lo	16.8	32.7
Low Nuclear	Hi	8.1	16.1
	Ref	10.1	20.8
	Lo	13.4	29.4
Accelerated Renewables	Hi	12.4	16.1
	Ref	15.5	20.8
	Lo	20.7	29.5
Medium Nuclear	Hi	8.6	14.0
	Ref	10.8	18.4
	Lo	14.3	11.8

* From ESPM Data Base Projections. See Annex

** From Department of Energy Projections. See section 3 Appendix G.3

electricity facilities such as solar and nuclear. Contrasts between the high nuclear or solar strategies and the others support this. In particular the plans to expand such facilities in the post 1990 period and beyond the year 2000 further accelerate the electricity investment growth.

Comparisons using the estimates of total energy investment yield similar though less marked results. To the extent both of these correctly portray future trends, then concerns might be raised that the energy expansion program could, with its increasing share of total investment, be depriving other economic sectors of investment funds necessary for continued growth of the economy. The analysis is complex, but it should be noted that proposed energy expansions only make sense if there is also provision for well-planned industrial, infrastructure and other sector programs adequate to utilize and eventually pay for the energy supply capability.

7.2.2 Debt and debt service: The investment costs for the energy programs suggest the need for significant borrowing and the accrual of external debt for creation of the facilities to the year 2000. This is particularly true given the present Egyptian situation and the time needed to fulfill overall development objectives. Factors that might affect domestic and external financing and repayment of this debt have been discussed. The actual levels involved, however, are shaped very much by the choice of energy facility as well as the total investment cost. In particular, the amounts and impacts of foreign borrowing will also depend on the imported amounts of the projects, the feasibility of direct foreign investment, the length of construction periods, and the impacts of inflation and interest during construction. Projections of total debt, debt repayment and grace have been estimated to illustrate the effect of these factors over several energy program strategies. The assumptions for these are given below.

Imports and Foreign Debt. The scarcity of foreign exchange in Egypt has dictated in the past that external financing be sought for most materials, equipment and manpower which must be imported for infrastructure investment projects. Though a slight possibility exists that direct foreign investments in Egypt's energy supply facilities may be permitted, it is likely that most large energy facility categories will remain in the public sector (with the exception of oil and gas exploration, development and production). This approximation of foreign borrowing needed to finance energy programs may be made by aggregating import requirements for all but the oil and gas energy investments.

These import levels might for the future vary significantly across major energy supply categories depending on changes in Egypt's domestic manufacturing capabilities.* For the investment cost estimation however, all categories except solar have assumed import levels of approximately 70 to 80 percent of their total investment.** The 30 percent import

---

*See particularly Annex 7-Nuclear Energy and Annex 8-Potential Use of Renewable Resources.

**See assumptions in Annex 13-Cost, Equipment, Manpower Requirements: ESPM.

content for solar has been chosen in part to illustrate the possibility of domestic production which could be achieved with expansion of existing materials, manufacture and manpower capabilities.

Construction Lead Time and Debt in Grace. Two major considerations should affect the amount of foreign debt accumulated and the annual debt services for energy investments. First, project construction periods range from two years or less for many facilities, including solar; to over nine years for nuclear plants* and pumped storage facilities. Second, it is common practice in borrowing agreements for large construction, such as envisaged in the energy program projects, that a period of grace on payment of debt service (interest plus amortization) normally be granted while the project is under construction. Interest during construction is then accumulated adding to investment costs and borrowing while the maturity is effectively shortened.

Interest and Inflation. The potential sources for financing Egypt's energy program and the respective interest rates have been discussed in section 4 of Appendix G. For the period to the year 2000, many factors can affect these decisions. An average 5 percent interest rate including inflation effects has been assumed for debt projection. This rate reflects a high projection of grants and concessionary funds for these long-term loans, conditions which may change dramatically with political and economic conditions. The assumption is that 25 percent of funds will be grants or IDA 1 percent loans, 25 percent concessionary at 4.5 percent, and 50 percent at commercial 8 percent rates.

Market interest rates embody a rate of international inflation. Because interest during construction accrues to capital, the debt calculation must take into account inflation during the construction period. Therefore, a 7 percent rate of inflation is assumed to the year 2000 as reflecting possible developed country-lender conditions**. This is considerably below that seen recently for much of energy facility construction***. It should be noted that the interest and inflation assumptions together yield negative real rates of interest - a decided bias in support of the borrowing to finance long-lead time construction, and activities such as those of many energy supply facilities.

Debt Calculation. The considerations of construction time, grace period, interest and inflation were incorporated into preliminary calculations of external debt for energy projects. Very briefly, the estimation procedure consists of: (1) creating an annual series of energy facility capital costs including those for solar but excluding international investments in oil and gas exploration and development; (2) dividing this series into categories of construction of five years or longer (nuclear, pump storage, hydro-electric) and all shorter projects; (3) calculation

---

* See Annex 13-Cost, Equipment, Manpower Requirements: ESPM for average construction periods.

** This is near the approximate value assumed in the macro projection discussed earlier in this Appendix.

*** See Annex 7-Nuclear Energy.

of a weighted grace period for each category and adjustment of the loan period; and 4) calculation of the additional capital costs for interest and inflation during construction. Then using project completion schedules and a straight line amortization of 5 percent per year, debt levels and service were estimated. For comparability, the inflation rate was then applied to deflate these calculated debts to constant dollar terms.

7.3 Debt Levels For Energy Strategies

The results of the external debt calculation for the Comparative Case are given in Table F.25 in their current year prices. These amounts are made more meaningful in Table F.26 where they are given in 1978 prices. In this, table prices are smaller than the corresponding energy facility costs from which they were calculated due to amortization. The extent of this difference is lessened by the inclusion in the capital costs of the interest accrued during construction.

The most striking result of the debt calculation is the amount of total debt that is in construction period grace and thus not directly requiring debt service funds. For the Comparison Case strategy, the proportion of borrowing that is in grace never falls far below 40 percent due to the high proportion of nuclear and pumped storage building. This in turn permits the ratio of debt service to total debt to remain relatively low (5 to 6 percent) for long-term loans as compared to the case where little of the loan is in grace, (with 5 percent pay back and 5 percent interest this ratio could be above 10 percent). For this reason the relative burden of total borrowings for energy programs is somewhat lessoned.

Comparisons of amounts in grace for various energy strategies reflects the differences in the choice of energy options. Table F.27 illustrates this effect. After the initial levels of nuclear and pumped storage construction, both the Accelerated Renewable Resources and the Nuclear Capacity Variations strategies show declines in the amounts in grace as solar production is increased. The elimination in the Nuclear Capacity Variations strategy of nuclear facility development after 1990 yields the lowest grace proportion. The increase in the amount in grace in the year 2000 for the Low Nuclear strategy underlines the importance of the post-2000 construction. For that strategy it is assumed that construction of nuclear plants is resumed during the 1990's for initial plant operations in the early part of the next century.

By itself, a shift to solar programs would have the smallest effect on both total debt and grace, and the debt service. This is because of the assumed low levels of imports and the short gestation period required for solar system manufacture and installation. Solar development however, has been complemented with large amounts of pumped storage in order to make-up for the daily fluctuations in actual solar generation. These tend, to some extent, to counterbalance the effects of lowered solar imports on the external debt picture.

TABLE F.25
Comparison Case
External Debt Service Projections
for Energy Program in Current Year Prices

Interest=	0.050
Inflation=	0.07000
Amortization	0.058
Long-term Factor	1.150
Other Factor	0.903
Delivery	0.922

Year	Debt +	Grace=	Total Debt	Debt Service	DS Ratio	Inflation
1976	0.0	99.4	99.4	0.0	0.0	0.873
1977	99.4	139.9	239.3	0.0	0.0	0.935
1978	230.3	184.2	414.5	10.8	0.026	1.000
1979	392.1	224.4	616.5	24.9	0.040	1.070
1980	571.1	257.6	828.7	42.5	0.051	1.145
1981	722.9	406.4	1129.3	61.9	0.055	1.225
1982	923.0	643.0	1566.0	78.3	0.050	1.311
1983	1168.7	804.7	1973.3	100.0	0.051	1.403
1984	1313.3	1208.8	2522.1	126.6	0.050	1.501
1985	1505.1	1648.6	3153.6	142.2	0.045	1.606
1986	2058.2	1734.3	3792.5	163.0	0.043	1.718
1987	2070.1	2527.8	4597.9	222.9	0.048	1.838
1988	2800.1	2809.1	5609.2	224.2	0.040	1.967
1989	3521.4	3199.6	6721.0	303.3	0.045	2.105
1990	4241.7	3709.9	7951.7	381.4	0.048	2.252
1991	5228.0	4255.7	9483.6	459.4	0.048	2.410
1992	6061.2	5475.6	11536.8	566.2	0.049	2.579
1993	7502.0	6401.6	13903.6	656.4	0.047	2.759
1994	8926.2	7215.1	16141.3	812.5	0.050	2.952
1995	10393.9	8052.5	18446.4	966.7	0.052	3.159
1996	11899.4	9225.2	21124.6	1125.7	0.053	3.380
1997	14601.2	9381.7	23982.7	1288.7	0.054	3.616
1998	17747.2	9352.7	27099.9	1581.3	0.058	3.870
1999	18942.7	11717.8	30660.5	1922.0	0.063	4.140
2000	21283.3	13629.3	34912.5	2051.5	0.059	4.430

TABLE F.26

External Debt, Comparison Case
(Egyptian Energy Imports) Constant LE 1978 Prices

	Debt	Grace	Total	Debt Service	Debt Service Ratio
1978	230.3	184.2	4.4.5	10.8	0.026
1985	937.2	1026.5	1963.6	88.5	0.045
1990	1883.5	1647.4	3530.9	169.4	0.048
2000	4804.3	3076.5	7880.8	463.1	0.059

TABLE F.27

Estimation of External Energy Debt in Grace as a Percentage
of Total External Energy Debt

Strategy	Year			
	1978	1985	1990	2000
Comparison	44.4	52.3	46.7	39.0
Low Nuclear	43.7	48.7	16.0	40.2
Accelerated Renewable Resources	44.2	52.3	36.8	30.3
Nuclear Capacity Variations	43.3	45.1	17.9	19.8

Debt Service and Foreign Exchange. The estimated debt levels of the energy strategies accentuate the importance for Egypt to achieve its development goals and, in particular, to allocate their energy resources to the most productive uses. This is made clear by the foreign exchange requirements necessary to repay interest and amortization on energy sector borrowings. Increased energy availability will have to be developed for uses of that energy that provide returns based on international competitiveness of the Egyptian product.

Ratios of energy debt service to: (a) export earnings (DS/X); and (b) to export earnings plus foreign exchange from workers remittances (DS/X+wr) have been estimated using export earnings and workers remittance estimates used in the DOE GDP projection described in section 3 of Appendix G. These ratios are shown in Table F.28.

This indicates an increasing proportion of foreign exchange dedicated to the energy supply capital investments. The debt service to export ratios derived in this manner do not indicate immediate serious difficulties. However, borrowing a debt service to export and holding a remittance ratio of 20 percent for the total economy is considered near the maximum. The increasing ratios of Table F.28 emphasize the importance of Egypt's need to achieve its export goals in order to provide the sizable foreign exchange needs of its planned expansion of energy sector borrowing.

Comparisons using the estimates of total energy investment yield similar though less marked results. To the extent both of these correctly portray future trends, then concerns might be raised that the energy expansion program could, with its increasing share of total investment, be depriving other economic sectors of investment funds necessary for continued growth of the economy. The analysis is complex, but it should be noted that proposed energy expansions only make sense if there is also provision for well-planned industrial, infrastructure and other sector programs adequate to utilize and eventually pay for the energy supply capability.

Table F.28

ESTIMATED DEBT SERVICE* TO PROJECTED EXPORTS** AND DEBT SERVICE TO PROJECTED EXPORTS PLUS WORKERS REMITTANCES** (IN PERCENT)

		YEAR			
		1978	1985	1990	2000
Comparison	DS/X	0.8	4.1	5.3	6.5
	DS/X + WR	0.8	3.4	4.3	5.2
Low Nuclear	DS/X	0.8	3.6	5.5	4.5
	DS/X + WR	0.7	2.9	4.5	3.6
Accelerated Renewable Resources	DS/X	0.9	4.0	6.4	7.7
	DS/X + WR	0.8	3.3	5.2	6.1
Medium Nuclear	DS/X	1.0	3.8	5.5	5.7
	DS/X + WR	0.8	3.1	4.4	4.5

* As described in methodology of this section.

** From Department of Energy GDP projections

*** From estimated 10 percent growth after 1978.

APPENDIX G-CONSIDERATION IN ENERGY PLANNING AND ANALYSIS IN EGYPT

1.0 THE ROLE OF ENERGY ANALYSIS

In this initial cooperative assessment, time and resources placed severe limits on the scope of the assessment and integrated energy analysis that could be conducted. In the longer term, these limits might not apply. Therefore, it is appropriate that some comment be provided on the concept of integrated energy planning and analysis and the factors that should be considered in constructing that activity.

Energy is a ubiquitous commodity; it infuses itself into almost every facet of our daily lives and our nation's economy. In recent years, energy requirements and supply capabilities have become matters of major importance at both national and international levels in terms of policies, trade, finance, economics, environments and political stability considerations.

In this light, it is far too easy to overextend energy planning and analysis activities into areas where energy, appropriately, is only one of many factors rather than the dominant concern. Accordingly, one challenge to be faced in preparing a well-structured approach to integrated energy planning is to carefully define the proper relationship of energy planning activities to other policy and planning activities including the linkages that are needed between these activities.

The general topics addressed in this context of integrated energy planning are: (a) the national social and economic goals which must guide energy planning; (b) the interrelationship of energy planning with economic planning both at the macro and sectoral levels; and (c) consideration of absorptive capacity or infrastructural needs of the national system.

The discussions of this appendix do not claim to be a complete prescription for an energy policy and planning activity. Rather, it is presented as a set of observations developed during the course of this initial assessment that may be of utility in future extensions of this work.

The Elements of Energy Analysis. Energy is a pervasive element. Its assured availability in different forms is essential to almost every industrial, economic and service activity in the economic system. Its delivered cost can be critical in the economic competitiveness of industrial or service endeavors and in the ability of the general public to raise its standard of living. At the same time, the supply of energy (from exploration of fuels resources through processing, transport, conversion and delivery to the point of end-use) is a major sector of the economy of most countries. Integrated energy planning must properly take into account this dual role. Figure G.1 schematically indicates the role of energy planning in relation to national policy formulation and other national planning activities.

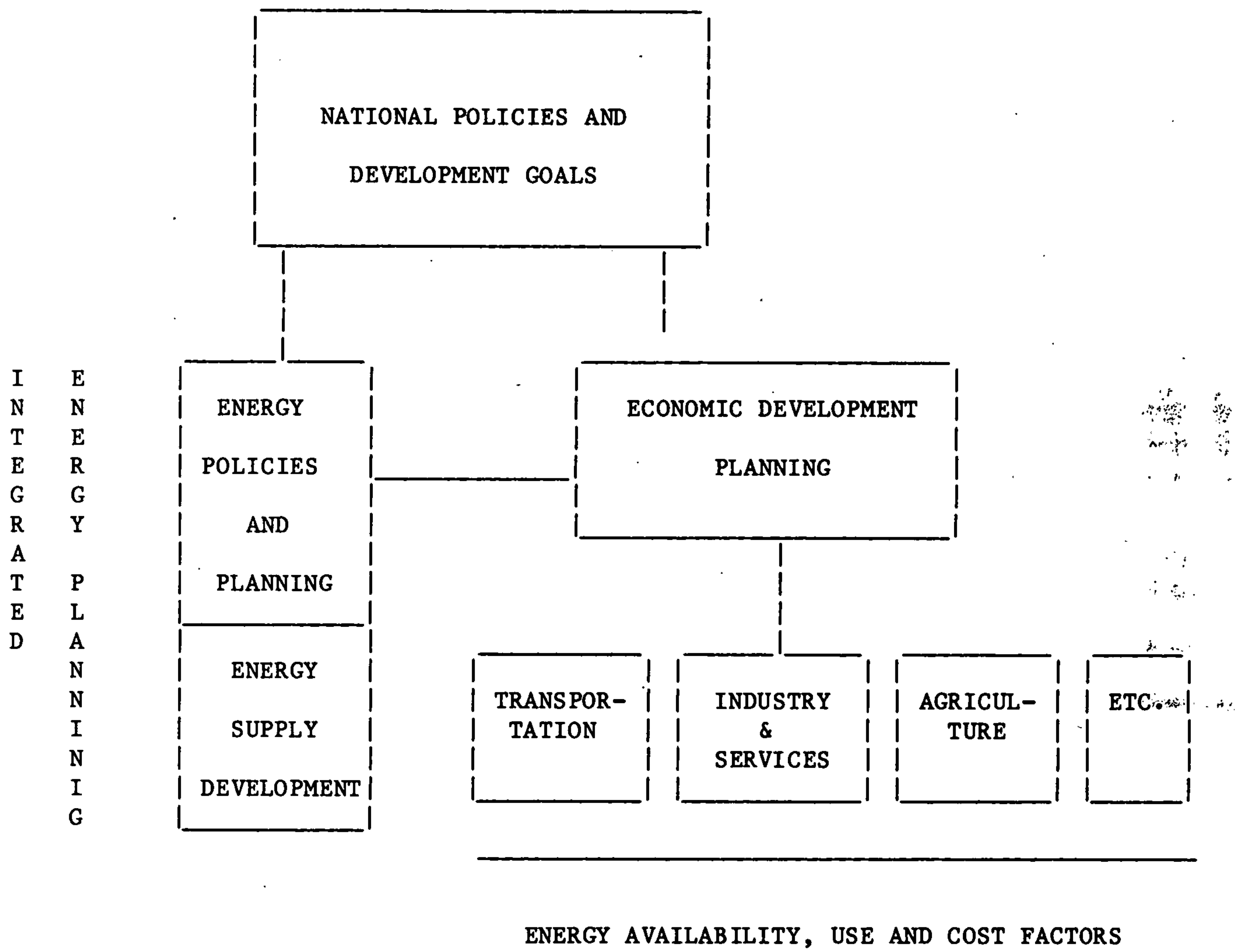


Figure G.1 SCHEMATIC ROLE OF INTEGRATED ENERGY PLANNING AND ANALYSIS

Energy planning and analysis must be closely tied to overall economic planning, both in the sense of drawing macroeconomic assumptions from longer-scale planning and in the terms of supplying to that process detailed analyses of energy investment costs, preferred technical options, implications of alternative pricing systems, etc.

Economic development planning is used here in quite a general sense to include financial and budgetary analysis and decision making. Energy cuts across all sectors of the economy. Thus, energy planning must interact with the planning process in sectors such as transportation, housing, industry, etc. On the one hand the sectoral planning process should be called upon to provide to the energy planning process data on current activity levels in their sectors (industrial outputs, amounts of transportation of various kinds, etc.) and planned future activity levels. On the other hand, the energy planners should provide sectoral planners with information on the energy implications of their plans and the energy constraints that could condition the achievement of the sectoral development plans.

Finally, energy supply is, itself, a major economic sectoral activity. It constitutes a significant portion of the nation's financing requirements, makes heavy demands for skilled manpower and sophisticated equipment, and is frequently one of the most important construction and labor producing activities in the whole economy.

Assurance of adequate energy supply is, in many countries, a leading function of the government and, in Egypt, supply of fuels and energy is the primary function of at least two major ministries.

The continuing sections of this Appendix address the following:

Section 2.0: Government Policies and Plans Relative To Energy Development

This section summarizes current Egyptian policies and existing long range, land reclamation, regional, rural electrification and new cities development plans as they could impact energy planning.

Section 3.0: The Economic Context of Energy Growth

This section presents in summary fashion, a preliminary parametric macroeconomic growth analysis and implication of different economic growth rates upon total energy demand. This helps place in context the energy projection used in this analysis.

Section 4.0: Overview of Economic and Financial Absorptive Capacity Factors For Energy Development

This section provides a historical perspective, identifies financial factors in energy development and reviews potential foreign sources of financing.

Section 5.0: Institutional and Resource Mobilization Factors

This section summarizes management, institutional and infrastructure aspects of Egypt's ability to adequately mobilize and effectively apply the resources necessary for energy development activities.

2.0 GOVERNMENT POLICIES AND PLANS RELATIVE TO ENERGY DEVELOPMENT

Under the terms of Arab Socialism as propounded repeatedly since 1952, the Government has full responsibility for establishing the social, economic and political bases for development, and controls all the basic development factors. All major energy, mineral and water resources and unimproved land are considered national or public property and can be exploited only by, or under license of, the Government. The Government has also assumed responsibility for the social and economic welfare of the people. It controls and/or operates, either directly or through the public sector, all transportation, post and telecommunications infrastructure, the financial system, most major construction firms, most transportation services and the bulk of industrial production.

Therefore, it is important to understand the Government policies, structure and practices relevant to the development of energy resources in order to assess the practicability of implementing such developments. This section summarizes briefly the social and economic aspects of Government national and regional development policies considered to be relevant for this assessment. It reviews, in turn, long-range development plans, the Government's land reclamation plans, regional development plans and the "new cities" development plans. In each case, an attempt is made to relate these plans and policies to energy requirements in response to the questions raised by the energy supply and demand option assessments.

2.1 Long-range Development Objectives

The basic policy document under which Egypt's current development program operates is the so-called October Working Paper promulgated by President Sadat in early 1974. This paper established the general policy framework for the current Five Year Plan and other long-term development plans. Among its major objectives, the following were relevant to energy demand and energy resource development:

(a) Modernization of Egypt by the year 2000 through the acceleration of economic growth emphasizing modern industry, high-value agriculture, oil and energy development, and tourism.

(b) Improvement in the living standards and social welfare of the population, with more equitable growth among regions and between urban and rural areas.

To implement these objectives, the Five Year Plan (1978-1982) laid down the following socio-economic goals[1]:

(a) Increase the national production growth rate by placing first priority on the rapid completion of the many projects currently under construction, on renovating and expanding badly-neglected utilities, on increasing investment in existing farmlands and bringing reclaimed land into production, and on strengthening the construction industry.

(b) Develop Egypt's energy resources - particularly oil and natural gas - to assist rapid industrialization and thus to improve living standards and employment opportunities.

(c) Reduce pressures on the major cities - particularly Cairo and Alexandria - and on agricultural land by promoting the dispersion of the population out of the Nile Valley and Delta through the reclamation of unused or desert land and the creation of new cities as development centers.

Although it is not possible to quantify with any confidence the effect of the fulfillment of any one of these goals on the consumption of energy, it is clear that each will have a significant impact. For example, modernization of industry in Egyptian terms appears to mean the establishment of relatively capital-intensive industries, which require high energy inputs. The long-term industrialization program projects the establishment of three direct reduction steel mills employing electric furnaces, each of which will require something like 200 MWe electric power. Improvement in the standard of living, particularly in the rural areas, is equated in part with the introduction of electricity and the increase in the consumption of other forms of energy, such as butagas, kerosene, diesel fuel and solar energy. At a 500,000 population level, each of the five new cities that are currently in the planning stage will consume about 300 GWh per year in electricity for residences and services by the year 2000, plus 1000 GWh/year or more for industry. In addition, each will use about 50,000 metric tons of butagas per year for residences and about 250,000 tons of petroleum products for industry and transportation.[2]

---

1 Obviously not all these goals can be fully realized within the Five Year period; rather, they establish the direction for long-term development.

2 These estimates are based on figures in the Sadat City and Tenth of Ramadan development plans. At this time, these new city development plans have been separately prepared and have not yet been coalesced into a consistent set of planning documents. This is to be expected at this stage of the planning process.

2.2 Land Reclamation Plans

With one of the highest population densities in the world and a rapidly growing population that is putting heavy pressure on the severely limited agricultural land, Egypt must reclaim large areas of desert land over the next 25 years in order to survive. The Government has placed the highest priority on reclaiming the desert for agricultural use through irrigation and drainage and for resettlement of the population out of the Delta and the Nile Valley. At about LE 5000 per feddan, it will cost at least LE 12.5 billion to bring the proposed 2.5 million feddans into irrigated cultivation.

Currently, only about 38,000 square kilometers (under 4 percent of the total area) are inhabited giving a population density in the Delta and Nile Valley of about 1,000 per square kilometer.[3] Including the agricultural land reclaimed in the Delta over the past decade, total land under cultivation amounts to between 6.5 and 7 million feddans, or less that 0.2 feddans per person. Urbanization and industrial growth have for many years taken place at the expense of cultivatable land, with the result that as population has grown, Egypt must now import a very substantial part of its basic food needs. Without the successful implementation of strong Government measures to curb population growth and increase land areas available for habitation and cultivation, population pressures in the urban areas and, even more critically, on agricultural land could become virtually intolerable by the year 2000.

The dimensions of the problem can best be seen by comparing the extremely uneven distribution of population by governorate. Population density in Cairo in 1976 was about 24,000 per square kilometer and in some parts of the city exceeded 150,000 per square kilometer. Port Said had a population density of over 3,600 per square kilometer, while Giza and Qalyoubia (outside Cairo) had densities of 2,400 and 1,700 per square kilometer respectively. Eight of the governorates - all in the Delta or Nile Valley - had densities in excess of 1,000 per square kilometer. At the other extreme, four border governorates were virtually uninhabited with densities under 0.5 person per square kilometer. Without basic changes in settlement patterns by the year 2000, the entire Nile Valley and almost all of the Delta will experience population densities of over 1,300 persons per square kilometer, thus suffocating the agricultural land.

Under the slogans "a new map for Egypt" and "the Green Revolution," the Egyptian Government is undertaking a forced-draft program to open new lands and disperse the population out of the Valley and Delta and to establish food sufficiency. The Government's Five Year Plan land reclamation and population dispersion projection is summarized in Table G.1.

---

3 This is based on generally accepted estimates of the magnitude of the inhabited area. The Five Year Plan cites a density figure for 1976 of 735 per square kilometer.

TABLE G.1

LAND RECLAMATION AND POPULATION DISPERSION PROJECTION *

Region	Land Reclaimed (000 feddans)	Agric. Pop. (millions)	Land Exploit. for mining & ind. (000 km^2)	Non-ag. Popul. (mill.)	Total New Popl. (millions)
Canal Zone	600	1.8	20	2.0	3.8
Middle & Upper Egypt	260	0.9	--	--	0.9
New Valley & Aswan	1510	4.5	60	6.5	10.9
Sinai	18	0.04	0.7	1.5	1.54
Red Sea	---	----	33	3.5	3.5
NW Coast	---	----	30	3.0	3.0
TOTAL	2500	7.2	144	16.5	23.6

(N.B. This does not include proposed new cities' population of 2.5 million in 2000. It does not necessarily agree with figures reported in individual regional development plans.)

* Five-year Plan, Egyptian Government

This "new lands" program includes plans for converting all existing irrigation pumps to electric and introducing electric pumping on all the reclaimed land. Extrapolating from the very rough estimate made in a recent study of the feasibility of introducing electrified irrigation pumping in Middle and Upper Egypt, a total of about 750 to 900 MWe of power would be required to supply electric pumps on all existing cultivated land and an additional 250 to 300 MWe for electric irrigation pumping on the new lands planned to be opened by the year 2000.

If this program is successful, the population density in the year 2000 (based on a projected population of 66 million at current growth rates) will be reduced to about 350 per square kilometer. However, the number of feddans cultivated per capita will be about 20 percent less than at present. Thus, while these new lands programs are absolutely essential, it is equally important that the Government take firm measures to reduce population growth rates and increase agricultural yields. The latter program in particular will be difficult since yields on the currently cultivated land in the Nile Valley are among the highest in the world and can probably not be increased by mechanization or other proposed means to reduce the intensity of labor on small farms.

2.3 Regional Development Plans

The Ministry of Housing and Reconstruction is responsible for the preparation of long-range plans for the development of the regions outside the Nile Valley and Delta in which the Government is concentrating its hopes for a "new map" for Egypt. (See above - Land Reclamation Plans).

The first such plan was produced for the reconstruction of the Suez Canal region, which had been severely damaged and largely depopulated as a result of the 1967 war. Most of the damage in the three Canal region cities had been repaired and life in the cities has been restored nearly to normal. Implementation of the sketched-out long-range regional development plans, however, will take many years, much further study and large-scale investments.

2.3.1 Suez Canal region: Government policy for the Suez Canal region calls for the development of the region as a major urban growth alternative to Cairo, Alexandria and the urban centers of lower Egypt. This area is an important locale for oil refinery developments and as the site for a massive pumped energy storage project (see Annex 5-Fossil Fuel Supply Options, oil refineries, and Annex 6-Hydroelectric Power, pumped storage).

The 1976 Plan for the Suez Canal Region foresees the growth of the Region to a population of about 3.2 million by the year 2000. In keeping with this plan and with expected increases in demand on the national power grid, the Egyptian Electricity Authority plans to build a 300 MWe thermal power plant at Ismailia and a 600 MWe thermal plant at Suez, both to come on stream in 1982. The grid is to be extended in the Canal Region during the Five Year Plan period as well. If the planned pumped storage facility near Ain Sukhna, about 55 kilometers south of Suez along the Gulf, is realized, the combination of these projects will help create the base for the industrial development of this part of the Canal Region and assist in the opening of the Red Sea coast to development.

2.3.2 Coastal zone of western desert: The first full-scale regional development plan undertaken by the Ministry of Housing and Reconstruction was for the coastal zone of the Western Desert, which was published in 1976. This plan foresees a population in the region of 675,000 to 781,000 by the year 2000 with a total labor force of between 218,000 and 248,000. This will mean the attraction of between 465,000 and 570,000 new settlers, mainly from the Nile Valley. The coastal zone west of Alexandria has been selected as the site of the first nuclear power plant being planned for installation in Egypt (see Annex 7 - Nuclear Power). It is also one of two regions in which the utilization of wind energy is feasible, particularly for water pumping (see Annex 8 - Potential Use of Renewable Resources in Egypt).

One of the primary projects of the Regional Plan is the construction during the first half of the 1980's of a fresh-water irrigation canal along the coast from the Nile to Sidi Barrani at an estimated cost of LE 140 million. This will permit the opening of about 130,000 feddans of agricultural land and make possible the economical supply of domestic and industrial water.

Plans also call for major investments in improvement of the road and rail transportation systems and in electrification. Very substantial investments will also be required in social infrastructure, such as schools, hospitals, recreation and sports facilities, and housing. Without these investments on a timely basis, it will be impossible to attract the needed workers and their families out of the Valley. Total investment requirements for the Regional Plan have been estimated at LE 1.27 billion between 1976 and 2000. The difficulty in attracting immigrant families is shown by the fact that at present, construction workers--who come into the area for the most part without families--can be attracted into the region only by offering wage differentials of 50-100 percent. The aims of the Regional Plan cannot reasonably be fulfilled on this basis.

On the other hand, it is anticipated that if the Plan is realized, the Region could ultimately absorb as many as three million persons from the overcrowded urban and rural areas of the Valley, and that by the year 2000, average per capita income could increase from the current level of LE 110 to LE 250 to 300 per year.

Obviously, the supply of increasing amounts of electric power to the region in keeping with the social and economic development is a basic requirement for the successful fulfillment of the Plan. As development extends along the coast--west from Alexandria and around the Marsa Matruh development node--it is expected that the national grid will be extended, at least as far as Marsa Matruh, but probably not until about 1990.

The planned construction by 1986 of a 600 MWe nuclear power plant at Sidi Krier, about 35 km west of Alexandria, will have a number of social impacts:

(a) The large-scale construction project will provide employment for a large number of Bedouins who inhabit the area and who need alternative employment to low-yield dry farming and sheep-herding. This will assist in the accomplishment of a major Government objective to settle the nomadic Bedouin tribes in the coastal region of the Western Desert and bring them more fully and equitably into the national economy.

(b) It will attract several thousand workers into the region from the overcrowded urban and rural areas of the Delta and Nile Valley. Many of these workers will probably commute from around Alexandria during the early construction phase, unless the Government undertakes a major infrastructure development scheme. But as regional development progresses, many of these workers will probably move permanently to the area.

(c) It will form one node for the planned industrial development of the El Hammam district within which Sidi Krier is located.

At present, Sidi Krier is a village of a few hundred; El Hammam, the major town in the district, has a population of only about 8,000 while the district population is estimated at 17,000. There are few amenities in the area; it is, however, along the beach west of Alexandria which is gradually building up as a summer resort for Egyptians and foreign residents. The Regional Plan for the coastal zone of the Western Desert proposes to site heavy industrial development in the area of Sidi Kreir, which is also the Mediterranean terminus of the Sumed pipeline.

2.3.3 Red Sea coastal area: Government policy calls for the development, between now and 2000, of the Red Sea coastal area. Like the coastal zone of the Western Desert, the Red Sea coastal area is under consideration as a site for nuclear power plants. It also has an excellent potential for the exploration of wind energy, (see Annex 7-Nuclear Power, and Annex 8-Potential Use of Renewable Resources in Egypt, wind energy). Although no regional plan has yet been developed, the Ministry of Housing and Reconstruction is preparing to have such a plan developed under contract. President Sadat's visit to Hurghada and Safaga on the Red Sea in April 1978 underlined the Government's intention to promote the development of their region in fulfillment of a number of Government objectives:

(1) Improvement of living standards in the region, to bring the local population into full equality with the national society.

(2) Reversal of out-migration - settlement of populations from over-crowded urban and rural areas of the Nile Valley and Delta.

(3) Exploration of local mineral, fishing, shipping and resources.

(4) Reclamation of land for agriculture.

The fulfillment of these aims will require heavy investment in infrastructure -- upgrading existing coastal roads and construction of additional road and rail connections with the Nile Valley; extension of the national grid into the region, ultimately along the length of the coast; improvement in water supplies--most potable water must now be shipped or trucked into existing communities; creation of employment opportunities in existing communities based on the exploration of regional resources--minerals, fish, tourist potential, port facilities--and the development of other industries that might be economically sited in the region; and the development of public services and amenities in existing and new communities to attract and hold workers and their families.

The expansion of the ports at Quseir and Safaga, extension of a 220 kv transmission line from Nag Hammadi to Safaga, tourist development at Hurghada, improved fish processing capabilities and oil exploration near Hurghada are steps toward the needed development of the area. It will probably be 10 years or more, however, before development reaches the point where nuclear plants could feasibly be sited south of Ain Sukhra, except possibly around Safaga if an arm of the national grid were built there from Aswan or Qena.

<u>2.3.4 Upper and middle region</u>: Until now, no formal large-scale regional development programs have been prepared either in the Upper Nile-Lake Nasser or the New Valley areas. What development schemes have been promulgated have related to individual plants or small, integrated areas. Terms of reference are currently being developed by the Ministry of Housing and Reconstruction (MOHR) for a regional plan of the New Valley Governorate. It is anticipated that a similar program will be undertaken for other parts of Upper Egypt by MOHR in conjunction with the Governorates of the region. The major users of energy in the region are the aluminum plant at Nag Hammadi, and the Kima fertilizer plant, which produces ammonia fertilizer based on hydrogen produced by electrolysis of water. Each of these plants draws heavily on the electric power produced by the Aswan hydroelectric complex.

The Government's determination to complete the installation of electric generating capacity at the Aswan High Dam and the three existing Nile River barrages is based on the planned increase in the demand for electricity, particularly in Upper Egypt. This will be created by the planned expansion of the fertilizer and aluminum plants as well as other proposed industrial, agricultural and community developments in Upper and Middle Egypt. Current plans for industrial development include: (1) the construction of a sugar refinery at Sohag; (2) the expansion of the new refinery at Deshna; (3) a phosphates plant at Abu Tartur; (4) a fish processing plant and a chicken and egg factory at Aswan; (5) a flour mill at Kom Ombo; and (6) brick and refractories plants, and tourist hotels and facilities at Aswan (see Annex 6-Hydroelectric Power, Upper Egypt Hydropower Plants).

Although no formal long-range plans have yet been published, it is known that the regions of the Upper Nile, Lake Nasser, and the New Valley constitute major areas of Upper Egypt in which the Egyptian Government has the most ambitious hopes for development. President Anwar Sadat and senior members of his Government toured these areas in April 1978 underlining the importance the Government attaches to them and their potential for realizing a number of basic Government goals:

(a) Reclamation of unproductive or desert lands for the production of foodstuffs as part of the foods sufficiency program - the Green Revolution.

(b) Exploitation of the resources of the area - fish, minerals, including phosphate and iron ore, and tourist attractions - as part of the general economic development of the nation.

(c) Industrial development, including fish and food processing, construction and tourist industries, with ancillary service industries.

(d) Redistribution of population out of the Old Valley into reclaimed areas - including those of Upper Egypt. The creation of new communities in the Aswan and New Valley regions will be based on the employment opportunities outlined above.

(e) Improvement of life in the towns and rural areas of several of the most impoverished governorates.

The potential for agricultural development in Upper Egypt is considered to be enormous. A total of over 500,000 feddans in the New Valley and the New South Valley and 250,000 feddans around Lake Nasser have been estimated to be potentially productive if reclaimed. Reclamation will occur primarily by the addition of irrigation water, mostly from groundwater sources on the basis of increased electricity available as a result of the expansion of the hydroelectric potential of the Upper Nile. Pumping will also be required to assist the flow of water into the dry New South Valley from Lake Nasser via a suggested canal from Wadi Tushka, now under study.

It is expected that with the development of a viable agricultural and industrial base, the regions of Upper Egypt will not only hold their populations, but reverse the current large-scale migration to the cities of Lower Egypt. Three new villages are currently planned near Aswan. The newly developing communities of Lake Nasser fishermen will be expanded. The areas of the New and South Valley can absorb many hundreds of thousands in population as newly reclaimed land becomes productive. An estimated 5,500 workers are slated to work in the Abu Tartur phosphate mine and associated infrastructure. Planned industrial development near Aswan should absorb several tens of thousands in the direct labor force plus their families, and two or three times as many to be employed in industry and commerce spawned by the creation of new communities of the industrial workers.

2.3.5 Sinai development: The Sinai Peninsula is almost totally empty and unexploited. Little is known of the mineral wealth in the area. However, two major energy resources are known to exist in the region: a major coal deposit is known to exist in Gebel Maghara about 150 km east of Ismailia; petroleum is currently being pumped along the Gulf of Suez, particularly in the vicinity of Abu Rudeis, (see Annex 5-Fossil Fuels Supply Option). In addition, manganese was earlier mined in Southwestern Sinai and these mines presumably could once again be made productive. It has been estimated that well over 100,000 feddans of agricultural land could be reclaimed just east of the Suez Canal with the introduction of irrigation water. The potential for tourism is considered good along the Red Sea coast and east of the Canal. A major survey must still be made to assess the economic potential of the region and prepare a coordinated long-range plan for its development. (It is assumed that the major portion of the Peninsula--east of the Mitla and Gidda passes--currently under Israeli occupation, will be restored to Egyptian control.)

The Government, and specifically the Ministry of Planning, places considerable importance in the development of the agricultural, industrial and tourism potential of the Sinai, and suggests that by the year 2000, 40,000 persons might be resettled on agricultural land and as many as 1.5 million resettled in connection with the exploitation of industrial potential and tourism in the Peninsula. The following Government policies can be identified in relation to the proposed development of the Sinai:

(a) Develop the natural resources of the Sinai for the economic benefit of Egypt as a whole.

(b) Create employment opportunities to make possible the migration of a significant number of the population out of the Delta and Nile Valley into new areas.

(c) Establish population centers in the Sinai to discourage incursion into the area by Israelis.

(d) Prove Egypt's interest in peace by developing industrial and population centers in the Sinai.

(e) Settle the Bedouin nomads in the Sinai.

No overall, long-range Sinai program has yet been developed, but the Government is undertaking or planning a number of specific projects to develop the region. These are enumerated below:

- Construction of three tunnels under the Suez Canal to connect the area by road and rail with the rest of the country. This includes plans for the construction of a railroad tunnel south of Ismailia, which would be of potential importance in connection with the exploitation of the Sinai coal deposits.

- Planned reopening of the manganese mines near Abu Rudeis and expansion of the pumping of oil at Abu Rudeis and other recovered areas of the Sinai.

- o Proposed reclamation of over 100,000 feddans of agricultural land east of the Canal based on the introduction of irrigation water from an extension of the Nile-Ismailia fresh-water canal pumped under the Suez.

- o Development of tourism, including the west bank of Lake Timsah, near Ismailia.

- o Desert development plans by the Ministry of War and Military Production, including surveying.

No specific Government higher council or other agency has yet been created for the development of the Sinai.

2.3.6 Summary of regional development plans: A substantial portion of Egypt is thus covered by regional plans or by individual projects under serious consideration for development between now and the year 2000. The purpose of each of the regional plans is to maximize the use of locational and natural resources to establish the economic base to stem and ultimately reverse migration from the poorer regions of the country into the already overcrowded Nile Valley and Delta. Central to each of these regional and new city plans is the creation of an industrial base, the development of water resources--since each is in areas in which water is scarce -- and the creation of well-developed community infrastructure and amenities aimed at attracting populations out of the urban areas where they are accustomed to such facilities. Each of these elements assumes the availability of large amounts of fuels and energy.

In each region the locally available energy resoures will have to be developed, since by their nature the new regions are outside the national power grid and the established distribution systems for oil and gas. Development plans for the Suez Canal region include the projected construction of two 300 MWe thermal power plants in the Suez and Ismailia to be connected to the national power grid, extension of the grid to include Port Said, and development of a major pumped storage facility along the Gulf Coast south of Suez. Each of the new cities will be connected to the national power grid. Natural gas will be piped to Sadat City and New Ameriyah, and after about ten years, to Tenth of Ramadan, according to the present plans. Plans for the coastal zone of the Western Desert include: (1) the extension of the national power grid along the coast west of Sidi Kreir, which is the westernmost point on the coast presently linked to the grid; (2) construction of a 600 MWe nuclear power plant near Sidi Kreir; and (3) additional plants as regional and national demand increases.

2.4 Rural Electrification Plans

The Government is also undertaking a major rural electrification program in keeping with its policy of improving living standards in the rural areas. Presently about 2,400 of Egypt's 4,000 villages are connected to the national grid. Plans call for the electrification of 600 more villages in 1978. Costs have been estimated at about LE 40,000 per village, paid by the Government. Village electricity is used primarily for street lighting and public buildings, irrigation pumping, and to a limited extent, residential lighting. Electric pumping reduces the need for animals to operate the waterwheels, thus freeing much of the 30-40 percent of cropped land currently used for animal feed. It also improves the irrigation system generally, through better control of the amount of water applied to the land, reducting waterlogging and salination. Electric lighting, TV and appliances improve the quality of life for rural residents and allows increased labor manhours per day by encouraging the scheduling of home activities after dark. Consideration is being given to the introduction of solar collectors in many of the villages for heating domestic hot water and for the generation of electricity for lighting and/or water pumping.

2.5 New Cities Development Plans

As part of its program to create a "new map for Egypt" by opening new lands for settlement and establishing new industrial employment centers, the Government is in the process of creating a number of "new cities" outside the inhabited areas of the Delta and Nile Valley. Five such cities have so far been named: Tenth of Ramadan, Sadat City, New Ameriyah, El Obor and King Khaled. Only the first three have been subjected to detailed planning at this time, however, and even the proposed sites for the latter two are open to question. In its pronouncements, the Government has made reference to other future cities in Upper Egypt, but nothing is known about the location, economic bases or plans for these centers. Each of these cities will require additional capacity on the electricity grid and will lead to the increased consumption of petroleum products.

2.5.1 Tenth of Ramadan: The first new city to be planned under the aegis of the Ministry of Housing and Reconstruction and the furthest along in the development phase is Tenth of Ramadan. Land is currently being offered for sale and the Government is undertaking negotiations with industrial companies to site their plants in the new community. It is anticipated that Tenth of Ramadam will have a population of about 150,000 at the end of year 10 (1988) and of about 500,000 by year 25 (about 2003). The economic base is an estimated employment (at 500,000 population) of about 80,000 in medium and light industry, plus an additional 72,000 in services. The implementation schedule calls for the construction of 3-4,000 housing units per year to a total by year 25 of 111,000. Ultimate family size is assumed to be 4.5; although consideration is given to the fact that in the early years, families will probably be smaller than that average and many single workers will locate in the new city; this has not impacted the plan for residences. A mix of low-rise, single-family houses varying in size according to family income is planned as follows:

Income level	Percent of houses	Average family size		Persons/room
Low	50	5.2	30-60	1.5-2
Medium	25	4.2	20-100	1.2
Upper medium	20	4.5	80-140	1.0
High	5	4.0	140	0.8

Natural gas is not presently assumed to be available in Tenth of Ramadan for the first ten years of the project. After that, it is assumed that it will be used only for industrial purposes. Homes will be served by butagas distributed in the normal way. According to plan, total energy use in 2000 (500,000 population) will be 1,500 GWh/year electricity for industry, 700 GWh/year electricity for housing and services, plus 100,000 tons/year butagas and 260,000 tons/year oil.

2.5.2 Sadat City: The overall plan for Sadat City was accepted by the Government in March 1978, and implementation plans are under active consideration. Population targets are the same as for Tenth of Ramadan, i.e., 150,000 by year 10, and 500,000 by year 25. Government officials have stated publicly, however, that Sadat City may grow to an ultimate population of one million. The economy is planned to be based on heavy manufacturing industry with an employment in year 25 of 60,000. Service industries will employ 25,000, construction will employ 20,000 and other services 60,000 for a total employment of 165,000. Because it is assumed that in the early years, much of the population will be single, male construction workers, and that a delay of about one year is anticipated between the arrival of the worker and the moving of his family to the new city, 40 percent of the permanent housing to be built during the first 2-3 years will be apartments catering mainly to single persons. By year 10, housing for 150,000 persons will be as follows:

Type of Unit	No.
Detached single-family houses	300
Attached single-family	17,880
Free-standing apartments	1,904
Apartments over stores, offices	2,452
Luxury apartments	36
TOTAL:	22,572

Housing construction costs for the first ten years is estimated at LE 52 million. By year 25, there are planned 98,000 housing units, including 14,760 apartments and 83,640 individual houses. Although natural gas will be piped to Sadat City for industrial use, no plans presently exist for distribution to residences. Butagas will be distributed as at present. According to plan, total energy use in 2000 (500,000 population) will be 305 GWh/year electricity for housing and services, and 1,009 GWh/ year for industry (assuming construction of a steel mill). No figures are available for oil for butagas demand.

2.5.3 Other new cities: New Ameriyah and other proposed new cities have not been studied as thoroughly as the two described on the previous page. Each is expected to follow similar population growth patterns as Sadat City, and for the purposes of estimating energy requirements, each can be assumed to be similar to Sadat City.

3.0 THE ECONOMIC CONTEXT OF ENERGY GROWTH

One of the requirements of energy planning is that it be closely tied with overall economic planning. Future energy requirements are closely connected with future energy economic activity, in particular future industrial output, personal expenditures for energy consuming devices and fuels, etc. In the original plan for the Egypt-US collaborative assessment, the importance of carrying out energy analysis starting with projections of energy consuming activities was emphasized. Such analyses, however, should be implemented by more aggregated analyses starting with assumptions regarding expected macroeconomic growth. Although such economically-based analyses were not carried out as part of the collaborative assessment, it is useful to examine in a very preliminary way, the consistency of the Comparison Case with potential economic growth in Egypt.

3.1 The Economic Future

As a starting point for our analysis, we establish a range of plausible economic growth rates in Egypt to 1985 and from 1985 to 2000. Table G.2 presents the various growth rates considered, the medium case being based on estimates by the World Bank. In Table G.3 the levels of GDP and GDP per capita are summarized. A reduction in the rate of economic growth in the later period has been assumed, based on a maturing of the economy and broadened industrial base. However, GDP levels in 2000 similar to the high case could also be achieved if the 6.5 percent annual growth rate assumed for the initial period of the medium case were able to be sustained beyond 1985 to 2000.

A simplified macroeconomic model has been used to obtain an estimate of the level of investment required to obtain the economic growth rates

TABLE G.2

REAL GDP GROWTH ASSUMPTIONS

(Percent Per Year)

Case	1975-1985	1985-2000	1975-2000
Low	5.5	4.3	4.8
Medium	6.5	5.0	5.6
High	7.5	5.7	6.4

TABLE G.3

PROJECTED REAL GDP AND GDP PER CAPITA

	1975	1985	2000
Population (millions)	37.0	47.2	67.0
Real GDP (millions of 1975 Egyptian Pounds)			
Low	4779	8165	15355
Medium	4779	8995	18700
High	4779	9850	22625
Real GDP Per Capita (in 1975 Egyptian Pounds)			
Low	129	173	229
Medium	129	191	279
High	129	209	338

shown in Table G.3.[4] These levels of investment are shown in Table G.4. The ratio of investment to GDP in the high case, particularly in the 1975 to 1985 period, is considered inordinately high. Only in the exceptional year of 1975, when major reconstruction in the Suez Canal Zone and a substantial build-up of inventories occurred, has the ratio been above 0.21 for Egypt. Indeed, even the medium case would appear to imply unusually high levels of investment.

3.2 The Relationship Between Energy and Economic Growth

Commercial energy consumption and economic growth are often correlated by using an income elasticity of energy demand, IE in the following relationship:

$$\left(\frac{E_t}{E_o}\right) = \left(\frac{GDP_t}{GDP_o}\right)^{IE} \qquad (1)$$

E_t and E_o' are total commercial energy consumption in year t and a starting year, respectively,[5] and GDP_t and GDP_o are the Gross Domestic Product in the same year. Applying this relationship results in the projections of demand for commercial energy (direct fuels and electricity) set forth in Table G.5. For countries at a stage of economic development characterized by increased industrialization, it is unreasonable to consider an income elasticity of less than unity over the long term. Historically, middle income countries in Africa and West Asia have experienced elasticities of around 1.3. In the Workshop on Alternative Energy Strategies (WAES) an income elasticity of 1.10 was used for the middle income developing countries (including Egypt) for the 1976 to 1985 period and 1.0 to 1.05 for the 1985 to 2000 period.[6] These elasticities took into account current high energy costs relative to the periods of historical analysis. For this analysis we consider a range of elasticities between 1.0 and 1.3, the upper end of the range being justified by the experience in Egypt between 1970

---

4 A more complete description of this analysis and the underlying model is contained in J. Allentuck, et al., A Preliminary Analysis of the Range of Possible Electricity Demands in Egypt in 1985 and 2000 (in draft) Brookhaven National Laboratory. The macroeconomic section of the model draws heavily on the World Bank's Revised Minimum Standard Model and also draws upon the Hicks-Pinto SIMILINK model of trade and growth.

5 This use of income elasticity is somewhat unconventional. It is usually defined as the percentage change in energy consumption by consumers as a result of a one percent change in their income. The definition used here is more appropriate, however, in a country such as Egypt in which much of the energy consumption is directly or indirectly controlled by the national government.

6 Workshop on Alternative Energy Strategies (WAES), Energy: General Prospects 1985-2000, McGraw Hill, NY 1977.

TABLE G.4

PROJECTED INVESTMENT UNDER ALTERNATIVE ECONOMIC GROWTH ASSUMPTION: 1975 - 2000

(Unit = Millions of 1975 Egyptian Pounds)

	1975-1985 Real GDP Growth				1985-2000 Real GDP Growth		
	High 7.5%	Medium 6.5%	Low 5.5%		High 5.7%	Medium 5.0%	Low 4.3%
1975 Investment Level	1329	1329	1329	1985 Investment Level	3050	2435	1825
1985 GDP Level	9850	8995	8165	2000 GDP Level	22625	18700	15355
1985 Investment Level	3050	2435	1825	2000 Investment Level	4985	3825	2710
1985 Ratio of Investment to GDP	.310	.271	.224	2000 Ratio of Investment to GDP	.220	.205	.176

TABLE G.5

PROJECTED ENERGY DEMAND (DIRECT FUELS AND ELECTRICITY)

(Energy Unit - 10^{15} Joules)

	1975-1985 Real GDP Growth High 7.5%	1975-1985 Real GDP Growth Medium 6.5%	1975-1985 Real GDP Growth Low 5.5%		1985-2000 Real GDP Growth High 5.7%	1985-2000 Real GDP Growth Medium 5.0%	1985-2000 Real GDP Growth Low 4.3%		1975-2000 Growth Rate in Energy Demand	Growth Rate in Real GDP
1975 Energy Consumption	350	350	350	1985 Energy Consumption Range	720 890	655 790	600 700			
ELASTICITY = 1.0								**ELASTICITY = 1.0**		
Energy Consumption Growth Rate	7.5%	6.5%	5.5%	Energy Consumption Growth Rate	5.7%	5.0%	4.3%	High Case	6.4%	6.4%
								Medium Case	5.6%	5.6%
1985 Energy Consumption	720	655	600	2000 Energy Consumption	1650	1360	1130	Low Case	4.8%	4.8%
ELASTICITY = 1.15								**ELASTICITY = 1.15**		
Energy Consumption Growth Rate	8.6%	7.5%	6.3%	Energy Consumption Growth Rate	6.55%	5.75%	4.95%	High Case	7.4%	6.4%
								Medium Case	6.4%	5.6%
1985 Energy Consumption	800	720	645	2000 Energy Consumption	2070	1665	1330	Low Case	5.5%	4.8%
ELASTICITY = 1.3								**ELASTICITY = 1.3**		
Energy Consumption Growth Rate	9.75%	8.45%	7.15%	Energy Consumption Growth Rate	7.4%	6.5%	5.6%	High Case	8.35%	6.4%
								Medium Case	7.3%	5.6%
1985 Energy Consumption	890	790	700	2000 Energy Consumption	2600	2030	1505	Low Case	6.2%	4.8%

and 1975. The portion of the range between 1.15 and 1.30 would be considered most probable in the 1975-1985 period and the portion of the range between 1.0 and 1.15 most probable in the post-1985 period.

The aggregate energy demands based on the above assumptions of economic growth and elasticities implies some effect of increasing energy prices. It is revealing to get a more quantitative estimate of the effect of increasing energy prices. With prices taken into account equation (1) becomes

$$\frac{E_T}{E_o} = \left(\frac{GDP_T}{GDP_o}\right)^{IE} \left(\frac{P_T}{P_o}\right)^{PE} \qquad (2)$$

where P is the aggregate price for energy and PE is the price elasticity of energy demand. If we assume PE = -0.3[(7)] (i.e. that the price of energy follows in parallel with an increase in world oil prices from $12.70/barrel in 1985 to $30.00/barrel), take IE = 1.30 and consider the range of economic growth assumptions stated earlier, the results are shown in Table G.6. In all cases, price effects, under the above assumptions reduce demand in 2000 by about 23 percent.

The various estimates of energy demand in 1985 and 2000 are shown in Figure C.1 Appendix C. An important result of the analysis is the very wide range of possible demands in 2000. This is a reality of the current planning situation that must be recognized. We have indicated a range of estimates to which we would ascribe a somewhat higher probability than others. In particular the upper part of the full range has been ascribed a low probability since its accomplishment necessitates a combination of conditions better than any previously experienced, e.g: high growth in the early period, high growth in the late (1985 to 2000) period, a high income elasticity of demand and little or no price effects. On the other hand, many combinations of conditions could produce the results in the lower end of the range of demands. It should also be noted that we have by no means exhausted the full universe of possible futures. It is quite possible that energy demand in Egypt in 2000 will be outside the area covered by our various cases, but we have attempted in this analysis to span the region of highest probability.

From Figure G.2, we can see that the Comparison Case direct fuel and electricity demand in 1985 and in 2000 falls in the mid to lower range of the various cases examined. If anything the Comparison Case would seem to underestimate the required level of commercial energy demand (direct fuel and electricity) in both 1985 and 2000 if an economic growth rate of greater than 6 percent is to be sustained.

This analysis would indicate that the Comparison Case represents a fairly reasonable projection of aggregate energy demand. Policy makers

---

7 World Bank Development Policy Staff, <u>Prospects for Developing Countries 1978-1985</u> November 1977, Washington D.C.

Table G-6

EFFECT OF PRICE INCREASES IN FUTURE ENERGY DEMAND

(ENERGY UNIT = 10^{15} JOULES)

Economic Growth Case (1985-2000)		Energy Demand in 1985	Energy Demand in 2000[a] No Price Effects	Energy Demand in 2000[a] with Price Effects
Low	(4.3%)	700	1585	1225
Medium	(5.0%)	790	2030	1569
High	(5.7%)	890	2600	2009

a. Assumes Income Elasticity = 1.30

b. Assumes Price Elasticity = 0.30 and prices increase by a factor of 2.36 between 1985 and 2000 in real terms.

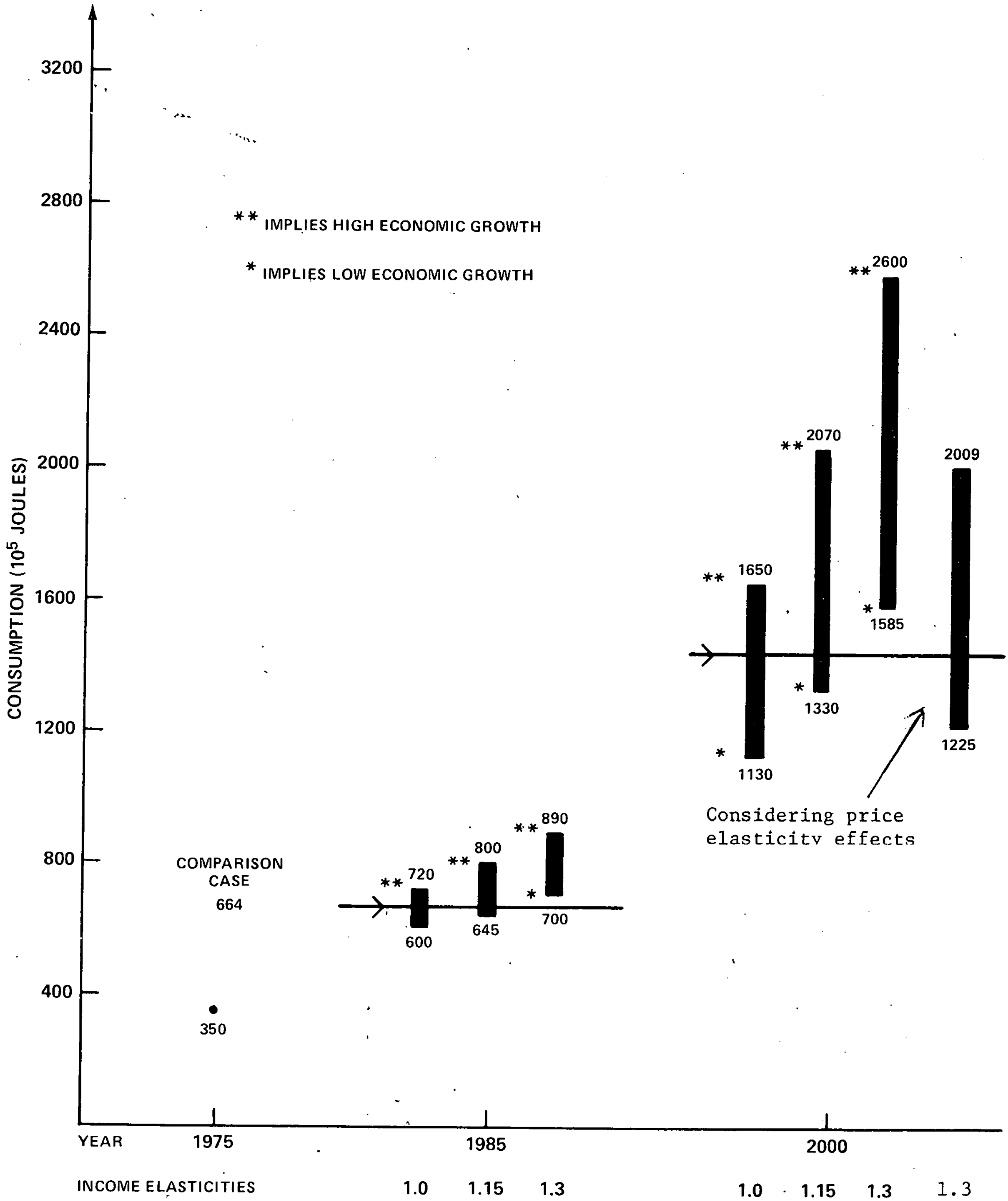


FIGURE G.2 PROJECTED ENERGY DEMANDS UNDER ALTERNATIVE ASSUMPTIONS should recognize, however, that there are circumstances which could lead to a significantly higher (by 30-40 percent) level of demand. As discussed in Appendix C there is considerable evidence that in the year 2000 Case there is an unreasonably high ratio of electricity demand to demand for direct fuel usage. This, in combination with the discussion above, would indicate that the level of direct fuel use in 2000 anticipated in the Comparison Case could well be an underestimate.

4.0 AN OVERVIEW OF ECONOMIC AND FINANCIAL ABSORPTIVE CAPACITY FACTORS FOR ENERGY DEVELOPMENT

The question of Egypt's ability to successfully undertake a large-scale energy development program is part of a larger question; namely, Egypt's capacity to generate and effectively utilize large investment funds in development generally. Studies which have addressed this question have reached basically similar conclusions: that Egypt has considerable potential to develop into a modern industrialized state, but that a number of factors in support of this development must be given increased attention. This section addresses those absorptive capacity factors, which can be characterized generally as relating to finance, management, institutions, infrastructure and resource mobilization.

4.1 Historical Perspective

The performance of the Egyptian economy in the past twenty-five years has been uneven. The 1952 Revolution coincided with a downturn in the business cycle following the boom years during the Korean war. The Middle East war in October 1973 coincided with the "oil revolution," which opened up new opportunities for investment and development in Egypt, but also triggered a phase of recession combined with inflation in the world economy, with adverse repercussions on developing countries.

In between these important dates, two different periods must be distinguished. The decade from 1955 to 1965 witnessed fairly rapid and substantial economic growth as well as a major structural transformation of the Egyptian economy. Output of goods and services increased and employment rose substantially. The second period, the years after 1965, saw a steady decline in the rate of economic growth, with a marked fall in both the rate of investment and domestic savings.

Egypt's present situation is made more complex by the fact that the country has been at war since 1967. Concomitantly, the physical infrastructure has suffered from inadequate investment and has deteriorated considerably.

Egypt's future is not without opportunities, however. Because of the prospects of earnings from petroleum exports, revenues from a widened Suez Canal, rapidly increasing remittances from Egyptians working abroad, the opportunities for tourism, the cultural and political links with the capital-surplus Arab countries, the geographic location of the country (i.e., near European markets), and a reasonably well trained labor force, the Egyptian economy possesses a considerable potential for economic development.

A further significant development is President Sadat's "Open Door" policy, which is designed to cure the ills of the past, promote private foreign investment, and accelerate the role of economic growth.

With economic aid from Arab, American, and European sources, Egypt is beginning to mobilize its own resources for a comprehensive and detailed economic development program in which the private sector plays a significant role. Further, recent pressures from the IMF and incentives for large loans and guarantees contingent on austere and well planned economic targets are having a salutory effect.

A new economic policy has been designed to secure a balanced budget by the 1980's and to reduce systematically the balance of payments deficit. For the first time in a quarter of a century, in January 1978 there was a surplus in Egypt's balance of payments of approximately $30 million.

Other encouraging signs become apparent as Egypt continues its corrective efforts. For example, from 1974 until the end of 1977 the Central Authority for Investment and Free Zones approved 744 foreign investment projects valued at $4.3 billion. Of these approvals, 184 projects involving investments of over 500 million dollars are already in production and 227 projects worth $1.8 billion are under construction. If these figures are evaluated relative to Egypt's 1977 gross national product of only $12 billion, the substantial amount of investment present in Egypt is easily appreciated.

4.2 Financial Factors In Energy Development

At present, there is no formal Egyptian energy policy in the sense of an explicit statement of national objectives and specific plans for attaining them. However, this Cooperative Energy Assessment for Egypt has attempted to identify options for the development of Egypt's indigenous energy resources including the utilization of solar and nuclear energy.

The developmental issues involved are complex and will have far-reaching effects on all sectors of the economy. Thus, it is of great importance that a clearly defined national energy strategy be formulated in order to adequately deal with the problems that lie ahead, one of which is the procurement of sufficient investment capital at a reasonable cost.

It is the purpose here to focus on Egyptian financial factors relevant to the energy development options described elsewhere in this report. This general discussion will include Egypt's overall capital requirements, and her ability to secure financing.

4.3 Capital Investment Requirements for the Expansion of the Industrial, Transport and Telecommunications Sectors.

In order to evaluate the ability of Egypt to finance alternative energy expansion paths, some perspective must be gained as to the anticipated financial requirements of the other sectors of the country through the year 2000.

4.3.1 The industrial sector: The Egyptian industrial sector has been rapidly increasing in importance within the Egyptian economy. The share of manufacturing and mining, as a percentage of GDP, has increased from an estimated 9 percent in 1946 to about 24 percent in 1976, and Egyptian industry currently employs more than one million persons, or some 13 percent of civilian labor force. Egypt's industrial sector is dominated by the production of basic consumer goods (textiles, shoes, food, beverages, and cigarettes) and essential intermediates (building materials, fertilizers, chemicals, paper, petroleum products, and some metals for the domestic market). To justify the projected large capital investments in the expansion of Egypt's electricity generating facilities between now and the year 2000, a vigorous expansion of electricity consuming industries must take place at the same time.

The following industrial development scenario has been described by individuals within the Ministry of Industry:

- Iron and steel: eight-fold expansion of blast furnace and direct reduction capacity by the year 2000;
- Doubling of aluminum production by the year 2000;
- Nine-fold expansion of cement production by the year 2000;
- Construction of a new petrochemicals complex by 1981 and subsequent development of a new petrochemical industry;
- Increase in fertilizer production;
- Expansion of textile industry;
- Expansion and modernization of food processing industry;
- Expansion of educational facilities of all kinds; and
- Modernization of agriculture including emphasis on agribusiness.

It is beyond the scope of this study to project and analyze in detail the total capital investment requirements through the year 2000 for the industrial sector. However, as a first approximation, empirical evidence indicates that capital investment needs of all industries which depend on electric power is about 6 to 7 times the capital required for the construction of electricity generating facilities.[8]

The total capital investments required through the year 2000 for the expansion of the electrical generation capacity described in the Comparison Case is projected by the ESPM to be LE 13.4 billion, (1978 LE). The electricty investment projection implies, based upon the six-fold assumption, total capital investment requirements through the year 2000 for the expansion of electricity consuming industries of LE 80.4 billion.

4.3.2 Transport: The Egyptian Five Year Plan, covering the period from 1978 to 1982, projects the following capital investment requirements for the transport sector.

Project	Capital Investment[9]
Roads:	
Construction	106.5
Vehicles and equipment	330.2
Railway	330.2
Waterways	78.8
Ocean Transport and Ports	153.3
Air Transport	180.0
Suez Canal	527.2
TOTAL	1,706.2

Unfortunately, transport plans for the years 1983 to 2000 are not available. Therefore, for purposes of comparison, it was necessary to generate an estimate of investment in those years by assuming that the annual transport investment implied by the Five Year Plan would continue through 2000. This results in an estimate of projected cumulative capital investment for transport through 2000 of 8.2 billion.

4.3.3 Telecommunications: The Five Year Plan projects capital investment requirements for telecommunications through 2000 of LE 730 billion[10] (1978 LE). Because similar estimates for 1983 to 2000 were not available,

---

8 Cross section statistics for various LDC's. This method was used, for instance, in the Egyptian Electrical Authority report for Senator Ribicoff in 1976.

9 World Bank, ARE, Vol. V, May 8, 1978, p. 22.

10 World Bank, ARE, Vol. V, May 8, 1978, p. 26.

it was assumed that the average investment shown in the Five Year Plan would continue through 2000. This results in projected cumulative capital investment in telecommunications through 2000 of LE 3.5 billion (1978 LE).

In summary, total projected cumulative capital investment for industry, transport, and telecommunications is LE 115.5 billion. It appears that this amount may exceed the capital investment planned for the entire economy through the year 2000.

4.4 Financing Sources For Energy Development

This section considers potential domestic and foreign sources of financing for Egypt's economic and energy development programs and the implications of Egypt's potential debt.

4.4.1 Potential sources of domestic financing: An increase in domestic investment is essential to the future growth of Egypt. Development has to be accompanied by a very substantial increase in domestic resource mobilization, which means a sharp increase in public savings given the present dominant role of the public sector in Egypt.

4.4.1.1 Public investment: Historically speaking, the savings-investment gap has widened enormously since the mid 1960's, largely because of the deterioration in the domestic savings effort. Thus, it is imperative that the restoration of balance between domestic resources and expenditures be given strong emphasis among the policy priorities for the coming decades. An improvement in the resource balance will require a wide range of measures, the more important ones of which have been listed below:

1. The tax system will have to be restructured so as to make it more flexible and responsive to the current realities of the economy.

2. The public sector enterprises will have to increase their savings, and hence their efficiency, by a substantial margin. To accomplish this task, the following steps should be considered: (1) reduce the large-scale over-staffing of enterprises and increase capacity utilization; (2) grant a greater measure of decentralization of decision-making to enterprise management; and (3) use the relative size of financial surpluses as an indicator of efficiency. This, in turn, will require a major review of price policy which has been arbitrarily fixed for several years. Such major review of price structures is a prime condition for improving the performance of the public sector.

3. Measures must be taken that will protect the public sector surplus for investment. This requires that surpluses generated in the public enterprises be earmarked for investment in the public sector and not be transferred to the "general resources" of the budget.

4. Expenditure limitations must be placed on subsidies. This, no doubt, is a sensitive issue and will have to be instituted gradually.

It should be noted that much of the future growth in revenues is predicated upon the realization of substantial increases in revenues from the petroleum sector and from an expanded Suez Canal. These revenues will accrue directly to the Government. It is very important, therefore, that a firm decision be made to earmark these funds for productive purposes.

The level of public savings will be closely related to the Government's growth strategy because the rate of growth of the economy will have a feedback effect on savings. Thus, a rapid growth strategy will tend to support itself through the generation of higher tax and other revenues. These could be translated into savings if Government consumption expenditures did not increase in like proportion.

Public sector long-term industrial investments are financed primarily by the Treasury and with internally generated funds. The commercial banks generally provide only working capital financing, although some investments in fixed assets are also financed with short-term loans that are rolled over.

The Development Industrial Bank (DIB) provides long-term financing for public sector projects, but the amounts are small in comparison to total investments and are generally for small reconstruction and expansion projects. When DIB does finance larger projects, it constitutes only a small portion of the total financing for the purpose of supplementing insufficient budgetary allocations and internally generated funds.

4.4.1.2 Private savings: The new economic strategy favored by the Egyptian authorities requires a considerable increase in the rate of savings. In this, the private sector has an important role to play.

Unfortunately, private savings are currently low for several reasons: (1) expectation of inflation, (2) the relatively low level of interest rates on available instruments, (3) lack of familiarity with existing savings instruments and their merits, and (4) lack of alternative, competing savings instruments.

To boost private savings, a number of measures are available to the Government: combat inflation, reduce taxes on interest income from savings, increase the availability and variety of financial instruments and, in concordance, financial institutions.

Institutional financing for industry has been provided in the past almost entirely by the banking sector. Of the non-banking institutions, only insurance companies have recently shown some interest in providing long-term financing of a few large industrial projects.

The two stock exchanges in Egypt, one in Cairo and the other in Alexandria, have not been contributing to the mobilization of equity and debt capital. No new securities have been issued for the last 20 years. The exchanges have about 43 listed securities with a total market value of about $23 million, of which bonds represent 60 percent (mainly four Government issues) and stocks 40 percent, (mainly issues of mixed public/private companies).

The Egyptian banking sector continues to be dominated by the four public sector commercial banks: Misr Bank, Banque due Caire, National Bank, and Bank of Alexandria, all wholly owned by the Central Bank of Egypt. The Government's "open door" policy in recent years has led to the establishment of a large number of new financial institutions, such as joint venture banks, foreign branches, and offshore institutions, most of which are only gradually initiating operations.

For private sector investments, the main source of long-term investment funds is DIB, for both local currency and foreign currency denominated loans. Limited term lending for investment projects has also been undertaken by Chase Manhattan Bank and Barclays Bank of Cairo. Among the local commercial banks, only Bank Misr plans to finance a few large industrial investments, particularly in textiles.

Other financial institutions have shown some interest in consortium financing with DIB or other institutions of large industrial and tourism projects. These financial institutions include insurance companies, local joint venture banks, and off-shore banks. Aggregate data quantifying industrial investment financing are not available since they are not compiled in Egypt.

4.4.2 Foreign sources of financing: The major sources of funds from the United States are U.S. government grants, U.S. AID loans, Ex- and Import Bank loans, private financial institutions (especially commercial banks and insurance companies) and joint venture participations.

The Ex- and Import Bank extend loans having maturities from 7 to 15 years. Interest charges range from a minimum of 5-3/4 percent per year depending on the length of the loan and other factors, such as risk involved, size of the loan, maturity, etc. When large sums of money are involved, the Ex- and Import Bank will ask U.S. commercial banks or other financial institutions to join in a so-called "participation loan."

Most loans from Western Europe, Japan, and other non-Arab countries outside of the U.S., tend to be in the form of "economic development assistance" credits or short-term, intermediate term, and long-term loans from commercial banks, insurance companies, other private financial institutions and government-to-government loans. Joint venture capital is also becoming available in increasing amounts.

Western economic assistance and aid from Iran, Japan and international organizations reached significant proportions in 1975 and 1976.

Additionally, these commitments led to the creation of a substantial aid pipeline for potential use in future years.

Although the resources that the World Bank and its affiliate, the International Development Association, can devote to assist the economic development of Egypt are limited, the World Bank has committed funds to assist in the financing of Egypt's rural electrification and other programs and can be counted upon as a source for limited long-term funds in the future. Table G.7 illustrates the magnitude of these non-Arab sources of foreign funds.

Arab financial aid has been a regular feature of the Egyptian economic scene ever since 1967 when Egypt received grants to compensate for the loss of the Suez Canal revenues. The October War of 1973 led to a massive acceleration in Arab grant assistance to Egypt. As can be seen from Table G.8 the bulk of these grants was provided by Saudi Arabia, Kuwait and the United Arab Emirates (UAE).

Possible other sources of long-term funds would be the following Arab financial institutions:

- Abu Dhabi Fund for Arab Economic Development;
- Saudi Fund for Development;
- Iraqi Fund for External Development;
- Arab Fund for Social and Economic Development;
- Arab Monetary Fund; and
- Inter-Arab Investment Guarantee Corporation.

4.5 Interest Rates

Since Egypt, in its drive toward rapid economic development, will be dependent on numerous domestic and foreign sources of funds, interest rates payable on capital borrowed will vary considerably depending upon source, risk, the time to maturity, the size of the loan, supply and demand factors, and the existing or projected economic, political, and social stability or instability of the country at the time the loan decision is made.

Of course, outright grants will neither require the payment of interest nor repayment of princpal. However, the total amount of grants that Egypt realistically expects to obtain will be small in relation to the total amount of funds needed for the projected development program through the year 2000.

Loans extended by international organizations can be expected to carry the lowest interest rate. For example, IDA loans tend to be long-term, up to 50 years, without any interest payment whatsoever.

TABLE G.7

MEDIUM AND LONG-TERM LOAN COMMITMENTS TO EGYPT[11]
(In Million of Dollars)

Source	1975	1976
World Bank	77.0	157.0
IDA	55.0	40.0
United States	401.0	694.0
Denmark	—	6.6
France	81.4	113.0
West Germany	99.8	91.4
Netherlands	4.4	17.4
Japan	178.6	39.2
Iran	320.0	--
TOTAL	1,217.2	1,158.6

[11] Source: World Bank, ARE, Vol. IV, May 8, 1978, p.50

TABLE G.8

GRANT ASSISTANCE PROVIDED BY ARAB COUNTRIES TO EGYPT[12]
(In Millions of Dollars)

Country	1973	1974	1975	1976	Total
Saudi	353	572	272	277	1,657
Kuwait	202	288	406	69	965
UAE	--	103	77	150	330
Qatar	--	24	64	25	113
Other Arab Countries	--	277	25	4	306
TOTAL	555	1,264	945	625	3,389

12 World Bank, ARE, Vol. IV, May 8, 1978, p.50.

Unfortunately, the amounts available are severely limited. The World Bank, generally speaking, charges interest rates about equal to the rate which it itself would have to pay in the capital market at the time the loan is made. Other low-interest loans can be expected from U.S. AID, non-Arab foreign economic assistance organizations (usually government directed), the U.S. Ex- and Import Bank, and various Arab financial organizations.

Nothing definite can be said about the interest policy of private lending institutions in Western Europe, Japan, and the United States, other than that interest rates, on the average, will be on the high side and are likely to contain escalator clauses (based on the interbank London rate or some other indicator) in order to protect lenders from potential losses that might arise from upward movements in the price level.

The foremost concern of private lending institutions is to make certain, to the extent possible, that the borrower is able to pay interest as agreed and repay the principal at maturity. Therefore, private financial institutions as well as organizations such as the World Bank and the U.S. Ex- and Import Bank will carefully investigate the credit worthiness of potential borrowers before making any firm commitments.

Thus, it is next to impossible to quantify here the interest payments Egypt would have to meet on its various projected debt obligations. Under present circumstances, private financial institutions such as commercial banks and insurance companies would probably charge from 8-1/2 to 9-1/2 percent per annum, with escalator clauses built in. Of course, these interest rates would be lowered if Egypt were able to obtain loan guarantees from such organizations as the Arab Monetary Fund, the Inter-Arab Investment Guarantee Corporation, etc. As previously discussed above, the U.S. Ex- and Import Bank extends loans having maturities from 7-15 years, with interest rates ranging from a minimum of 7-3/4 percent to a maximum of 9-1/4 percent. Funds from Arab financing sources tend to be low-interest loans (probably 5 to 7 percent per year) with long-term maturities.

4.6 Loan Maturities, Debt Amortization, and Grace Periods

The size of loans, schedules for the repayment of principal, the length to maturity, and grace periods during construction of the projects in question will vary from institution to institution, depending upon the credit policies of the particular lending source and external factors.

As regards length to maturity, the more uncertain lenders are about the future, the less willing they will be to commit funds on a long-term basis, unless ironclad guarantees can be obtained along with interest escalator clauses and other protective covenants guaranteeing a reasonable return.

Since, generally speaking, interest payments should be paid out of internally generated funds of the public sector or private sector enterprises in question, it is important that Egypt negotiate terms that will postpone payment of interest until the project is completed and in operation. With rare exceptions, grace periods granted during construction do not imply overall lower interest payments. They merely give the enterprises in question the opportunity to defer payment until operations commence and revenues are realized. Since most lenders will not make funds available for free, borrowers will have to pay for the privilege of postponed interest payments with higher charges in later years.

Although not exact, the following schedule (Table G.9) may serve as a rough guide in identifying lending sources and the amounts, expressed in percentages, that they may be willing to extend. The schedule assumes that of Egypt's total capital investment requirements, 80 percent will consist of "imported" or hard-currency loans and 20 percent of Egyptian-pound-denominated funds.

The mobilization of financial resources, both external and domestic, is one of the most important areas on which economic strategy will have to focus and fundamental choices be made. The question is not only whether external funds will be available at the required levels, but will they be available on terms that will not exacerbate the debt problem. Would a slower growth strategy, which required a smaller inflow of foreign savings, be preferable to a high-growth, high-aid option? What would be the costs of the slow-growth strategy in terms of income and employment foregone? Even if the external funds are available, can the complementary domestic resources be mobilized in a non-inflationary manner and without adversely affecting income distribution?

The ultimate choices will have to be made by the Egyptian authorities, and there is no compelling reason for their decisions to be in agreement on all points with the views of external donors or lenders.

4.7 Implications on Egypt's Potential Debt From Energy Development

Two major facts stand out concerning Egypt's finances: first, for nearly three decades the country has been a war economy. Second, Egypt has represented the largest-scale experiment in "Arab socialism" since the 1960's, when the National Charter declared Arab socialism to be the basis of the country's economic system.

No doubt, past events have had a profound effect on the country's finances. The reform of the "State Budget" in 1962/63 created two new mechanisms: the Services Budget and the Business Budget. The latter included the current and capital transactions of all "Public Authorities and Organizations."

The creation of the Business Budget meant that henceforth the Government had to carry the burden of investment decisions, which were national in scope and included the procurement of foreign capital. It

TABLE G.9

SUMMARY OF POTENTIAL SOURCES OF FUNDS TO MEET REQUIRED CAPITAL INVESTMENTS[13]

Source	Percentage
Domestic Sources:	
Public sector enterprises (internally generated funds)	10%
Private sector enterprises (internally generated funds)	4
Egyptian Government loans	4
Egyptian Government grants	2
Total Domestic sources	20%
Foreign Sources:	
World Bank and IDA	5
U.S. / U.S. Ex- and Import	10
U.S. Private financial institutions	15
Official foreign sources other than U.S. (Western Europe, Japan)	5
Private foreign sources other than U.S. (Western Europe, Japan)	15
Joint venture capital	10
Arab sources of funds	20
Total Foreign sources	80%
GRAND TOTAL	100%

13 Author's estimates, based on assumption that public sector enterprises will generate savings, foreign governments will be willing to make available grants and loans, and private financial institutions will be able and willing to extend funds, etc.

is the latter aspect that is of special interest here since the amounts of medium and long-term external financing received in recent years have substantially increased Egypt's foreign indebtedness.

To wit, Egypt's non-military medium and long-term debt outstanding and disbursed as of December 31, 1976, amounted to $5,858 million, or almost twice the sum of $3,175 million outstanding at the end of 1975. The major creditors were Saudi Arabia and Kuwait, followed by the United States, the U.S.S.R., and West Germany.

Service on medium and long-term debt, i.e., payment of interest and repayment of principal due, amounted to $897 million in 1976, giving a debt service ratio of 15.3 percent. These figures do not include East-bloc military debt, on which Egypt is reportedly trying to obtain a rescheduling of service payments.

4.7.1 The role of domestic financial institutions: At present, all financial institutions are Government controlled. Egyptian commercial banks offer the usual spectrum of deposit facilities, as do certain of the specialized banks and the post office savings system. In addition, government banks, banks of previously nationalized companies, and some stock of private companies are also available, but in limited amounts. Well developed money and capital markets do not exist. The nationalized banking system is left with the role of providing short-term credit at rates that are not related to the international cost of money.

What can be done to channel savings in a more efficient manner to the users of funds? Adding savings deposits linked to housing mortgages and mortgage bonds would be a desirable addition to the existing spectrum. Commercial bank certificates of deposit and private and public sector enterprise commercial paper could also be offered as additional instruments, thus assuring a better utilization of short-term savings. In practice, not all of these instruments could be introduced at once as it will take time to educate the public and to gain the confidence of market participants.

While it is up to the Government to establish the broad policy which builds a positive attitude toward savings and the utilization of money and capital market institutions, it is the financial institutions that must undertake the effort of marketing savings instruments. What is more, the existence of a wide range of financial institutions, such as commercial banks, thrift institutions, mortgage banks, insurance companies, pension funds, etc., would increase the public's awareness of savings opportunities available and serve as an inducement to save, provided the return is equal to yields realizable on competing instruments of similar risk.

4.7.2 Egypt's ability to service its external debt: The "open door" policy enunciated by President Sadat after the October War in 1973, was aimed specifically at attracting Arab and Western capital, both government and private, for investment in a country that was becoming increasingly liberal and market oriented. Efforts were made to institutionalize this foreign assistance. In April 1976, the Gulf Organization for the Development of Egypt (GODE) was formed, comprising Saudi Arabia, Kuwait, Qatar and the United Arab Emirates. Also in April 1976, the Consultative Group for Egypt was established under the chairmanship of the World Bank, consisting of Arab and OECD countries and international and bilateral institutions.

The institutionalization of foreign assistance through the creation of GODE and the Consultative Group for Egypt led to substantial results in 1977. GODE committed $1,725 million directly to Egypt. In addition, it guaranteed a $250 million loan by a consortium of international banks led by the Chase Manhattan Bank.

The Consultative Group for Egypt pledged commitments for $2,080 million in 1977; i.e., United States $900 million, World Bank/IDA $370 million, IMF $150 million, France $115 million, West Germany $111 million, United Kingdom $73 million, and other commitments totalling $361 million. This, together with Arab grant payments and suppliers' credit enabled Egypt to meet its 1977 deficit on goods and services, service its long-term external debt and also significantly reduce its short-term foreign obligations.

Substantial aid inflows are also anticipated in the future. Egyptian policy makers realize, however, that aid of this magnitude is unlikely to continue indefinitely. Thus, they are making efforts to strengthen Egypt's export potential and put the country on the path to self-sufficiency in its external relations with the world.

4.7.3 Balance of payments projections for Egypt: In order to evaluate possible balance of payments prospects and identify critical growth sectors, a balance of payments scenario which should be regarded as being essentially illustrative is presented in Table G.10. The data are based on the World Bank's minimum standard model.

In this illustration, commodity export prospects center on the performance of the petroleum sector. While the bulk of petroleum production and exports in the earlier years is expected to come from existing oil fields, Egypt's medium-term prospects are dependent upon expected new discoveries. The projections assume that 75 percent of these new discoveries will be realized, which means that the target date of production of 1 million barrels of oil per day will not be reached until 1982.

On the payments side, import elasticity has been projected to be slightly higher than unity. Wheat and flour imports are expected to increase by about 3 percent per annum (slightly above the rate of population growth of about 2.5 percent per annum); other agricultural commodities by 3.5 percent per year; intermediate goods by 9 percent annually; capital goods by 10 percent per annum; other manufactured goods by 5 percent yearly; and non-factor services by 5 percent annually.

TABLE G.10

EGYPT

BALANCE OF PAYMENTS PROJECTIONS FOR THE YEAR 1986[14]
(In Millions of U.S. Dollars)

	Projected 1986 (In 1986 Prices)
TRADE BALANCE	- 9,280
Exports, f.o.b.	10,620
Cotton	1,120
Yarn and textiles	1,030
Petroleum	5,560
Other	2,910
Imports, c.i.f.	-19,000
Food	- 3,500
Intermediate goods	- 8,715
Machinery and equipment	- 4,365
Other	- 3,320
NON-FACTOR SERVICES, NET	- 3,700
Receipts	- 5,800
Suez Canal	- 1,275
Travel	2,800
Payments	- 2,100
FACTOR SERVICES, NET	3,350
Receipts	4,850
Workers' remittances	4,650
Other	200
Payments	- 1,500
Interest on short-term debt	- 174
Interest of intermediate and long-term debt	- 1,326
BALANCE	- 2,230
AMORTIZATION OF INTERMEDIATE AND LONG-TERM DEBT	- 2,280
FOREIGN EXCHANGE REQUIREMENTS	- 4,510

---

14 World Bank, ARE, Vol. IV, May 8, 1978, p.57.

4.7.4 Requirements for the future: The balance of payment projections reveal the vulnerability of Egypt's external finances, particularly the trade accounts, over the medium term. If the trade sector (including petroleum) falters, either imports would have to be severely constrained (with corresponding effects on growth of national income) or aid inflows stepped up considerably. It is thus urgent to orient the economy toward a greater volume of exports.

Because exports are vitally affected by many different factors in the economy (national production, consumption patterns, investment policies, factor productivity, marketing and so forth), an export promotion program would have to be comprehensive and include exchange rate and tariff adjustments. Consideration should be given to the export potential offered by the Arab Common Market as well as other markets of the East and West. Elements that could constitute such a policy are the following:

1. Maximization of growth of national production, control over consumption, and creation of exportable surplus would have to form the basis of any successful export growth program. In the short run, this involves efficient utilization of existing capacity; over the medium and long term, it depends on the quality of the investment program. Appropriate fiscal and monetary policies would also have to be adopted to set limits on consumption and to encourage investment.

2. Decontrol of prices in the economy, exchange rate adjustment, and effective use of tariffs would be important as well as consideration of export subsidies and lower tax rates on export income, especially for import industries.

3. Maximization of foreign exchange receipts from the services sector should also be actively pursued. The Suez Canal is now being expanded to allow the passage of ships with 53-foot drafts by 1981 at a cost of $1 billion. Upon completion, and assuming world shipping conditions justify it, a minimum increase in the rate structure of some 10 percent should be seriously considered at that time.

4. The growth of workers' remittances could be further encouraged by systematic manpower training to meet the specific needs of the Arab countries.

5. The tourism industry is another sector that should be given immediate attention. Besides its archeological sites, Egypt has many natural assets: the Nile, the desert, the beaches along the Meditteranean coast, and its good climate, which makes most of Egypt conducive to year-round tourism.

Other elements of policy that should contribute to an increase in Egypt's exports are, preferential lending terms for export credit and for investments in export industries, promotional and marketing programs to exploit international market opportunities, and a systematic study of the products in which Egypt now has a comparative advantage or, with some assistance and corrections, could have in the future.

4.7.5 The need for changing the structure of energy prices: Presently, the Egyptian Electricity Authority (EEA) purchases its residual fuel oil (and natural gas) from domestic refineries, not at the export value of the fuel oil of about $70 per metric ton, but at a subsidized price of LE 7.50 per ton (or heat value equivalent for gas). This is equivalent to only $11.00 per ton at the existing exchange rate of $1 = LE 0.70.

If EEA were required to pay the real international price for its oil consumption, the existing tariff structure would have to be increased sharply. While presently all consumer sectors are being charged rates below the marginal cost of producing and delivering electricity, the lowest rates and greatest disparities exist in the industrial sector.

In order to increase EEA's borrowing potential, especially hard-currency loans, EEA should set system-wide tariffs (with the exception of the rural and household sectors which account for some 24 percent of total demand) sufficient to produce a reasonable return on average net fixed assets in operation. EEA's financial forecasts show that it could achieve a 9 percent rate of return on average net fixed assets if it increased electricity tariffs by about 50 percent above present levels. While this is not likely to happen soon, the industrial sector should be prepared to accept a 25 percent rise almost immediately, thus enabling EEA to realize a return on average net fixed assets of between 3 and 4 percent. Such results would go a long way to favorably affect EEA's credit rating, make international loans much easier to obtain, and allow EEA to finance part of its expansion program out of current earnings.

More important, however, for the national economy, is that if EEA and the industrial sector are required to pay a price for energy equivalent to its opportunity cost (i.e., international price), then energy resources will be allocated to those uses which are most productive. Previously, artificial prices for energy have encouraged the development of energy intensive industries such as aluminum processing, fertilizer by electrolysis and now, petrochemicals. However, the economy would have profited much more if, for example, oil would have been exported at the international price.

4.7.6 Management of the external debt: In the short run, financial management involves the continued need to retire maturing short-term and long-term debt obligations and to pay interest on the existing debt.

Over the longer term, financing the development needs of the Egyptian economy requires sustained external financing. As studies on capital investment requirements for the expansion of the Egyptian economy through the year 2000 indicate, debt procurement and debt servicing will reach significant proportions in the 1980's and 1990's.

In operational terms, effective management of external finances will increasingly require sophisticated debt management policies (including control, reporting and analysis) and continued mobilization of external sources of funds for viable development needs. The former will involve the strengthening of the debt management unit of the Central Bank of Egypt and the latter sound mechanisms for planning and investmment appraisal. Ultimately, Egypt's external finances will depend upon the kind of economic policies it adopts over the next decade and its success in developing a strong and viable economy.

5.0 INSTITUTIONAL INFRASTRUCTURE CONSIDERATIONS

It has been also considered important to identify the numerous institutional, social and economic factors that may affect the practicability of implementing the proposed energy developments. The basic questions which were addressed included:

- How are energy development programs planned and implemented through Government structures and practices?
- What institutional, social and management factors are relevant to the evaluation of energy development programs?
- What is the probable impact of such factors on the practicability of developing specific energy resources?

The following sections are organized to address the above questions. Obviously, much more in-depth analysis will be required as part of those necessary planning evaluations before commitments are made to specific energy resource development programs.

5.1 Management and Institutional Factors

Despite the policy of "libration" initiated by President Sadat in early 1974, prospects for economic development still depend very largely on governmental and public sector actions. The primary instrument for this development in the medium term is the Five Year Plan (1978-82). This plan has not yet, however, been fully developed and consists largely of an amalgam of proposals for specific development projects from the various ministries. The Ministry of Planning is not yet in a position to thoroughly evaluate the projects submitted to it, nor does it have sufficient authority to enforce priorities among these projects to promote balanced development which can be implemented effectively by the government. An official of the Ministry of Planning cited in a recent study (GAO Report to the Comptroller General of the U.S., September, 1977), "Egypt's ongoing projects committed more local resources than were available and priorities based on international committments have reached a level beyond Egypt's capacity to fulfill."

Responsibility of economic development is divided among a large number of ministries, each of which aggresively promotes its own projects, often with little apparent coordination with other affected government agencies. As a result, development priorities are set by the individual ministries on the basis of their own criteria and objectives and these may not coincide. The Ministry of Finance has some budgetary control over implementation of these plans, but its control is exercised mainly through negotiation with the ministries. Energy development planning is undertaken primarily by the Ministry of Electricity and Energy, and the Ministry of Industry, Petroleum and Mining. These two ministries are operated from different viewpoints and the objectives of each sometimes appear to be at cross purposes. The Government recognizes these problems and is taking measures to alleviate them, but much remains to be done to promote effective development planning.

Partly as a result of these difficulties, prospective foreign donors of development assistance have found insufficient well-conceived and planned projects to permit effective aid. Observers have noted that donors often compete for ready assistance projects, a practice which could exacerbate the imbalance in development. The Consultative Group of donors has met twice in 1977 and 1978 to consider overall development objectives and requirements, and to better coordinate their efforts to assist in Egypt's development.

Another factor that affects Egypt's development potential is the generally recognized inefficiency of many of the public sector institutions. Most industrial plants are operating well below capacity. Government policy guaranteeing employment for all graduates of universities and higher technical schools has led to serious over-staffing both in Government offices and in public sector companies. Observers have placed the excess staff in some extreme instances at times that required efficient operation. These practices not only sharply and unnecessarily increase production costs, but make more difficult the improvement of operating efficiency and quality control.

Efficiency in the public sector is also undermined by the lack of adequate profit incentives. The Government policy of administratively establishing prices for products and services, at levels not necessarily equal to marginal costs, means that public sector enterprises lack the information required for them to allocate resources efficiently. Also, their incentives to do so are poor since their deficits are covered out of the Government budget and any profits are moved into the general budget. The relatively low wages paid to managers, high-level engineers and technicians in public sector firms also has disincentive effects.

Many of the better managers and skilled workers have moved into the private sector or have accepted employment with foreign firms inside and outside the country. The resulting shortage in managerial and technical skills is a serious impediment to development.

5.2 Infrastructural Factors

An adequate and well-operating transportation and telecommunications network, public utilities system and construction industry are essential bases for development. Although the infrastructures for such services have long been established, their underdevelopment for current needs and their generally poor condition are major stumbling blocks to Egypt's planned growth, creating imbalances in the development of the productive sectors. Severe shortages in construction materials and labor make it difficult for Egypt to absorb foreign assistance available for development. Problems in transportation and telecommunications tend to discourage potential foreign private investors. The Government is fully aware of these deficiencies and is attempting to overcome them. It has allocated about 50 percent of all public investments in the Five Year Plan to the various infrastructure subsectors, including 27 percent for transportation and communications, 8 percent for construction and housing, 9 percent for electric power network development and over 6 percent for other utilities.

5.2.1 Transportation: Despite Egypt's post 1973 acceleration in investments, serious capacity limitations characterize its port facilities, railways and inland water transportation system. The road transport system is not seriously deficient, however, and has experienced rapid growth during the last decade.

Roads are the main mode of transport, and in 1975 they carried more than 80 percent of total freight tonnage and around 75 percent of passenger kilometers. There are about 27,000 kilometers of roads in the country, about 12,000 kilometers of which are paved.

Road projects under construction amount to about 2,810 kilometers. This, however, includes construction, resurfacing, widening, doubling and such minor improvements as shoulder paving. New construction alone amounts to only 1,700 kilometers or 60 percent of the total. Total traffic on Egypt's roads is expected to rise 13 percent annually through 1980 and at a rate of 8 percent between 1980 and 1985. The volume of freight movement on roads is projected to increase to 67 million tons per year by 1980 and 75 million tons annually by 1985.

The Government-supervised railroad system covers over 3,900 kilometers of standard-gauge track connecting all major urban areas in the Delta and extending from Cairo to Aswan and along the Mediterranean coast. Because of the poor condition of much of the trackage, the shortage of serviceable locomotives and the deterioration of rolling stock, railroad transport has become increasingly unreliable and slow, causing many shippers to switch from rail to other modes of transportation. As a result, railroad freight traffic has declined steadily; it dropped by 31 percent between 1970 and 1975.

Egypt has only one major port, Alexandria, at the western corner of the Nile Delta on the Mediterranean Sea. The other ports of any significance are Port Said at the Mediterranean end of the Suez Canal, Suez at the Red Sea end, and Safaga on the Red Sea. Alexandria's port capacity has been deficient since 1969, and the port has been suffering from serious congestion with average waiting time for general cargo ships increasing from 3.3 days in 1974 to 6.2 days in 1975. Causes of congestion are poor equipment, blockage of access ways by stored cargo, inadequate dock transport, and insufficiently trained manpower. Based on the economic prospects of the Egyptian economy, port traffic forecasts over the coming decade show a considerable increase in annual growth, 7.7 percent from 1975 to 1985.

The structure of tariffs in the various transport subsectors follows the general pattern of underpricing of public goods and services. Prime examples are the railway and road tariffs. The railway freight tariffs have not changed since 1957, while passenger tariffs were last raised in 1967. Combined with decreasing freight traffic, they largely account for the 1977 operating railways deficit of LE 22 million.

Similarly, the road user charges bear no relation to the cost of road construction. The charges are arbitrarily determined by the Government. Admittedly, the break from this pattern of underpricing of transport services can only be gradual, but a recognition of the need to bring about policy changes that would permit increases in tariffs based on construction, maintenance, and operating costs is essential.

<u>5.2.2 Telecommunications</u>: Egypt has a density of 1.34 telephones per 100 population, significantly lower than other Middle East countries. There is a registered waiting list for phone service of 268,000; undoubtedly thousands more would-be customers of the state-owned telephone service are not registered. Service is totally inadequate with frustrating delays in completing calls even within the same city. The Government is trying to overcome the shortages and inadequacy in service, but years of low investment levels have made the upgrading of the system to required levels very expensive.

Egypt's tourism potential, its proximity to the European market, availability of relatively skilled population, low wages, varied raw materials, and its key geographical location in the Mid East, combine to make it a natural base for industries that wish to supply the growing domestic and regional markets. Egypt's inadequate telecommunications system is a significant constraint on the development process to effectively take advantage of these inherent advantages. The single most important factor that has impeded progress in the telecommunication sector has been the lack of adequate investment capital. As with all government boards in Egypt, the Arab Republic of Egypt Telephone Organization (ARETO) must turn over to the Ministry of Finance any operating surplus in lieu of dividends, and the Ministry of Finance, in turn, provides ARETO with budgetary funds for capital investment. As a result, ARETO's investment programs and works have mainly been dictated by the availability of funds, and these have been far from adequate. Compounding this is the fact that ARETO's tariffs have not been changed since 1966 despite domestic price inflation.

5.2.3 Construction: One of the most serious constraints to development stems from the problems facing the construction industry. Most public sector construction projects are undertaken by the ten public-sector construction companies under the Ministry of Housing and Reconstruction. Given access to construction materials on a timely basis and adequate funding these companies have shown themselves capable of successfully undertaking very large-scale projects. For example, the reconstruction of three cities of the Suez Canal Region was substantially completed in a three-year period and the Aswan High Dam was built largely with Egyptian construction workers. However, the steep and continuing rise in materials and labor costs, (which increased over 500 percent in the past 15 years), and the severe shortages being experienced in both materials and labor, create serious problems for the construction of new projects.

Many projects take an inordinate amount of time to complete with the result that millions of pounds in assets are tied up in non-productive incomplete projects. The Government has placed the highest priority on completing the 27 percent of current projects that are more than half completed, and has allotted for this purpose LE 938 milion to a total of LE 3,150 million allocated under the Five Year Plan for industrial projects. To help resolve the problem of the shortage of skilled construction workers, the government has allocated LE 20 million under the Five Year Plan for the establishment of 65 training centers to train 60,000 workers per year.

In summary, much of the problem the Government faces in maintaining an adequate infrastructure stems from chronically low investments resulting in part from its inability to cover operating costs due to its policy of subsidizing all transportation, telecommunications, utilities and construction services. Consideration is being given to changing this policy and establishing rate structures based more fully on marginal costs, but great care will have to be taken to minimize the disruptive effect any sudden large-scale change in rate could have on the economy.

5.3 Resource Mobilization

One of the most important factors determining development potential is the ability of the Government to mobilize external and domestic resources to fund development plans. The rapid development of Egypt during the 1955-1965 decade was made possible in large part by the mobilization of resources through such policies as the nationalization of banks and insurance companies, particularly of the Bank Misr group, the "Egyptianizing" of the economy through the nationalization of British and French assets and all foreign banks and commercial agencies, and the expropriation of the private ownership in most large, privately owned firms. These moves were not without cost, however, foreign investment declined sharply, the newly created public sector proved difficult to manage efficiently, and as part of the socialist philosophy reflected in the Government's increasing intervention in the economy, it also assumed very heavy responsibilities for the social welfare of the population.

The disastrous effects of the 1967 war, coupled with the deterioration in Egypt's terms of trade, caused a serious slowdown in development in this policy, but, to the present, it has had only limited success in overcoming the institutional and infrastructural problems discussed above or in promoting adequate resource mobilization.

The Egyptian Government still suffers large and growing budgetary deficits, which it is forced to cover primarily by external assistance and domestic borrowing. Although the Government has tried hard to reduce these deficits, expenditures in defense, Government services and subsidies continue to represent an usually large percentage of GNP for a developing country, and make public savings for investment difficult. Public savings dropped from 12.5 percent of GNP in 1970-1971 to less than one percent in 1975. It increased to 5.8 percent in 1976, but remains far below the level considered essential to fund the development projected by the Government. Private sector savings also remain at too low a level in view of the new economic strategy, and are not being encouraged either by Government financial policies or by the character and practices of the financial institutions.

The high level of private consumption also impacts negatively on the savings ratio, in addition to the continuing high levels of Government and public sector consumption indicated above. Private consumption has been particularly high since the introduction of the liberalization policy and is largely uncontrolled. Foreign exchange earned by Egyptians working abroad is not taxed and is permitted to flow out of the country again through the policy of the "own" exchange facility. Much of this is used for the import of consumer durables and luxury consumer non-durables, and almost none is used to invest in raw materials or equipment needed for production.

Together with sharply increasing amounts of medium and long-term financial assistance received in recent years from foreign donors, the large trade imbalance, particularly striking since 1974, has added substantially to Egypt's foreign debt. At the end of 1976, Egypt's non-military medium and long-term foreign debt amounted to $5.8 billion, an increase of almost $2.7 billion since the end of 1975. This has forced the Government to spend almost $900 million on debt service, or about 18 percent of GNP.

Low productivity and high consumption levels have created serious inflationary pressures. At official prices, inflation has been recognized to exceed 10 percent per year. Indications exist that inflation for some commodities is running above 25 percent per year. Obviously, this reduces the propensity to save and further undermines the Government's ability to cover the domestic costs of development.

☆ U.S. GOVERNMENT PRINTING OFFICE : 1979 O—297-547

United States
Department of Energy
Washington, DC 20585

PENALTY FOR PRIVATE
USE TO AVOID PAYMENT
OF POSTAGE, $300

DOE 350

U.S.MAIL

Official Business
Penalty for Private Use, $300

THIRD CLASS MAIL