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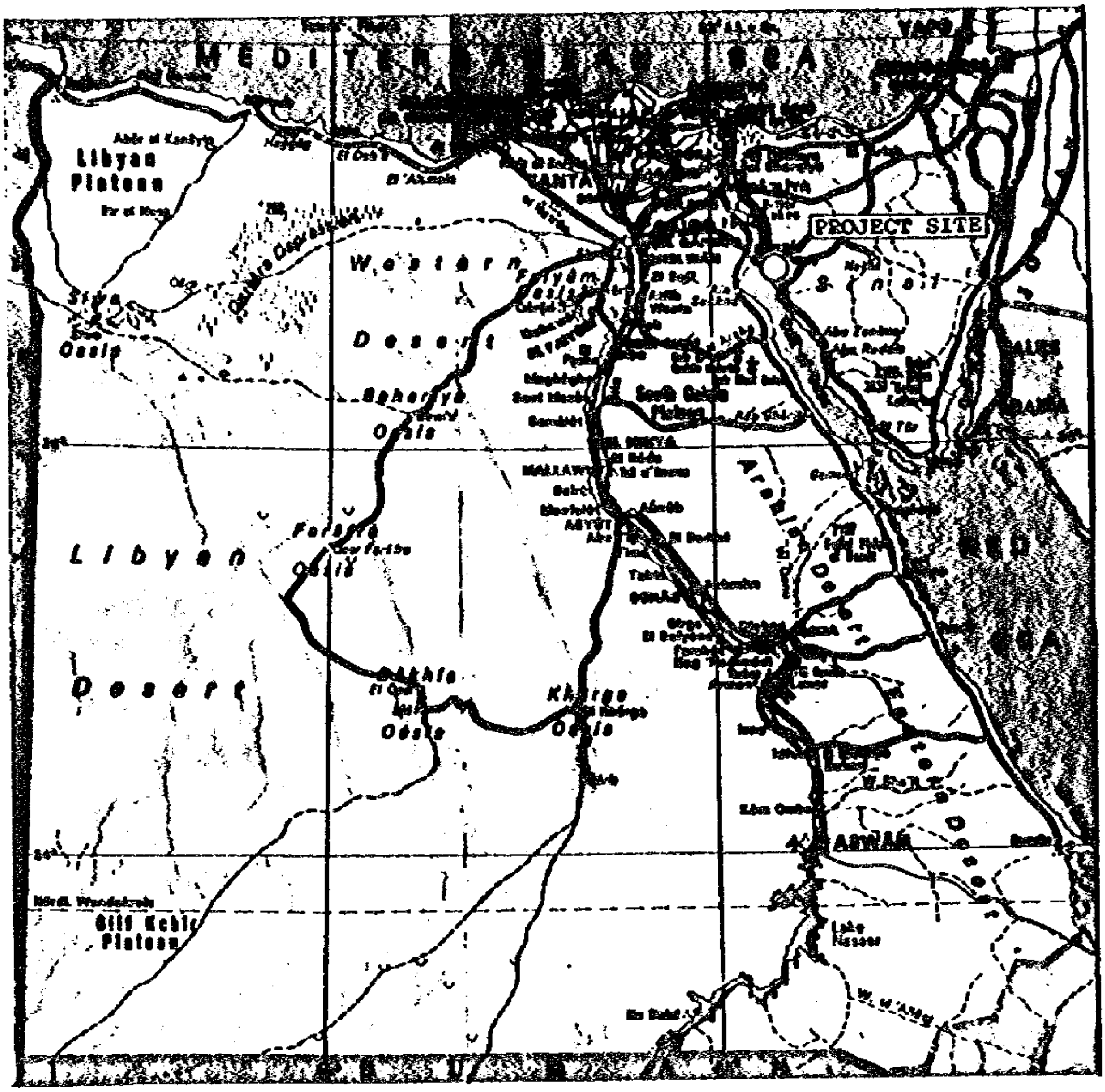
MEDITERRANEAN SEA
PROJECT SITE
Libyan Plateau
Siwa Oasis
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Libyan Desert
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Khârga Oasis
Gilf Kebir Plateau
ASYÛT
MALLAWI
ASWÂN
Lake Nasser
Arabian Desert
Sinai
RED SEA
South Galala Plateau
TANTA

CHAPTER 1

BACKGROUND AND OBJECTIVE OF FEASIBILITY STUDY

CHAPTER 1 BACKGROUND AND OBJECTIVE OF FEASIBILITY STUDY

1-1 BACKGROUND OF STUDY

The electric power in the Arab Republic of Egypt is represented by 2,445 MW of the Aswan High Dam completed in 1970 on the Nile and other hydro power plants and the 500 kV x 2 transmission line over 800 km to Cairo and vicinity.

Since the Aswan High Dam (175 MW x 12 units) was completed in 1970, Egypt has advanced its nationwide electrification program, and as a result, the electric power demand increased at a high annual rate of 12% until 1971 and at 15 - 18% in 1974 - 1977 years.

The peak power demand of the Egyptian Electricity Authority (EEA), the main body of electric utilities in the Ministry of Electricity and Energy, in 1982 was 3,900 MW and the generating capacity reached over 5,000 MW. It is anticipated that the electric power demand will increase at a rate of 12% annually in the next 5 years, and EEA plans to expand the installed capacity to approximately 8,800 MW by 1987.

As for the composition of the electric power sources, the supply capacity of the Aswan power stations is 47% of the total installed capacity of 5,132 MW in Egypt in 1982, 12 years after the Aswan High Dam was completed, and if there should occur a failure of Aswan power stations or a failure of the 500 kV transmission lines, the power supply in whole Egypt would be affected.

In this connection, EEA is now proceeding with the expansion of base-load thermal power plant for the purpose of stabilization of power supply.

Thermal power plants are also operated by use of heavy oil in Egypt, one of oil producing countries. On the other hand, oil export has contributed much to the domestic economy. And the annual increase rate of domestic oil demand for power generation, etc. marked 15 to 20%. Therefore, as for power generation substitute energy for petroleum has been emphasized and petroleum export has been promoted. The present project is along this policy, and the plant under this project is first coal-fired thermal power plant in Egypt, and this project will be very important one to contribute much to rehabilitation of Sinai Peninsula.

With this background, in December, 1981, the Egyptian Government filed with the Japanese Government the request for cooperation in the development of this project.

In response to this request, Japan International Cooperation Agency (JICA) carried out the preliminary investigation in March, 1982 and the preliminary survey in August, 1982. Then it conducted and the feasibility study from the period of January, 1983.

1-2 OBJECTIVE OF STUDY

With the foregoing background, the Japan International Cooperation Agency (JICA) has organized the Study Team to carry out the study requested by EEA of the Arab Republic of Egypt. The objective of this study is to conduct the field survey and formulate the optimum development plan and evaluate its technical, economic and financial feasibility, with respect to the large scale coal-fired thermal power plant (first phase: 600 MW) planned by EEA on the Suez Gulf Coast of Sinai Peninsula to utilize a part of coal from the Maghara Coal Field.

1-3 SURVEY AREAS

The survey was made in the proposed power plant site areas, coal unloading port areas, and the transmission line route and substation areas, and the electric power demand and power system survey was made all over Egypt.

1) Proposed Site for the Power Plant
   - Ayun Musa (Coast of Gulf of Suez on northern part of Sinai Peninsula)
   - Abu Zenima (Southern part of East coast of Gulf of Suez on west side of Sinai Peninsula)
   - Zafarana (Western coast of the Suez Gulf on Mainland Egypt)
2) Proposed Site for Coal Unloading Port and Facilities
   - Suez Gulf Coast in front of proposed power plant sites (Ayun Musa, Abu Zenima and Zafarana and the following sites)
   - Adabiya (Western coast of the Gulf of Suez and the Mainland Egypt)

   and/or

   El Galala (Gulf of Suez Coast on the Mainland Egypt)
3) Transmission line route and substation sites for interconnection with the existing ultra-high voltage power system.
4) Whole area of Egypt was covered with respect to the power demand and power system studies.

1-4 SCOPE OF STUDY

Field surveys including the geological survey were made at Ayun Musa, the power plant site, and the coal unloading port and transmission line route selected by comparative studies of the foregoing proposed sites, and the facilities planning, construction program, financing program were prepared.

And the final feasibility report covering the evaluation of feasibility of the Project from the technical, economic and financial stand points are submitted.

1-5 STUDY ITEMS

1-5-1 Main Study Items

The main items of study are as follows, and the study was carried out in two phases.

1) Phase I

The survey team was formed and the team visited Egypt to carry out the survey on the following basic items.

Main Item	Items to be Compiled
(1) Review and analysis of available data and information (2) Reconnaissance of proposed power plant and port sites and transmission line routes (3) Final decision of sites and routes (It was carried out in Phase II.)	°General conditions of Arab Republic of Egypt °General electric power situation °Power demand forecast °Necessity and size of power development °Decision on sites and routes °Preliminary design conditions °Conditions of construction cost estimate and construction program °Conditions and data for economic and financial studies

2) Phase II

Feasibility report is prepared based on the field survey and analysis of data as a result of the First Phase and on the basis of the following basic items.

The site survey of the most prospective Ayun Musa and final decision of sites and routes was made additionally in this Phase by the circumstances of the site.

Main Item	Items to be Compiled
(1) Preliminary design of power plant	Preliminary design
(2) Preliminary design of coal and other fuel storage facilities adjacent to power plant site	
(3) Preliminary design of coal unloading and transportation facilities	
(4) Preliminary design of ash and other waste handling system	
(5) Preliminary design of interconnection of transmission lines and substations to the National Grid	
(6) Utilization of by-products such as ash, heat and steam	Seawater desalination, cement, brick, road pavement and other by-product utilization plans
(7) Preparatory works and construction program for execution of the project	Construction Program of different project parts e.g. powerhouse, coal receiving harbor, coal storage, oil storage, desalination plant

(8) Economic and financial analysis of project	Economy and financing Cost of kW installed Cost of kWh generated Economic return of project Cost of Cu. m of desalted water, etc.
(9) Analysis and assessment of environmental impact	Environmental measures in design: E.P., stack height, coal sulphur countermeasure, etc.
(10) Recommendations	Conclusion and recommendation for project design and implementation

1-5-2 Field Surveys

1) First Field Survey

The First Field Survey was carried out by the team comprising the following members and field reconnaissance, collection of data and information and discussions with EEA were made according to the basic plans prepared prior to the departure from Japan.

Name	In Charge of	Survey Items
Tetsuya WACHI	Team Leader General	Collection and study of existing data and general analysis
Yutaka MATSUMOTO	Deputy Leader Power Supply & Demand and Power System	Collection and study of existing data and study of power supply & demand and power system

Name	In Charge of	Survey Items
Tetsuro KOBAYASHI	Economic Evaluation	Analysis of social and economic conditions, and analysis of financial conditions
Kanekazu ARAI	Power Plant Facilities	Collection and study of existing data and planning & design of coal unloading and coal handling facilities
Yoshiyuki BABA	Power Plant Facilities	Collection and study of existing data and planning & design of mechanical equipment
Masakazu NAKAMOTO	Power Plant Facilities	Collection and study of existing data and planning & design of electrical equipment
Shigenobu ITO	Fuel Procurement Planning	Collection and study of existing data and fuel procurement planning
Hideharu KANEDA	Civil Facilities	Collection and study of existing data, planning & design of harbor and civil facilities of power plant

Name	In Charge of	Survey Items
Masahiro YOKOGAWA	Harbor Planning	Collection and study of existing data and planning & design of harbor and civil facilities of power plant
Yukiro KOGA	Architectural Facilities	Collection and study of existing data and planning & design of powerhouse and appurtenant buildings of power plant
Masanao IWAKUMA	Transmission Lines and Substation Facilities	Collection and study of existing data and planning & design of transmission lines and substations
Kenji FUJII	Economic Evaluation	Analysis of social and economic conditions, and analysis of financial conditions

The survey periods were as follows.

Names	Departure	Survey Period	Return
Wachi	8 JAN 1983	9 JAN - 22 JAN	23 JAN 1983
	11 FEB 1983	12 FEB - 8 MAR	9 MAR 1983
Matsumoto	8 JAN 1983	9 JAN - 28 JAN	1 MAR 1983
Kobayashi	15 JAN 1983	16 JAN - 14 FEB	15 FEB 1983
Ito	15 JAN 1983	16 JAN - 14 FEB	15 FEB 1983
Yokogawa	15 JAN 1983	16 JAN - 14 FEB	15 FEB 1983
Fujii	15 JAN 1983	16 JAN - 14 FEB	15 FEB 1983
Arai	15 JAN 1983	16 JAN - 28 FEB	1 MAR 1983
Iwakuma	15 JAN 1983	16 JAN - 28 FEB	1 MAR 1983
Koga	15 JAN 1983	16 JAN - 28 FEB	1 MAR 1983
Kaneda	15 JAN 1983	16 JAN - 8 MAR	9 MAR 1983
Baba	8 JAN 1983	9 JAN - 8 MAR	9 MAR 1983
Nakamoto	8 JAN 1983	9 JAN - 8 MAR	9 MAR 1983

2) Second Field Survey

The second field survey team visited Egypt with the interim report compiled of the results of the first field survey, and discussed with EEA on the demand forecast, preliminary design conditions, construction cost estimate conditions and conditions for economic and financial analyses and carried out the field survey of North Ayun Musa Site, which had not been carried out at the time of the first field survey.

The members and period of the second field survey were as follows.

Name	In Charge of	Survey Period
Tetsuya WACHI	Team Leader General	24 MAY - 7 JUL 1983
Yutaka MATSUMOTO	Deputy Leader Power Supply & Demand and Power System	24 MAY - 7 JUL 1983
Tetsuro KOBAYASHI	Economic Evaluation	10 JUN - 24 JUN 1983
Hideharu KANEDA	Civil Facilities	24 MAY - 3 JUL 1983
Yoshiyuki BABA	Power Plant Facilities	8 JUN - 7 JUL 1983
Masahiro YOKOGAWA	Harbor Planning	24 MAY - 3 JUL 1983
Masakazu NAKAMOTO	Power Plant Facilities	24 MAY - 7 JUL 1983
Toshio FUJINO	Geological Survey	24 MAY - 26 JUN 1983

3) Counterparts

Both the first and the second survey teams were divided into 5 groups and worked with the following counterparts from EEA.

	EEA		JICA Team
General Coordination			
	Dr. Emad El Sharkawi		T. Wachi
	Project Coordinator		
	Dr. M. Serry		Y. Matsumoto
	Assit. Coordinator		
Group-1 Power Plant Equipment with Accessories			
	Eng. Said Essa	*1	K. Arai
	Eng. Saad El Din		Y. Baba
	Mr. Kamal Hassan		M. Nakamoto
	Dr. M. Serry		
	Eng. Hazim El Tanbouli		
	Chemist Salah Hanna		
	Eng. Mansour Mohamad		
Group-2 Civil/Architectural Works including Harbor Facilities			
	Eng. Hassan Zaki		T. Wachi
	Eng. Ahmed Abdel Halim		H. Kaneda
	Eng. Adel Abdullah		M. Yokogawa
	Eng. Salah El Shirbini	*1	Y. Koga
		*2	T. Fujino
Group-3 Fuel Planning			
	Chemist Salah Hanna	*1	K. Arai
	Eng. Gamil Abdel Kader		Y. Baba
	Eng. Zenab Abdel Azim	*1	S. Ito
	Dr. Ahmed Ghorab		M. Nakamoto
	Eng. Fathy Zahran		
	Eng. Nasr Waheeb		

EEA	JICA Team
Group-4 T/L, S/S and Power Demand Forecast and Development Plan	
Dr. Mahmed Hegazi	T. Wachi
Eng. Adawi Emira	Y. Matsumoto
Dr. Mohammed Awad	*1 M. Iwakuma
Eng. Fauzi Shanab	T. Kobayashi
Eng. Farouk Ghallab	
Eng. Ikbal Abou El Fadel	
Eng. Nagi El Gawli	
Eng. Hassan Foudah	
Eng. Loutfy Abdel Kader	
Group-5 Economic Conditions	
Accountant Helmy Hassanein	T. Kobayashi
Dr. Talaat Tabalawi	*1 K. Fujii
Eng. Fawzia Abou Neima	
Dr. M. El Gazzar	
Mr. Ahmed Abou El Ella	

Note: *1 Member of the First Survey Team

*2 Member of the Second Survey Team

Others participated in both surveys.

4) Related Organizations

During the survey periods, the Survey Team got the cooperation from the following organizations.

- Egyptian Electricity Authority (EEA) Head Office
  (Nasr City,Abbassia,Cairo,Egypt
  Tel. 830170, Telex 92097 POWER UN)
- EEA Cairo Zone Office
- Ministry of Planning
- Governorate Suez
- Sinai Rehabilitation Authority
- Nuclear Power Plant Authority
- Survey Authority
- Aero Survey Authority
- Geological Survey Authority
- Military Survey Authority
- General Petroleum Authority
- Ministry of Transportation
- Ministry of Industrialization
- Red Sea Port Authority
- Alexandria Port Authority
- Adabiya Port Authority
- Ahmed Hamdi Tunnel Authority
- Suez Canal Authority
- Meteorological Authority

1-5-3 Meetings with EEA in Japan

The EEA team composed of the following members stayed in Japan from September 24 to October 19, 1983 for discussions on the survey report.

Eng. Fazem El Tanbouli
Manager Director for Power Plants Cairo Elect. Zone
Mr. Helmy Hassanein
Manager Director for Financing, Commercial & Economics
Dr. M. Serry
General Assist. Coordinator for Sinai Coal Power Plant
Eng. Abdel Halim
Director General for Civil Works
Dr. Mohamed A. El-Gazzar
Senior Planning Engineer
Eng. Loutfy Abdel Kader
Senior Engineer, Study & Developing Network Dept.

1-5-4 Team's Works in Japan

After returning to Japan, the members of the Survey Team have been engaged in the analysis of the collected data and information and preparation of the Feasibility Report until December, 1983.

1-5-5 Explanation on Draft Feasibility Report

A team composed of Tetsuya WACHI, Team Leader, Yutaka MATSUMOTO, Deputy Leader, Tetsuro KOBAYASHI, Economist and Masakazu NAKAMOTO, Power Plant Engineer, visited Egypt for 15 days from the end of November 1983 and explained to EEA on the draft Feasibility Report.

1-5-6 Collected Data

The following data and information were collected during site surveys.

Based on the data and information listed below, the Feasibility Report is prepared.

1) EEA Head Office
    (1) Steam Power Plants
    (2) Summary of Sinai Development (Arabic)
    (3) Emergency and Tripping in Power Station
    (4) Table of Environmental Pollution Standard
    (5) Natural Gas Analysis Data
    (6) Report on Construction of Power Station by Using Local and Imported Coal (Arabic)
    (7) Data of Building Work (Material and Construction Unit Price)
    (8) Local Contractor of Civil Works
    (9) Abstruct from "Condition of Tender and Specification of 220 kV O.H.T.L. El Ahrmai"
    (10) Annual Report of Electric Statics 1981
    (11) Abstruct from "Conditions of Tender of El Kassaby Station"
    (12) Monthly Report (Load Distribution Statistics (Jan. 1982 to Oct. 1982) Except Jul.
    Abstruct
    (13) Insulator Design & Dimensions
    (14) System Map as of 1986
    (15) Communication System in Canal Zone
    (16) Technical Data upto 1986
    (17) Load Flow Actual
    15/Jul. 1981; 30/Dec. 1981; 28/Jun. 1982; 16/Jan. 1983

(18) A Map "Single Line Diagram Suez North"

(19) A Map "General Layout of Suez North"

(20) A Map "Drawing of Cross Section of Tunnel"

(21) A Map "Suez City; Scale 1/50,000"

(22) A Map "Single Line System Map as of 1987"

(23) Energy Sold and Electricity Pricing

  i. General Price Escalation Ratio (Applied for tariff amendment)

  ii. 1st Tariff Amendment

  iii. 2nd Tariff Amendment

  iv. Annual Consumption by Each of the Main Consumer Categories

  v. Energy Sales from DC to Consumers

  vi. Selling Prices for Energy Consumption (According to Ministerial Decree No. 259-1974)

  vii. Tariff as per International Price (Projected)

  viii. Tariff as per Subsidized Price of Fuel (Projected)

  ix. Operating Data from 1980 to 1982

  x. Large New Industrial Loads (1982 - 1986)

  xi. H.V. Tariff Study - August 1981 (Addendum)

  xii. H.V. Tariff Study - March 1981

  xiii. Data Collection - April 1982

  xiv. M.V. and L.V. Tariffs Study - April 1982

(24) Power Demand Forecast and Power Development Program

  i. Report on Economical Expansion Planning of Generation System - (1985 - 2000)

  ii. Energy and Load Forecast - (1981 - 2000) (Peak Load and Annual Energy)

- iii. Peak Load, Installed Capacity and Reserve Margin - (1986 - 2000)
- iv. Optimum Expansion Generation Plan (1986 - 2000)
- v. Peak Load, Total Energy, Installed Capacity and Types of Generation
- vi. Annual Report of EEA, 1981
- vii. Map (Sketch) showing Service Areas of Each Zone and DC
- viii. Monthly Peak Load by Zone - (1972 - 1979)
- ix. Report on Economical Expansion Planning of Generation System
- x. Report on Economical Comparative Cost Study between Conventional and Renewable Energy Generation - May
- xi. The Introduction of the New Capacities to the UPS

(25) Financial Statement

- i. EEA Balance Sheet - (1976 - 1980/81)
- ii. Revenues and Expenses (1976 - 1980/81)
- iii. Sources and Application of Funds - (1976 - 1980/81)
- iv. Standardized Depreciation Table

(26) Organization and Function

- i. Law No. 12 - 1976 for Establishment of EEA
- ii. EEA Organization Structure and Job Classifications Description - November 1980

(27) Others

- i. Growth of Production and GNP - (1970 - 1979)
- ii. Retirement Schedule of Power Plant (1983 - 2000)

2) Chemnical Laboratory

(1) Physical Characteristics for Turbine Oil & Tr. Oil, etc.

(2) Data Sheet

(3) Sea Water Analysis Data

3) Ataka Thermal Power Station (EEA)

 (1) Bidding Documents Part II, Appendix (Oceanology Data)

 (2) Construction Schedule

 (3) Organization Chart for Construction

 , (4) Ataka Thermal Power Station (Brief Description)

 (5) Meteorological Data

 (6) Contract Document for S.E.D.E. (Technical Specification)

4) Governorate Suez

 (1) Suez Development Plan

 (2) Suez Master Plan, March 1978 (Meteorological Data)

 (3) Development Plan in Sinai

 (4) Topographic Map of Ayun Musa 1:50,000

4) Sinai Rehabilitation Authority

 (1) Data Sheet (for Water Supply Plan)

 (2) Brief of Sinai's Projects (Arabic)

 (3) El Arish Port (Arabic)

 (4) Ayun Musa Project (Arabic)

6) Nuclear Power Plant Authority

 (1) Sea Water Analysis Data (El Dabaa, North Zafarana, South Safaga)

 (2) Sea Water Temperature (Alexandria, Gulf of Suez, Red Sea)

 (3) Meteorological Data for Cairo, Suez and Alexandria

  Temperature

  Humidity

  Rainfall

  Wind velocity and direction

  Monthly thunderbolt

  Earthquake record

7) Survey Authority

Topographic map

"Suez"	scale 1:100,000
"Abu Zenima"	scale 1:100,000
"Ayun Musa"	scale 1:100,000
"Zafarana"	scale 1:100,000

8) Geological Survey Authority

- (1) The Main Tectonic Features of Egypt, 1959 (The Tectonic Map of Egypt)
- (2) Geological Map of Egypt (1:2,000,000, 1981)
- (3) Extract from "Studies on Some Mineral Deposit of Egypt" - Article 5
- (4) Chemical Studies on Ayun Musa Coal, 1965
- (5) Geology and Coal Deposits of Gabal El-Maghara (Northern Sinai)
- (6) Ayun Musa Boring Log Sheet

9) General Organization of Industrization (Mining Section)

- (1) Call for Offer for the Reactivation of Maghara Coal Mine North Sinai A.R.E. (The Geological Survey)

10) Military Survey Authority

- (1) Topographic Map

Ayun Musa	scale 1:25,000
Bair El Mor	scale 1:25,000
Abu Zenima	scale 1:100,000
Zafarana	scale 1:100,000
Suez	scale 1:50,000
East Great Lake	scale 1:50,000
El Shaloufa	scale 1:50,000
Genefa	scale 1:50,000

Ismailia	scale 1:50,000
Eltasa	scale 1:50,000
Great Lake	scale 1:50,000

11) Petroleum Corporation

(1) Retail Sale Consumer for Petroleum Products

(2) Production of Crude Oil and Natural Gas

(3) Egyptian Standard Specification for Gas Oil and Diesel Oil

(4) Specifications of Fuel Oil for Exportation "Straight Run"

(5) Fuel Oil Analysis Data

(6) Annual Report (Arabic), 1981

(7) Natural Gas Analysis Data (Western Desert)

12) Ministry of Transportation

(1) Road Map of Sinai Peninsula

(2) Water Way Network (Map), etc.

13) Red Sea Port Authority

(1) Adabiya Port "Master Plan"

(2) Tidal Table "Red Sea Suez"

(3) Adabiya Port Planning Dwg.

(4) Location of Bore Holes

(5) Port of Suez Future Plan Data

14) Alexandria Port Authority

(1) Data Sheet for Harbor Facilities

15) Ahmed Hamdi Tunnel Authority

(1) A Leaflet "Ahmed Hamdi Tunnel"

16) Suez Canal Authority

Sounding Map of Suez Bay	scale 1:20,000

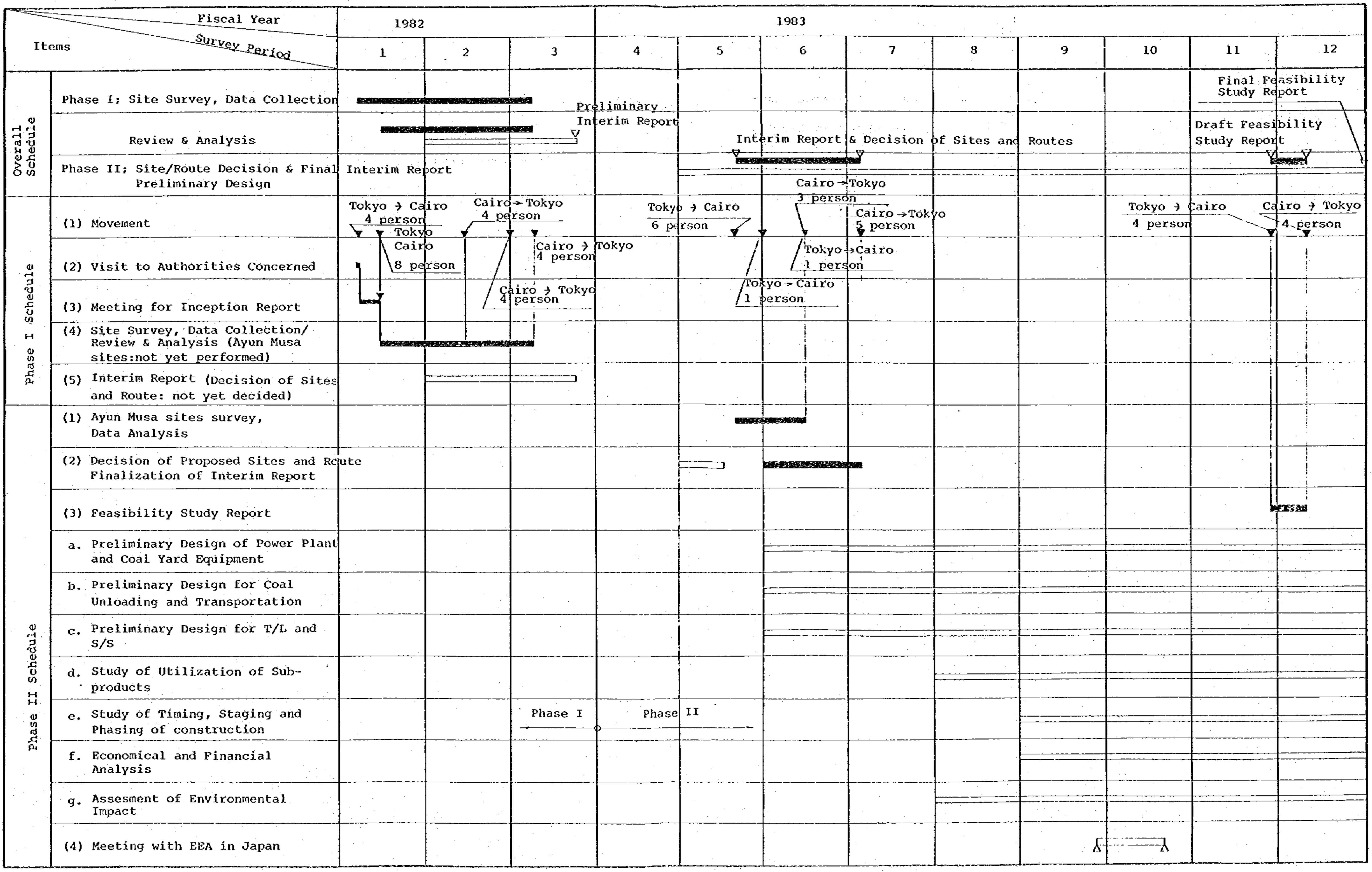
17) Meteorological Survey Authority

(1) Meteorological Data of Ayun Musa

(2) Meteorological Data of Abu Zenima

(3) Meteorological Data of Zafarana

Fig. 1-1 Overall Schedule for Feasibility Study on the Construction of the First Coal-Fired Thermal Power Plant in Sinai



CHAPTER 2

GENERAL DESCRIPTION OF THE PROJECT

CHAPTER 2 GENERAL DESCRIPTION OF THE PROJECT

2-1 THE PROJECT

2-1-1 Outline of Electricity Industries in Egypt

1) Electric Utilities in Egypt

The electric utilities in the Arab Republic of Egypt are composed of the following 4 agencies under the Ministry of Electric Power and Energy, which were organized in 1976.

. Egyptian Electricity Authority (EEA)
Rural Electrification Authority (REA)
Nuclear Plants Authority for Generation (NPA)
Quattara Hydro and Renewable Energy Authority (QHREA)

And the construction and operation of the power generating plants except nuclear power plants, and the power line networks are managed by EEA. The organization has been put into actual operation since 1979.

EEA is directly supplying electric power to the major industries such as SOMED (pipe manufacturer), KIMA (fertilizer factory), aluminum production, etc. through 220 kV and 132 kV lines, and to other industries such as shipyards, textile, petroleum refinery, chemical plants, irrigation, broadcasting, land formation, etc. with 66 kV and 33 kV lines. For the other customers, EEA wholesales electric energy to distribution companies which supply the power to individual customers.

In other words, EEA is the general electric utility organization in charge of the construction and operation of the major parts of electric power generation, transmission and distribution in Egypt.

2) Outline of Electric Supply System by EEA

The power generating facilities of EEA were composed of hydro power of 2,445 MW and thermal power (including gas turbine) of 2,687 MW, or a total of 5,132 MW, in 1982.

Looking back into the recent history of electric power development in Egypt, Aswan Dam No. 1 Power Station of 345 MW was built in 1960 and Aswan High Dam Power Station of 2,100 MW (175 MW x 12) was completed in 1970, or a total hydro capacity of 2,445 MW was built till 1970. No addition of the hydro generating capacity was made up until 1982.

On the other hand, the thermal generating capacity in 1970 was 1,330 MW, and the sum of hydro and thermal generating capacities in 1970 was 3,775 MW. Increase of capacity for 12 years up to 1982 was 0 with hydro and about 200% with thermal, or 136% overall. The annual average growth rate over the 12 years was approximately 2.6%.

As shown in the following Table 2-1, no development in the generating facilities was made for a 1970 - 1975 period, since the country was satisfactorily supported by the hydro power of 2,445 MW.

The hydro power sources constituting about 65% of the total generating facilities are concentrated in Aswan, and should there be any failure in the 500 kV x 2 circuit Aswan-Cairo line, the power supply system would be seriously troubled.

Therefore, for the promotion of industries by stable power supply and for the expansion of rural electrification, the expansion of base load carrying thermal power stations and power supply networks were implemented intensively in the framework of the Five-year Program from 1976. As a result the ratio of hydro and thermal generating capacities became 48% hydro versus 52% thermal.

Table 2-1 Installed Capacity (MW)

Year	Thermal	Hydro	Total
1970	1,330	2,445	3,775
1975	1,330	2,445	3,775
1976	1,334	2,445	3,789
1977	1,415	2,445	3,860
1978	1,460	2,445	3,905
1979	1,784	2,445	4,229
1980	2,261	2,445	4,706
1981	2,469	2,445	4,914
1982	2,687	2,445	5,132

As of 1982, available capacity and peak demand as against the installed capacity, were as follows.

	Installed Capacity (MW)	Available Capacity (MW)	Peak Demand (MW)	Margin Rate (%)
Hydro	2,445	2,000 (82%)	-	-
Thermal	2,687	2,077 (77%)	-	-
Total	5,132	4,077 (79.4%)	3,900	4.54

Percent in the available capacity column represents the availability ratio.

The availability ratio of 79.4% as of 1982 should be improved to 90% approximately in the future.

It must be noted that operation of hydro power plants is occasionally and inevitably limited if the priority of flow should be given to irrigation and other purposes since the useful flow for generation varies depending on the discharge flow condition of the year. And the decline of availability of thermal power generating capacity is mainly due to superannuated facilities, or trouble/accidents of facilities even if those are new.

Electric Power System

The electric power system of EEA is divided into two main areas; Lower Egypt and Upper Egypt.

Upper Egypt: This is the network made up mainly of 500 kV x 2 cct transmission line from Aswan High Dam, along the Nile and to the south of Metro Cairo Zone.

Lower Egypt: This system is divided into the following 4 zones.

Metro Cairo Zone
Alexandria Area
Delta Zone
Canal Zone

The networks are interconnected with 500 kV, 220 kV and 132 kV lines, and the extension and improvement program to attain higher supply reliability is now under consideration.

Line routes of the trunk transmission systems are as follows:

a. Upper Egypt

500 kV System

° Aswan High Dam Power Station - Nag. Hammadi - Samalout - Cairo

132 kV System

° Aswan High Dam Power Station - Aswan Dam Power Station - Luxor - Nag. Hammadi - Samalout - Beny Souef

° Samalout - Beharia Oasis

b. Lower Egypt

220 kV System

° EL Harm - Cairo South - Wadihoof - Sokhna

° Cairo South - Cairo East - Suez

° Cairo South - El Harm - Cairo West

° Cairo 500 - Cairo West - Cairo North - Heliopolis

° Cairo North - Zagazig - Ismailia (Manaif)

° Cairo 500 - El Tahrir I - Damanhour - Kafr El Dawar - Alexandria I

° Cairo 500 - El Tahrir II - Ameria (Alexandria II) - Somid

° El Tahrir I - Tanta - Talkha

° Damanhour - Mahmoudia - Kafr El Shikh - Talkha

° Manaif - Port Said

° Manaif - Abu Sultan

The transmission line length and transformer capacities at substations as of 1981 are tabulated in the following.

Table 2-2 Transmission Line Length

(As of the end of 1981)

Unit: km

	Ultra High Voltage (UHV)			High Voltage (HV)		
Region	500 kV	220 kV	132 kV	66 kV	33 kV	Total
Cairo	-	352	-	431	-	783
Alexandria	-	417	-	518	138	1,073
Canal	-	728	-	620	-	1,348
Delta	-	714	-	1,235	911	2,860
Upper Egypt	1,576	-	2,098	368	1,142	5,184
Total	1,576	2,211	2,098	3,172	2,191	11,248

Table 2-3 Transformer Capacities of Substations

(As of the end of 1981)

Unit: MVA

	Ultra High Voltage (UHV)			High Voltage (HV)		
Region	500 kV	220 kV	132 kV	66 kV	33 kV	Total
Cairo	-	1,245	-	1,723	-	2,968
Alexandria	-	845	-	325	365	1,535
Canal	-	670	-	199	-	869
Delta	-	860	-	1,037	200	2,097
Upper Egypt	3,280	-	1,377	227	408	5,292
Total	3,280	3,620	1,377	3,511	973	12,761

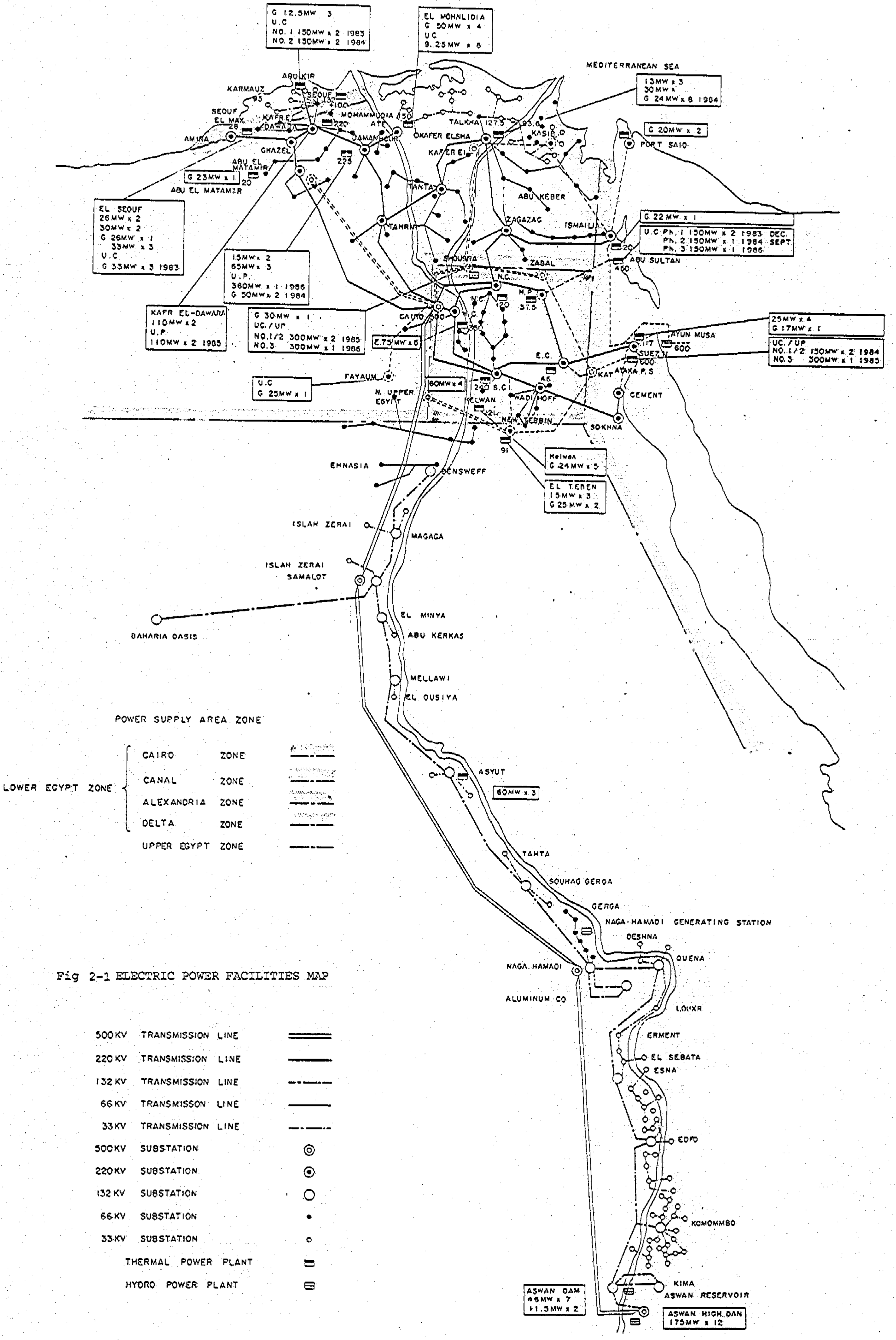


Fig 2-1 ELECTRIC POWER FACILITIES MAP

2-1-2 Power Demand Forecast and Development Program

1) Outline of Evolution of Power Demand and Supply by EEA

The expansion of power sources during 1970 - 1982 period and the growth of energy sales are tabulated in the following.

Table 2-4 Annual Generation and Peak Load

Year	Annual Generation (GWh)			Energy Sold (GWh) EEA	Peak Load (MW)
	Thermal	Hydro	Total		
Direct Selling to Consumer					
1970	2,225.5	4,689.9	6,915.4	5,937.1	1,100
1975	3,009.3	6,790.3	9,799.6	8,307.6	1,733
1976	3,642.7	8.002.8	11,645.5	9,661.5	1,909
1977	4,478.1	9,037.5	13,516.6	11,488.9	2,284
1978	5,077.6	9,935.1	15,012.7	12,722.5	2,564
Direct Selling + Wholeselling					
1979	6,750.7	9,608.3	16,359.0	14,549.0	2,829
1980	8,628.1	9,801.3	18,429.4	16,113.7	3,239
1981	10,532.4	10,215.1	20,747.5	17,940.1	3,553
1982	-	-	23,350.0	20,267.8	3,900
Annual Increase Rate					
1970 - 75			7.2%	7.0%	9.5%
1975 - 82			13.2%	(13.6%)	12.3%
1970 - 82			10.7%	(10.8%)	11.1%

Table 2-5 Energy Sold by Zone

	Energy Sold (GWh)			Component Ratio (%)		
Zone	1979	1980	1981	1979	1980	1981
Cairo	4,957.3	5,608.1	5,902.8 (9.1%/annum)	34.0	34.8	32.9
Alexandria	1,833.8	1,923.9	2,088.2 (6.7%/annum)	12.5	12.0	11.6
Delta	2,258.5	2,552.0	3,065.1 (16.5%/annum)	15.6	15.8	17.1
Canal	925.5	1,069.2	1,265.4 (16.9%/annum)	6.4	6.6	7.1
Lower Egypt	9,975.1	11,153.2	12,321.5 (11.1%/annum)	68.5	69.2	68.7
Upper Egypt	4,573.9	4,960.5	5,618.6 (10.8%/annum)	31.5	30.8	31.3
Total	14,549.0	16,113.7	17,940.1 (11.0%/annum)	100.0	100.0	100.0

As shown in the foregoing tables, there was no addition of new generating capacity during 1970 - 1975 period, but the energy sales grew by 7% of an annual average rate. After the power sources and networks expansion program was started in 1976 under the 5-year program, the energy sales increased at an annual average rate of about 13% until 1982.

The peak load increased at an average rate of about 12% per year from 1976 and reached 3,900 MW in 1982, leaving only 4.5% of margin as against the available capacity of 4,077 MW. Therefore, the expansion of power sources must urgently be implemented.

On the other hand, seeing the energy consumption upto 1981 from 1979 when the new electric utility system was put into effect, the energy sales in Lower Egypt Zone of Cairo, Alexandria, Delta Canal and Upper Egypt Zone grew at an annual rate of 11%. The growth rates of 9.1%/annum in Cairo and 6.7%/annum in Alexandria were stagnated at lower than the average while growth in Delta and Canal were 16.5%/annum and 16.9%/annum respectively. This tendency is due to the promotion of rural electrification and industries supported by the public character of the electric utilities. In Upper Egypt, 10.8%/annum of growth rate as near as the average value was seen.

The monthly average maximum peak load from 1972 to 1979 generally fell in December as shown in the following table.

Table 2-6 Peak Load by Zone (Monthly Average)

Unit: MW

Maximum Load Month - Year	Cairo	Alexandria	Delta-Canal	L. Egypt Total	Upper Egypt	Total
November 1972	507	173	225	905	270	1,123
December 1973	549	193	237	979	264	1,198
September 1974	565	222	263	1,050	350	1,335
December 1975	671	235	348	1,254	447	1,691
December 1976	761	250	408	1,419	486	1,836
December 1977	872	297	492	1,661	637	2,238
December 1978	884	286	645	1,815	683	2,449
December 1979	1,055	349	699	2,103	716	2,742
Component Ratio in 1979	37.4%	12.3%	24.8%	74.5%	25.5%	100.0%

Source: Statistic Data Provided by Planning Department

The load factors as against annual generation were tabulated as follows. 66 - 67% of load factor will continue into future.

Year	Load Factor	Year	Load Factor
1975	64.6%	1979	66.0%
1976	69.6%	1980	65.0%
1977	67.6%	1981	66.7%
1978	66.8%	1982	68.3%

In 1981/1982 fiscal year, the direct sales of UHV and HV by EEA (UHV at 500 kV, 220 kV and 132 kV and HV at 66 kV and 33 kV) amounted to 5,326 GWh, or only 28% as against 19,013.3 GWh of generation at the substation end, and the balance of 13,687.3 GWh, or 72% was wholesaled to the distribution companies, out of which 11,839.5 GWh was distributed to customers through MV and LV lines. Namely, the energy sold was 17,165.5 GWh as against the 19,013.3 GWh at EEA substation end. The system loss was 13.2% within EEA's system and 21.6% in the entire system including distribution companies. The energy sales by categories are tabulated in the following.

Table 2-7 Energy Sold by EEA and DC and Component Ratios

Category	1980/81 (GWh)	1981/82 (GWh)	Component ratio (%)
EEA (UHV and HV)			
Industries	4,907.7	4,793.5	27.9
Agriculture/Irrigation	440.7	512.5	3.0
BATRA Broadcast	20.0	20.0	0.1
Sub-Total	5,368.4	5,326.0	31.0
Wholesale to D.C.	11,867.1	13,687.3	
Total EEA	17,235.5	19,013.3	
Distribution Companies (MV and LV)			
Industries	4,278.0	4,799.6	28.0
Agriculture	335.9	323.0	2.0
Housing Companies	258.8	337.0	2.0
Public Utilities	1,153.9	1,324.4	7.7
Residential/Commercial	3,583.1	4,372.9	25.4
Governmental Buildings	612.5	682.6	3.9
Total D.C.	10,222.2	11,839.5	69.0
Total Energy Sold (EEA+DC)	15,590.6	17,165.5	100.0

Power Plant	Gross Generation (GWh)	Net Generation (GWh)	Station Service Loss (%)
Steam P.P.	7,526.5	6,986.3	7.2
Gas Turbine	3,005.9	2,984.0	0.7
Hydro P.P.	10,215.1	10,090.6	1.2
Total	20,747.5	20,060.9	3.3

(as of 1981)

Table 2-8 Sold Energy by EEA and Averaged Tariff

(Unit: LE)

Category	Energy Sold (GWh)			Average Tariff (mill./kWh)		
	1979	1980	1981	1979	1980	1981
A. 220 kV and 132 kV						
KIMA	1,534.3	1,453.5	1,451.8	3.4	3.4	3.4
Aluminium	1,831.8	2,096.4	2,407.5	2.6	2.8	2.9
SOMED	280.6	275.1	327.1	5.3	5.1	5.1
B. 66 kV and 33 kV						
Egypt Chemical	95.1	104.5	85.4	6.5	6.5	6.5
NASR Petroleum	81.5	94.2	101.8	5.0	5.0	4.9
Abu Qir Fertilizer	12.1	8.3	9.9	6.4	7.2	6.5
Talkha Fertilizer	233.1	222.3	306.9	6.5	6.5	6.5
ARSENAL	10.9	10.0	10.8	6.7	6.4	6.5
MEHALLA EL KORBA	44.9	34.4	81.3	7.0	7.0	6.8
Alex. Petroleum	-	-	21.3	-	-	5.7
Alex. Cement	-	-	100.0	-	-	6.5
Total Industries	4,124.3	4,298.7	4,903.8	3.5	3.5	3.7
Irrigation/Drainage	213.1	453.1	489.4	6.9	6.9	6.4
Land Reclamation	-	24.6	8.6	-	8.3	8.3
Total Agriculture	213.1	477.7	498.0	6.9	7.0	6.5
BATRA Broadcasting	21.2	18.9	18.6	8.3	7.5	6.5
C. Wholesale to D.C.	10,187.5	11,318.4	12,519.7	9.0	9.0	9.0
Total EEA	14,546.1	16,113.7	17,940.1	7.41	7.47	7.47

2) Load Forecast and Development Program

a. Load Forecast

Because of the influence of the Middle East War as stated before, the economic growth was stagnant during the period of 1970 - 1975, and no expansion of electric power facilities was made, partly because of the completion of Aswan High Dam Hydro Power Station in 1970.

After the end of the Middle East War, development of electric power industry was attained with an annual average growth rates of more than 10% as a trunk industry for reconstruction of the country and reactivation of economy under the 5-year program started in 1976.

Passing through the unfortunate war state, the economy of Egypt could not grow straightforwardly, but has been growing involving distortions by the war.

However, taking advantage of the fact that Egypt is an oil producing nation, the country could achieve stabilization of rural districts and promotion of industries through implementation of electrification programs aided by the highest priority treatment in electric rate setting.

On the other hand, in line with the worldwide recession of economy, the funds required for the electric power development programs have increased, and the electric rate will have to be revised step by step after 1983. The plan of rate revision formulated by EEA is now under review by the government.

The load forecast was made for the whole Egypt for 1983 - 1995 period, with a view to establishing the basis for the development program of electric power sources and power systems, including the present Project.

In making the load forecast, the correlation among GDP, electric power demand, electric power rate and wholesale commodity prices were traced for the past 12 years of 1970 - 1981. And based on the correlation, the electric power demand forecast was made for the 1983 - 1995 period by the multiple regression method, with the new 5-year plan over 1982/83 - 1987/88 years taken into account.

Table 2-9 Long Range Load Forecast

	A.	B.	C.	D.		Macro Multiple Regression Method	
Fiscal Year	Energy Sold (GWh)	Generation at P/S Tr. End (GWh)	Load Factor	Peak Load B/8.76xC (MW)	Calendar Year	E. Generation at P/S Tr. End (GWh)	F. Peak Load (MW)
1981/1982	17,323	22,068	0.683	3,688	1982	22,915	3,899
1982/1983	18,653	23,762	0.66	4,110	1983	25,093	4,340
1983/1984	26,742	26,423	0.66	4,570	1984	28,056	4,853
1984/1985	23,305	29,688	0.66	5,135	1985	31,547	5,456
1985/1986	26,223	33,405	0.66	5,778	1986	35,207	6,097
1986/1987	29,123	37,009	0.66	6,417	1987	38,876	6,732
1987/1988	31,983	40,743	0.66	7,047	1988	42,573	7,363
1988/1989	34,856	44,403	0.66	7,680	1989	46,368	8,020
1989/1990	37,941	48,332	0.66	8,360	1990	50,506	8,736
1990/1991	41,354	52,680	0.66	9,112	1991	55,052	9,522
1991/1992	45,077	57,423	0.66	9,932	1991	59,707	10,327
1992/1993	48,662	61,990	0.66	10,722	1993	64,159	11,097
1993/1994	52,067	66,327	0.66	11,472	1994	68,652	11,875
1994/1995	55,720	70,981	0.66	12,277	1995	73,705	12,748

By the macro multiple regression method, as stated before the forecast figures of the required annual generation and the peak load at the transformer ends in power plants were obtained as shown in columns E. and F. in the foregoing table.

In view of the importance of the short-range and the long-range load forecast as an index for the national development in future, EEA has made various studies, and resulted in adopting the following load forecast.

Calendar Year	Generation at P/S Tr. End (GWh)	Peak Load (MW)
1982	23,350	3,900
1983	25,107	4,320
1984	27,984	4,815
1985	31,376	5,455
1986	35,862	6,100
1987	39,246	6,735
1988	42,991	7,360
1989	45,856	8,000
1990	51,074	8,720
1991	55,671	9,505
1992	60,679	10,360
1993	64,925	11,085
1994	69,464	11,860
1995	73,735	12,645

b. Outline of Development Program

As against the required annual generation and peak load in the foregoing load forecast for 1983 - 1995, and with the standard reserve capacity of 15% taken into account, the scale of development, unit capacities and types of power sources were selected as shown in Table 2-10 and Figs. 2-2, 2-3.

As shown in the table and figures, the Sinai Coal-fired Thermal Power Project is incorporated in the development program in due consideration of the necessary periods for the preparatory and the construction works for the Project as follows:

1988/89 : 600 MW in 1st stage
1990 : 600 MW in 2nd stage

In 1988 and 1989, however, the peak demand will be 7,360 MW and 8,000 MW, and even with the addition of 600 MW by this Project and another 600 MW at El Kurimat, the total available capacity would be 8,042 MW and 8,942 MW respectively. The reserve capacity ratio in these years would be 9.27% and 11.78% respectively both of which are lower than the standard 15%. So, supply conditions would become very severe.

Therefore, it is desired that this Project would be completed and commissioned on schedule by all means.

a) Determination of Unit Capacity for Sinai Coal-fired Thermal Power Project

This Sinai Coal-fired Thermal Power Project of 600 MW in 1988/89 (1st Stage) and another 600 MW in 1990 (2nd Stage), or an ultimate capacity of 1,200 MW, is highly important as a base load power station for elevation of supply reliability.

For the 1st stage 600 MW, two alternatives of unit capacity, namely 600 MW x 1 and 300 MW x 2, were compared and it was concluded that 300 MW x 2 was more desirable.

i. Study on Supply Reliability

The available capacity in EEA as of the end of 1982 was 4,077 MW.

For simplicity's sake, a case where the unit capacity of 300 MW is adopted for all plants of required capacities larger than 300 MW to be developed in the 1983 - 1990 period is called Case 1, and the other case where the unit capacity and scale of development in the 1983 - 1987 period are the same but 600 MW per unit capacity is adopted for development in 1988 - 1990, is called Case 2. With these two cases, the probability of occurrence of failure per year (allowable probability = 0.02/year or 0.6 day/month/year) was obtained, and the minimum required reserve capacities to maintain this allowable probability were compared for an economic assessment.

Available Capacity in 1990

	Case 1	Case 2
Up to 1982	4,077 MW	4,077 MW
1983 - 1987	300 MW x 5	300 MW x 5
	110 MW x 2	110 MW x 2
	150 MW x 10	150 MW x 10
1988 - 1990	300 MW x 8	600 MW x 4
Total in 1990	10,118 MW	10,118 MW

(Including 421 MW of aggregate capacity of hydro and gas turbine power plants and retired capacities)

Peak load in 1990 : 9,000 MW

Scheduled outage rate: 20% (utilization factor: 80%)

Unscheduled outage rate: 2% (allowable value of outage probability by combination of various power sources

Outage rate of units: (Refer to APPENDIX-E.)

100 MW class : 1.8% (by statistics on outage)

150 MW class : 1.5% (by statistics on outage)

300 MW class : 2.0% (by statistics on outage)

600 MW class : 2.0% (by statistics on outage)

Range of load fluctuation: ± 50 to 100 MW

The probability of occurrence of failure in the range of 1,000 MW - 100 MW is obtained in the following.

Case 1 (Max. 300 MW units)

Against 2% of probability of unscheduled outages, the probability becomes 3.52% for power failure of 600 MW and 1.95% for 650 MW. Therefore, it is necessary to have a reserve capacity of 650 MW or larger.

Case 2 (Max. 600 MW units)

Against 2% of probability of unscheduled outages, the probability becomes 2.05% for power failure of 900 MW and 0.91% for 950 MW. Therefore, it is necessary to keep a reserve capacity of 950 MW or larger.

When the above two cases are compared, Case 1 requires 300 MW less reserve capacity than Case 2, and involves no technical problem in the system operation, and therefore, Case 1 is desirable up until 1990.

ii. Economic Study

i) Case 1 requires 300 MW less minimum required reserve capacity as stated above, and adoption of 300 MW units is more economical.

ii) Comparison of Generating Cost and Annual Revenue

The construction cost of 600 MW x 1 is about 5% less than that of 300 MW x 2. The station service power rates are:

6.25% with 300 MW x 2

(Generator capacity: 320 MW x 2)

6.00% with 600 MW x 1

(Generator capacity: 638 MW x 1)

and the unit capacities will be 320 MW x 2 and 638 MW x 1.

	300 MW x 2	600 MW x 1
Availability of power plant operation	80%	75%
Annual gross GWh	4,485.1	4,191.7
Annual available energy at Tr. end GWh	4,204.8	3,940.2
Plant efficiency	39%	39%
Fuel consumption	$1,521.6 \times 10^3$ tons	$1,422.0 \times 10^3$ tons
Construction cost excluding T/L	464.2×10^6 LE	441.0×10^6 LE
Total annual expenses	34.6×10^6 LE	32.7×10^6 LE
Generating cost at Tr. end	8.23 millimes/kWh	8.30 millimes/kWh

Thus, by simple comparison of construction cost, 600 MW x 1 is more advantageous. However, maintenance period and forced outage rate for 300 MW x 2 units are lower than those for 600 MW x 1. Thus 300 MW x 2 would give longer operating hours per year than 600 MW x 1 and, the generating costs of 300 MW x 2 unit is lower than that of 600 MW x 1 unit.

And, in case of 300 MW x 2, as there are two same units in the power plant, scheduled shutdowns (e.g. overhauls) can be carried out on one unit per year basis, and the maintenance spare parts being interchangeable, the prevention of troubles would be made more effectively.

The annual revenue of these two plants as the base load power plant are compared as follows.

	300 MW x 2	600 MW x 1
Salable energy at consumer end GWh	3,700.2	3,467.4
Salable unit price at P.S. Tr. end	*23.55 millimes/kWh (Average unit price at 33.646 millimes x 0.7 in 1989/90)	*23.55 millimes/kWh
Annual revenue	56.7 x 10^6 LE	52.9 x 10^6 LE

From the above, it is seen that 300 MW x 2 is somewhat more advantageous, because of its operational flexibility.

In conclusion, there will be from a technical view point no problem in demand and supply balance whiever the unit capacity will be adopted.

Annual revenue of 300 MW x 2 is slightly larger than that of 600 MW x 1, as the Sinai Coal-fired Thermal Power Plant, through the difference is small.

As regard to the reserve capacity requirement for stable system operation, 600 MW unit needs about 300 MW larger minimum required margin capacity than 300 MW x 2 units, which is equivalent to 230 x 10^6 LE of highter construction cost.

Therefore, 300 MW would be appropriate as the unit capacity of the base load carrying thermal power plant.

Table 2-10 Development Plan and Demand-Supply Balance

Year	Project	A. Installed Capacity (MW)				B. Available Capacity (MW)				C. Peak Demand at P/S Tr. End G/(8,760xF)	D. Reserve Margin B - C	E. Margin Rate (%) D/C	F. Load Factor (%)	G. Annual Required Generation at P/S Tr. End (GWh)	H. Available Generation at P/S Tr. End Bx8,760x0.7 (GWh)	I. Balance H - G (GWh)
		Hydro	Thermal	Gas T.	Total	Hydro	Thermal	Gas T.	Total							
1982	Existing	2,445	1,675	1,012	5,132	2,000	1,225	852	4,077	3,900	177	4.54	68.3	23,350	25,000	1,650
1983	Abu Quir (150x2)		+300				+300									
	Abu Sultan (150x2)		+300				+300									
	El Suif (33x3)			+100				+100								
	El Mahmoudia (25x8)			+200	6,032			+200	4,977	4,320	657	15.21	66.35	25,107	30,519	5,412
1984	Abu Quir (150x2)		+300				+300									
	Abu Sultan (150x1)		+150				+150									
	Ataka (150x3)		+300				+300									
	Wadi Houf (33x3)			+100				+100								
	Damanhour (50x2)			+100	6,982			+100	5,927	4,815	1,112	23.09	66.35	27,984	36,344	8,360
1985	Kafr El Dawar (110x2)		+220				+220									
	Ataka (300x1)		+300				+300									
	Shoubra El-Kheima (300x2)		+600				+600									
	*Cairo North		-100				-75									
	*Talkha		-39		7,963		-36		6,936	5,455	1,481	27.15	65.66	31,376	42,532	11,156
1986	Abu Sultan (150x1)		+150				+150									
	Shoubra El-Kheima (300x1)		+300				+300									
	Damanhour (300x1)		+300				+300									
	*Karmauz		-64		8,649		-10		7,676	6,100	1,576	25.84	66.18	35,362	47,069	11,707
1987	Aswan II (75x4)	+300				+230										
	*Cairo South		-180		8,769		-120		7,786	6,735	1,051	15.60	66.52	39,246	47,744	8,498
1988	Sinai (1st Stage) (300x1)		+300				+300									
	*El Tebine		-45		9,024		-44		8,042	7,360	682	9.27	66.86	42,991	49,314	6,323
1989	Sinai (1st Stage) (300x1)		+300				+300									
	El Kurimat		+600		9,924		+600		8,942	8,000	942	11.78	66.86	46,856	54,832	7,976
1990	Sinai (2nd Stage) (300x2)		+600				+600									
	El Kurimat (600x1)		+600				+600									
	*Damanhour		-30		11,094		-24		10,118	8,720	1,398	16.03	66.86	51,074	62,044	10,970
1991	Sidi Kerier (300x2)		+600				+600									
	El Dabhaa (900x1)		+900				+900									
	(Nuclear)															
	*El Suif		-52		12,542		-16		11,602	9,505	2,097	22.06	66.86	55,671	71,144	15,473
1992	Sidi Kerier (300x2)		+600				+600									
	---		+900		14,042		+900		13,102	10,360	2,742	26.47	66.86	60,679	80,341	19,622
	(Nuclear)															
1993	-				14,042				13,102	11,085	2,017	18.20	66.86	64,925	80,341	15,416
1994	-				14,042				13,102	11,860	1,242	10.47	66.86	69,464	80,341	10,877
1995	*Cairo South		-60				-40									
	*Suez		-100		13,882		-75		12,987	12,695	292	2,30	67.20	74,735	79,636	4,901

Remarks;

*Retired Plant

*Available Capacities for Gas Turbine Project are Assumed on the Condition in Winter Season

*Utilization Factor is Assumed as Average of 70% Considering Whole Power Plants in Egypt

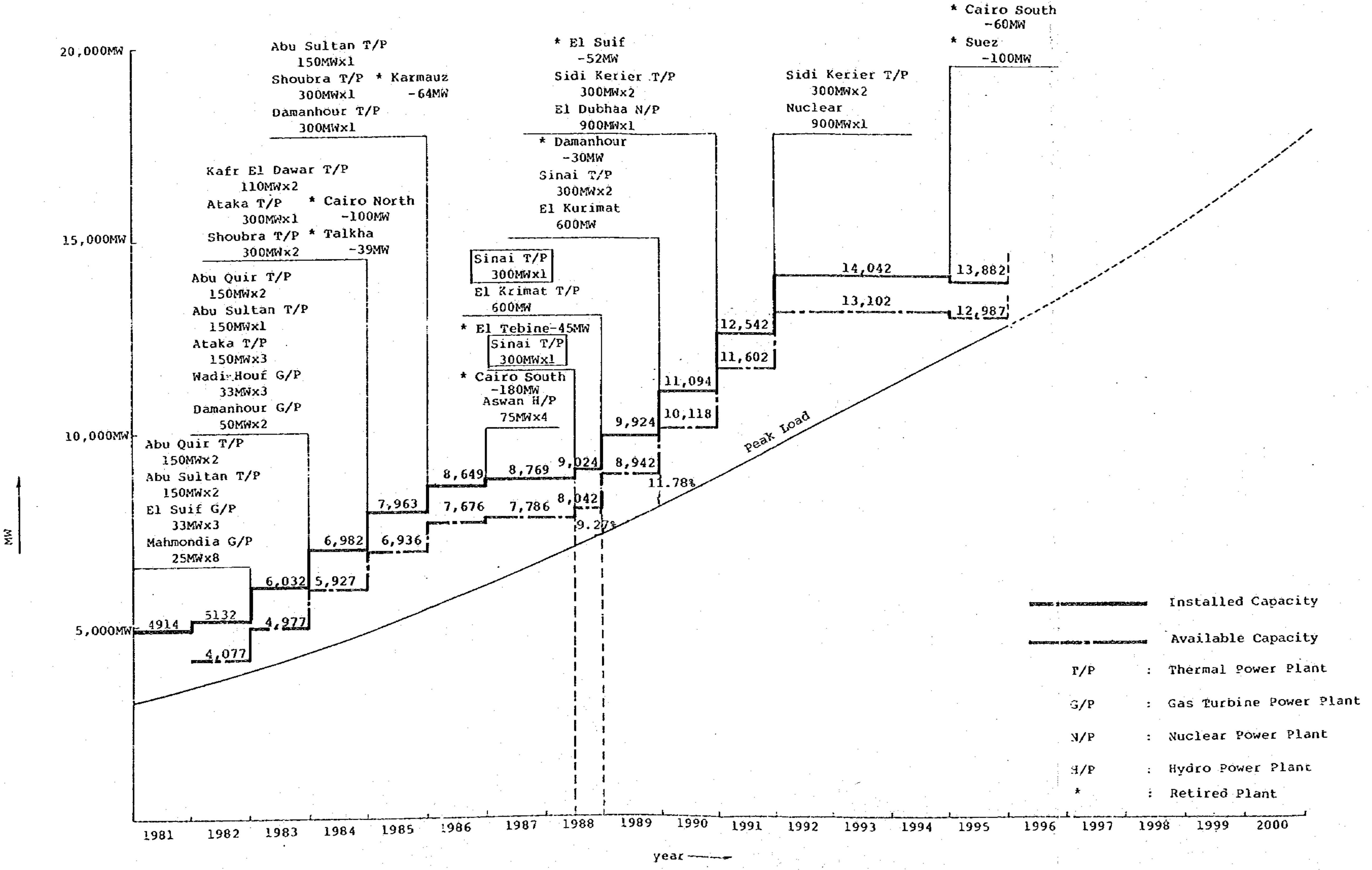


Fig 2-2 Power demand and Supply Balance

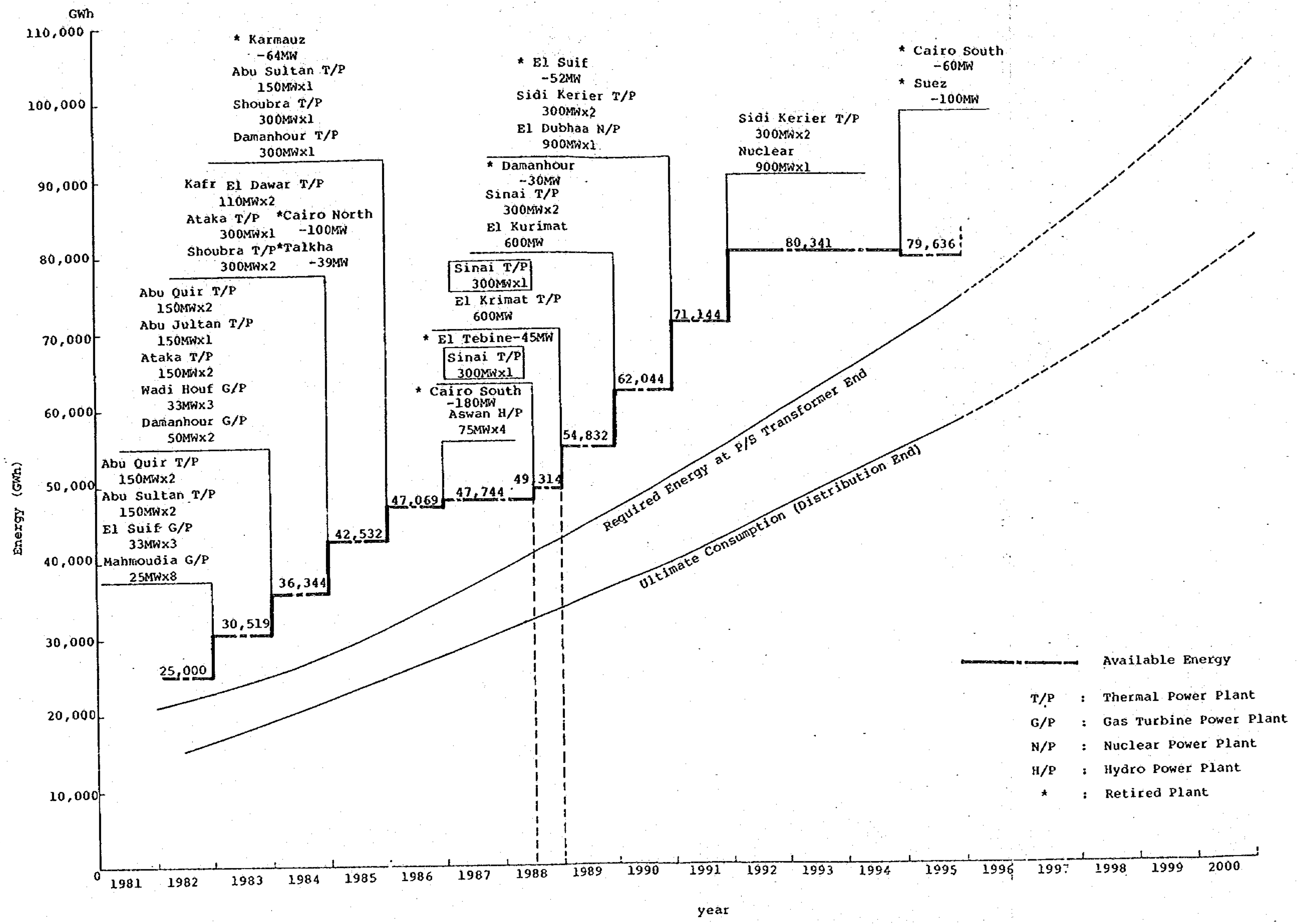


Fig. 2-3 Energy Demand and Supply Balance

b) Selection of North Ayun Musa Site

South and North Ayun Musa and Abu Zenima on the Sinai Peninsula and El Galala and Zafarana on the mainland Egypt were proposed as the possible sites for the power plant and harbor facilities.

All the nominated sites are located on the Gulf of Suez, and the siting condition was based on the interconnection of the transmission line from the power plant into the existing 220 kV x 2 circuits trunk line to Cairo via Suez City.

Since it is uneconomical to separate the sites of the power plant and the port, it was planned to locate the power plant and the coal unloading harbor at the same site.

Under these conditions, North Ayun Musa was selected for the project site, after studies on the transportation of coal from Maghara coal mine, extension of transmission line for interconnection, topographic and geological conditions, environmental pollution and other problems.

(Refer to the Map of North Ayun Musa Site.)

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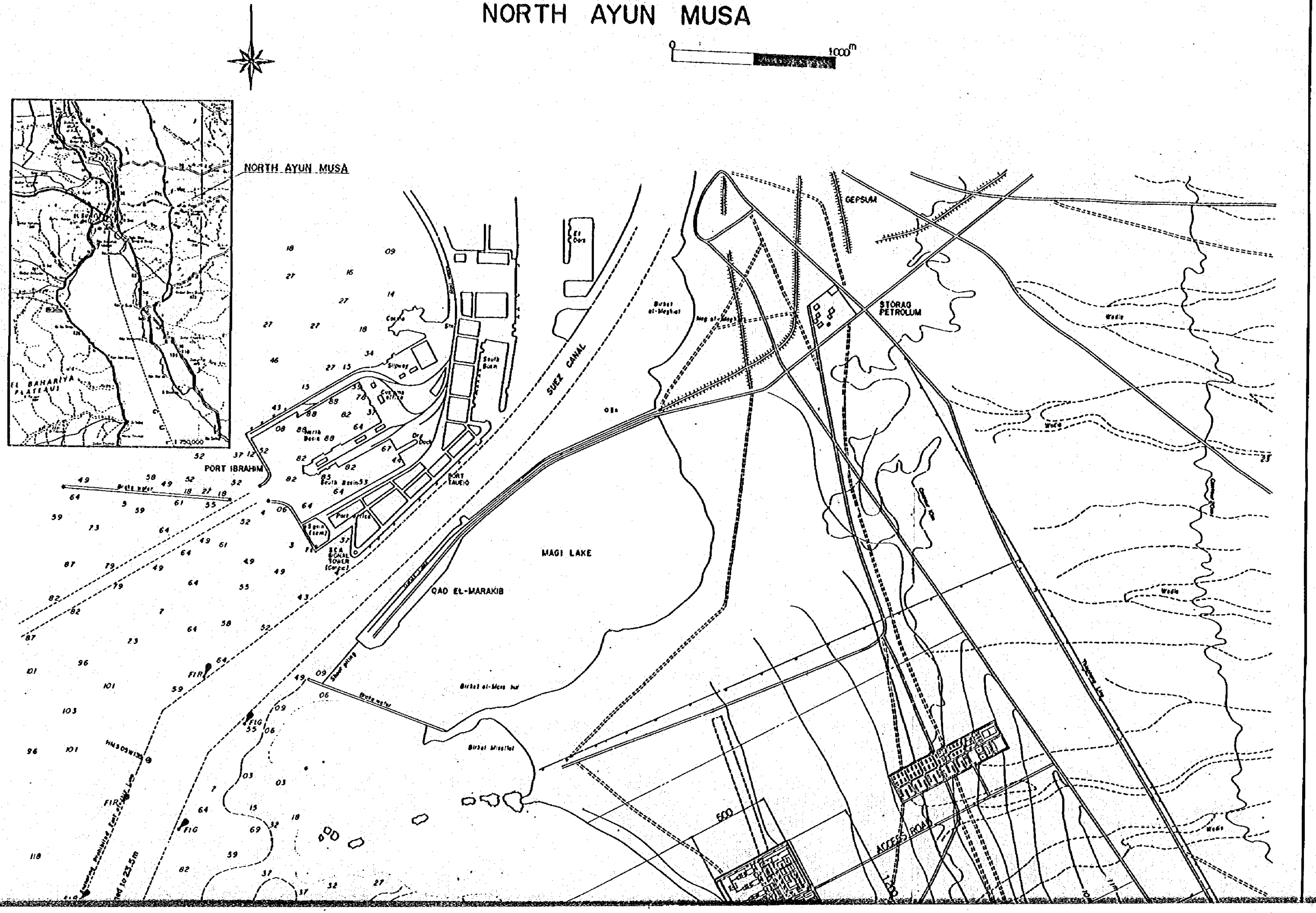
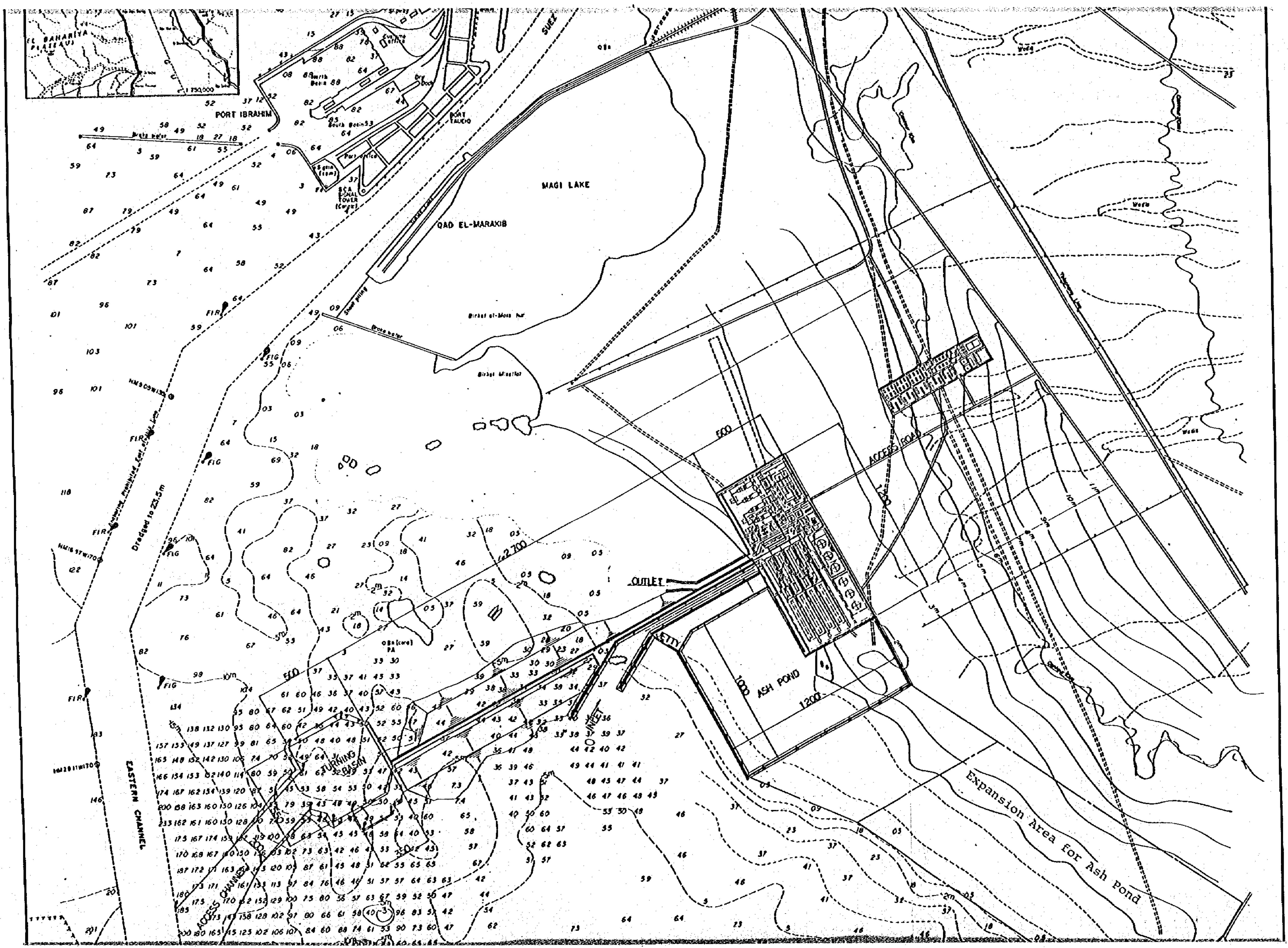
NORTH AYUN MUSA




EL BAHARIYA PLATEAU
1:750,000
PORT IBRAHIM
North Basin
South Basin
Dry Dock
Port office
PORT TAUFIQ
SCA SIGNAL TOWER
SUEZ
MAGI LAKE
QAD EL-MARAKIB
Birket el-Mossi
Broke water
Dredged to 23.5m
EASTERN CHANNEL
FIR
FIG
600
2700
OUTLET
INLET
JETTY
ACCESS ROAD
TURNING BASIN
ACCESS CHANNEL
1000
ASH POND
1200
Expansion Area for Ash Pond
Wadi
5m
10m

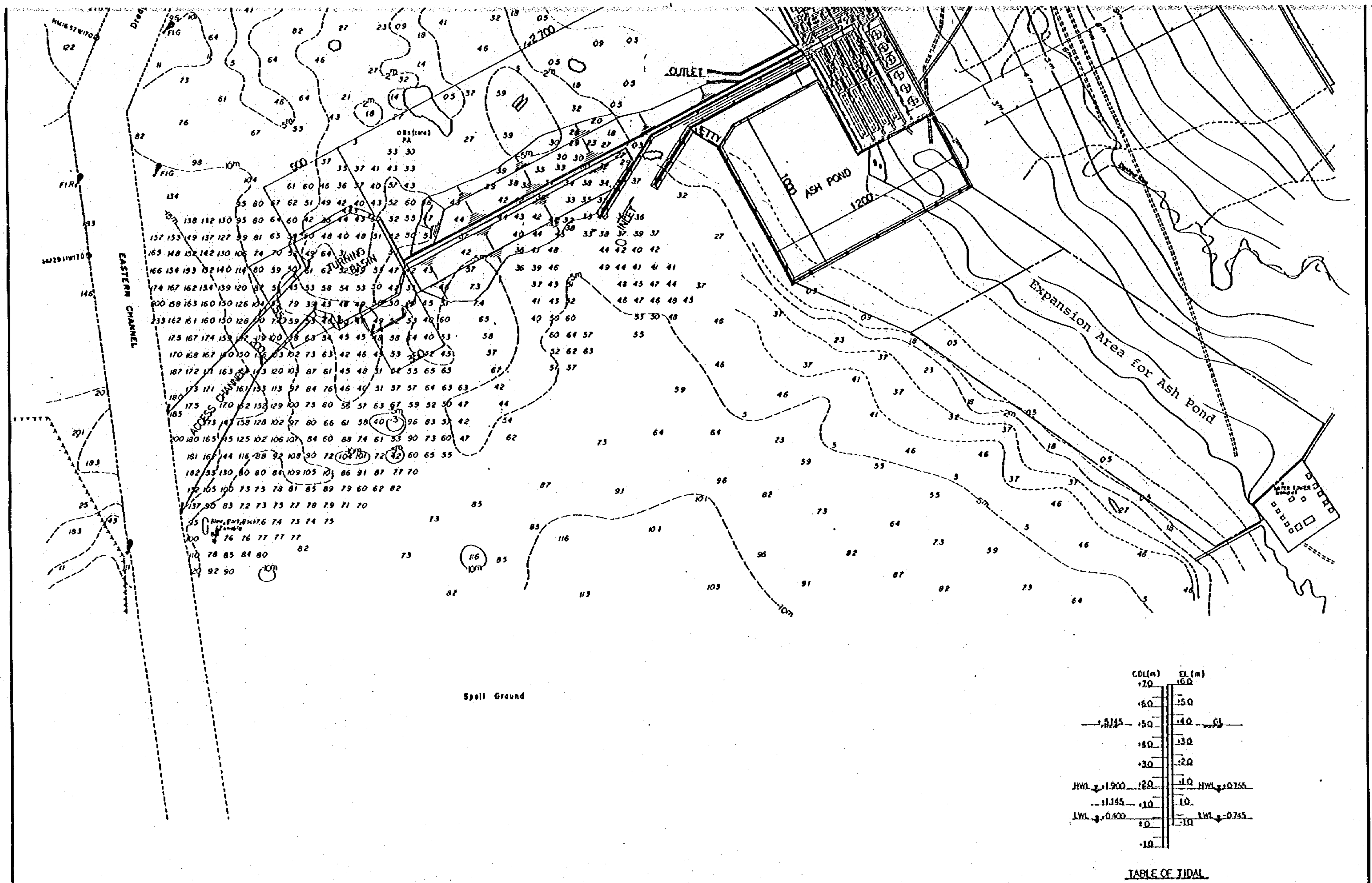


Fig. 2-4 General Layout of Sinai Coal-Fired Thermal Power Project (North Ayun Musa Site)

2-1-3 Necessity of Development of the Project

1) The oil reserve in Egypt is approximately 2.5 billion barrels (400 million tons), and it will surely increase by the future explorations. The present reserve of 2.5 billion barrels corresponds to 0.42% of the world oil reserve.

The crude oil production in 1980 was 29.8 million tons, out of which 11 million tons (30% of which consumed in electric power generation) were consumed domestically and 18.8 million tons were exported.

As of 1982, the annual rate of increase of domestic consumption was 15-20%, and if the consumption continues to increase at this rate, the domestic consumption would become about 30 million tons in 1987. It would exceed the production in 1980, and would seriously affect the foreign currency income from the export. (The foreign currency income by export of oil in 1980 was about 3 billion dollars and 60% of the total export, the income from Suez Canal was ranked second at 1.2 billion dollars, and the tourist industry was third at about 1 billion dollars.)

Therefore, it is necessary to export oil as much as possible for foreign currency income and for stabilization of the national economy. Thus, it is formed a policy to avoid construction of oil-fired thermal power plants as much as possible, in future.

It is urgent for Egypt to utilize the natural gas of 131 billion m³ of reserve and coal in Sinai Peninsula of 40 million tons of reserve, effectively as the substitute fuel.

Consequently, this Project to be completed by 1988 - 1989 would use the Maghara coal from Sinai effectively under the mass production plan, with the deficiency supplemented with imported coal, and would contribute to the saving of oil and increase of foreign fund income.

2) The necessity of this project is viewed from the stand point of electric power demand and supply balance.

As of 1982, EEA has 5,132 MW of generating capacity (hydro 2,445 MW and thermal 2,687 MW including gas turbine generators), of which the available capacity is 4,077 MW as against 3,900 MW of peak demand. This means that the reserve power margin rate is 4.54%, which is a severe condition in the supply reliability.

The power development program based on the 1983 - 1995 demand forecast, especially the development plan under the new 5-year program (1982/83 - 1987/88) is as follows.

Year	Available Capacity (MW)	Peak Demand (MW)	Margin Rate (%)
1982	4,077	3,900	4.5
1983	4,977	4,320	15.2
1984	5,927	4,815	23.1
1985	6,936	5,455	27.1
1986	7,676	6,100	25.8
1987	7,786	6,735	15.6

And 3,709 MW (hydro 230 MW, thermal 3,720 MW and retirement 241 MW) will be built by 1987 and the margin rate will be improved to be larger than 15%.

However, in 1988 and 1989, the peak demand will be 7,360 MW and 8,000 MW respectively and the available capacity of 7,786 in 1987 would fall short. And therefore, 1,200 MW must be added and a minimum of 10% of margin rate should be maintained.

Namely, 600 MW of El Kurimat, the Egypt's last oil-fired power plant and 600 MW (300 MW x 2) of the 1st Stage of Sinai Coal-fired Power Plant using coal as the substitute fuel for oil should be built by all means.

3) Production of Maghara Coal Mine Industry will reach 600,000 tons per annum in and after 1987, out of which 300,000 tons will be supplied to Chemicoke and 300,000 tons will be used for power generation.

On the other hand, the fuel consumption by this Project will be approximately 1,521,000 tons per year at 600 MW, 6,500 kcal/kg of calorific value of coal and 80% of plant utilization factor, and 1,221,000 tons will be imported from overseas. And stable long-term importation of coal blendable with Maghara coal is confirmedly possible as described in Chapter 4.

The development site is located at Ayun Musa on the Sinai Peninsula in front of Canal Port on the Gulf side of Suez Canal, where the conditions are very favorable for installation of the generating facilities including the coal receiving facilities, as well as for the environmental protection.

The power plant will be interconnected with the 220 kV x 2 circuit Suez-Cairo Line by construction of about 42 km of 220 kV x 2 circuit x 2 lines.

The development of this Project at Ayun Musa would make a great contribution to the reconstruction of Sinai Peninsula, together with the Ahmed Hamdi Tunnel connecting Sinai Peninsula and the mainland and the development of Maghara Coal Mine.

4) The construction cost of this Project will be approximately 620 x 10^6 US$, made up of 529 x 10^6 US$ of F.C. and 91 x 10^6 US$ of L.C. (0.823 LE/US$).

In Egypt, the electric rate is set at very low policy rates for expansion of electrification and promotion of industries.

The average rate in 1981 was 9.08 mill/kWh (US$ unit) and is very low as compared with 50 - 100 mill/kWh in the other countries.

EEA plans to improve the average rate situation step by step in consideration of balance of advancement of construction projects and promotion of industries, in steps of 19.0 mill/kWh in 1983/84, 35.0 mill/kWh in 1987/88, 37.9 mill/kWh in 1988/89 and 40.9 mill/kWh in 1989/90 (US$ unit).

The annual fuel costs in case of coal firing and in case of oil firing are compared at the international prices (coal: 59 US$/ton, oil: 180 US$/ton) as follows:

Coal firing = 59 US$/ton x 1,521,000 ton/annum
= 89.8 x 10^6US$

Oil firing = 180 US$/ton x 958,000 ton/annum
= 172.4 x 10^6US$

And the fuel cost of the oil-fired power plant is about doubled that of the coal-fired power plant.

Although the construction cost of the oil-fired plant is less than that of the coal-fired plant, the generating cost is lower with the coal-fired plant as summarized below.

	Oil-fired plant (600 MW)	Coal-fired plant (600 MW)
At generator end	42.9 mill/kWh	23.5 mill/kWh
At consumer end	50.5 mill/kWh	28.6 mill/kWh

(US$ Unit)

Thus, the coal-fired power plant is more advantageous than the oil fired power plant.

On the other hand, the present situation in Egypt, due to the above-mentioned electric power rate, the heavy oil for thermal power plants is priced at 9.1 US$/ton, about 1/20 of 180 US$/ton of the international price.

The price of coal is about 56.5 US$/ton of the composite price of domestic and imported coal, and the political price of coal by the coal/oil calory ratio should be lower than 5.9 US$/ton at least.

$$(9.1\ \text{US\$/ton} \times \frac{6{,}500\ \text{kcal/kg}}{10{,}000\ \text{kcal/kg}} = 5.9\ \text{US\$/ton}).$$

The annual fuel cost on the actual basis of the 600 MW coal-fired power plant is

$$56.5\ \text{US\$/ton} \times 1{,}521{,}000\ \text{ton/annum} = 85.9 \times 10^6\ \text{US\$},$$

and the export price of oil saved by operation of this coal-fired power plant is

$$180\ \text{US\$/ton} \times 958{,}000\ \text{ton/annum} = 172.4 \times 10^6\ \text{US\$}.$$

The difference, or the profit of 86.5 x 10^6 US$, will be appropriated for adjustment in the calculation of the political generating cost of the coal-fired power plant, to match the political electric rate, and the generating costs on the actual basis of coal-fired plant and oil fired plant are compared as follows.

	Oil-fired Plant (600 MW)	Coal-fired Plant (600 MW)
At generator end	5.22 mill/kWh	3.40 mill/kWh
At Consumer end	6.20 mill/kWh	4.13 mill/kWh

(US$ unit)

And at the salable cost, the generating cost of coal-fired power plant is 2.07 mill/kWh (US$ unit) lower than that of oil-fired power plant.

In other words, if the energy generated by the coal-fired power plant is sold on the basis of the generating cost of the oil-fired power plant, the amount of fuel subsidies from the oil export revenue to the generating cost of coal-fired power plant can be reduced by 2.07 mill/kWh (US$ unit), and by operating the coal-fired power plant, a net increase of oil export revenue of

2.07 mill/kWh x 3,700,200 MWh = 7.7 x 10^6 US$

will be obtained per year.

And if the electric rate is raised in 1988 when this project is commissioned, the subsidies from the oil export revenue could be reduced, and the coal-fired power plant would be much more favorable.

On the other hand, the internal rate of return (IRR) of this project is 11.29% at the point of benefit/cost = 1, at the present worth in 1984, and this project is feasible from the stand point of financing.

The cash flow balance is + 1,335 x 10^6 US$ (+ 1,099 x 10^6 LE) in the durable life of the facilities, and the project is sufficiently viable.

5) From the above, this Project is the most important project that must be realized with the highest priority from the view point of the electric power demand and supply balance in Egypt, and is amply feasible by obtaining a low interest, long term soft loan.

2-1-4 Outline of Sinai Coal-Fired Thermal Power Project for 1st Stage 300 MW x 2 Units

Specifications of major facilities for 1st stage 300 MW x 2 units are as follows.

1) Outline of Power Generating Facilities

a. Boiler

a) Type : Either natural or forced circulation drum-type, subcritical, reheat, outdoor type

b) Maximum continuous rating (MCR) : Suitable capacity with 300 MW net output at Tr. end

c) Number of unit : 2 units/plant

d) Fuel : Coal and oil for emergency

e) Draft system : Balanced draft system

b. Turbine

a) Type : Reheat, condensing, tandem compound type

b) Rated output at generator end : Suitable capacity with 300 MW net output at Tr. end

c) Steam conditions

Main steam pressure at turbine inlet : 169 kg/cm^2

Main steam temperature at turbine inlet : 538°C

Reheated steam temperature at IP turbine inlet : 538°C

d) Number of unit : 2 units/plant

e) Rated condenser vacuum : 710 mmHg

f) Rated speed : 3,000 rpm

c. Generator

a) Type : Horizontal-shaft, totally enclosed, hydrogen cooled type

b) Rating : About 400 MVA

c) Number of unit : 2 units/plant

d) Power factor : 0.8

e) Rated voltage : 18.3 kV or appropriately

f) Number of phase : 3

g) Frequency : 50 Hz

d. Transformers

a) Main transformer with off-load tap changer

Type : 3-phase, OFAF, outdoor type

Capacity & number : 380 MVA x 2 sets

Voltage : 18.3 kV or appropriately/230 kV

b) Station service transformer with off-load tap changer

Type : 3-phase ONAF, outdoor type

Capacity & number : 25 MVA x 2 sets

Voltage : 18.3 kV or appropriately/6.9 kV

c) Starting transformer with on-load tap changer

Type : 3-phase, ONAF, outdoor type

Capacity & number : 30 MVA x 1 set

Voltage : 230 kV/6.9 kV

e. Switchyard

a) Bus configuration : One and half circuit breaker system, double bus

b) Distribution system

Voltage : 22 kV

Transformer : 230/22 kV, 40 MVA x 1 bank

Circuit breaker : Metal-clad type

Main circuit breaker : 1

Feeder circuit breaker : 4

f. Emergency Generating Facilities

Type : Package type gas turbine driven

Rating:

Gas turbine : 17,500 kW x 1 unit (at 40°C)

Generator : 35,000 kVAx 1 unit, 6.9 kV or appropriately

Fuel : Light oil

g. Fuel Handling Facilities

a) Coal Handling

i. Storage Capacity: 313,000 tons (full load operation of 600MW for 60 days)

ii. Coal Unloader

Capacity : 1,300 tons/h

Number : 2 sets

iii. Coal Unloading Conveyor

Capacity : 1,600 tons/h each

Number : 2 sets

iv. Stacker

Capacity : 3,200 tons/h

Number : 1 set

v. Reclaimer

Capacity : 1,200 tons/h each

Number : 2 sets

vi. Stacker/Reclaimer

Capacity : 3,200 tons/h/1,200 tons/h

Number : 1 set

b) Oil Handling

i. Unloading arm : 1 sets (Heavy oil)

ii. Air separator : 2 sets (incl. 1 set for light oil)

iii. Flow meter : 2 sets (incl. 1 set for light oil)

2) Outline of Civil Works

a. Land Reclamation

a) Land Reclamation for 600 MW: 600,000 m^2

b) Formation Level

Ground level : EL+4.00 m

Existing ground level: EL+2.00 m

b. Cooling Water Intake Facilities

a) Inlet of Intake Channel for 1,200 MW

Velocity of intake water : 0.3 m/sec

Elevation of channel bed : CDL -5.0 m

b) Intake Channel for 1,200 MW

Sectional area of stream : 220 m^2

Velocity of intake water : 0.3 m/sec

c) Intake Pit Structure for 600 MW

Size : 20 m x 25 m x 10 m (invert level: CDL -5.0 m)

Maximum usable flow: 61.4 m^3/sec

Screen well : 4 pcs

Pumping well : 4 pcs

d) Cooling Water Pipe for 600 MW: øi 2.0 m x 4 lines

c. Cooling Water Discharge Facilities for 1,200 MW

Box culvert : 70 m (3 boxes), 170 m (4 boxes)

Open channel : 297 m

Revetment open channel: 1,267 m

Channel Outlet

Velocity of discharge water: 1.11 m/sec (L.W.L. tidal conditions)

Elevation of channel bed : CDL -1.0 m

d. Fuel Handling System

a) Fuel Oil Tank Foundation for 600 MW

Capacity of tank: about 34,000 kℓ x 3 (ø50.360 x 18.260 m height)

Foundation type : Displacement of gravel and sand

b) Harbor Facilities

i. Harbor

			Length		Width
Coaler berth	:	60,000 DWT			
		1 berth	300 m	x	25 m
Oil tanker berth	:	5,000 DWT			
		1 berth	140 m	x	10 m
Small craft berth	:	500 GT			
		1 berth	50 m	x	5 m

Wharf crown height : EL 3.00 m

Coaler wharf: Open-type wharf with coupled battered piles

Oil tanker, small craft wharf: Wall of concrete block type

Structural types shall be studied in detail if it is possible to be find more economical one after soil investigation.

ii. Channel and Basins

Water depth of access channel and basins:

(below elevation level) : EL-16 m, EL-8.5 m, EL-5 m

Width of access channel : 200 m

Side slope : 1 : 3

Area of turning basin : 685 m x 500 m

iii. Causeway

Length of causeway : 2,700 m

Height of causeway crown: EL+3.00 m

Width of causeway crown : 20 m

c) Foundations for Coal Storage Yard

i. Coal storage yard: 50 m (W) x 250 m (L) x 4 lanes

ii. Foundations for stacker : 1 lane

iii. Foundations for reclaimer : 2 lanes

iv. Foundations for stacker-reclaimer: 1 lane

e. Road

a) Access Road

Width : 8.00 m (2 lanes)

Pavement : Asphalt concrete

b) Main Road in the Plant

Width : 8.00 m (2 lanes)

Pavement : Asphalt concrete

f. Drainage System for Rain Water and Sewage Water: 1 set

g. Landscaping in the Power Station Area and Access Road

h. Dike for Ash Disposal Pond (Area for 10 years for 600 MW)

a) Height : EL+4.00 m at crown

b) Width : 6.00 m at crown

c) Material: Soil (for well compacted)

Rubble stone (for protector of both sides of soil embankment)

3) Outline of Architectural Works

a. Buildings

a) Powerhouse

i. Building Area

Total building area : 6,880 m^2

Total floor area : 19,730 m^2

Total building volume: 193,340 m^3

ii. Substructure

Pile : High strength prestressed concrete pile or bored pile

Foundation : Reinforced concrete, tie beam

iii. Superstructure

Frame : Steel structure

Roof : Corrugated resin coated steel sheet with insulation materials and partly RC structure, asphalt waterproof, and others

Floor : R.C. structure, tile and mortar finish and others

Exterior wall : Corrugated resin coated steel sheet wuth insulation materials and partly concrete hollow block, sand textured coating

Interior wall : Concrete hollow block, paint on plastered and others

Ceiling	:	Suspended ceiling, acoustic board, asbestos board and others

b) Service Building (2 stories)

Total floor area	:	2,740 m²
Foundation	:	Reinforced concrete, footing foundation
Superstructure	:	Reinforced concrete and other materials

c) Appurtenant Building (workers house, storehouse, control house and others)

b. Stack

Type	:	Steel made, collective, inside lining
Height	:	85 m
Diameter	:	3,300 mm
Foundation	:	Reinforced concrete, high strength prestressed concrete pile or bored pile

4) Outline of Transmission Line and Substation

Transmission line system will be interconnected with the existing transmission line 220 kV x 2 cct (Suez-Cairo line) from Sinai Coal-fired Thermal Power Station through a newly constructed New Suez Substation(about 42 km off the power station).

a. Transmission Line

a) Ayun Musa PS - New Suez SS

Voltage	:	220 kV
Size of conductor	:	620 sq.mm x 2
Kind of conductor	:	AAAC (All Aluminum Alloy Conductor)
No. of circuit	:	2 circuits x 2 lines

Line length : 40 km (except the part of canal crossing and branch line to existing T/L)

b) 220 kV branch line

Voltage : 220 kV

Conductor : AAAC 620 sqmm x 2

No. of circuit : 4 circuits

Length : 1.5 km

c) Canal crossing cable

Voltage : 220 kV

Conductor : OF cable 2,000 mm²

No. of circuits : 4 circuits

Length : 2.0 km

b. New Suez Substation

a) Bus configuration for 220 kV yard will be a double bus, single breaker system.

b) Drawing out facilities for 220 kV transmission line will be one circuit breaker three-disconnecting switch system.

c) A conventional SF_6 gas insulated circuit breaker will be used.

d) 220 kV drawing out facilities will be installed as follows.

  i. Four circuits for Ayun Musa Power Station

  ii. Two circuits for Suez Transformer Station and another two for Sakr S.S.

5) Communication System

a. Micro Wave Communication System: 1 system

b. Power Line Carrier System (PLC): 1 system (using optical fiber)

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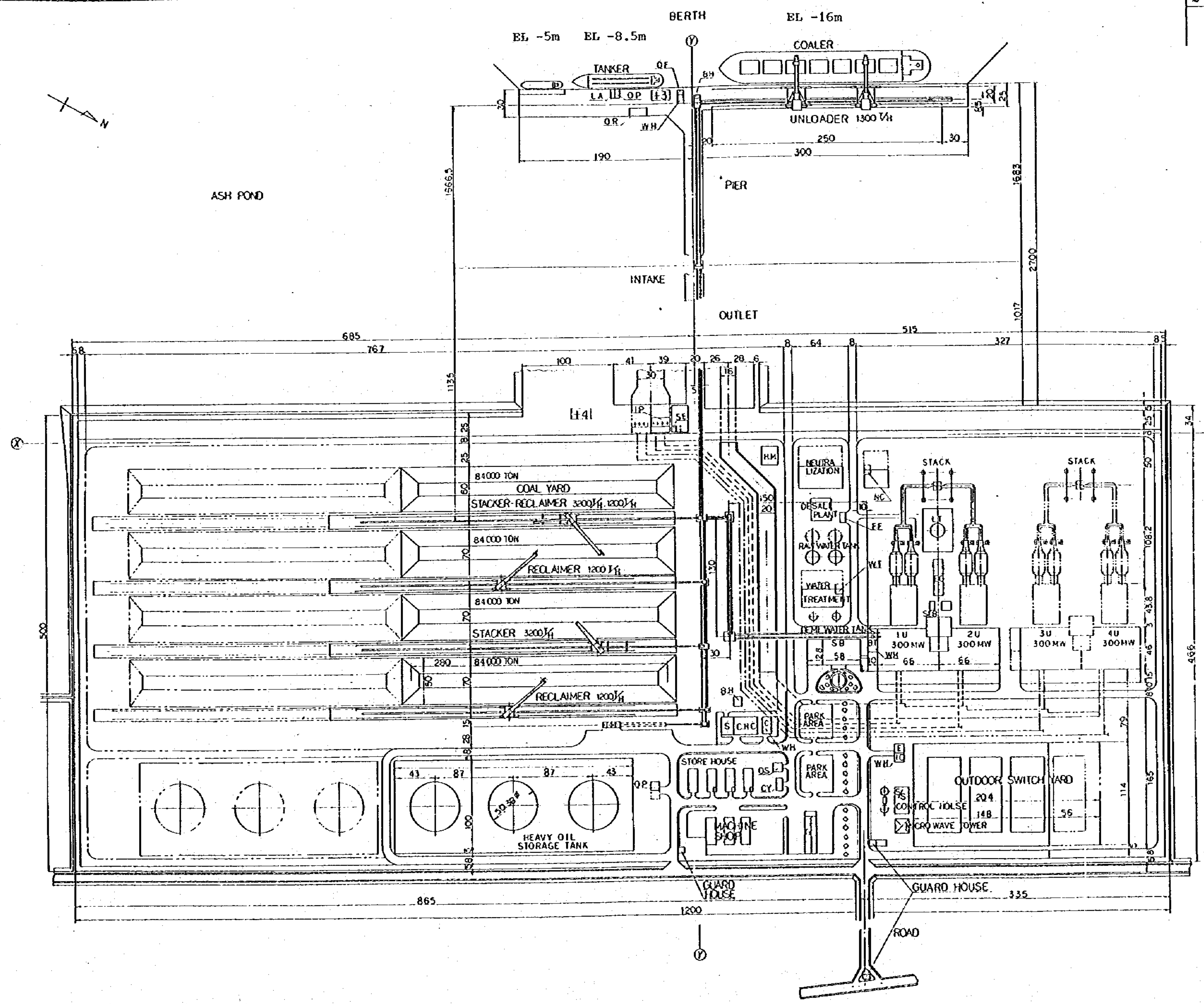
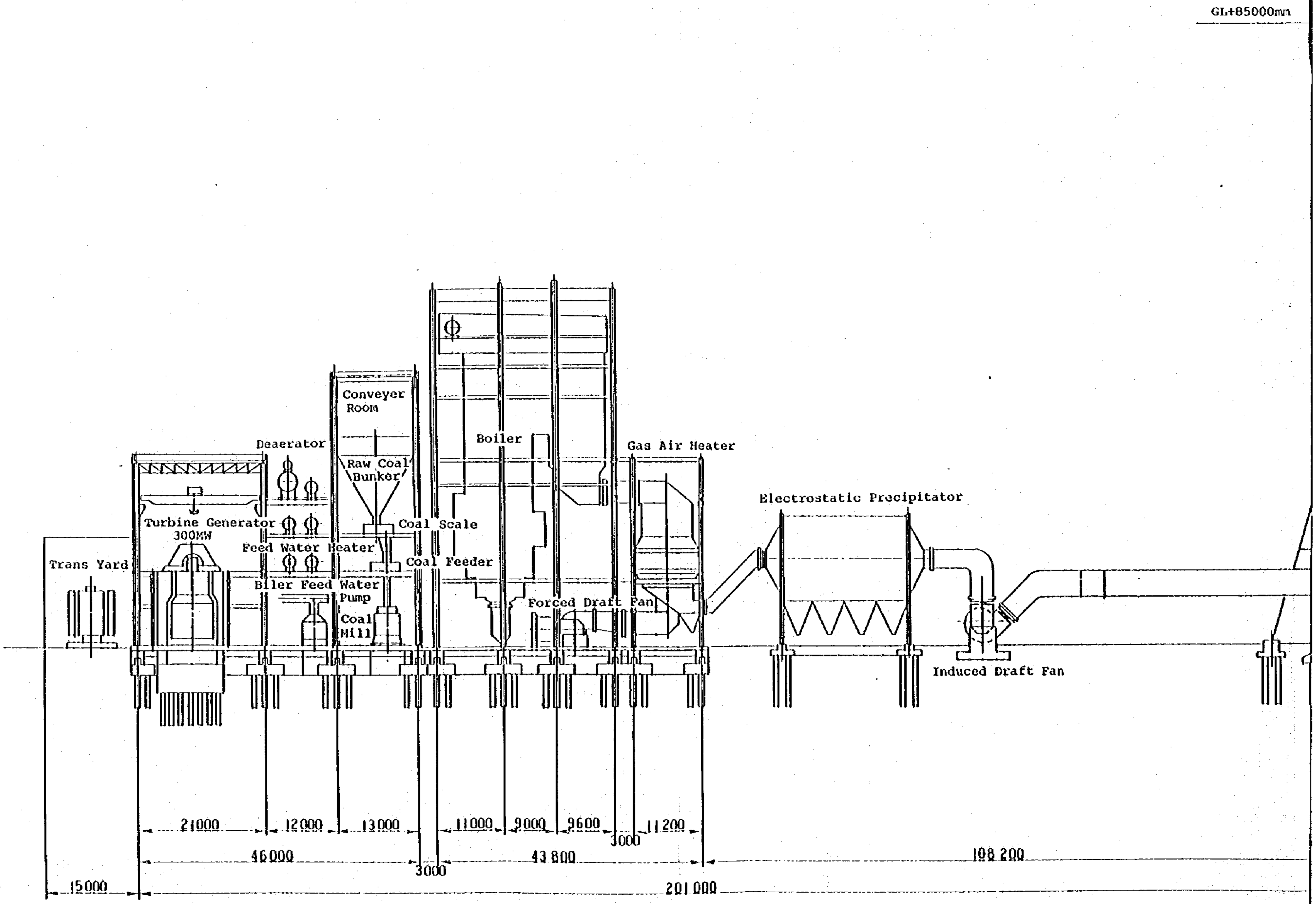


Fig. 2-5

SYMBOL	EXPLANATION
HM	H. MANUFACTURE EQIPMENT
STB	STATION BOILER
SB	SERVICE BUILDING
OS	LUB.OIL STORAGE HOUSE
OR	OIL RECEIVING FACILITIES
LT	LIGHT OIL TANK
LA	LOADING ARM
IP	INTAKE PUMP HOUSE
G	GARAGE
EG	EMERGENCY GAS TARBINE
BH	BULLDOZER HOUSE
CHC	COAL HANDLING CONTROL HOUSE
CY	CYLINDER HOUSE (N.CO₂.H₂)
EF	FIRE FIGHTING PUMP HOUSE
OF	OIL FENCE HOUSE
OP	OIL PUMP HOUSE
NC	NEUTRALIZATATION CONTROL HOUSE
S	COAL DATA MAKING AND REDUCTION HOUSE
SE	SEA-WATER ELECTROLVSIS HOUSE
WH	WOKERS HOUSE
WT	WATER TREATMENT CONTROL HOUSE

THE ARAB REPUBLIC OF EGYPT
SINAI COAL-FIRED THERMAL POWER PROJECT
TITLE
PLOT PLAN
(300MWx4U)
SCALE
DRAWING NO.
P - 1

1/5


GL+85000mm
Conveyer Room
Boiler
Deaerator
Raw Coal Bunker
Gas Air Heater
Electrostatic Precipitator
Turbine Generator 300MW
Coal Scale
Feed Water Heater
Coal Feeder
Trans Yard
Biler Feed Water Pump
Forced Draft Fan
Coal Mill
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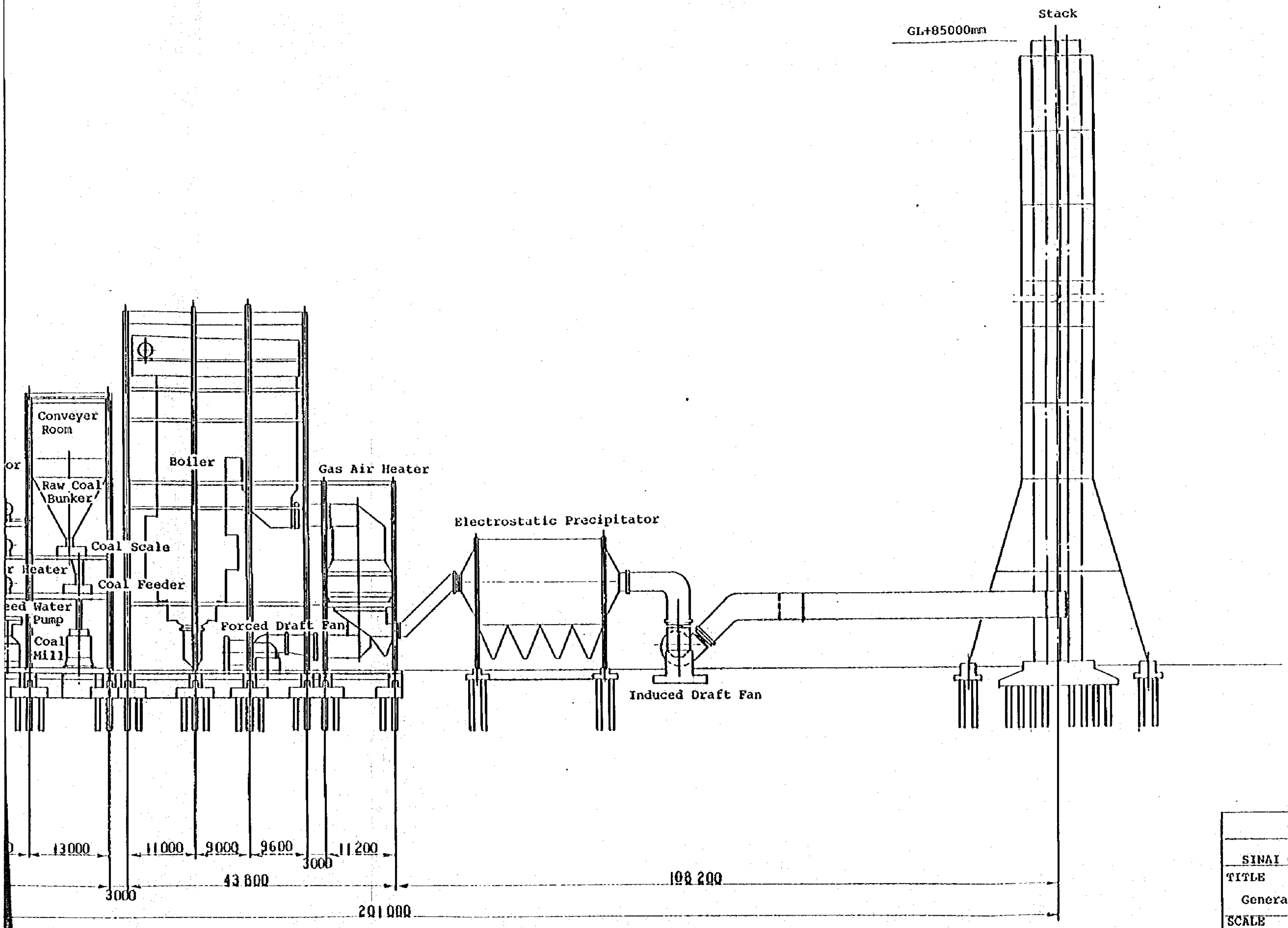

Fig. 2-6

THE ARAB REPUBLIC OF EGYPT

SINAI COAL-FIRED THERMAL POWER PROJECT

TITLE

General Arrangement Plant Side View

SCALE 1/600

DRAWING NO. P - 2

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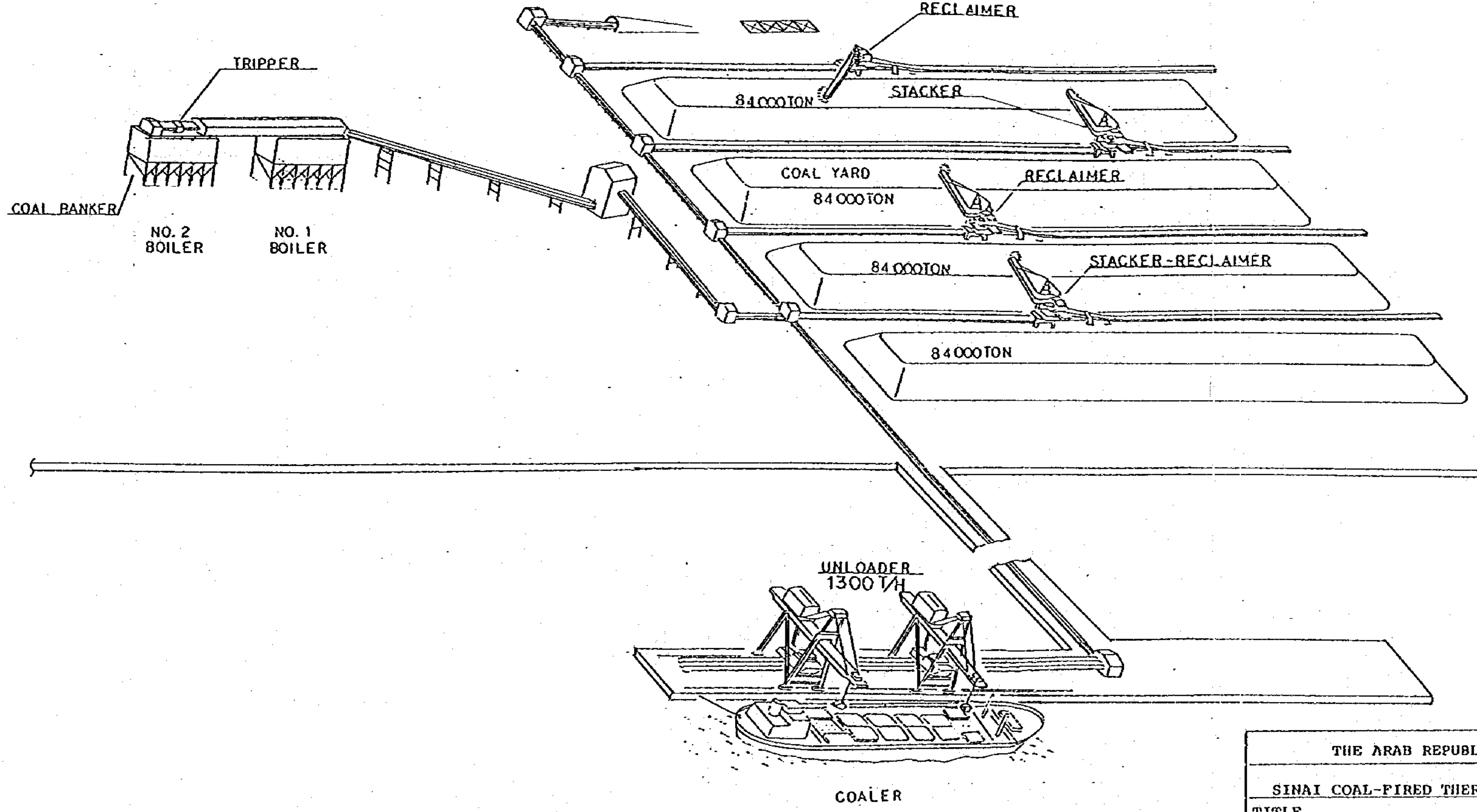


Fig. 2-7

THE ARAB REPUBLIC OF EGYPT

SINAI COAL-FIRED THERMAL POWER PROJECT

TITLE
Outline of Coal Handling

SCALE
NON

DRAWING NO.
P - 6

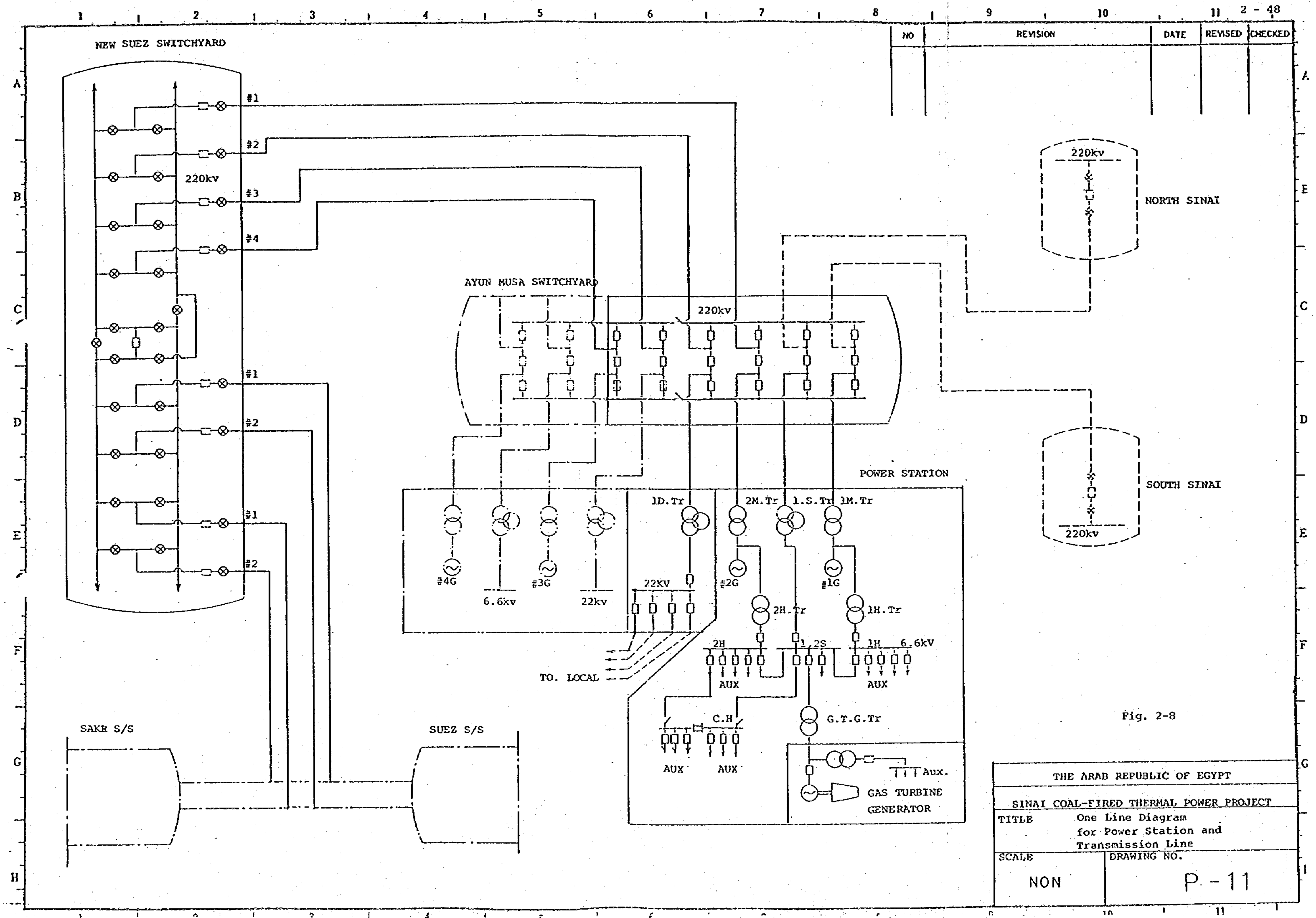


Fig. 2-8

THE ARAB REPUBLIC OF EGYPT

SINAI COAL-FIRED THERMAL POWER PROJECT

TITLE One Line Diagram
for Power Station and
Transmission Line

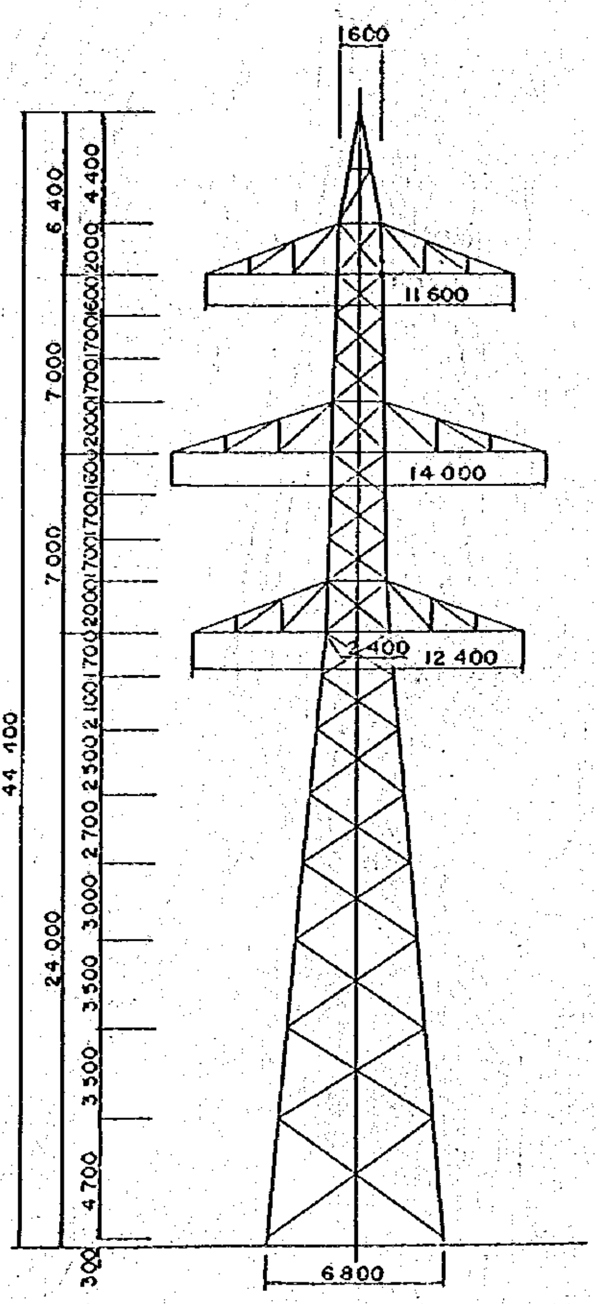
SCALE	DRAWING NO.
NON	P - 11

Fig. 2-9 Map of Transmission Line Route

Fig. 2-10

220KV AAAC 620mm²x 2 : two circuits A Type

220KV 2cct A Type



220 kV 2 cct A Type

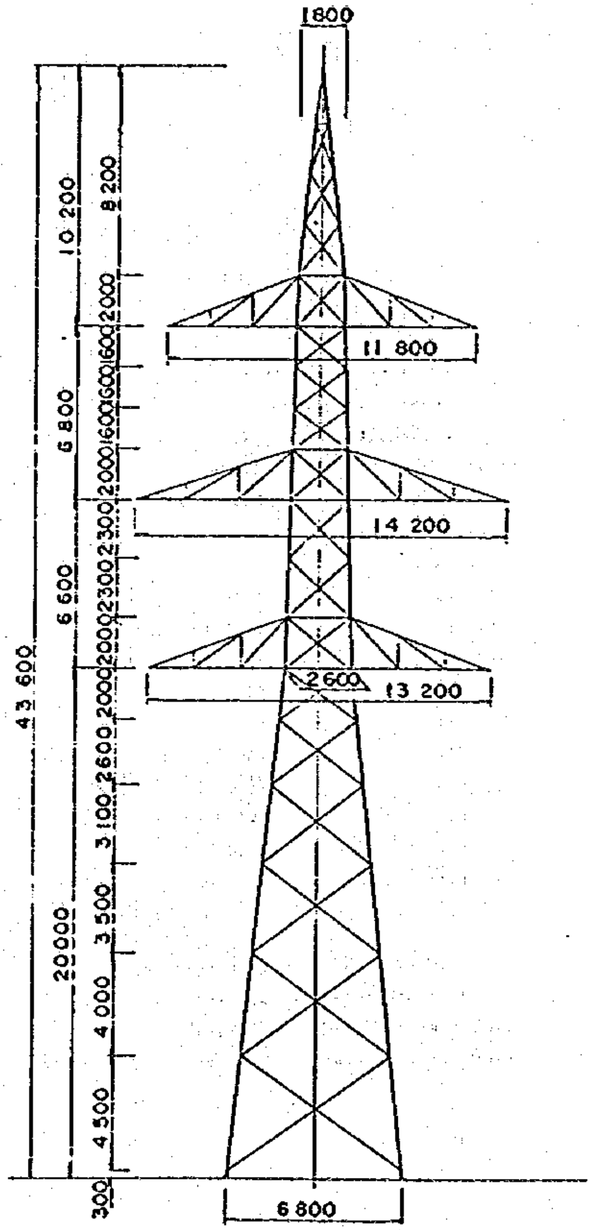
Design condition

No. of circuits	2
Span	350 m
Horizontal angle	3°
Vertical angle	0.1 [illegible]
Conductor	
Size	AAAC 320 mm² x 2
Dia	28.1 mm
Weight	1674 kg/km/one cond.
Max. tension	5500 kg
Gr. Wire	
Size	130 mm² Compound wire with Optical fiber
Dia	17.3 mm
Weight	785.9 kg/km
Max. tension	3250 kg
Insulator	
Type	320 mm Smog 20 pc 1 string
Weight	880 kg/each
Wind pressure	200kg/each
Wind pres. to wire	90 kg/m²
Wind pres. to tower	255 kg/m²

Fig. 2-11

220 KV AAAC 620mm² x 2 : two circuits Tower : B & C Type

220 KV 2cct C Type



220 kV 2 cct B & C Type

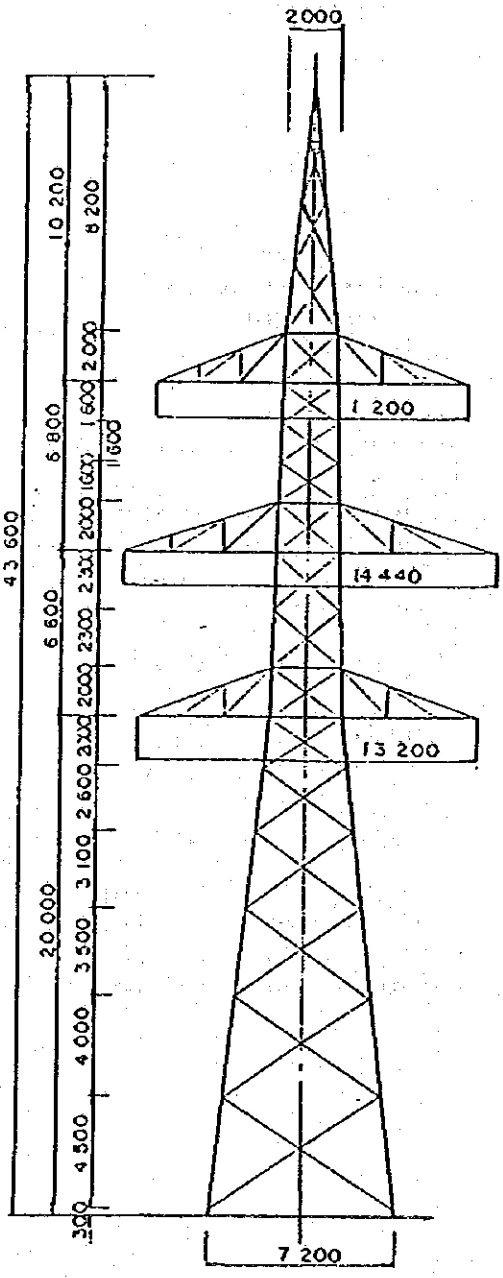
Design Condition

No. of circuit	2
Span	350 m
Horizontal angle	30°
Vertical angle	0.1 T
Conductor	
Size	AAAC 520 mm^2 x 2
Dia	28.1 mm
Weight	1674 kg/km/one cond.
Max. tension	5500 kg
Gr. Wire	
Size	130 mm^2 Compound wire with Optical fiber
Dia	17.4 mm
Weight	765.3 kg/km
Max. tension	3200 kg
Insulator	
Type	320 mm Smog 20 pc 2 string
Weight	2200 kg/each
Wind pressure	560 kg/each
Wind pres. to wire	90 kg/m^2
Wind pres. to tower	255 kg/m^2

Fig. 2 -12

220KV AAAC 620mm^{2}x 2 : two circuits D Type

220 KV 2cct D Type



220 kV 2 cct D Type

Design Condition

No. of circuit	2
Span	350 m
Horizontal angle	Dead end
Vertical angle	0.1 %
Conductor	
Size	AAAC 620mm^2 x 2
Dia	28.1 mm
Weight	1674 kg/km/one cond.
Max. tension	5500 kg
Gr. Wire	
Size	130 mm^2 Compound wire with Optical fiber
Dia	17.4 mm
Weight	785.9 kg/km
Max. tension	3200 kg
Insulator	
Type	320 mm Smog 20 pc 2 string
Weight	2200 kg/each
Wind pressure	560 kg/each
Wind pres. to wire	90 kg/m^2
Wind pres. to towr	255 kg/m^2

Fig. 2-13 Cross-section of Ahmed Hamdi Tunnel

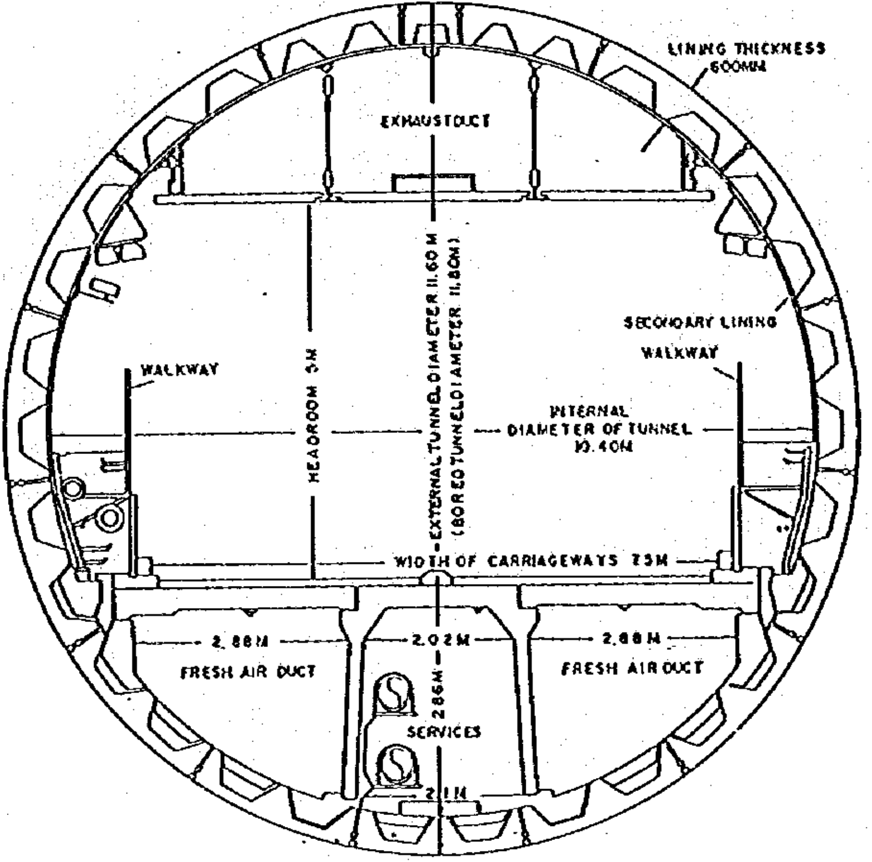
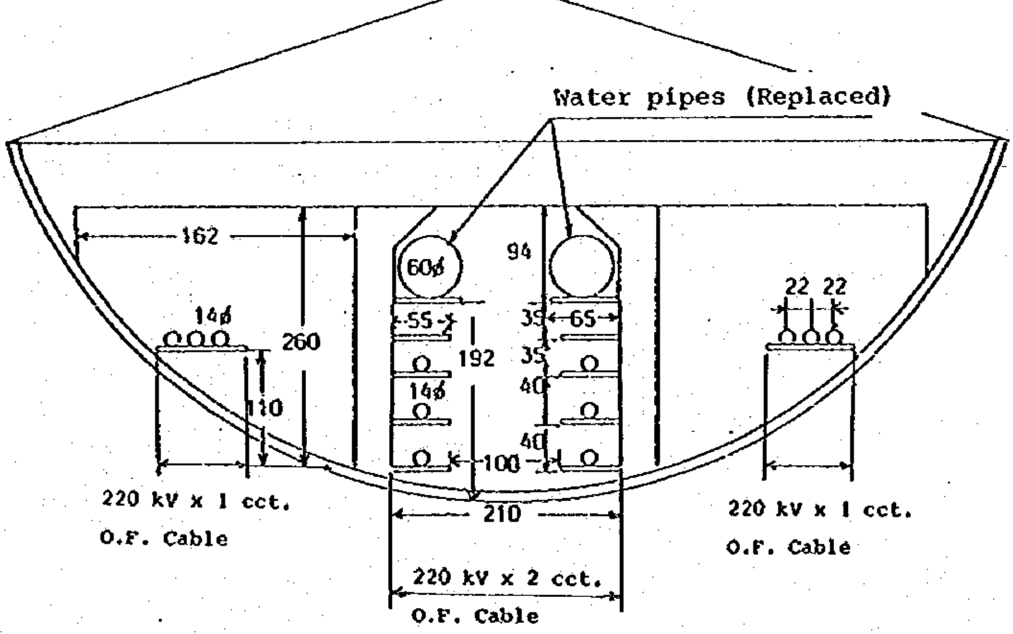


FIG. Arrangement of Cable in Ahmed Hamdi Tunnel

Scale unit: cm



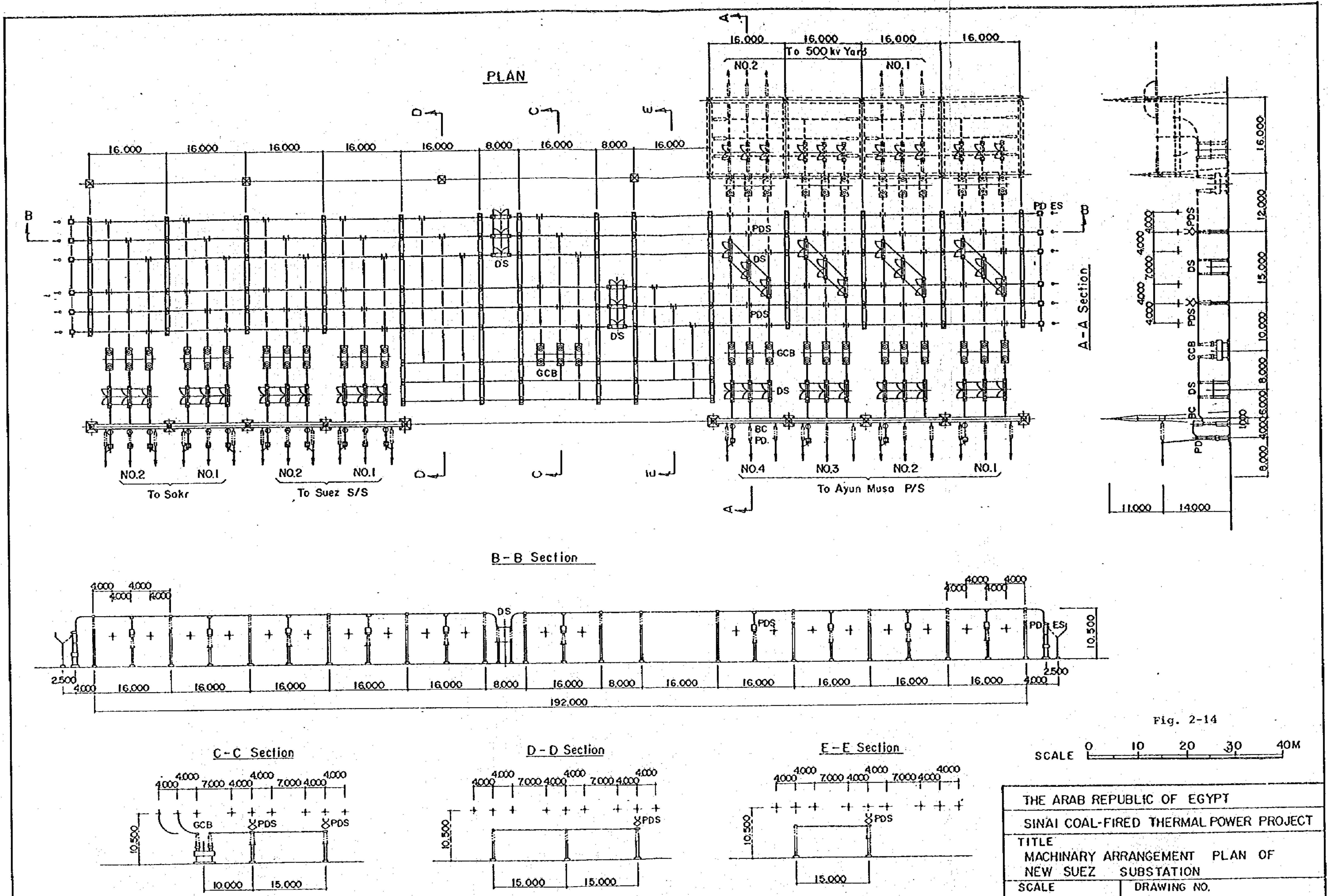


Fig. 2-14

THE ARAB REPUBLIC OF EGYPT

SINAI COAL-FIRED THERMAL POWER PROJECT

TITLE
MACHINARY ARRANGEMENT PLAN OF
NEW SUEZ SUBSTATION

SCALE

DRAWING NO.
E-1

2-1-5 Project Schedule

As shown in the Project Schedule on Table 2-11-(1) and -(2), the Project implementation will be divided into three phases.

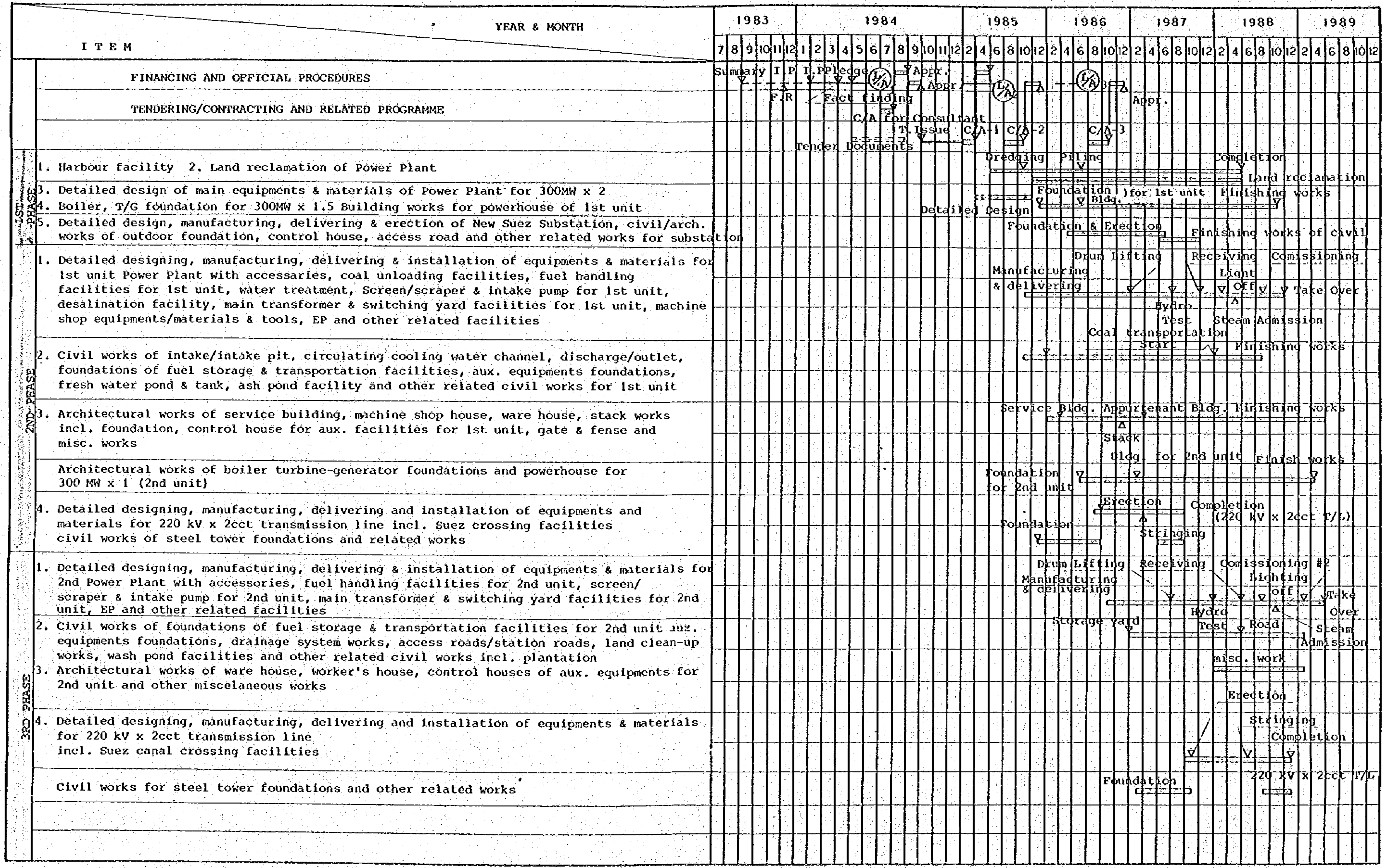
In the first phase, construction of harbor facilities, power plant site reclamation works, detailed design of main equipments and materials of power plant for 300 MW x 2, foundation works of boiler, turbine and generator, and construction of powerhouse for 300 MW No. 1 unit and construction works of New Suez substation will be carried out.

In the second phase, erection works of two 220 kV outgoing transmission lines out of 4 lines as well as erection and installation works, and civil and architectural works for No. 1 Unit and foundation works and powerhouse of No. 2 Unit following the 1st phase will be carried out uninterruptedly.

In the third phase, the erection works, civil and architectural works for No. 2 Unit, and erection works of the remaining two 220 kV outgoing transmission lines will be carried out following the second phase.

For execution of the construction, the contractors should prepare temporary facilities such as auxiliary power generating facilities, water supply facilities, construction offices and accommodations for workers and labors for construction works, and construction equipment and materials. Heavy equipment such as generator stator, major transformers will be unloaded directly from the pier to be constructed near the circulating water intake facilities.

Table 2-11(1) Overall Construction Program (Tentative) 1st Stage



ITEM — YEAR & MONTH

FINANCING AND OFFICIAL PROCEDURES

TENDERING/CONTRACTING AND RELATED PROGRAMME

1ST PHASE

1. Harbour facility 2. Land reclamation of Power Plant
3. Detailed design of main equipments & materials of Power Plant for 300MW x 2
4. Boiler, T/G foundation for 300MW x 1.5 Building works for powerhouse of 1st unit
5. Detailed design, manufacturing, delivering & erection of New Suez Substation, civil/arch. works of outdoor foundation, control house, access road and other related works for substation

2ND PHASE

1. Detailed designing, manufacturing, delivering & installation of equipments & materials for 1st unit Power Plant with accessaries, coal unloading facilities, fuel handling facilities for 1st unit, water treatment, screen/scraper & intake pump for 1st unit, desalination facility, main transformer & switching yard facilities for 1st unit, machine shop equipments/materials & tools, EP and other related facilities
2. Civil works of intake/intake pit, circulating cooling water channel, discharge/outlet, foundations of fuel storage & transportation facilities, aux. equipments foundations, fresh water pond & tank, ash pond facility and other related civil works for 1st unit
3. Architectural works of service building, machine shop house, ware house, stack works incl. foundation, control house for aux. facilities for 1st unit, gate & fense and misc. works

Architectural works of boiler turbine-generator foundations and powerhouse for 300 MW x 1 (2nd unit)

4. Detailed designing, manufacturing, delivering and installation of equipments and materials for 220 kV x 2cct transmission line incl. Suez crossing facilities civil works of steel tower foundations and related works

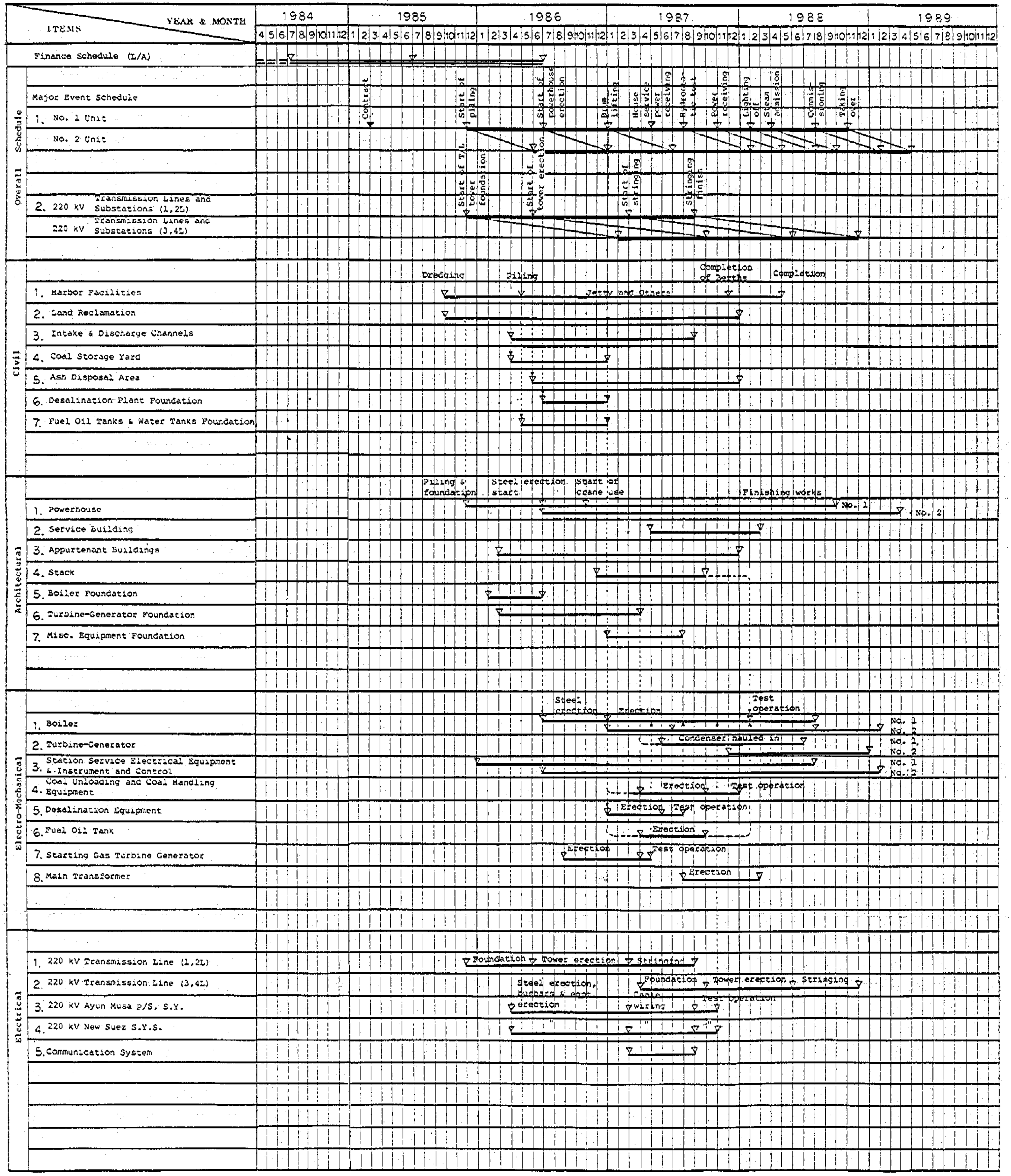
3RD PHASE

1. Detailed designing, manufacturing, delivering & installation of equipments & materials for 2nd Power Plant with accessories, fuel handling facilities for 2nd unit, screen/scraper & intake pump for 2nd unit, main transformer & switching yard facilities for 2nd unit, EP and other related facilities
2. Civil works of foundations of fuel storage & transportation facilities for 2nd unit aux. equipments foundations, drainage system works, access roads/station roads, land clean-up works, wash pond facilities and other related civil works incl. plantation
3. Architectural works of ware house, worker's house, control houses of aux. equipments for 2nd unit and other miscelaneous works
4. Detailed designing, manufacturing, delivering and installation of equipments & materials for 220 kV x 2cct transmission line incl. Suez canal crossing facilities

Civil works for steel tower foundations and other related works

Table 2-11-(2) SINAI COAL-FIRED THERMAL POWER PROJECT

CONSTRUCTION PROGRAM (Tentative) 1st STAGE



2-1-6 Funding Plan

1) Fund Procurement

With respect to the funds required for this Project, since recovery of investment will be made over an extremely long period, it will be necessary for long-term, low-interest funds to be borrowed and administrated both for foreign and local currency portions. Accordingly, it is assumed that the foreign currency will be borrowed from government to government funds or an international financing institutions while the local currency will be made available by a financial institution in Egypt normally used by the government organs. In addition, since the project is very big scale, fund procurement will be divided into three stages in accordance with the project schedule.

2) Terms of Loan

a. Foreign Currency

Applicable intrest and repayment period are set up as follows:

- For 80% of foreign currency portion, an interest rate of 4% and a repayment period of 30 years including grace period of 5 years (both interest and principal)
- For 20% of foreign currency portion, an interest rate of 9% and a repayment period of 15 years including grace period of 5 years (both interest and principal)

b. Local Currency

Applicable interest for local currency is set to be 8% per annum.

It is assumed that repayment of principal and interest during construction will be deferred for 3 years and repayment of principal and interest (including both interest imposed on principal and interest on interest during construction) made in equal installments over a 12-year period.

3) Financial Analysis

The financial analysis was made by comparison of the construction cost of the Sinai Coal-fired Thermal Power Project and the revenue of energy sales, namely by

Internal Rate of Return (IRR)

Repayment Schedule

Statement of Income

Cash Flow Analysis

The basic conditions of analysis are as follows.

Electric Rate: The electric rate of EEA is set very low at 7.92 millimes/kWh (9.6 mill (U.S. Unit)/kWh) as of 1981, in line with the national policy of expansion of electrification and stabilization of peoples' living. However, in view of unbalance with the soaring commodity prices, the average rate at consumer end is scheduled to be revised as follows.

1983/84	15.666 mill./kWh
1987/88	28.846 mill./kWh
1988/89	31.154 mill./kWh
1989/90	33.646 mill./kWh

Fuel Cost (coal):

Subsidized cost of heavy oil for power generation:

7.5 LE/ton (9.1 US$/ton)

Coal prices: Domestic coal 44.0 LE/ton

Imported coal 47.1 LE/ton
(Australian coal)

Overall 46.5 LE/ton

The actual political price of coal may be adjusted by the annual profit obtained by export of oil saved by the use of coal, at the equivalent value corresponding to the unit price of oil, namely

$$7.5 \text{ LE} \times \frac{\text{Coal } 6{,}500 \text{ kcal/kg}}{\text{Oil } 10{,}000 \text{ kcal/kg}} = 4.9 \text{ LE/ton}$$

Therefore,

$$\frac{2{,}205 \text{ kcal/kWh}}{6{,}500 \text{ kcal/kg}} \times 4.9 \text{ LE/ton} = 1.66 \text{ millimes/kWh}$$

Plant efficiency: 39%

Table 2-12 Construction Cost

Unit: x 10^6 LE (x 10^6 US$)

Items	F.C.		L.C.		Total	
(1) Generating Facilities						
Equipment	262.0	(318.3)	-		262.0	(318.3)
Erection	42.2	(51.3)	19.6	(23.8)	61.8	(75.1)
Civil works	10.4	(12.6)	18.3	(22.2)	28.7	(34.8)
Architectural works	34.0	(41.3)	16.1	(19.6)	50.1	(60.9)
Harbor facilities	28.3	(34.4)	7.6	(9.2)	35.9	(43.6)
Sub-total	376.9	(457.9)	61.6	(74.8)	438.5	(532.7)
Unit Construction Cost [LE/kW (US$/kW)]	-	-	-	-	730.8	(887.8)
(2) Transmission Lines and Substation						
1) Transmission line	25.6	(31.1)	7.5	(9.1)	33.1	(40.2)
Unit Construction Cost [10^3 LE/km (10^3 US$/km)]	-	-	-	-	760.9	(924.1)
2) Substation	10.8	(13.1)	2.3	(2.8)	13.1	(15.9)
Sub-total	36.4	(44.2)	9.8	(11.9)	46.2	(56.1)
(3) Engineering Fee	5.4	(6.6)	-	-	5.4	(6.6)
(4) Total (1)+(2)+(3)	418.7	(508.7)	71.4	(86.7)	490.1	(595.4)
(5) Contingency	16.7	(20.3)	3.6	(4.4)	20.3	(24.7)
(6) Grand Total (4)+(5)	435.4	(529.0)	75.0	(91.1)	510.4	(620.1)

This project will be implemented in 3 phases continuously, as shown on the construction schedule.

Table 2-13 Budget for Each Phase

Unit: x 10^6 LE (x 10^6 US$)

Items	F.C.		L.C.		Total	
1st Phase	63.4	(77.0)	24.1	(29.3)	87.5	(106.3)
2nd Phase	207.5	(252.1)	32.6	(39.6)	240.1	(291.7)
3rd Phase	164.5	(199.9)	18.3	(22.2)	182.8	(222.1)
Total	435.4	(529.0)	75.0	(91.1)	510.4	(620.1)

Table 2-14 Budget for Each Year

Unit: x 10^6 LE (x 10^6 US$)

Year	F.C.		L.C.		TOTAL	
1984	4.0	(4.9)	1.2	(1.5)	5.2	(6.4)
1985	54.0	(65.6)	8.2	(10.0)	62.2	(75.6)
1986	121.6	(147.8)	19.0	(23.0)	140.6	(170.8)
1987	183.9	(223.4)	29.5	(35.8)	213.4	(259.2)
1988	58.7	(71.3)	15.9	(19.4)	74.6	(90.7)
1989	13.2	(16.0)	1.2	(1.4)	14.4	(17.4)
TOTAL	435.4	(529.0)	75.0	(91.1)	510.4	(620.1)

Table 2-15 Operating Revenue: (durable year: 30 years)

Fiscal Year		Salable Capacity (MW)	Annual Operation Hour (Hr.)	Annual Salable GWh at Consumer end (GWh)	Salable Price (mill./kWh)	Operating Revenue (10^6 LE)
1988	No. 1	300	4,655	1,232	21.81	26.8
	No. 2	300	1,133	299	21.81	6.5
	Subtotal	600	5,798	1,531	21.81	33.4
1989	No. 1	300	7,008	3,700	23.55	87.1
-2017	No. 2	300	x 29 years	x 29 years		x 29 years
	Subtotal	600	121,945	107,300	23.55	2,526.9
2018	No. 1	300	2,342	619	23.55	14.6
	No. 2	300	5,875	1,550	23.55	36.5
	Subtotal	600	8,217	2,169	23.55	51.1
	Total					2,611.4
Total Repayment (including interest)						903.5
Total Operating Expenses (excluding depreciation)						609.0
Cash Balance						1,098.9

The results of analysis based on the foregoing conditions are as follows.

IRR: The equalizing discount rate (FIRR) will be 11.29%, and this project is feasible from the view point of financial aspect.

Cash Flow: In the balance between the operating revenue and the operating expenses including depreciation, repayment, etc., the net benefit, after deduction of will be about + 4.2 million LE in the initial year of power plant operation and + 19.5 million LE in the second year, and the total revenue in 30 years of durable life would amount to + 1,099 million LE. The Project is proved to be well feasible.

2-1-7 Economic Analysis

Oil-fired plant and coal-fired plant are compared at the present worth of the benefit and cost as of 1984 when the construction is started. The present worth factor is obtained by the social discount factor of 8%, 10% and 12%.

The result of analysis shows that the coal-fired plant is 1.5 mill./kWh more economical in the generating cost on the actual basis than the oil fired plant, and the ratio of benefit/cost (oil-fired plant/coal-fired plant), showing that the latter is more advantageous.

Table 2-16 Data for Analysis

	Oil-fired	Coal-fired	Remarks
° Installed capacity	620 MW	640 MW	
° Sending end capacity	600 MW	600 MW	
° Station service loss kWh	3.5%	6.25%	
° Utilization factor	80%	80%	
° Transmission and Distribution losses	12%	12%	
° Annual generation at Generator end	4,344,960 MWh	4,485,120 MWh	
° Annual Salable energy at consumer end	3,689,740 MWh	3,700,200 MWh	
° Construction cost	466.4 x 10^6 LE	510.4 x 10^6 LE	
° Operation and maintenance cost	9.3x10^6 LE (2%)	10.2x10^6 LE (2%)	
° Administration cost	2.3x10^6 LE (0.5%)	2.6x10^6 LE (0.5%)	
° Annual Fuel Consumption	958.1x10^3 ton	1,521.5x10^3 ton	
° Fuel price	$180(148.1 LE)/ton	$59(48.6 LE)/ton	- Theoretical basis
	$9.1(7.5 LE)/ton (Subsidiged price)	$56.5(46.5 LE)/ton	- Actual basis
° Fuel Cost	141.9 x 10^6 LE	73.9 x 10^6 LE	- Theoretical basis
	7.2 x 10^6 LE	70.7 x 10^6 LE	- Actual basis
° Durable years	30 years	30 years	
° Plant efficiency	39%(2,205 kcal/kwh)	39%(2,205 kcal/kwh)	
° Fuel calorific value	10,000 kcal/kg	6,500 kcal/kg	
° Annual Cost	153.5 x 10^6 LE	86.7 x 10^6 LE	- Theoretical basis
	18.8 x 10^6 LE	83.5 x 10^6 LE	- Actual basis
° Annual saving cost (Benefit cost by coal-firing)	-	-	- Theoretical basis
	-	-71.1 x 10^6 LE	- Actual basis
° Subsidiged annual cost	153.5 x 10^6 LE	86.7 x 10^6 LE	- Theoretical basis
	18.8 x 10^6 LE	12.4 x 10^6 LE	- Actual basis
° Generating Cost at Generator End	35.3 mill./kWh	19.3 mill./kWh	- Theoretical basis
	4.3 mill./kWh	2.8 mill./kWh	- Actual basis
° Salable Price at Consumer End	41.6 mill./kWh	23.5 mill./kWh	- Theoretical basis
	5.1 mill./kWh	3.4 mill./kWh	- Actual basis

Benefit/Cost Ratio (Discount rate: 8%):

	Sinai Plant	Alternative Oil-fired Plant
Construction Cost:	510.4×10^6 LE	466.4×10^6 LE

Annual Disbursement and Present Worth:

Year	Disbursement	Present Worth at 1984	Disbursement	Present Worth at 1984
1984	5.2	5.2	4.8	4.8
1985	62.2	57.6	56.8	52.6
1986	140.6	120.5	128.5	110.2
1987	213.4	169.4	195.1	154.9
1988	74.6	54.8	68.1	50.1
1989	14.4	9.8	131.1	8.9
Total	510.4	417.3	466.4	381.5

Total Annual Costs:	86.7×10^6 LE	153.5×10^6 LE	- Theoretical basis
	12.4×10^6 LE	18.8×10^6 LE	- Actual basis
Present Worth of Annual Expenses for Durable Year (30):	664.3×10^6 LE	$1,176.1 \times 10^6$ LE	- Theoretical basis
	95.0×10^6 LE	144.0×10^6 LE	- Actual basis

Benefit/Cost Ratio:

Cost: $(417.3 + 664.3) \times 10^6$ LE = $1,081.6 \times 10^6$ LE - Theoretical

$(417.3 + 95.0) \times 10^6$ LE = 512.3×10^6 LE - Actual basis

(Sinai Plant)

Benefit: $(381.5 + 1,176.1) \times 10^6$ LE = $1,557.6 \times 10^6$ LE- Theoretical

$(381.5 + 144.0) \times 10^6$ LE = 525.5×10^6 LE- Actual basis

(Alternative oil-fired plant)

$$\frac{\text{Benefit}}{\text{Cost}} = \frac{1,557.6 \times 10^6 \text{ LE}}{1,081.6 \times 10^6 \text{ LE}} = 1.44 \quad \text{- Theoretical basis}$$

$$\frac{\text{Benefit}}{\text{cost}} = \frac{525.5 \times 10^6 \text{ LE}}{512.3 \times 10^6 \text{ LE}} = 1.03 \quad \text{- Actual basis}$$