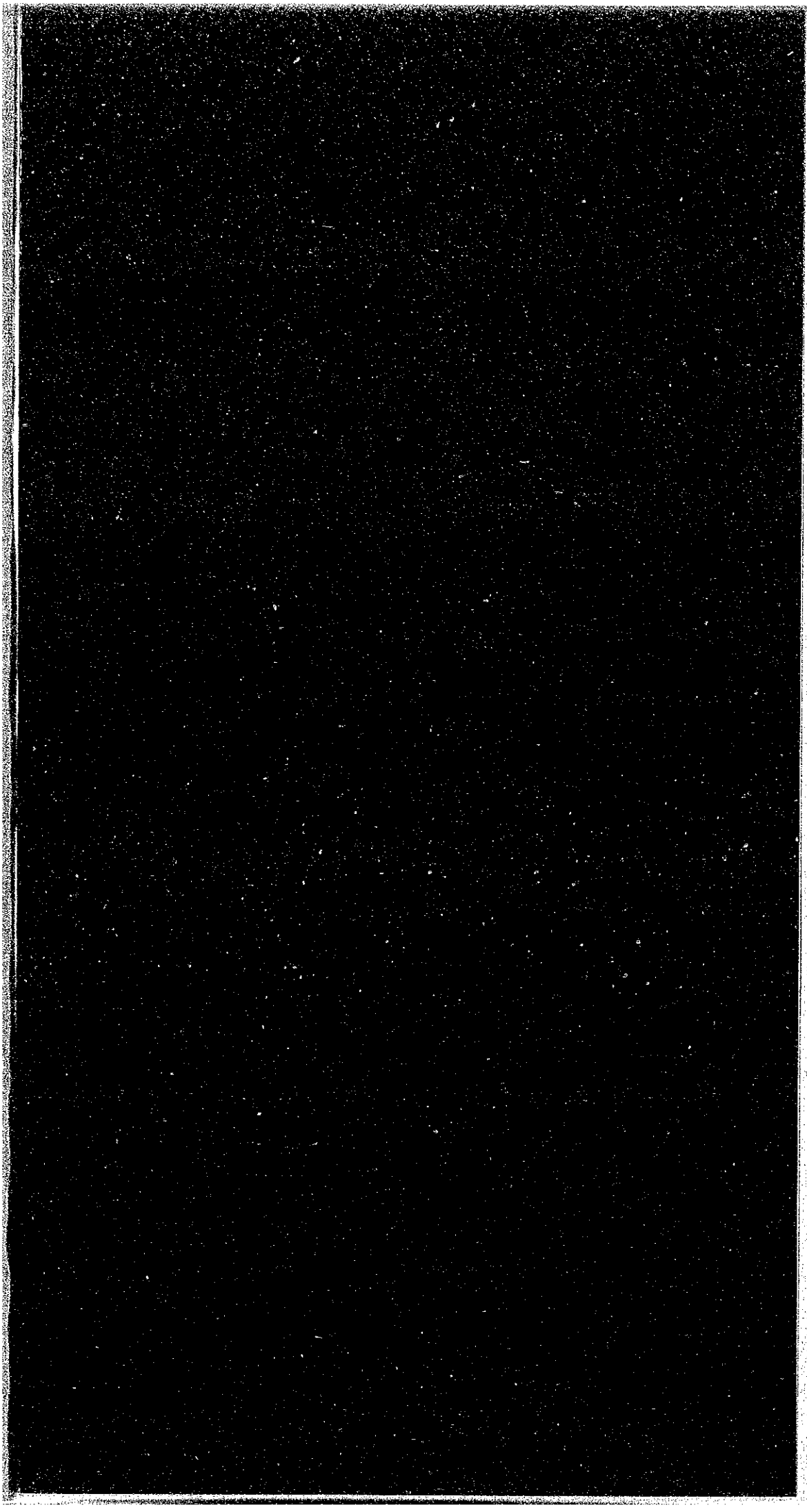
GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA



GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

SECTORAL REPORT

VOL. 8

POWER MARKET

OCTOBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

LIST OF REPORTS

MAIN REPORT

Vol. 1. MASTER ACTION PLAN
Vol. 2. WATER RESOURCES DEVELOPMENT AND USE PLAN

STATE REPORT

Vol. 1. PERLIS/KEDAH/P. PINANG
Vol. 2. PERAK
Vol. 3. SELANGOR
Vol. 4. N. SEMBILAN/MELAKA
Vol. 5. JOHOR
Vol. 6. PAHANG
Vol. 7. TRENGGANU
Vol. 8. KELANTAN
Vol. 9. SABAH
Vol. 10. SARAWAK

SECTORAL REPORT

Vol. 1. SOCIO-ECONOMY
Vol. 2. METEOROLOGY AND HYDROLOGY
Vol. 3. GROUNDWATER RESOURCES
Vol. 4. GEOLOGY
Vol. 5. RIVER CONDITIONS
Vol. 6. WATER QUALITY
Vol. 7. ECOLOGY
Vol. 8. POWER MARKET
Vol. 9. DOMESTIC AND INDUSTRIAL WATER SUPPLY
Vol. 10. AGRICULTURE
Vol. 11. IRRIGATION WATER DEMAND
Vol. 12. INLAND FISHERY
Vol. 13. INLAND NAVIGATION, WATER-RELATED RECREATION
Vol. 14. WATERSHED MANAGEMENT
Vol. 15. WATER RESOURCES ENGINEERING
Vol. 16. WATER SOURCE AND HYDROPOWER DEVELOPMENT PLANNING
Vol. 17. PUBLIC EXPENDITURE AND BENEFICIAL AND ADVERSE EFFECTS
Vol. 18. WATER RESOURCES MANAGEMENT
Vol. 19. WATER LAWS AND INSTITUTIONS

COMPOSITION OF THIS VOLUME

This Volume consists of two parts: Part 1 deals with the subject matters of Peninsular Malaysia and Part 2 is devoted to the States of Sabah and Sarawak.

ABBREVIATIONS

(1) Plan

FMP	:	First Malaysia Plan
SMP	:	Second Malaysia Plan
TMP	:	Third Malaysia Plan
4MP	:	Fourth Malaysia Plan
5MP	:	Fifth Malaysia Plan
6MP	:	Sixth Malaysia Plan
7MP	:	Seventh Malaysia Plan
NEP	:	New Economic Policy
OPP	:	Outline Perspective Plan
RESP	:	Rural Environmental Sanitation Program

(2) Domestic Organization

DID (JPT)	:	Drainage and Irrigation Department
DOA	:	Department of Agriculture
DOE	:	Division of Environment
DOF	:	Department of Forestry
DOFS	:	Department of Fishery
DOM	:	Department of Mines
DOS	:	Department of Statistics
EPU	:	Economic Planning Unit
FAMA	:	Federal Agricultural Marketing Authority
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
ICU	:	Implementation and Coordination Unit
MARDI	:	Malaysian Agricultural Research and Development Institute
MIDA	:	Malaysian Industrial Development Authority
MLRD	:	Ministry of Land and Regional Development
MMS	:	Malaysian Meteorological Service
MOA	:	Ministry of Agriculture
MOF	:	Ministry of Finance

MOH	:	Ministry of Health
MOPI	:	Ministry of Primary Industries
MRRDB	:	Malaysia Rubber Research and Development Board
NDPC	:	National Development Planning Committee
NEB (LLN)	:	National Electricity Board
PORIM	:	Palm Oil Research Institute of Malaysia
PWD (JKR)	:	Public Works Department
RDA	:	Regional Development Authority
RISDA	:	Rubber Industry Small-holders Development Authority
RRIM	:	Rubber Research Institute of Malaysia
SEB	:	Sabah Electricity Board
SEBC	:	State Economic Development Corporation
S(E)PU	:	State (Economic) Planning Unit
SESCO	:	Sarawak Electricity Supply Corporation
UDA	:	Urban Development Authority

(3) International or Foreign Organization

ADAA	:	Australian Development Assistance Agency
ADB	:	Asian Development Bank
ASCE	:	American Society of Civil Engineers
FAO	:	Food and Agriculture Organization of the United Nations
IBRD	:	International Bank for Reconstruction and Development
ILO	:	International Labour Organization
IMF	:	International Monetary Fund
IRRI	:	International Rice Research Institute
JICA	:	Japan International Cooperation Agency
JSCE	:	Japan Society of Civil Engineers
MOC	:	Ministry of Construction, Japan
OECD	:	Organization for Economic Cooperation and Development
OECF	:	Overseas Economic Cooperation Fund, Japan
UK	:	United Kingdom
UNDP	:	United Nations Development Program

UNSF	:	United Nations Special Fund
US or USA	:	United States of America
US/AID	:	United States Agency for International Development
USBR	:	United States Bureau of Reclamation
WHO	:	World Health Organization
WMO	:	World Meteorological Organization

(4) Others

B	:	Benefit
BOD	:	Biochemical Oxygen Demand
C	:	Cost
CIF	:	Cost, Insurance and Freight
COD	:	Chemical Oxygen Demand
D&I	:	Domestic and Industrial
dia	:	Diameter
EIRR	:	Economic Internal Rate of Return
El.	:	Elevation above mean sea level
Eq.	:	Equation
Fig.	:	Figure
FOB	:	Free on Board
FSL	:	Full Supply Level
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
H	:	Height, or Water Head
HWL	:	Reservoir High Water Level
LWL	:	Reservoir Low Water Level
O&M	:	Operation and Maintenance
Q	:	Discharge
Ref.	:	Reference
SITC	:	Standard International Trade Classification
SS	:	Suspended Solid
V	:	Volume
W	:	Width

ABBREVIATIONS OF MEASUREMENT

Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer
ft = foot
yd = yard

Area

cm^2 = square centimeter
m^2 = square meter
ha = hectare
km^2 = square kilometer

Volume

cm^3 = cubic centimeter
l = lit = liter
kl = kiloliter
m^3 = cubic meter
gal. = gallon

Weight

mg = milligram
g = gram
kg = kilogram
ton = metric ton
lb = pound

Time

s = second
min = minute
h = hour
d = day
y = year

Electrical Measures

V = Volt
A = Ampere
Hz = Hertz (cycle)
W = Watt
kW = Kilowatt
MW = Megawatt
GW = Gigawatt

Other Measures

% = percent
PS = horsepower
° = degree
' = minute
" = second
°C = degree in centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)

Derived Measures

m^3/s = cubic meter per second
cusec = cubic feet per second
mgd = million gallon per day
kWh = kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
kWh/y = kilowatt hour per year
kVA = kilovolt ampere
BTU = British thermal unit
psi = pound per square inch

Money

M$ = Malaysian ringgit
US$ = US dollar
¥ = Japanese Yen

CONVERSION FACTORS

	From Metric System	To Metric System
Length	1 cm = 0.394 inch 1 m = 3.28 ft = 1.094 yd 1 km = 0.621 mile	1 inch = 2.54 cm 1 ft = 30.48 cm 1 yd = 91.44 cm 1 mile = 1.609 km
Area	1 cm^2 = 0.155 sq.in 1 m^2 = 10.76 sq.ft 1 ha = 2.471 acres 1 km^2 = 0.386 sq.mile	1 sq.ft = 0.0929 m^2 1sq.yd = 0.835 m^2 1 acre = 0.4047 ha 1 sq.mile = 2.59 km^2
Volume	1 cm^3 = 0.0610 cu.in 1 lit = 0.220 gal.(imp.) 1 kl = 6.29 barrels 1 m^3 = 35.3 cu.ft 10^6 m^3 = 811 acre-ft	1 cu.ft = 28.32 lit 1 cu.yd = 0.765 m^3 1 gal.(imp.) = 4.55 lit 1 gal.(US) = 3.79 lit 1 acre-ft = 1,233.5 m^2
Weight	1 g = 0.0353 ounce 1 kg = 2.20 lb 1 ton = 0.984 long ton = 1.102 short ton	1 ounce = 28.35 g 1 lb = 0.4536 kg 1 long ton = 1.016 ton 1 short ton = 0.907 ton
Energy	1 kWh = 3,413 BTU	1 BTU = 0.293 Wh
Temperature	°C = (°F - 32)·5/9	°F = 1.8°C + 32
Derived Measures	1 m^3/s = 35.3 cusec 1 kg/cm^2 = 14.2 psi 1 ton/ha = 891 lb/acre 10^6 m^3 = 810.7 acre-ft 1 m^3/s = 19.0 mgd	1 cusec = 0.0283 m^3/s 1 psi = 0.703 kg/cm^2 1 lb/acre = 1.12 kg/ha 1 acre-ft = 1,233.5 m^3 1 mgd = 0.0526 m^3/s
Local Measures	1 lit = 0.220 gantang 1 kg = 1.65 kati 1 ton = 16.5 pikul	1 gantang = 4.55 lit 1 kati = 0.606 kg 1 pikul = 60.6 kg

Exchange Rate
(as average between July and December 1980)

$1 = M$2.22
¥100 = M$1.03

PART 1

PENINSULAR MALAYSIA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

This Sectoral Report presents the results of power market survey which was done in December 1980. It consists of the inventory of the existing power situation, performance of power system, power development plan, future power demand and planning materials required for the future hydropower development in Peninsular Malaysia.

2. EXISTING POWER SUPPLY FACILITIES

2.1 Generating Facilities

National Electricity Board (NEB) is responsible for electric power supply in Peninsular Malaysia. Power generating facilities of NEB at the end of August, 1979 are summarized in Table 1 (see Ref. 3). Some details of the major generating plants each having installed capacity above 5 MW are shown in Table 2 (see Ref. 3). Out of the total installed capacity of 1,795.7 MW in NEB system, thermal power facilities stand for 65.5%. The majority is oil fired units. In addition to the facilities listed in Table 1, additional 3 units of 120 MW oil fired steam plant in Prai power station were constructed and commissioned as of November, 1980 (see Ref. 6).

Apart from NEB power system, there are many licenced public power stations in 66 towns/villages as shown in Table 3.

2.2 Transmission and Distribution Systems

An outline of NEB power system is as illustrated in Fig. 1 (see Ref. 2). Features of NEB transmission and distribution lines are shown in Table 4 (see Ref. 3). The major transmission line voltages are 275 kV, 132 kV and 66 kV. Major cities, towns and villages in the west coast and Kuantan in the east coast are connected by these transmission lines. There are interconnections with Singapore and Thailand. Towns along the east coast will be linked with the western system by 275 kV lines by 1985. Voltages of trunk distribution lines are mainly 11 kV and 6.6 kV. Distribution line to each household is 400/230 V, 50 Hz system.

2.3 Substation Facilities

Transformer capacities of NEB system are shown in Table 5 (see Ref. 3).

2.4 Inventory of Hydropower Facilities

Details of the existing hydropower stations within NEB power supply system are listed in Tables 6 to 9 (see Refs. 3 and 7).

Among 12 hydropower stations, 6 power stations (632.0 MW in total) are located in Perak State and 5 power stations (8.9 MW in total) are located in Pahang State, respectively. Remaining one (2.3 MW) is in Selangor State. Three major hydropower stations owned by NEB are Temengor (348 MW), Sultan Yussuf (100 MW) and Sultan Idris II (150 MW) and the aggregate installed capacity of these power stations accounts for 93% of the total capacity of 643.2 MW of the 12 stations.

The Temengor reservoir in the Temengor river has an active storage capacity of 1,270 x 10^6 m^3. Generating facilities of Temengor power station, which is the largest hydropower station in Peninsular Malaysia, consist of four 87 MW units and those were completed from July, 1978 to April, 1979. The Temengor power station generated 226 GWh from September 1978 to August 1979. It will generate 908 GWh annually, after its reservoir is filled to a sufficient level.

The Sultan Yussuf power station (4 x 25 MW) was completed in 1963 and Sultan Idris II power station (3 x 50 MW) has been operated since 1968. From September 1978 to August 1979, the Sultan Yussuf power station generated 251 GWh with the maximum output of 100 MW, and the Sultan Idris II power station produced 372 GWh with the maximum output of 150 MW; the load factor was 28.6% for the former and 28.3% for the latter (see Ref. 3).

A medium scale power station of Chenderoh (27 MW) was completed in 1930. This power station has been owned and operated by the Perak River Hydroelectric Co., Ltd. (see Refs. 3 and 7).

Total output of the remaining 8 hydropower stations is 18.2 MW. One of these power stations is Rahman Hydraulic Tin (2.8 MW), which is owned by Rahman Hydraulic Tin Berhad and has supplied power for Klian Intan village and Intan Mines (see Ref. 3). Other 7 power stations are owned by NEB and have supplied power to NEB system.

3. PERFORMANCE OF POWER SUPPLY SYSTEM

3.1 Historical Demand and Supply

Power generation record of NEB system for the past 10 years is summarized in Tables 10 to 12 (see Refs. 1, 2 and 3). In 1978/1979, the total gross generation was 7,651 GWh. Total energy sold was 6,541 GWh at an average revenue of 12.56 Mc/kWh. Monthly energy generation of NEB power stations and bulk purchases in the period of 1978/1979 are shown in Table 13 (see Ref. 3).

Within NEB system, gross generation was 7,251 GWh with the maximum demand of 1,244 MW in 1978/1979 (see Ref. 3). The auxiliary power use was 333 GWh (4.6% of the gross generation of 7,251 GWh) and unaccounted energy was 673.6 GWh, which corresponds to 9.7% of the net energy generation (total power sent out) of 6,918 GWh. The annual load factof of NEB system was 66.5%.

Historically, the ratio of unaccounted energy to net energy generation was almost constant. The annual growth rate has been declined gradually, but it is still as high as 10% to 12%. The load factor in NEB system ranged between 67% and 72%.

The composition of total energy sold of 6,541 GWh in 1978/1979 was as shown in Table 14 (see Ref. 2).

3.2 Characteristics of Load

The development of monthly maximum demand in NEB power system is as illustrated in Fig. 4 (see Refs. 1 and 3). The seasonal variation of demand is insignificant compared with the growth of demand.

Typical daily load curves for NEB system and small diesel stations in August for 5 years from 1974 to 1978 are as shown in Fig. 2 (see Ref. 1).

Peak demand in NEB system occurs twice a day, in the daytime and nighttime. The peak demand in the daytime is mainly for the industrial loads including lighting in offices and shops. It continues at a high level for about 7 hours except lunch time of one hour and usually reaches the maximum of the day at 11:00 or 16:00 o'clock. The peak demand in the nighttime is for the lighting loads and continues for about 3 hours at slightly lower level than that in the daytime. Accordingly, characteristics of the load in NEB system is daytime type or industrial type.

In small diesel stations, the power in the daytime is almost flat and low, but for several hours in the nighttime it sharply increases due to the lighting loads. Characteristics of the load in the small diesel stations is nighttime type or lighting type.

Typical daily load curves in the system connected to a large scale diesel station (for example, Kuala Trengganu) show comparatively similar characteristics to those in NEB system, but the maximum demand occurs around 20:00 o'clock (see Ref. 1).

Based on the load curve in NEB system for August 1978, a typical load duration curve was derived as shown in Fig. 3. The daily load factor is 79% and the minimum load is 55% of the peak load.

3.3 Electricity Tariff

New electricity tariff system was announced by the Government on October 30, 1980 and it has become effective on and after December 1, 1980. Old and new electricity tariff systems are compared in Tables 15 to 17 (see Ref. 9).

New tariff system intends to encourage more efficient utilization of electricity and to discourage unnecessary waste; i.e., the energy conservation and social welfare policies are incorporated in the new tariff structures; the rates were increased, especially for high electricity consumption, but, on the other hand, the rate for small consumers was reduced.

3.4 Revenue and Expenditure

Total revenue and expenditure of NEB for the last 6 years were as shown in Fig. 5 (see Refs. 1 and 2). Average annual increase rate was 24% for the revenue and 25% for the expenditure, while annual increase rate of fuel cost was 33%. The composition of revenue and expenditure in 1978/1979 was as shown in Table 18 (see Ref. 2). Fuel cost in 1978/1979 was M$412.6 x 10^6 or 59.0% of the total operating expenditures of M$698.8 x 10^6.

3.5 Organization of NEB

Organization of NEB as of December, 1980 is as shown in Fig. 6. Total number of employees as of August 31, 1979 was 17,679 (see Ref. 2). The composition of the employees was as shown in Table 19.

3.6 Operation Record of Hydropower Plant

The monthly gross energy production at the hydroelectric power stations during the period from September 1, 1978 to August 31, 1979 was as shown in Tables 20 and 21 (see Ref. 10). The annual energy production by 613.4 MW of NEB's hydropower stations was 901.4 GWh and the annual plant factor was 16.8%. Seasonal plant factors per every three months were calculated to be 16.6% for September to November, 17.5% for December to February, 15.0% for March to May and 18.1% for June to August. An illustration showing the seasonal change in the energy production at each

power station in Fig. 7 was prepared based on the data in Tables 20 and 21. All power stations except for Temengor show little seasonal variation in the operation hours; 6 to 8 hours. Temengor power station was operated for 1 to 3 hours per day. After the reservoir is filled to certain level, the operation hour will be increased to 7.1 hours.

4. POWER DEVELOPMENT PLANS

4.1 Power Demand Projection by NEB

Future power demand in Peninsular Malaysia projected by NEB is as shown in Fig. 8 (see Refs. 4, 5 and 6). Round figures of the demand up to the year 2000 are as shown in Table 22. The demand is estimated to be 14,910 GWh with the maximum power of 2,430 MW in 1985, 23,080 GWh with 3,780 MW in 1990 and 51,820 GWh with 8,600 MW in 2000. Average annual growth rate of the energy production is estimated to be 11.6% for the period from 1980 to 1985, 10.4% for 1980 to 1990 and 9.4% for 1980 to 2000. Load factors of the power system are not anticipated to change greatly over the forecasted period, but they are calculated to be 68% to 70%.

4.2 Expansion Plan of Power Supply System

Expansion program of the generating facilities by NEB up to the fiscal year 2000 is as shown in Tables 23 to 25 and Fig. 8 (see Refs. 2, 4 and 5). According to this program, total installed capacity in NEB system including power to be received through interconnection lines will amount to 4,198 MW in 1985, 5,458 MW in 1990 and 11,027 MW in 2000. The composition of the generating facilities except for power received from the interconnection lines is as shown in Table 26. Ratio of hydro to the total installed capacity is 28.7% in 1985, 32.4% in 1990 and 22.3% in 2000.

4.3 Rural Electrification Plan

Rural electrification plan in Peninsular Malaysia is as shown in Table 27 (see Refs. 11 and 12). As of the end of 1980, 68% of the population in Peninsular Malaysia lived in the rural area, but only 55% of them had access to electricity. The Malaysian Government intends to give power supply to 65% of the households in the rural area by the end of 1985. By the year 2000, the households of $2,190 \times 10^3$, which is 95% of total households of $2,289 \times 10^3$ in the rural area, is planned to be electrified. The total expenditure of the rural electrification development in Peninsular Malaysia for the period of five years from 1981 to 1985 is estimated to be M\$870 x 10^6.

The power supply to the rural area has been carried out with small diesel power stations through low voltage overhead distribution lines, in case the bulk power supply system is not extended yet. NEB is presently constructing 22 mini hydro projects at a cost of M\$31 x 10^6 for the rural power supply as the fuel oil for the diesel stations is rising high. Another 102 mini hydro projects have been programed to be constructed for 4 MP (see Ref. 12).

5. PLANNING MATERIALS

5.1 Hydropower Potential

Gross surface hydro potential in Peninsular Malaysia is estimated to be 85,300 GWh/annum, of which 16,100 GWh/annum is considered to be technically exploitable. The distribution of the gross hydro potential is as shown in Table 28 and Fig. 9 (see Ref. 8).

Energy and power outputs of hydro projects in operation, under construction and undeveloped in Peninsular Malaysia are approximately 8,900 GWh/annum and 2,300 MW as shown in Tables 29 and 30 (see Ref. 2, 7 and 8). Energy output of 8,900 GWh/annum corresponds to about 55% of the technically exploitable potential of 16,100 GWh/annum estimated in Peninsular Malaysia.

5.2 Anticipated Operation Hours of Hydropower

Typical daily load duration curves in summer in U.K., Germany and Switzerland are superposed on that of NEB power supply system in Fig. 10. These curves are not largely different each other. Assume that the daily load duration curve in Peninsular Malaysia remain within the range of these curves in the future. Thermal power stations will be operated for 20 - 22 hr everyday on an average, taking the lower portion of the load duration curve by their nature. On the other land, hydropower will be responsible for the upper portion of the curve. The average operation hours of hydropower stations is estimated to be 8 - 10 hr from Fig. 10.

5.3 Cost Data of On-going Hydropower Development

Cost data of on-going hydropower projects such as Bersia, Kenering and Trengganu (Kenyir) were unavailable, because some portions of these projects had been in the course of tender. According to Ref. 8, however, the estimated capital costs of these projects are as shown in Table 31.

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TABLES

Table 1 EXISTING NEB GENERATING FACILITIES
AS OF AUGUST 31, 1979

	No. of Stations	Installed Capacity (kW)	(%)
Major Generating Facilities			
(above 5 MW)			
Thermal			
Oil-fired steam	6	970,000	54.0
Gas turbine	5	100,000	5.6
Diesel	5	81,130	4.5
Sub-total	16	1,151,130	64.1
Hydro	4	603,500	33.6
Total	20	1,754,630	97.7
Generating Facilities			
(below 5 MW)			
Thermal			
Diesel	16	25,996	1.4
Hydro	6	9,923	0.6
Total	22	35,919	2.0
Rural Stations*	151	5,200	0.3
Grand total	193	1,795,749	100.0

Remarks; *: Comparatively small scale oil engine power stations in isolated rural areas.

Source; Ref. 3

Table 2 MAJOR GENERATING PLANTS OF NEB
AS OF AUGUST 31, 1979

Name of Power Station	Unit Capacity x No. (kW)	Installed Capacity (kW)
1. Thermal power plant		
1.1 Steam		
Connaught Bridge	20,000 x 4	80,000
Glugor	10,000 x 4	40,000
Melaka	10,000 x 4	40,000
Prai	30,000 x 3	90,000
Sultan Ismail	30,000 x 3 + 10,000 x 3	120,000
Tuanku Jaafar	60,000 x 4 + 120,000 x 3	600,000
Sub-total		970,000
1.2 Gas turbines		
Connaught Bridge	20,000 x 1	20,000
Glugor	20,000 x 1	20,000
Sultan Ismail	20,000 x 1	20,000
Tuanku Jaafar	20,000 x 1	20,000
Tanjung Gelang	20,000 x 1	20,000
Sub-total		100,000
1.3 Diesel		
Kuala Trengganu		14,250
Kuantan		11,730
Lemal		5,200
Lundang		37,950
Weld Quay	6,000 x 2	12,000
Sub-total		81,130
Total of 1		1,151,130
2. Hydro power plant		
Habu	2,750 x 2	5,500
Sultan Idris II	50,000 x 3	150,000
Sultan Yussuf	25,000 x 4	100,000
Temengor	87,000 x 4	348,000
Total of 2		603,500
Grand total		1,754,630

Source; Refs. 3 and 6

Table 3 LICENSED PUBLIC POWER STATIONS NOT INCLUDED IN NEB SYSTEM AS OF AUGUST 31, 1979

Name of State	Nos. of Town or Village	Aggregate Capacity of Generating Plant in kW	Motive Power
Perlis	1	25.0	Oil engine
Kedah	12	1,931.56	Oil engine
Perak	1	64,000	Steam
	2	42.1 kVA	Diesel
	11	9,032.0	Oil engine
	12	5,006.4 kVA	Oil engine
	2	29,800.0	Hydro
Selangor	2	1,167.6	Oil engine
Pahang	5	1,495.0	Oil engine
Johore	18	2,743.7	Oil engine
Total	66	110,194.86 kW + 5,048.5 kVA	

Remarks; Hydropower stations are the Chenderoh (27 MW) and Rahman Hydraulic Tin (2.8 MW), which are connected with NEB power system (see Table 9).

Source; Ref. 3

Table 4 TRANSMISSION AND DISTRIBUTION SYSTEM OF NEB AS OF AUGUST 31, 1979

Voltage kV	Length in Commission (km)		Length under Construction (km)	
	Overhead	Underground	Overhead	Underground
275	371.8	-	350.9	-
132	1,595.4	64.4	222.1	-
66	537.1	2.7	90.1	-
33	954.8	205.8 (a)	15.0	-
22	42.1	139.1	-	-
11	537.5	8,147.6 (b)	1.3	29.4
6.6	2.7	398.6	-	-
3.3	1.1	0.7	-	-
2.2	5.4	5.3	-	-
Total	4,047.9	8,964.2	679.4	29.4
	13,012.1		708.8	

Remarks; (a): Including 18.60 km of submarine cable.
(b): Including 1.64 km of submarine cable.

Source; Ref. 3

Table 5 SUBSTATIONS OF NEB AS OF AUGUST 31, 1979

Voltage of Substation Transformers (kV)	No. in Commission	Total Capacity (kVA)
275	4	2,270,000
132	31	1,941,500
66	23	503,830
33	426	1,179,550
22	28	120,863
11	5,115	2,536,989
6.6	308	141,010
Total	5,935	8,693,742

Source; Ref. 3

Table 6 EXISTING HYDROPOWER PLANTS (1/4)

Name of Power Plant	Unit	Temengor	Sultan Yussuf	Sultan Idris II
Name of River		Temengor	Bertam	Batang Padang
Installed Capacity	MW	348	100	150
Unit Capacity	MW x No.	87 x 4	25 x 4	50 x 3
Average Energy Production/ Year	GWh	908.0	320.0	486.0
Reservoir				
Catchment Area	km^2	3,420	183.1	
Normal Full Supply Level	El.m	248	1,070.8	
Min. Operating Level	El.m	221	1,058.9	
Surface Area	km^2	152		
Total Storage Cap.	10^6m^3	6,050		
Active Storage Cap.	10^6m^3	1,270	4.55	
Dam				
Height (m) x Length (m)		127 x 537		
Volume	10^3m^3	7,280	52	
Water Turbine				
Type		V.F.	H.P.	V.F.
Net Head	m	101	545.6	355.1
Generator				
Unit Output	MW	85	25	50
Speed	rpm		428	600
Year of Completion		1978/1979	1963	1968

Remarks; Figures are as of August 31, 1979.
V.F. : Vertical Francis, H.P.: Horizontal Pelton
Blank: Data unavailable

Source; Refs. 3 and 7

Table 7 EXISTING HYDROPOWER PLANTS (2/4)

Name of Power Plant	Unit	Odak		Robinson Falls
Name of River		Batang Padang	Bertam	Bertam
Installed Capacity	MW	4.2	5.5	0.9
Unit Capacity	MWxNo.	1.4 x 3	2.75 x 2	0.3 x 3
Average Energy Production/ Year	GWh	15.6	32.0	6.2
Reservoir				
Catchment Area	km^2	393.9	132.6	21.5
Normal Full Supply Level	El.m			
Min. Operating Level	El.m			
Surface Area	km^2			
Total Storage Cap.	10^6m^3			
Active Storage Cap.	10^6m^3			
Dam				
Height (m) x Length (m)				
Volume	10^3m^3			
Water Turbine				
Type		V.F.	H.F.	P
Net Head	m	15.8	91.4	
Generator				
Unit Output	MW	1.4	2.75	0.3
Speed	rpm	750	500	1,000
Year of Completion		1968	1964	1959

Remarks; Figures are as of August 31, 1979.
V.F. : Vertical Francis, H.F.: Horizontal Francis
P : Pelton
Blank: Data unavailable

Source; Refs. 3 and 7

Table 8 EXISTING HYDROPOWER PLANTS (3/4)

Name of Power Plant	Unit	Kampung Raja	Kuala Terla	Ulu Langat
Name of River		Telom	Telom	Langat
Installed Capacity	MW	0.8	0.5	2.288
Unit Capacity	MWxNo.	0.8 x 1	0.5 x 1	x 2
Average Energy Production/ Year	GWh	5.9	4.1	11.0
Reservoir				
Catchment Area	km^2	30.8		
Normal Full Supply Level	El.m			
Min. Operating Level	El.m			
Surface Area	km^2			
Total Storage Cap.	10^6m^3			
Active Storage Cap.	10^6m^3			
Dam				
Height (m) x Length (m)				
Volume	10^3m^3			
Water Turbine				
Type		H.F.	H.F.	
Net Head	m	79.9	37.2 (gross)	198 (gross)
Generator				
Unit Output	MW	0.8	0.5	
Speed	rpm			
Year of Completion		1964	1964	1927

Remarks; Figures are as of August 31, 1979.
H.F. : Horizontal Francis
Blank: Data unavailable

Source; Refs. 3 and 7

Table 9 EXISTING HYDROPOWER PLANTS (4/4)

Name of Power Plant	Unit	Sempam	Chenderoh	Rahman Hydraulic Tin
Name of River		Sempam	Perak	Pong
Installed Capacity	MW	1.235	27.0	2.8
Unit Capacity	MWxNo.	0.435 + 0.8	9 x 3	2.8 x 1
Average Energy Production/ Year	GWh	8.0	205.0	
Reservoir				
Catchment Area	km^2			
Normal Full Supply Level	El.m			
Min. Operating Level	El.m			
Surface Area	km^2			
Total Storage Cap.	10^6m^3			
Active Storage Cap.	10^6m^3			
Dam				
Height (m) x Length (m)				
Volume	10^3m^3			
Water Turbine				
Type				
Net Head	m	96 (gross)	18 (gross)	
Generator				
Unit Output	MW		9	
Speed	rpm			
Year of Completion		1910	1930	

Remarks; Figures are as of August 31, 1979.
Blank: Data unavailable

Source; Refs. 3 and 7

Table 10 GENERATION RECORD OF NEB POWER SYSTEM (1/3)

		1965 /1966	1966 /1967	1967 /1968	1968 /1969	1969 /1970
NEB System						
Maximum Demand	MW					363
Gross Generation	GWh					2,300
Load Factor	%					72.4
Auxiliary Use	%					3.8
Net Generation	GWh					2,214
Power used on Works	GWh					17.5
Unaccounted Energy	%					8.7
Power Sold	GWh					2,003
Diesel Stations & Bulk Supply Purchases						
Gross Generation	GWh					198
Auxiliary Use	%					2.6
Net Generation	GWh					192
Power used on Works	GWh					1.6
Unaccounted Energy	%					9.8
Power Sold	GWh					172
Rural Stations						
Gross Genration	GWh					
Auxiliary Use	%					
Net Generation	GWh					
Power Solid	GWh					
Total Gross Generation	GWh	1,417	1,587	2,026	2,223	2,498
Total Power Sold	GWh	1,226	1,372	1,766	1,936	2,175
Growth Rate	%	14.4	11.9	28.7	9.6	12.3
Average Revenue	Mc/kWh	8.97	8.87	7.93	7.88	7.71
No. of Consumers	10^3	339	362	387	423	459

Remarks; The fiscal year is ending August 31st.

Source; Refs. 1 and 2

Table 11 GENERATION RECORD OF NEB POWER SYSTEM (2/3)

		1970 /1971	1971 /1972	1972 /1973	1973 /1974	1974 /1975
NEB System						
Maximum Demand	MW	393	470	536	604	693
Gross Generation	GWh	2,533	2,952	3,383	3,815	4,325
Load Factor	%	73.6	71.8	72.1	72.1	71.2
Auxiliary Use	%	4.1	4.3	4.4	4.5	4.7
Net Generation	GWh	2,428	2,826	3,234	3,645	4,124
Power used on Works	GWh	16.7	19.2	21.2	24.3	26.3
Unaccounted Energy	%	8.5	8.6	9.0	10.1	9.6
Power Sold	GWh	2,206	2,563	2,922	3,253	3,703
Diesel Stations & Bulk Supply Purchases						
Gross Generation	GWh	223	233	259	287	322
Auxiliary Use	%	2.4	2.5	2.4	2.2	2.2
Net Generation	GWh	218	227	253	280	315
Power used on Works	GWh	1.6	1.6	1.8	1.8	2.0
Unaccounted Energy	%	10.7	11.1	11.8	11.4	11.5
Power Sold	GWh	193	201	221	246	277
Rural Stations						
Gross Generation	GWh		4.3	4.6	4.8	5.1
Auxiliary Use	%		1.4	1.7	1.8	1.4
Net Generation	GWh		4.3	4.5	4.7	5.0
Power Sold	GWh		2.4	2.5	2.7	2.9
Total Gross Generation	GWh	2,756	3,189	3,647	4,106	4,653
Total Power Sold	GWh	2,399	2,766	3,146	3,502	3,983
Growth Rate	%	10.3	15.3	13.7	11.3	13.7
Average Revenue	Mc/kWh	7.67	7.57	7.53	7.74	8.85
No. of Consumers	10^3	496	543	589	640	704

Remarks; The fiscal year is ending August 31st.

Source; Refs. 1 and 2

Table 12 GENERATION RECORD OF NEB POWER SYSTEM (3/3)

		1975 /1976	1976 /1977	1977 /1978	1978 /1979
NEB System					
Maximum Demand	MW	844	975	1,068	1,244
Gross Generation	GWh	4,974	5,914	6,646	7,251
Load Factor	%	67.3	69.2	71.0	66.5
Auxiliary Use	%	4.9	5.0	5.0	4.6
Net Generation	GWh	4,728	5,617	6,315	6,918
Power used on Works	GWh	30.0	32.6	37.0	45.4
Unaccounted Energy	%	10.1	10.3	10.1	9.7
Power Sold	GWh	4,223	5,006	5,641	6,199
Diesel Stations & Bulk Supply Purchases					
Gross Generation	GWh	377	337	338	389
Auxiliary Use	%	2.1	2.2	2.6	3.8
Net Generation	GWh	369	330	329	374
Power used on Works	GWh	3.1	1.8	1.9	2.5
Unaccounted Energy	%	13.1	12.4	11.7	9.7
Power Sold	GWh	318	287	288	336
Rural Stations					
Gross Generation	GWh	6.0	7.0	7.7	10.7
Auxiliary Use	%	1.6	1.4	1.4	1.7
Net Generation	GWh	5.9	6.9	7.6	10.5
Power Sold	GWh	3.4	4.0	5.1	6.3
Total Gross Generation	GWh	5,357	6,258	6,992	7,651
Total Power Sold	GWh	4,544	5,297	5,934	6,541
Growth Rate	%	14.1	16.6	12.0	10.2
Average Revenue	Mc/kWh	10.74	10.69	10.84	12.56
No. of Consumers	10^3	840	916	1,013	1,128

Remarks; The fiscal year is ending August 31st.

Source; Refs. 1 and 2

Table 13 MONTHLY ENERGY GENERATION OF NEB STATIONS AND BULK PURCHASES IN 1978/1979

Unit: GWh

Year and Month	Bulk Purchases	Diesel	Hydro	Steam	Gas	Rural	Total
1978 Sep.	23.3	21.4	58.5	483.6	-	0.8	587.6
Oct.	23.7	23.4	65.0	515.7	-	0.8	628.6
Nov.	23.3	20.8	98.4	463.2	6.6	0.8	613.1
Dec.	24.2	22.1	86.2	480.4	12.4	0.9	626.2
1979 Jan.	23.8	23.0	75.1	471.8	26.9	1.0	621.6
Feb.	22.6	22.9	70.0	426.7	30.3	0.8	573.3
Mar.	26.3	25.7	66.3	511.6	31.1	0.9	661.9
Apr.	24.0	24.7	59.3	519.9	21.2	0.9	650.0
May	24.1	26.7	77.6	515.8	32.3	0.9	677.4
Jun.	23.1	25.6	93.8	473.7	32.2	0.9	649.3
Jul.	22.9	27.2	86.6	511.4	28.3	1.0	677.4
Aug.	23.9	26.6	64.6	537.9	30.1	1.0	684.1
Total	285.2	290.1	901.4	5,911.7	251.4	10.7	7,650.5
	3.7%	3.8%	11.3%	77.3%	3.3%	0.1%	100.0%

Source; See Ref. 3

Table 14 COMPOSITION OF TOTAL ENERGY SOLD IN 1978/1979

Consumers	Energy Sold GWh	%
Domestic Consumers		
Lighting	63.0	1.0
Block tariff	923.7	14.1
Sub-total	986.7	15.1
Commercial Consumers		
Lighting	254.0	3.9
Power	1,650.5	25.2
Sub-total	1,904.5	29.1
Industrial Consumers		
Dredges	210.2	3.2
Open cast mines	84.6	1.3
Bulk supply to P.R.H.E.P.	773.2	11.8
Factories, workshops & others	2,447.8	37.5
Sub-total	3,515.8	53.8
Forces Consumers	74.6	1.1
Public Lighting Consumers	59.0	0.9
Total	6,540.6	100.0

Source; See Ref. 2

Table 15 ELECTRICITY TARIFF (1/3)

Monthly Tariffs by Nov. 30, 1980	Monthly Tariffs on and after Dec. 1, 1980
Tariff A (Domestic Consumer)	
The first 30 units ... 25 cents a unit.	The first 100 units ... 20 cents a unit.
The next 120 units ... 12 cents a unit.	The next 900 units ... 23 cents a unit.
Each additional unit ... 13 cents.	Each additional unit ... 26 cents.
The minimum charge ... $2.50.	The minimum charge ... M$2.50.
Tariff B (Medium or Low Voltage Commercial Consumer)	
The first 400 units ... 18 cents a unit.	The first 200 x 10^3 units ... 25 cents a unit.
The next 50 x 10^3 units ... 15 cents a unit.	Each additional unit ... 27 cents a unit.
Each additional unit ... 14 cents.	
The minimum charge ... $6.00.	The minimum charge ... M$6.00.
Tariff C (High Voltage Commercial Consumer)	
Each kW of maximum demand ... $12.00.	Each kW of maximum demand ... $12.00.
For each unit ... 10 cents.	For first 800 x 10^3 units ... 19 cents a unit.
	Each additional unit ... 21 cents.
The minimum charge ... $36,000.00.	The minimum charge ... M$500.00.

Table 16 ELECTRICITY TARIFF (2/3)

Monthly Tariffs by Nov. 30, 1980	Monthly Tariffs on and after Dec. 1, 1980
Tariff D (Medium or Low Voltage Industrial Consumer)	
The first 400 units ... 18 cents a unit.	The first 200 x 10^3 units ... 23 cents a unit.
The next 50 x 10^3 units ... 14 cents a unit.	Each additional unit ... 25 cents.
Each additional unit ... 11 cents.	
The minimum charge ... $6.00.	The minimum charge ... M$6.00.
Tariff E (High Voltage Industrial Consumer)	
Each kW of maximum demand ... $12.00.	Each kW of maximum demand ... $12.00.
First 1 x 10^6 units ... 8 cents a unit.	For each unit ... 17 cents.
Each additional unit ... 7 cents.	
The minimum charge ... $38,000.00.	The minimum charge ... M$500.00.
Tariff F (Mining Consumer)	
Each kW of maximum demand ... $12.00.	- (A) High Voltage Mining: Each kW of maximum demand ... $12.00.
For each unit ... 8 cents.	For each unit ... 17 cents.
The minimum charge ... $5,200.00.	The minimum charge ... M$100.00.
	- (B) Low Voltage Mining: The first 100 x 10^3 units ... 19 cents a unit.
	Each additional unit ... 21 cents.
	The minimum charge ... M$100.00.

Table 17 ELECTRICITY TARIFF (3/3)

Monthly Tariffs by Nov. 30, 1980	Monthly Tariffs on and after Dec. 1, 1980
Tariff G (Public and Street Lighting)	
For each unit ... 23 cents.	For each unit ... 33 cents.
Or a fixed charge per 60 watt lamp (or a proportion thereof) ... $4.00.	
The minimum charge ... 15% of the calculated revenue	

Remarks; One unit means one kWh.

Source; Ref. 9

Table 18 REVENUE AND EXPENDITURE OF NEB IN 1978/1979

		M$ x 10^6	%
1.	Revenue (A)		
	(1) Revenue from sales of electricity		
	Domestic consumers	141.4	16.7
	Commercial consumers	285.5	33.6
	Industrial consumers	372.3	43.9
	Forces consumers	11.4	1.3
	Public lighting consumers	11.0	1.3
	Sub-total	821.6	96.8
	(2) Other revenue	27.2	3.2
	Total	848.8	100.0
2.	Expenditure (B)		
	(1) Operating expenses		
	Generation and electricity purchased in bulk	514.2	67.0
	Transmission	21.3	2.8
	Distribution	81.9	10.6
	Consumers' service	7.5	1.0
	Meter trading, bulling and collection of accounts	17.1	2.2
	Training and welfare	12.5	1.6
	Administration	12.9	1.7
	General expenses	31.4	4.1
	Sub-total	698.8	91.0
	(2) Interest payable on borrowings and bank overdrafts	61.0	8.0
	(3) Provision of taxation	-	-
	(4) Interest payable on ordinary stock	8.7	1.1
	(5) Dividend received from investment in industries	-0.6	-0.1
	Total	767.9	100.0
3.	Balance of Revenue (A - B)		
	(1) Capital development account	63.1	78.0
	(2) General reserve	17.8	22.0
	Total	80.9	100.0

Source; Ref. 2

Table 19 COMPOSITION OF NEB EMPLOYEES

	Number of Employees	%
Senior Officers	638	3.6
Technical Staffs	3,159	17.9
Non-Technical Staffs	4,525	25.6
Industrial and Manual Group	9,357	52.9
Total	17,679	100.0

Remarks; Figures are as of August 31, 1979.

Source; Ref. 2

Table 20 MONTHLY GROSS ENERGY PRODUCTION OF NEB HYDROPOWER PLANTS (1/2)

Unit: MWh

Name of Power Plant Installed Cap. (MW)	Temengor 348	Sultan Yussuf 100	Sultan Idris II 150	Odak 4.2	Habu 5.5	Robinson Falls 0.9
1978						
Sep.	11,714	16,786	26,336	731	1,557	379
Oct.	8,845	20,122	31,742	933	1,689	403
Nov.	2,896	32,718	56,561	1,678	2,449	431
Dec.	8,759	29,526	42,007	1,380	2,753	514
1979						
Jan.	23,961	19,639	26,915	898	2,113	396
Feb.	23,532	18,476	23,989	794	1,723	309
Mar.	25,376	16,137	21,241	713	1,527	342
Apr.	5,427	19,983	29,956	872	1,619	391
May	21,311	22,331	29,614	901	1,948	483
Jun.	36,246	22,278	30,767	900	1,991	400
Jul.	36,223	17,260	28,785	916	1,799	440
Aug.	21,593	15,266	23,780	748	1,573	389
Annual Energy Production	225,883	250,522	371,693	11,464	22,741	4,877

Source; Ref. 10

Table 21 MONTHLY GROSS ENERGY PRODUCTION OF NEB HYDROPOWER PLANTS (2/2)

Unit: MWh

Name of Power Plant / Installed Cap. (MW)	Kampung Raja 0.8	Kuala Terla 0.5	Ulu Langat 2.288	Sempam* 1.235		Total 613.423	Three Months Total
1978							
Sep.	332	214	343	148	(142)	58,540	
Oct.	392	217	550	101	(97)	64,994	221,867
Nov.	515	239	745	101	(97)	98,333	
Dec.	491	275	381	157	(151)	86,243	
1979							
Jan.	510	292	233	131	(126)	75,088	231,225
Feb.	474	251	235	111	(107)	69,894	
Mar.	488	263	167	95	(91)	66,349	
Apr.	474	153	335	104	(100)	59,314	203,260
May	446	240	215	108	(104)	77,597	
Jun.	460	259	424	120	(116)	93,845	
Jul.	428	242	422	111	(107)	86,626	245,078
Aug.	374	220	561	103	(99)	64,607	
Annual Energy Production	5,384	2,865	4,611	1,390	(1,337)	901,430	

Remarks; *: (1) Figures between parentheses show the monthly net energy production.

(2) Monthly gross energy production of Sempam was estimated by the product of the monthly net energy production and the ratio of total gross energy production (1,390 MWh) to the net energy production (1,337 MWh).

Source; Ref. 10

Table 22 FUTURE POWER DEMAND IN PENINSULAR MALAYSIA PROJECTED BY NEB

Fiscal Year	Estimated Demand			Installed Capacity* (MW)	Power to be Received* (MW)
	Energy (GWh)	Maximum Power (MW)	Load Factor (%)		
1979	7,651	1,350	64.7	1,796	-
1980	(8,590)	1,440	68.1	2,156	-
1985	14,910	2,430	70.0	4,198	-
1990	23,080	3,780	69.7	5,458	-
1995	(34,580)	5,730	68.9	7,748	100
2000	51,820	8,600	68.8	10,727	300

Remarks; 1: Maximum power shows approximate value read out from Fig. 8.

2: Figures in parentheses for energy were calculated by interpolation from the estimated values in 1985, 1990 and 2000.

3: * see Tables 23, 24 and 25

Source; Refs. 2, 4, 5 and 6

Table 23 EXPANSION PROGRAM OF GENERATING FACILITIES (1/3)

Expected Completion Date Year	Month	Name of Plant	Cap. to be Installed (MW)	Total Capacity (MW)	Maximum Demand (MW)
1979	Aug.	Existing plants		1,796	1,350
1979/ 1980		Prai (steam) No. 4 to No. 6	120 x 3	2,156	1,440
1981	Jun.	Pasir Gudang (steam) No. 1	120 x 1	2,276	1,600
1981	Dec.	Pasir Gudang (steam) No. 2	120 x 1	2,396	1,790
1982	Dec.	Connaught Bridge (gas turbine) No. 6 and No. 7	80 x 2		
1983	Aug.	Bersia (hydro) No. 1 to No. 3	24 x 3		
		Sub-total	232	2,628	2,000
1984	Feb.	Kenering (hydro) No. 1 to No. 3	40 x 3		
	Feb.	Paka (combined cycle) No. 1 to No. 4	75 x 4		
	Aug.	Paka (combined cycle) No. 5 and No. 6	75 x 2		
		Sub-total	570	3,198	2,200
1984	Dec.	Port Kelang (stream) No. 1	300 x 1		
1985	Feb.	Kenyir (hydro) No. 1 and No. 2	100 x 2		
	Jun.	Port Kelang (stream) No. 2	300 x 1		
	Aug.	Kenyir (hydro) No. 3 and No. 4	100 x 2		
		Sub-total	1,000	4,198	2,430
1986			0		
		Retirement	-80		
		Sub-total	-80	4,118	2,670
1987		(thermal)	225		
		(hydro)	200		
		Sub-total	425	4,543	2,920

Remarks; The maximum demand was read out from Fig. 8.

Source; Refs. 2, 4 and 5

Table 24 EXPANSION PROGRAM OF GENERATING FACILITIES (2/3)

Expected Completion Date Year	Month	Name of Plant	Cap. to be Installed (MW)	Total Capacity (MW)	Maximum Demand (MW)
1988		(thermal)	225		
		(hydro)	100		
		Retirement	-30		
		Sub-total	295	4,838	3,180
1989		(thermal)	225		
		(hydro)	150		
		Sub-total	375	5,213	3,500
1990		(thermal)	225		
		(hydro)	110		
		Retirement	-90		
		Sub-total	245	5,458	3,780
1991		(thermal)	450		
		(hydro)	74		
		Sub-total	524	5,982	4,100
1992		(thermal)	450		
		(hydro)	100		
		Retirement	-90		
		Sub-total	460	6,442	4,450
1993		(thermal)	450		
		(hydro)	130		
		Retirement	-40		
		Sub-total	540	6,982	4,850
1994		(interconnection)	100		
		(hydro)	145		
		Sub-total	245	7,227	5,250

Remarks; The maximum demand was read out from Fig. 8.

Source; Refs. 2, 4 and 5

Table 25 EXPANSION PROGRAM OF GENERATING FACILITIES (3/3)

Expected Completion Date Year	Month	Name of Plant	Cap. to be Installed (MW)	Total Capacity (MW)	Maximum Demand (MW)
1995		(nuclear)	600		
		(hydro)	80		
		Retirement	-60		
		Sub-total	620	7,847	5,730
1996		(thermal)	300		
		(interconnection)	200		
		(hydro)	60		
		Sub-total	560	8,407	6,200
1997		(thermal)	900		
		(hydro)	40		
		Sub-total	940	9,347	6,750
1998		(thermal)	900	10,247	7,300
1999		(thermal)	900	11,147	7,950
2000			0		
		Retirement	-120		
		Sub-total	-120	11,027	8,600

Remarks; The maximum demand was read out from Fig. 8.

Source; Refs. 2, 4 and 5

Table 26 COMPOSITION OF NEB GENERATING FACILITIES

Fiscal Year		Thermal (MW)	Thermal (%)	Hydro (MW)	Hydro (%)	Total (MW)	Total (%)
1979	Steam	970	(54.0)				
	Gas	100	(5.6)				
	Diesel	112	(6.2)				
	Total	1,182	(65.8)	614	(34.2)	1,796	(100)
1985	Steam	2,170	(51.7)				
	Combine Cycle	450	(10.7)				
	Gas	260	(6.2)				
	Diesel	112	(2.7)				
	Total	2,992	(71.3)	1,206	(28.7)	4,198	(100)
1990		3,692	(67.6)	1,766	(32.4)	5,458	(100)
1995		5,452	(70.4)	2,295	(29.6)	7,747	(100)
2000		8,332	(77.7)	2,395	(22.3)	10,727	(100)

Remarks; 1. It is assumed that all facilities to be retired are thermal power plants.

2. Power to be received through interconnection lines is not included in this table.

Source; Ref. 2, 4 and 6

Table 27 RURAL ELECTRIFICATION PLAN IN PENINSULAR MALAYSIA

Year	Area	No. of Households 10^3	%	No. of Households with Electricity 10^3	%	NEB Total Consumers 10^3
1970	Rural	1,073	74	346	32	
	Urban	375	26	287	77	
	Total	1,448		633	43	469
1975	Rural	1,251	72	515	41	
	Urban	476	28	321	67	
	Total	1,727		836	48	704
1980	Rural	1,441	68	790	55	
	Urban	664	32	564	85	
	Total	2,105		1,354	64	1,191
1985	Rural	1,668	68	1,090	65	
	Urban	786	32	714	91	
	Total	2,454		1,804	73	
1990	Rural	1,934	67	1,390	72	
	Urban	931	33	864	93	
	Total	2,865		2,254	79	
1995	Rural	2,109	66	1,790	85	
	Urban	1,093	34	1,039	95	
	Total	3,202		2,829	88	
2000	Rural	2,289	64	2,190	96	
	Urban	1,285	36	1,214	95	
	Total	3,574		3,404	95	

Source; Ref. 11

Table 28 HYDROPOWER POTENTIAL IN PENINSULAR MALAYSIA

Zone/River Basin	Surface Area $10^3 km^2$	Gross Surface Hydro Potential		Technically Exploitable Potential GWh/annum
		Energy GWh/annum	Density GWh/km^2	
North-Western Zone	14.9	5,900	0.40	800
S. Perak Basin	14.9	16,900	1.13	3,800
S. Kelantan Basin	12.8	16,800	1.31	4,200
North-Eastern Zone	17.1	15,300	0.89	2,900
S. Pahang Basin	28.5	19,000	0.67	3,100
South-Western Zone	42.3	11,400	0.27	1,300
Total	130.5	85,300	0.65 (Average)	16,100

Source; Ref. 8

Table 29 HYDROPOWER PLANTS OF NEB IN OPERATION AND UNDER CONSTRUCTION

Plants or Projects	Average Energy GWh/annum	Installed Capacity, MW
In Operation	1,797	614
Under Construction		
Bersia	238	72
Kenering	456	120
Kenyir	1,585	400
Sub-total	2,279	592
Total	4,076	1,206

Source; Refs. 2, 7 and 8

Table 30 MAJOR UNDEVELOPED HYDROPOWER PROJECTS IN PENINSULAR MALAYSIA

Name of Project	Names of Rivers Involved	Average Energy Output GWh/annum	Proposed Capacity MW
Ulu Trengganu	Trengganu	360	100
Pergau	Pergau	540	100
Lebir	Lebir	410	120
Tembeling	Tembeling	440	110
Tekai and Penut	Tekai	370	74
Nenggiri	Nenggiri	430	82
Telom Hilir	Bertam, Telom	480	98
Jelai Kechil	Jelai, Telom	300	60
Maran	Pahang	680	130
Galas (Dabong)	Galas	530	145
Kelantan Barrage	Kelantan	275	40
Total		4,815	1,059

Source; Ref. 8

Table 31 MAJOR FEATURES AND ESTIMATED CAPITAL COSTS OF HYDROPOWER PROJECTS UNDER CONSTRUCTION

Description	Bersia	Kenering	Trengganu
Main Dam			
Type of Dam	Gravity	Gravity/Earth	Rockfill
Volume of Dam ($10^3 m^3$)	110	260/470	16,500
Reservoir			
Live Storage ($10^6 m^3$)	10	70	7,400
Power Plant			
Unit Capacity (MW) x Nos.	24 x 3	40 x 3	100 x 4
Average Energy (GWh/Year)	238	456	1,585
Estimated Costs (M$ x 10^6) in 1980 Level			
Preliminary Works			
Various local contracts	3.0	7.0	26.3
Civil Construction			
Diversion tunnel	-	-	33.2
Main dam and structures	63.6	110.0	239.6
Saddle dams	-	-	75.0
Electrical and Mechanical			
Various contracts including hydromechanical equipment, penstocks, etc.	58.5	68.4	201.0
Sub-total	125.1	185.4	575.1
Other Costs & Provisions			
Engineering and supervision, management, escalation, etc.	63.0	94.0	127.5
Total Investment	188.1	279.4	702.6

Source; Ref. 8

FIGURES

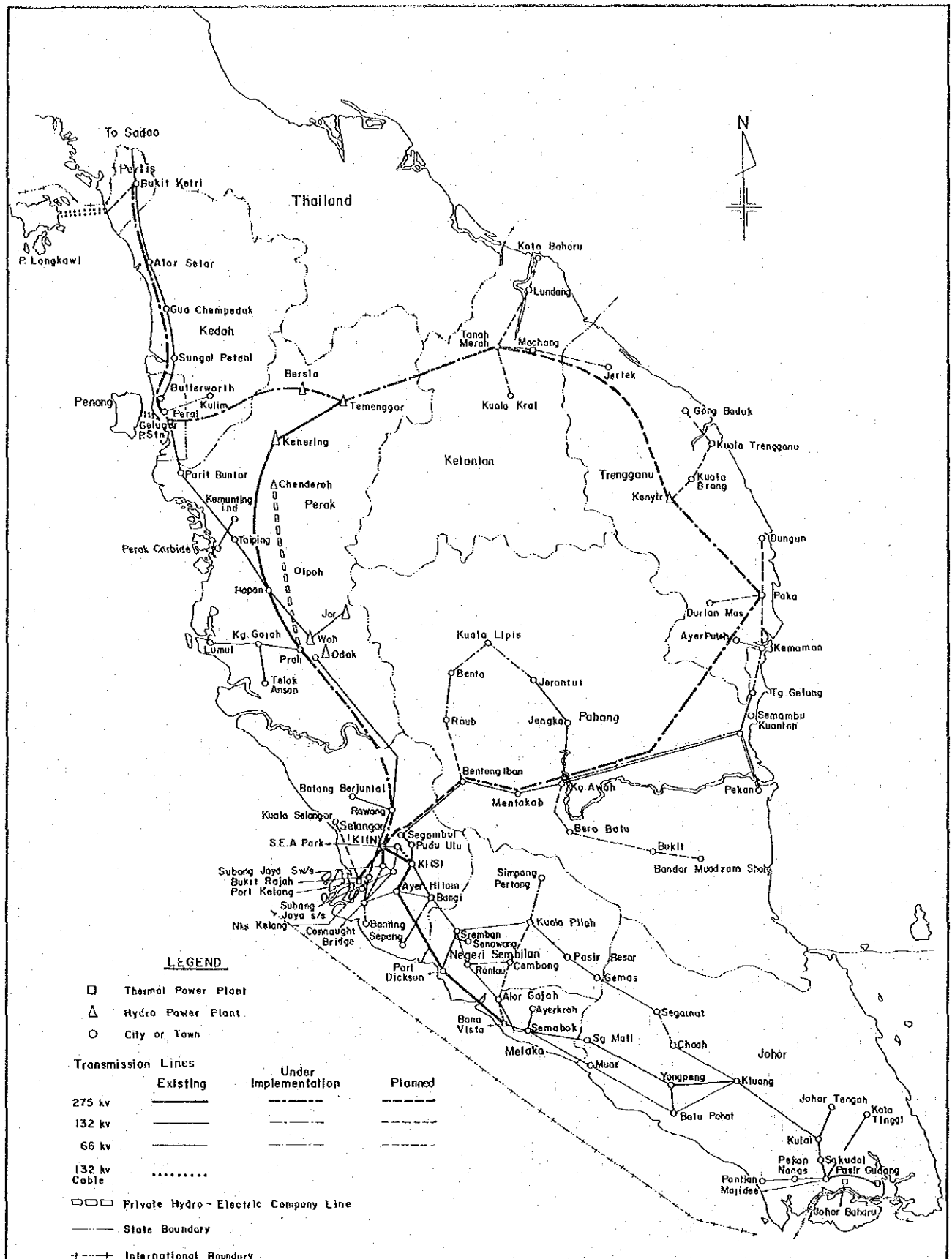

Fig. 1 NEB Power Supply System

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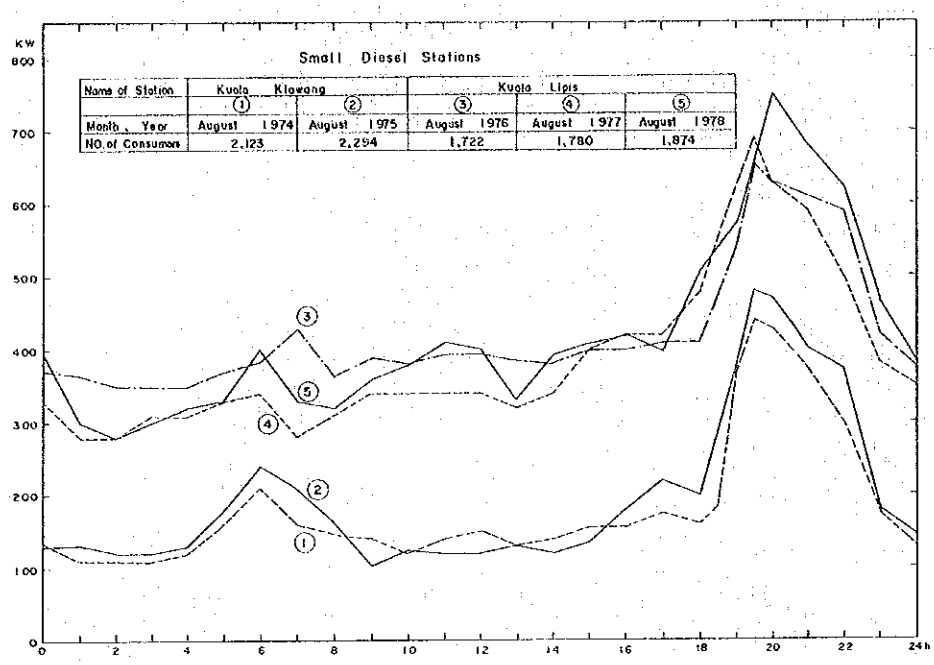

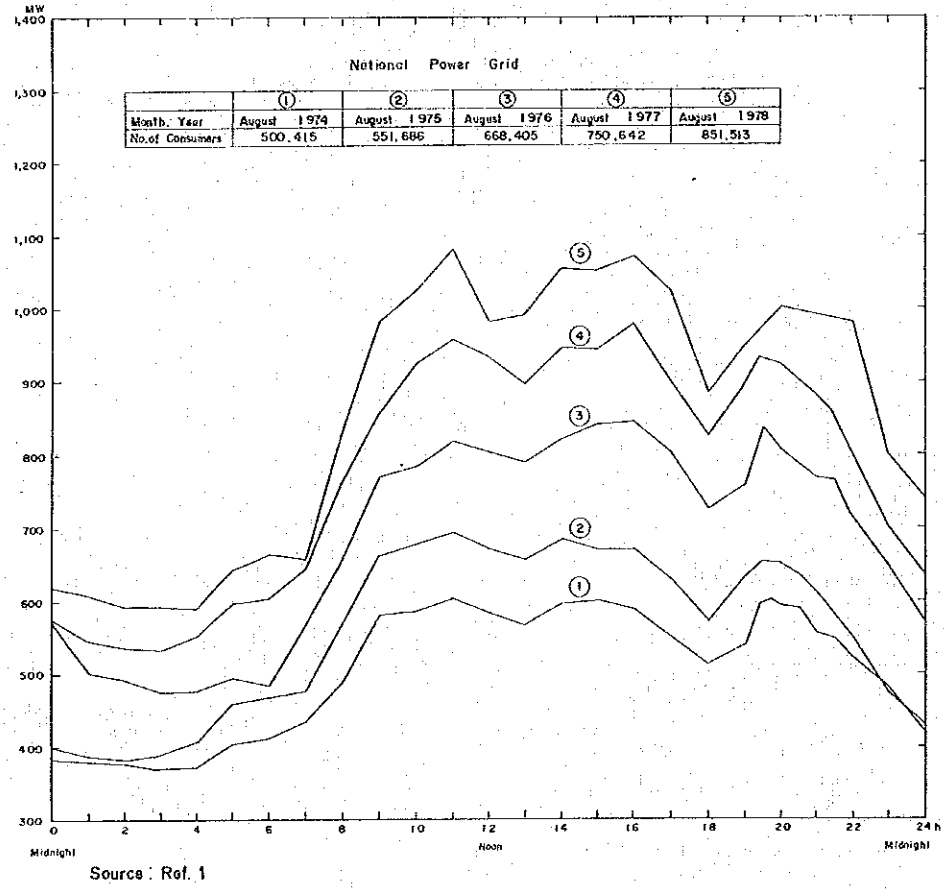

Source : Ref. 1

Fig.2 Typical Daily Load Curves

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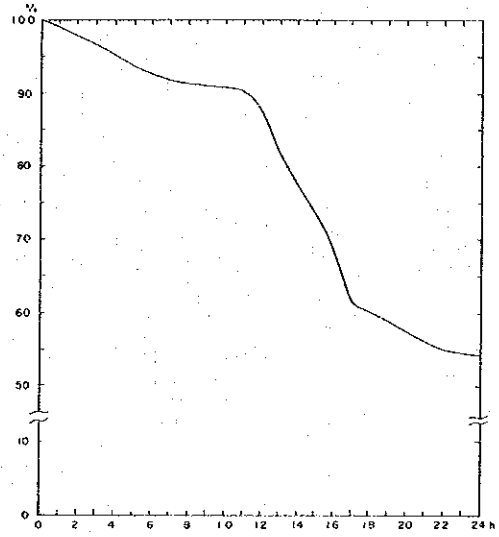
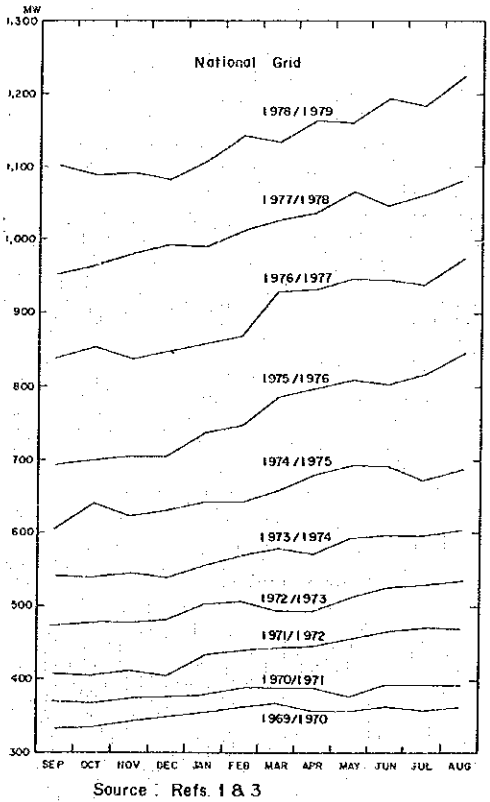
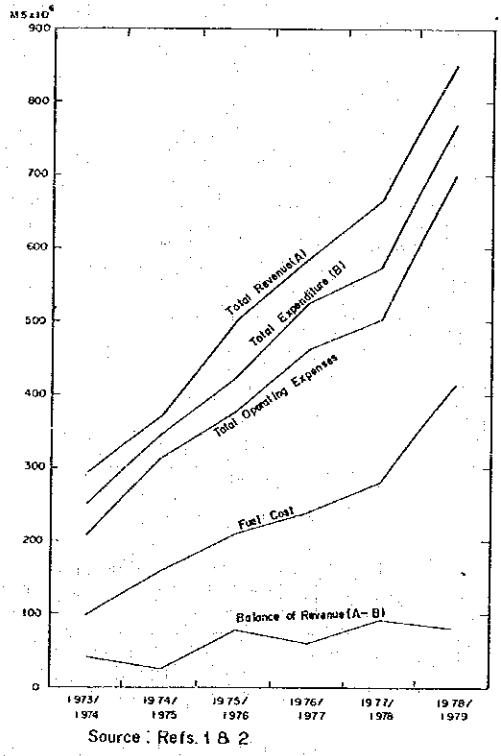


Fig. 3 Typical Load Duration Curve



Source : Refs. 1 & 3

Fig. 4 Monthly Maximum Demand



Source : Refs. 1 & 2

Fig. 5 Revenue and Expenditure of NEB

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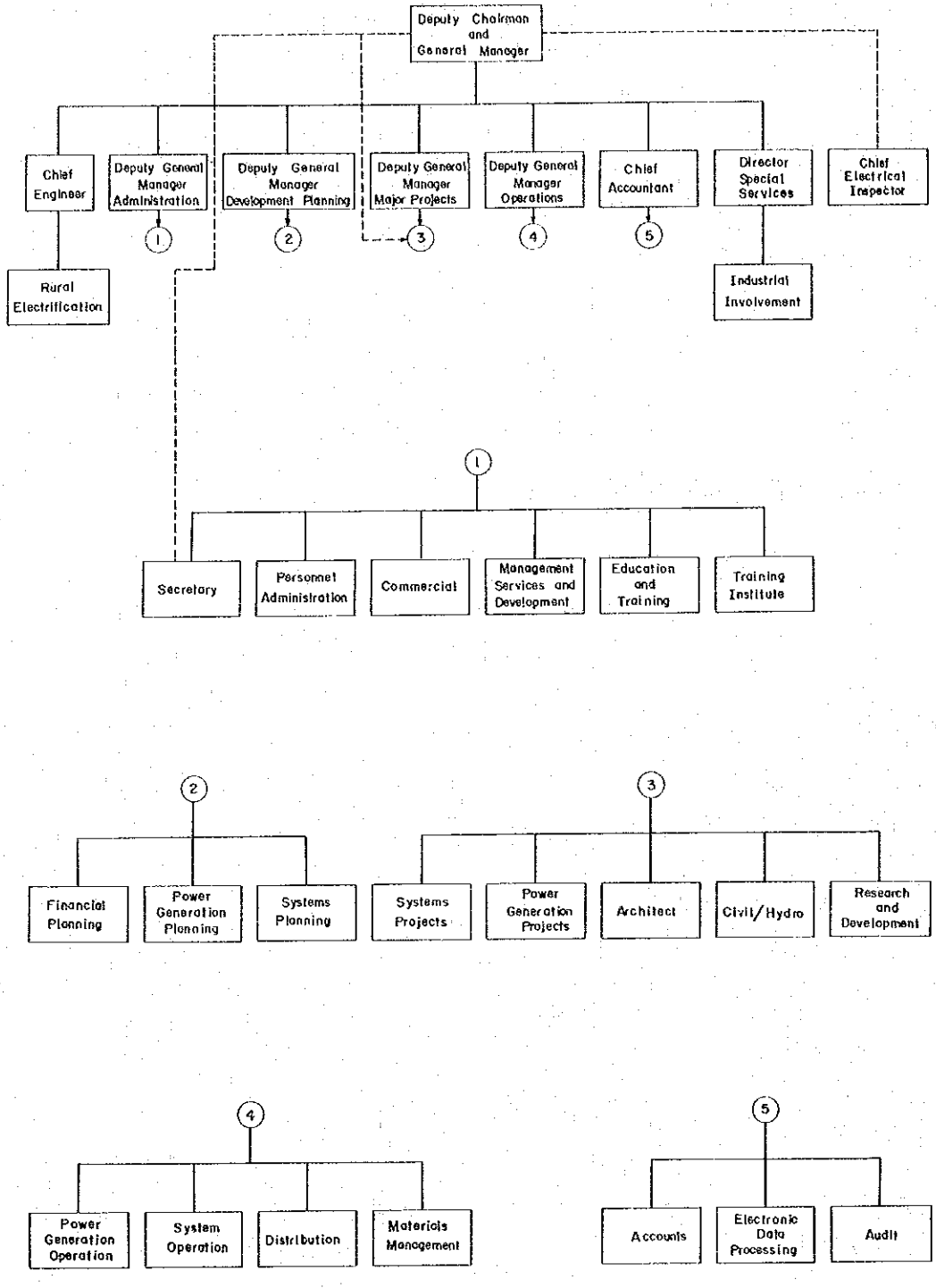

Fig.6 Organization Chart of NEB

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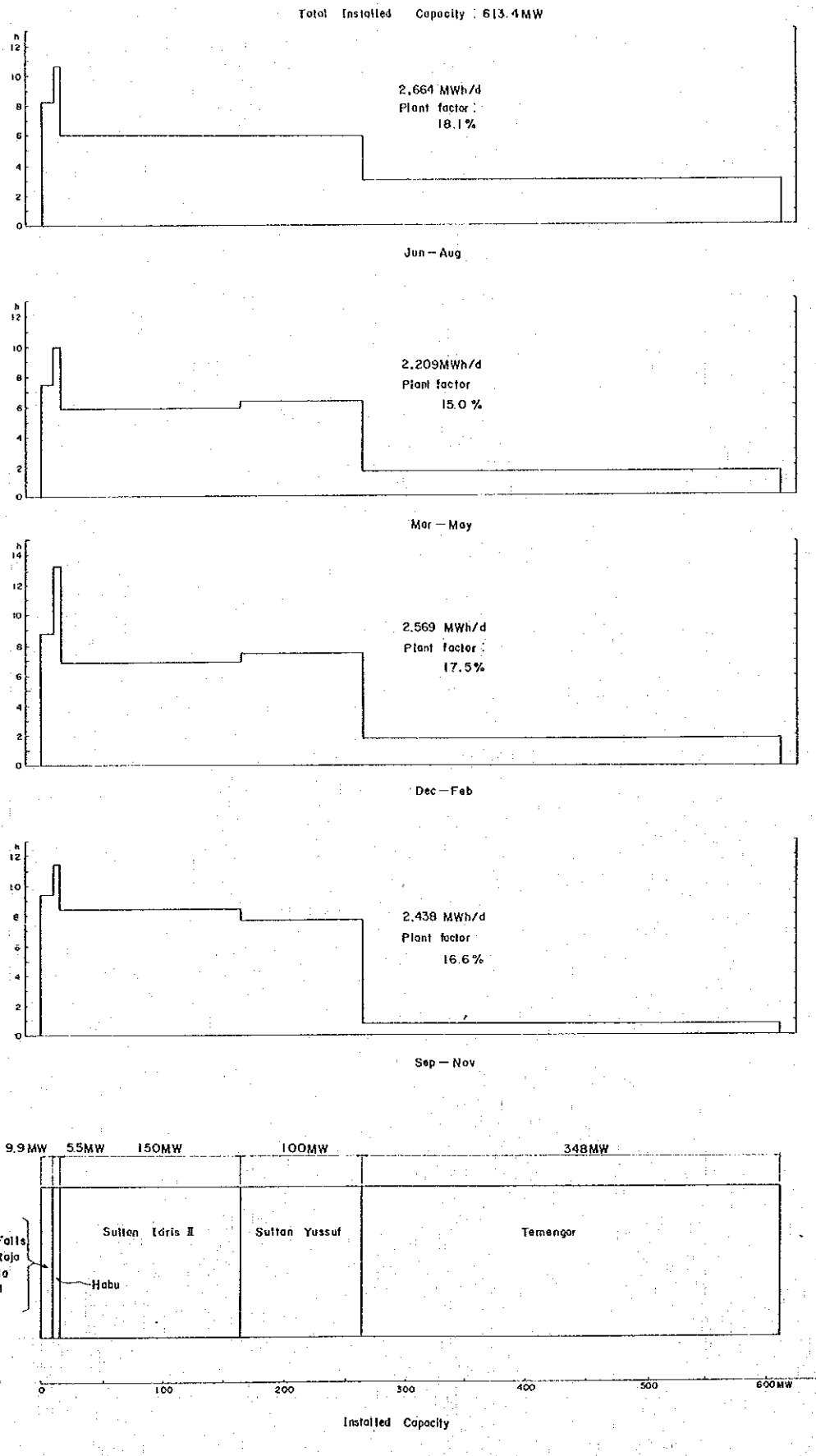

Fig. 7 Average Daily Operation Hours of NEB Hydro Power Stations in 1978/1979

(Source: Ref. 10)

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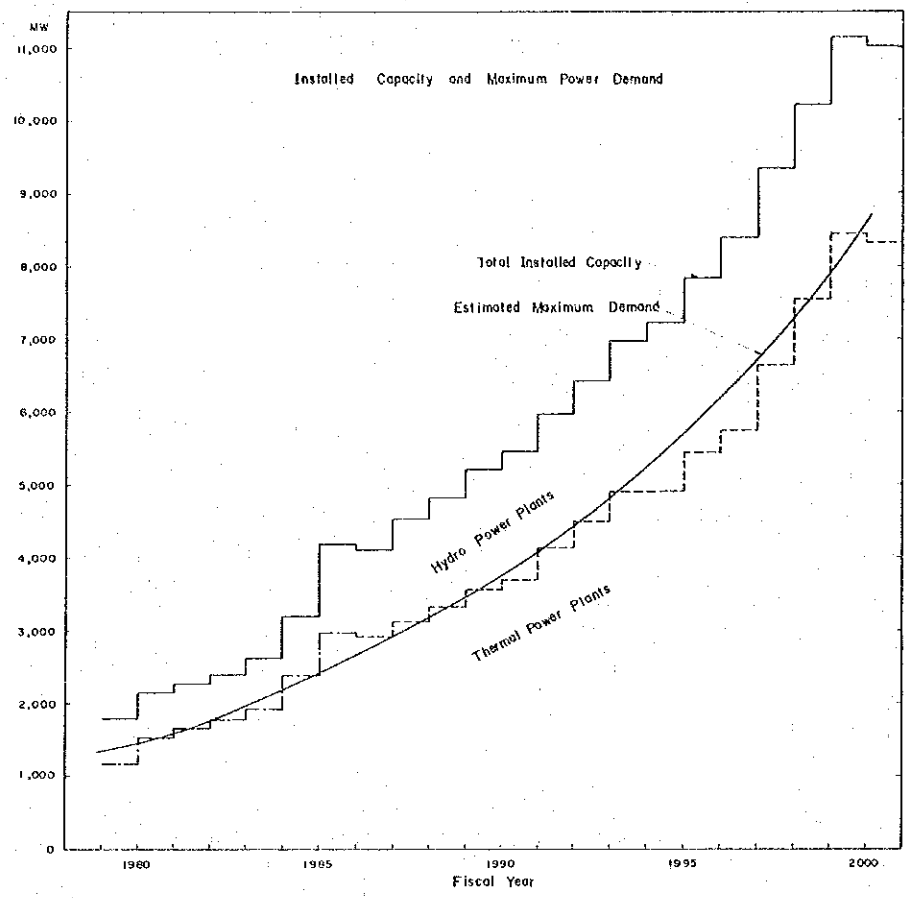

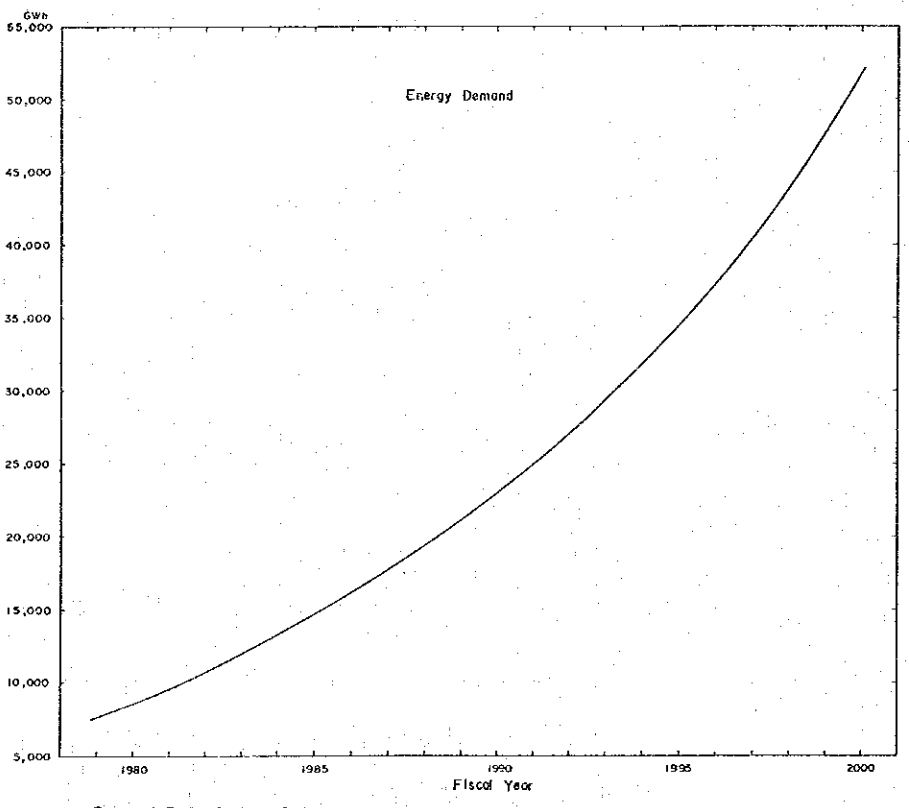

Source : Refs. 2, 4, 5, & 6

Fig. 8 Power Demand Projection by NEB

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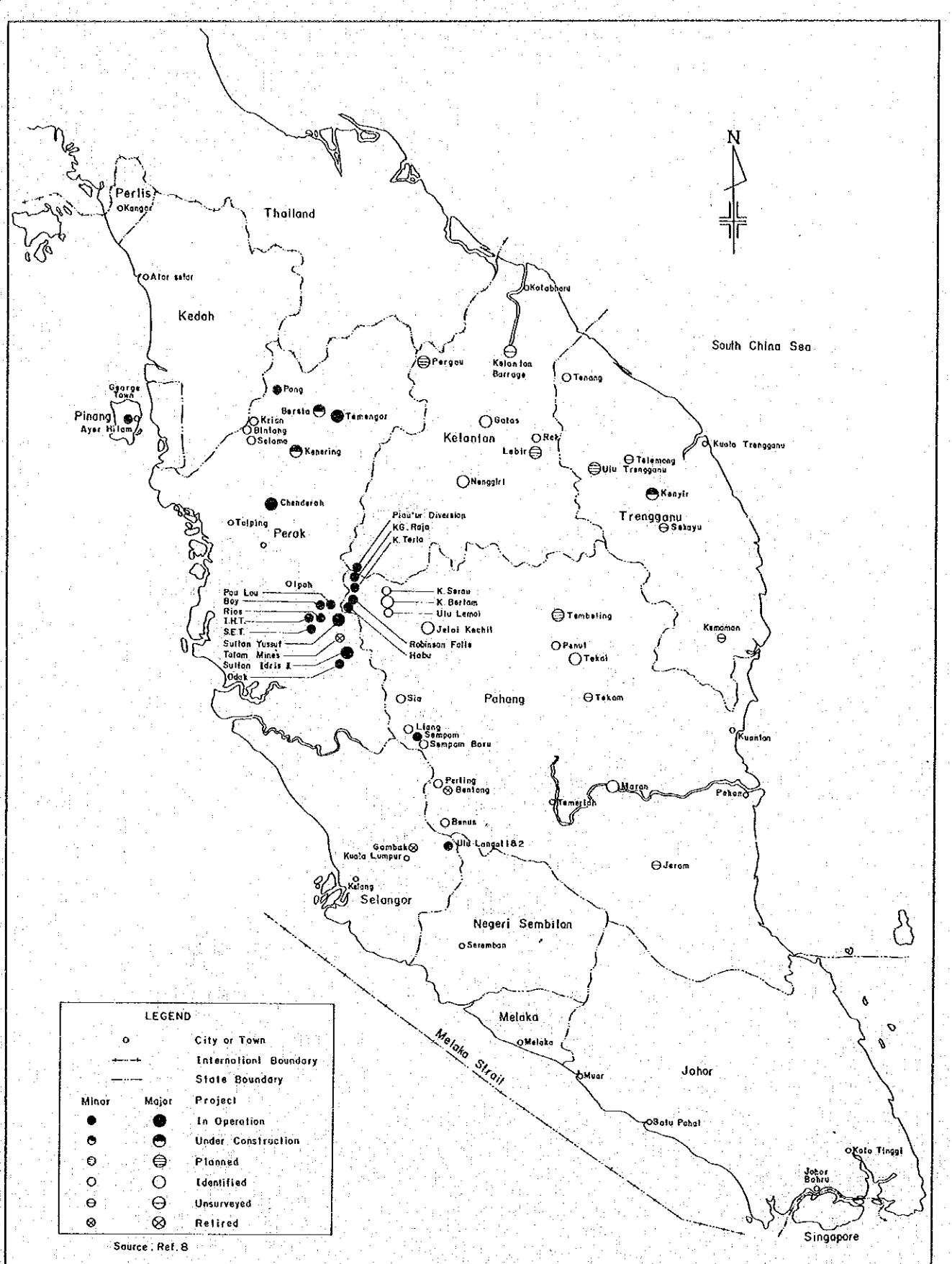

Source : Ref. 8

Fig. 9 Hydro Power Potential in Peninsular Malaysia

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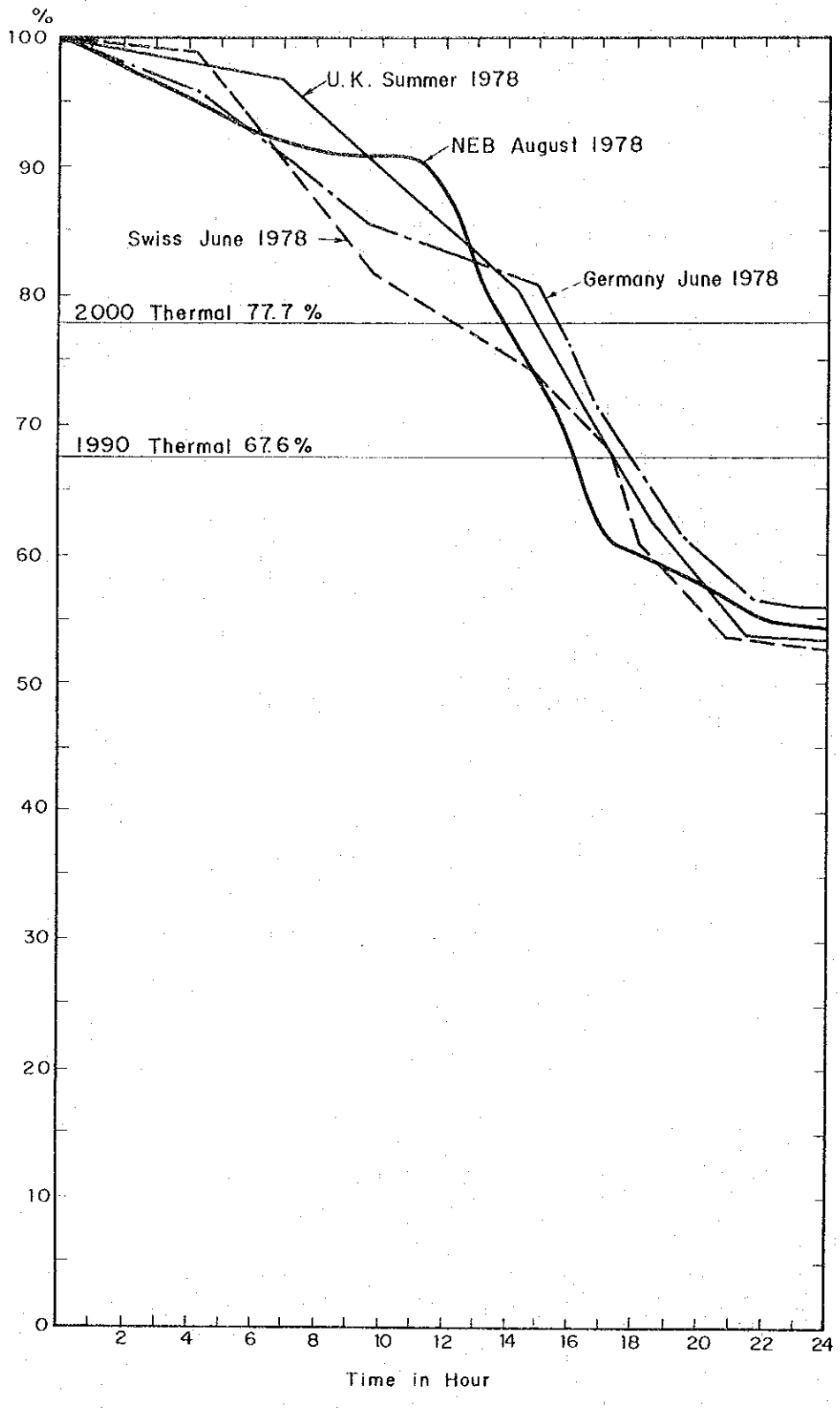

Source ; Ref 13 for foreign

Fig. 10 Daily Load Duration Curve with Indication of Future Proportion of Thermal Power Supply

GOVERNMENT OF MALAYSIA
NATIONAL WATER RESOURCES STUDY MALAYSIA
JAPAN INTERNATIONAL COOPERATION AGENCY

PART 2

SABAH AND SARAWAK

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

This Sectoral Report presents the results of power market survey which was done from July to August in 1981. It consists of the inventory of the existing power system, performance of power system, power development plan, future power demand and planning materials required for the future hydropower development in the States of Sabah and Sarawak.

2. EXISTING POWER SUPPLY FACILITIES

2.1 Generating Facilities

Electric power supply system in the State of Sabah is managed by the Sabah Electricity Board (SEB). Power generating facilities of SEB at the end of 1980 are summarized in Table 1 (see Refs. 1 and 2). All electric power is generated by diesel power plants. The location and the installed capacity of power stations are as shown in Fig. 1 (see Ref. 1).

In the Sabah of State, with the completion of generating units of 48 MW diesel at Kota Kinabalu, 31 MW at Sandakan, 11 MW at Labuan and other smaller units totalling 8 MW in various towns during TMP period, the total installed capacity of SEB power system in 1980 is 144 MW of 51 stations in 14 towns and 37 rural areas (see Refs. 2 and 3).

The major power stations are located in Kota Kinabalu (63.3 MW), Sandakan (25.7 MW), Tawau (23.9 MW), Labuan (13.0 MW), Lahad Datu (3.8 MW) and Kudat (2.4 MW). Some details of the major power stations are as shown in Table 2 (see Refs. 1 and 2). Their total installed capacity is 132.1 MW, which accounts for 92% of the total in the SEB's power system.

Presently, the Tenom Pangi Project of the first hydro-electric power scheme in Sabah is being implemented with generating facilities of 66 MW (3 x 22 MW). The power will be sent to Kota Kinabalu and Beaufort through 132 kV and 66 kV transmission lines. Commission of the project is scheduled in 1984. The main features of the project are as shown in Tables 3 and 4 and Fig. 2 (see Ref. 4).

A storage dam has been planned by SEB to be constructed in the Sook river which is a tributary of the Padas river. It is a 60-meter high earth dam with storage capacity of 480×10^6 m^3. If this dam is implemented, the installed capacity of the Tenom Pangi power station will be increased to 110 MW in total with additional two units of 22 MW each.

Electric power supply system in the State of Sarawak is managed by the Sarawak Electricity Supply Cooperation (SESCO). Power generating facilities of SESCO at the end of 1980 are summarized in Table 5 (see Refs. 5 and 6). At present, all electric power is generated by diesel power plants and gas turbine power plant which are classified as major, minor and rural stations. The location and the installed capacity of power stations are as shown in Fig. 1 (see Ref. 5).

In the State of Sarawak, during TMP period, three diesel units of 12 MW each at Sungai Biawak Power Station, two diesel units of 8.5 MW each of Sungai Priok, two diesel units of 7.8 MW each at Sibu, one 3.8 MW gas turbine at Miri and two gas turbines of 3.8 MW each at Bintulu were installed in SESCO power system (see Refs. 3 and 5).

The total installed capacity in 1980 is 148 MW of 34 stations in 15 towns and 19 rural areas. The major power stations among them are located in Kuching (77.7 MW), Sibu (31.6 MW), Miri (14.4 MW), Bintulu (11.4 MW) and Sarikei (2.6 MW) as shown in Table 6 (see Ref. 6). Their total installed capacity is 138 MW, which accounts for 93% of the total in the SESCO's power system.

In addition to the above, the Batang Ai Project of the first hydro-electric scheme in Sarawak has been being constructed since 1980 with generating capacity of 92 MW (4 x 23 MW). Electric power generated at the Batang Ai Power Station will be fed to Simanggang and Kuching through 275 kV transmission line. Commissioning of the project is scheduled in 1985. The main features of the project are as shown in Tables 7 and 8 and Fig. 3 (see Ref. 7).

The total installed capacity in both the power systems of SEB and SESCO is 292 MW in 1980. Besides SEB and SESCO power systems, there are several private self-producers, such as sawmills, oil and mine industries and other various industries.

2.2 Transmission and Distribution Systems

In SEB and SESCO, the existing power systems in towns and villages are at present isolated. There is no transmission line network for interconnecting any of these power systems except for 33 kV and 11 kV networks in the surrounding of several towns. The existing distribution line systems are composed of overhead lines and underground cables. The line voltages are 33 kV, 22 kV, 11 kV and 6.6 kV of the 3-phase and 3-wire system for high-tension and 400/230 V (50 Hz) of the 3-phase and 4-wire system for low-tension. Features of the lines are as shown in Table 9 (see Refs. 2, 5 and 6).

Presently, transmission lines of 66 kV and 132 kV in SEB and that of 275 kV in SESCO are being implemented in relation to the Tenom Pangi and Batang Ai Power Stations.

2.3 Transformer Facilities

Electric power generated at the power stations are fed to the distribution line systems through tie transformers and distribution transformers which are mounted on a pole or installed on the ground.

Transformer capacities of SEB and SESCO are as shown in Table 10 (see Refs. 2 and 6).

In connection with the Tenom Pangi and Batang Ai Hydro Power Projects, some substations will be constructed at Kota Kinabalu and Beaufort in Sabah and at Kuching and Simanggang in Sarawak. Features of these substations are as shown in Tables 3, 4, 7 and 8 (see Refs. 4 and 7).

3. PERFORMANCE OF POWER SUPPLY SYSTEM

3.1 Historical Demand and Supply

Power generation records of SEB and SESCO systems for the 10 years from 1971 to 1980 are summarized in Tables 11 to 16 (see Refs. 1, 2, 5 and 6).

In the SEB power system, the total energy generated in 1980 was 386.09 GHw with the maximum demand 79.00 MW. Total energy sold was 335.73 GWh at an average revenue of 22.6 Mc/kWh. Energy losses in the system was 50.36 GWh which corresponded to 13.0% of the energy generated. The annual load factor of SEB power system was 55.8% (see Ref. 2).

In the 10 years between 1971 and 1980, the average annual growth rate was 14.4% for energy generated, 14.3% for energy sold and 14.7% for maximum demand, respectively. The number of consumers grew from 25,090 to 73,620, the corresponding average annual growth rate of increase was 11.4%. The average energy consumption also grew from 3,520 kW to 4,560 kW, corresponding to an average annual growth rate of 2.6%. The compositions of total energy sold by SEB power system in 1980 is as shown in Table 17 (see Ref. 2).

In the SESCO power system, the total energy generated in 1980 was 356.24 GWh with the maximum demand of 73.60 MW. Total energy sold was 304.94 GWh with an average revenue of 22.6 Mc/kWh. Energy losses in the system including power station use were 51.30 GWh which corresponded to 14.4% of the energy generated. The annual load factor of SESCO power system was 55.3% (see Refs. 5 and 6).

The average annual growth rate in the above-mentioned 10 years is 13.9% for energy generated, 10.3% for energy sold and 13.1% for maximum demand, respectively. The number of consumers in the same period grew from about 33,000 to 72,860, with an average annual growth rate of 8.2%. The energy consumption per consumer was on an average 2,379 kW in 1971 and 4,185 kW in 1980, showing an average annual growth rate of 5.8%. The compositions of total energy sold by SESCO system in 1980 is as shown in Table 18 (see Ref. 6).

In both the power systems of SEB and SESCO in 1980, the total energy generated was 742.33 GWh with the maximum demand of 152.6 MW and the total energy sold was 640.67 GWh, respectively. The average annual growth rate for 10 years from 1971 to 1980 was 13.3% for energy generated, 13.1% for maximum demand and 13.6% for energy sold.

3.2 Characteristics of Load

The monthly maximum demand in some of SEB and SESCO power systems in 1978 as illustrated in Fig. 4 (see Refs. 2 and 6). The seasonal variation of demand is insignificant compared with the growth of demand.

The daily load characteristics in the SEB and SESCO systems are similar each other. Typical daily load curves for the major and minor stations in 1979 are as shown in Figs. 5 and 6 (see Refs. 2 and 6).

Peak demand is recorded three times a day, in the daytime and nighttime, at the major power stations. The daytime demand is dominated by the industrial loads, lighting and air-conditioning in office and shops. It continues for about seven hours except lunch break of one hour and usually reaches the maximum of the day at 11:00 or 4:00 o'clock. The peak demand in the nighttime is mainly for the domestic lighting loads and continues for about three hours at a little lower level than that in the daytime. Accordingly, the characteristics of the load in the major power stations are daytime type or domestic and commercial use type.

In the minor power stations, the power demand in the daytime is almost flat and low, but for several hours in the nighttime it sharply increases due to the domestic lighting. The characteristics of the load in the minor power stations are nighttime or lighting type.

Based on the typical load curves, the typical load duration curves were derived as shown in Fig. 7. The daily load factor is 64% and the minimum load is 36% of the peak load in the major power stations. The daily load factor is 61% and the minimum load is 48% of the peak load in the minor power stations.

3.3 Electricity Tariff

Electricity tariff structures of SEB and SESCO are as shown in Tables 19 to 23 (see Refs. 2 and 8).

The tariff structures include a provision of fuel cost variation charge to meet with the fluctuation in the price of fuel oil. The decrease on increase in the price of fuel oil is charged to consumers within the limitations stipulated in the tariff.

3.4 Revenue and Expenditure

Total revenues and expenditures of SEB and SESCO for last six years from 1974 to 1979 were as shown in Figs. 8 and 9 (see Refs. 2 and 5). The composition of revenue and expenditure in 1979 was as shown in Tables 24 and 25 (see Refs. 2 and 5).

SEB's account has been in deficit since 1974. Total revenues and expenditures in 1979 were M$63.6 x 10^6 and M$74.2 x 10^6. The balance of revenues was in deficit of M$10.6 x 10^6. Generation cost in the same year was M$46.7 x 10^6 corresponding to 63% of the total expenditures and was M$0.13/kWh in generated energy. The revenues from sales of electricity of commercial and domestic tariff were 57.9% of the total revenue. The average power rate was M$0.216/kWh sold.

Average annual increase rate in the past six years was 18.1% for the revenue, 6.9% for average price per kWh sold and 18.9% for the expenditure, while the annual increase rate of generation cost was 6.5%.

Total revenues of SESCO in 1979 was M$62.6 x 10^6 and the expenditure was M$43.8 x 10^6. The balance of revenue was M$18.8 x 10^6. Generation cost in the same year was M$26.5 x 10^6 or 61% of the total expenditures and was M$0.0834/kWh in generated energy. The revenues from sales of electricity of commercial and domestic tariff was 69.9% of the total revenue. The average power rate was M$0.228/kWh sold.

Average annual increase rate in the past six years was 20.9% for the revenue, 6.3% for average price per kWh sold and 25% for the expenditure, while the annual increase rate of generation cost was 28.1%.

3.5 Organization of SEB and SESCO

Organization of SEB and SESCO as of December 31, 1980 are as shown in Figs. 10 and 11. The total number of employees as of December 31, 1979 were 1,428 for SEB and 1,018 for SESCO. The compositions of the employees are as shown in Tables 26 and 27 (see Refs. 2 and 6).

The organization of SEB and SESCO is scheduled to be changed from the State statutory body to the Federal statutory body by the end of 1982.

Energy sold per employee was 232,864 kWh for SEB and 269,974 kWh for SESCO in 1979.

4. POWER DEVELOPMENT PLANS

4.1 Power Demand Projection by SEB and SESCO

Future power demand in the States of Sabah and Sarawak projected by SEB and SESCO is as shwon in Tables 28 and 29 and Figs. 12 to 14 (see Refs. 2, 5, 6 and 11 to 13). The projected demand in the major systems are as shown in Tables 30 and 31 (see Refs. 9, 10 and 11 to 13).

According to the previous studies, the power demand of SEB is estimated to be 573 GWh with the maximum power of 130 MW in 1985, 981 GWh with 222 MW in 1990, 1,583 GWh with 358 MW in 1995 and 2,351 GWh with 533 MW in 2000. Average rate of annual growth in the energy production estimated is 14.9% for the period from 1980 to 1985, 12.2% from 1985 to 1990, 8.2% from 1990 to 1995 and 7.7% from 1995 to 2000. Above forecast does not include the Labuan energy-intensive industrial development presently considered by the State Government of Sabah such as methanol plant (150 MW) and sponge iron direct reduction plant (400,000 t/a, 70 MW).

The demand projected by SESCO is estimated to be 1,413 GWh with the maximum power of 274 MW in 1990 and 3,260 GWh with 600 MW in 2000. Average annual growth rate of the energy production is estimated to be 17.6% for the period from 1980 to 1985, 11.7% from 1985 to 1990, 9.7% from 1990 to 1995 and 7.7% from 1995 to 2000. This forecast excludes the demand being planned by Bintulu-based energy-intensive industrial development in Bintulu. The power demand for the Bintulu development is estimated to be 1,075 MW as the maximum power in 2000.

The total future power demand in SEB and SESCO power system is calculated to be 5,757 GWh with the maximum power 971 MW in 1990 and 8,974 GWh with 1,608 MW in 2000, as shown in Fig. 15.

4.2 Expansion Plan of Power Supply System

Short-term expansion programs of the generating facilities by SEB and SESCO under 4 MP are shown in Tables 32 to 33 and Figs. 12 and 13 (see Refs. 1, 2, 5 and 6).

In the short-term expansion program of SEB, the total installed capacity in 1985 will amount to 307 MW as compared with estimated maximum power demand of 118 MW. For the Labuan energy-intensive industrial developments gas-fired combined cycle power station will be established in the Labuan island under the development program separate from SEB.

Long-term plans for future power development of SEB have not yet formulated. However, SEB intends to make the development of hydro-electric project in the Padas river basin (Sook Reservoir Project), Papar river basin and Kinabatangan river basin (see Refs. 14 and 15).

The total installed capacity in the short-term expansion program of SESCO system in 1985 will amount to 276 MW as compared with estimated maximum power demand of 160 MW. If an aluminium smelter is built in the Bintulu industrial development plan, SESCO intends to establish a gas turbine power station of 340 MW (17 x 20 MW) in Bintulu.

Expansion program for future power development for SESCO is studied under the master plan for power system development prepared by SAMA Consortium in 1980. The additional thermal plants of 86 MW in total will be required up to 1990 in addition to the short-term expansion program of SESCO. The long-term expansion program will be commenced in 1990 with the hydro-electric power development in the Upper Rajang river basin. The long-term expansion program and the features of the Upper Rajang River Basin Project are as shown in Table 34 and Fig. 13 (see Refs. 11 to 13). Besides, the transmission system for inter-connecting the power systems of SEB and SESCO is planned to be constructed during the period from 1990 to 1995 as shown in Fig. 15 (see Refs. 11 to 13).

The electric power to be developed under the Upper Rajang River Basin Project is calculated to be 770 MW with the energy production of 5,400 GWh per annum of the Raja dam, 2,580 MW with 18,100 GWh of the Balu dam, 940 MW with 6,600 GWh of the Muru dam and 260 MW with 1,800 GWh of the Rela dam. The total power and energy production to be developed in this project will be 4,550 MW and 31,800 GWh. These power and energy will be for greater than the power requirement in Sarawak and Sabah at that time. It is, therefore, being planned and studied that a surplus power will be supplied to Peninsular Malaysia by means of HVDC submarine cables transmission system as shown in Fig. 16 (see Refs. 11 to 13 and 16).

4.3 Rural Electrification Plan

Rural electrification plans in Sabah and Sarawak are as shown in Tables 35 and 36 (see Ref. 17). According to these, 0.80×10^6 persons or 80% of the total population in Sabah and 0.05×10^6 persons or 84% in Sarawak lived in the rural area as of the end of 1980, but 29% of them in Sabah and 18% in Sarawak had been supplied with electricity.

SEB and SESCO have an intention to make the expansion of their power systems in the rural areas in line with the Government's policy for rising living standard of the rural peoples. Under 4MP, the rural households of 70,000 in Sabah and 54,000 in Sarawak corresponding to 38% and 75% of total rural households of 0.18×10^6 and 0.22×10^6, respectively, are planned to be electrified with conventional diesel generations, mini hydro schemes and solar installations. The total expenditure of the rural electrification development are estimated to be M$94.7 $\times 10^6$ for SEB and M$51 $\times 10^6$ for SESCO.

5. PLANNING MATERIALS

5.1 Hydropower Potential

The survey of hydropower potential of river basins in the whole Sabah has not been made yet. The hydropower potential surveys in the past had been confined for the assessments of the Padas, Papar, Moyong, Tuaran and Kinabatangan rivers. Their total hydropower potential is estimated to be about 670 MW. The distribution of the hydropower potential is as shown in Table 37 and Fig. 17 (see Refs. 14, 15 and 17).

The total hydropower potential in Sarawak is estimated to be 80,000 MW at the identified 155 dam sites by SAMA. The technically utilizable potential would account for 20,000 MW with energy output of 87,000 GWh per annum at 55 dam sites. In view of the energy cost, firm energy generated, site accessibility, geological conditions and availability of construction materials at dam site, the high-priority hydroelectric projects of 11 dam sites have been selected by SAMA as shown in Table 38 and Fig. 17 (see Refs. 11 to 13 and 17 to 19).

5.2 Cost Data of On-going Hydropower Development

Cost data on-going hydropower projects such as Tenom Pangi in Sabah and Batang Ai in Sarawak were unavailable, because some portions of these projects had been in the course of tender. According to the previous studies (Refs. 4 and 7), however, the estimated capital costs of these projects are as shown in Tables 3, 4, 7 and 8.

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TABLES

Table 1 EXISTING GENERATING PLANT OF SEB
AS OF DECEMBER 31, 1980

		No. of Stations	Installed Capacity (kW)	Proportion (%)
Major Power Stations				
	Gas Turbine	-		
	Diesel	6	132,100	
	Sub-total	6	132,100	91.7
Minor Power Stations				
	Diesel	8	9,250	
		8	9,250	6.4
Rural Power Stations		37	2,710	1.9
Total		51	144,060	100

Source; Refs. 1 & 2

Table 2 MAJOR GENERATING PLANTS OF SEB
AS OF DECEMBER 31, 1980

Name of Power Station	Type of Unit	Range of Unit Size (kW)	No. of Unit	Installed Capacity (kW)
Kota Kinabalu	D	1,500 - 8,000	15	63,300
Sandakan	D	500 - 6,000	5	25,700
Tawau	D	750 - 5,400	12	23,900
Labuan	D	500 - 5,400	6	13,050
Lahad Datu	D	500 - 1,000	5	3,750
Kudat	D	150 - 300	9	2,400
Total			52	132,100

Remarks; D : Diesel
GT: Gas turbine

Source; Refs. 1 & 2

Table 3 MAJOR FEATURES AND ESTIMATED CAPITAL COST OF TENOM PANGI HYDROPOWER PROJECT (1/2)

Name of River		Padas
Location of Project Site		On the Padas river at the Tenom Gorge, 3.2 km down-stream from Tenom
Reservoir		
Catchment Area	(km^2)	7,815
Full Supply Level	(El. m)	173.9
Min. Operating Level	(El. m)	170.7
Total Storage Capacity	(10^6 m^3)	
Active Storage Capacity	(10^6 m^3)	
Power Station		
Type		Reinforcement concrete building
Size: Width	(m)	26.5
Length	(m)	53.5
Output	(MW)	66
Annual Energy Output	(GWh)	474.9
Power Generating Facilities		
Unit Capacity	(kW)	22,700
Number of Units		3
Turbine:		
Type		Vertical shaft Francis-type
Rated head	(m)	59.9
Speed	(r/min)	300
Generator:		
Output Capacity	(kVA)	25,000
132 kV Transmission Line		
Location		Pangi Power Station to Kota Kinabalu Substation
Distance	(km)	120
Voltage	(kV)	132
Number of Circuits		2
Conductor	(mm^2)	ACSR 350

Source; Ref. 4

Table 4 MAJOR FEATURES AND ESTIMATED CAPITAL COST OF TENOM PANGI HYDROPOWER PROJECT (2/2)

66 kV Transmission Line		
Location		Penampang Substation to Kota Kinabalu Substation
Distance	(km)	5
Voltage	(kV)	66
Number of circuit		1
Conductor	(mm^2)	ACSR 250
Substations		
Beaufort Substation		Suburb of Beaufort
Transformer		5 MVA x 1, 132/11 kV
Switchyard		Outdoor type
Penampang Substation		Southern suburb of Kota Kinabalu
Transformer		24 MVA x 3, 132/66 kV
Switchyard		Outdoor type
Kota Kinabalu Substation		Within existing Kota Kinabalu Power Station
Transformer		20 MVA x 2, 66/6.6 kV
Switchyard		Outdoor type

Estimated Cost based on Price as of January, 1978 ($M\$10^6$)	
Civil Works	147.0
Electrical & Mechanical Plant	64.7
Transmission Line & Substation	39.8
Construction Facilities	13.0
Engineering & Administration	22.6
Sub-total	288.1
Contingency & Others	40.9
Total	329.0

Source; Ref. 4

Table 5 EXISTING GENERATING PLANT OF SESCO
AS OF DECEMBER 31, 1980

		No. of Stations	Installed (kW)	Proportion (%)
Major Power Stations				
	Gas Turbine	(2)	11,400	
	Diesel	5	126,340	
	Sub-total	5	137,740	93.1
Minor Power Stations				
	Diesel	10	7,724	
		10	7,724	5.2
Rural Power Stations		19	2,409	1.7
Total		34	147,873	100

Source; Refs. 5 & 6

Table 6 MAJOR GENERATING PLANTS OF SESCO
AS OF DECEMBER 31, 1980

Name of Power Station	Type of Unit	Range of Unit Size (kW)	No.	Installed Capacity (kW)
Kuching				
(Sungai Biawak)	D	12,000		36,300
(Sungai Priok)	D	1,300 - 8,200	9	41,420
Sibu	D	1,300 - 7,900	8	31,550
Miri	D	1,000 - 3,300	6	10,680
	GT	3,800	1	3,800
Bintulu	D	200 - 100	7	3,810
	GT	3,800	2	7,600
Sarikei	D	140 - 600	6	2,580
Total			42D + 3GT	137,740

Remarks; D : Diesel
GT: Gas turbine

Source; Refs. 5 & 6

Table 7 MAJOR FEATURES AND ESTIMATED CAPITAL COST OF BATANG AI HYDROPOWER PROJECT (1/2)

Name of River		Batang Ai
Location of Project Site		On the Batang Ai river about 18-km upstream from Lubok Antu in the Second Division
Reservoir		
Catchment Area	(km^2)	1,200
Full Supply Level	(El. m)	108
Min. Operating Level	(El. m)	98
Total Storage Cap.	(10^6 m^3)	2,870
Active Storage Cap.	(10^6 m^3)	750
Main Dam and Lima Saddle Dam		
Type		Rock fill with concrete face
Height	(m)	85
Crest Length (Main Dam)	(m)	810
Crest Length (Saddle Dam)	(m)	510
Volume	(10^6 m^3)	5.3
Sebangki Saddle Dam		
Type		Homogeneous earthfill
Height	(m)	26
Crest Length	(m)	210
Volume	(10^6 m^3)	0.3
Bekatan Saddle Dam		
Type		Homogeneous earthfill
Height	(m)	40
Crest Length	(m)	550
Volume	(10^6 m^3)	

Source; Ref. 7

Table 8 MAJOR FEATURES AND ESTIMATED CAPITAL COST OF BATANG AI HYDROPOWER PROJECT (2/2)

Power Station		
Type		Reinforced concrete building
Size: Width	(m)	36
Length	(m)	85
Output	(MW)	92
Annual Energy Output	(GWh)	460
Power Generation Facilities		
Unit Capacity	(kW)	23,000
Number of Units		4
Turbine:		
Type		Vertical shaft Francis-type
Rated Head	(m)	65.3
Speed	(r/min)	300
Generator:		
Output Capacity	(MW)	23,000
Transmission Line		
Location		Batang Ai Power Station to Kuching Substation
Distance	(km)	220
Voltage	(kV)	275
Number of Circuits		2
Conductor	(mm^2)	300
Substations		-
Estimated Costs based on Price as of January, 1978	($M\$10^6$)	
Civil Works		147.0
Electrical & Mechanical Plant		64.7
Transmission Line & Substation		39.8
Construction Facilities		13.0
Engineering & Administration		22.6
Sub-total		288.1
Contingency & Others		40.9
Total		329.0

Source; Ref. 7

Table 9 TRANSMISSION AND DISTRIBUTION SYSTEM
AS OF DECEMBER 31, 1980

Unit: km

Voltage (kV)	SEB		SESCO	
	Overhead	Underground	Overhead	Underground
33	0	-	121	22
22	782	23	-	-
11	416	80	276	319
6.6	337	20	68	102
400/230 V	n.a.	n.a.	999	170
415/240 V	-	-	-	-
Total	1,535	123	1,464	613

Source; Refs. 2, 5 & 6

Table 10 SUBSTATIONS FACILITIES
AS OF DECEMBER 31, 1980

Voltage of Transformer	SEB		SESCO	
	No. of Transformer	Total Capacity (kVA)	No. of Transformer	Total Capacity (kVA)
33/11	-	-	22	211,500
33/6.6	-	-	-	-
22/11	6	9,000	-	-
22/6.6	11	18,500	-	-
11/6.6	5	35,000	4	5,000
33/L.T.	-	-	31	1,097
22/L.T.	182	37,855	-	-
11/L.T.	389	136,925	606	201,467
6.6/L.T.	347	71,627	75	15,560
Total	940	308,907	738	434,624

Remarks; L.T.: Low tension

Source; Refs. 2 & 6

Table 11 GENERATION RECORD OF SEB POWER SYSTEM (1/3)

		1970	1971	1972	1973
Installed Capacity	MW	33.78	45.82	52.58	57.98
Maximum Demand	MW	20.05	23.26	28.98	33.58
Energy Generated	GWh	100.57	114.92	137.51	164.49
Load Factor	%	57.3	56.4	54.2	55.9
System Loss/1	GWh	12.67	14.91	19.58	21.80
Loss Factor	%	12.6	13.0	14.2	13.3
Energy Sold	GWh	87.90	100.01	117.93	142.69
Annual Growth Rate	%	11.4	13.8	17.9	21.0
No. of Consumers	x 10^3	25.09	28.41	32.35	36.64
Power Sold/Consumer	kWh	3,503	3,520	3,645	3,894
Annual Growth Rate	%	1.7	0.5	3.6	6.8
Revenue	M$ x 10^6	12.3	13.8	16.4	21.5
Average Revenue	M$/kWh	0.14	0.14	0.14	0.15

Remarks; /1: Including energy losses in distribution system and station use.

Source; Refs. 1 & 2

Table 12 GENERATION RECORD OF SEB POWER SYSTEM (2/3)

		1974	1975	1976	1977
Installed capacity	MW	65.10	71.65	80.10	94.74
Maximum Demand	MW	36.18	40.15	44.93	49.74
Energy Generated	GWh	187.87	209.33	226.75	251.93
Load Factor	%	59.3	59.5	57.6	57.8
System Loss/1	GWh	26.57	29.76	34.61	36.80
Loss Factor	%	14.1	14.2	15.3	14.6
Energy Sold	GWh	161.30	179.57	192.14	215.13
Annual Growth Rate	%	13.0	11.3	7.0	11.97
No. of Consumer	x 10^3	42.19	45.49	51.10	54.75
Power Sold/Consumer	kWh	3,823	3,947	3,760	2,929
Annual Growth Rate	%	-1.8	3.2	-4.8	4.5
Revenue	M$ x 10^6	23.4	33.5	38.3	44.0
Average Revenue	M$/kWh	0.15	0.19	0.20	0.20

Remarks; /1: Including energy losses in distribution system and station use.

Source; Refs. 1 & 2

Table 13 GENERATION RECORD OF SEB POWER STATION (3/3)

		1978	1979	1980
Installed Capacity	MW	123.45	129.75	144.06
Maximum Demand	MW	58.31	69.24	79.00
Energy Genrated	GWh	297.13	359.08	386.09
Load Factor	%	58.2	59.2	55.8
System Loss/1	GWh	47.16	64.72	50.36
Loss Factor	%	15.9	17.5	13.0
Energy Sold	GWh	249.97	294.36	335.73
Annual Growth Rate	%	16.2	17.8	14.1
No. of Consumers	x 10^3	60.22	65.80	73.62
Power Sold/Consumer	kWh	4,151	4,474	4,560
Annual Growth Rate	%	5.7	7.8	1.9
Revenue	M$ x 10^6	52.2	63.6	76.0
Average Revenue	M$/kWh	0.21	0.22	0.23

Remarks; /1: Including energy losses in distribution system and station use.

Source; Refs. 1 & 2

Table 14 GENERATION RECORD OF SESCO POWER STATION (1/3)

		1970	1971	1972	1973
Installed capacity	MW	32.10	41.55	41.60	51.20
Maximum Demand	MW	19.30	21.50	25.94	29.91
Energy Generated	GWh	84.22	97.30	118.33	137.90
Load Factor	%	49.8	51.7	52.1	52.6
System Loss/1	GWh	15.42	18.80	21.83	23.79
Loss Factor	%	18.3	19.3	18.5	17.3
Energy Sold	GWh	68.80	78.50	96.50	114.11
Annual Growth Rate	%	17.9	14.1	22.9	18.3
No. of Consumers	x 10^3	30.45	33.00	36.45	39.20
Power Sold/Consumer	kWh	2,259	2,379	2,647	2,911
Annual Growth Rate	%	14.2	5.3	11.3	9.8
Revenue	M$ x 10^6	12.4	13.1	15.4	17.8
Average Revenue	M$/kWh	0.18	0.17	0.16	0.16

Remarks; /1: Including energy losses in distribution system and power station use.

Source; Refs. 5 & 6

Table 15 GENERATION RECORD OF SESCO POWER SYSTEM (2/3)

		1974	1975	1976	1977
Installed Capacity	MW	59.15	80.44	81.96	98.17
Maximum Demand	MW	33.06	37.33	44.69	50.05
Energy Generated	GWh	153.19	176.32	203.43	232.08
Load Factor	%	52.9	53.9	52.0	52.9
System Loss/1	GWh	26.59	29.89	35.38	36.58
Loss Factor	%	17.4	16.9	17.4	15.8
Energy Sold	GWh	126.60	146.43	168.05	195.50
Annual Growth Rate	%	9.9	13.8	14.8	16.3
No. of Consumers	x 10^3	42.47	45.81	49.32	52.65
Power Sold/Consumer	kWh	2,981	3,196	3,407	3,713
Annual Growth Rate	%	2.3	7.2	6.6	9.0
Revenue	M$ x 10^6	20.0	24.0	33.8	44.1
Average Revenue	M$/kWh	0.16	0.16	0.20	0.23

Remarks; /1: Including energy losses in distribution system and station use.

Source; Refs. 5 & 6

Table 16 GENERATION RECORD OF SESCO POWER SYSTEM (3/3)

		1978	1979	1980
Installed Capacity	MW	133.58	139.26	147.87
Maximum Demand	MW	61.05	69.07	73.60
Energy Generated	GWh	277.02	317.54	356.24
Load Factor	%	52.5	52.5	55.3
System Loss/1	GWh	43.87	42.71	51.30
Loss Factor	%	15.8	13.5	14.4
Energy Sold	GWh	233.15	274.83	304.94
Annual Growth Rate	%	19.3	17.9	11.0
No. of Consumers	x 10^3	60.61	64.90	72.86
Power Sold/Consumer	kWh	3,847	4,235	4,185
Annual Growth Rate	%	3.6	10.1	-1.9
Revenue	M$ x 10^6	51.7	62.6	70.8
Average Revenue	M$/kWh	0.22	0.23	0.23

Remarks; /1: Including energy losses in distribution system and station use.

Source; Refs. 5 & 6

Table 17 COMPOSITION OF TOTAL ENERGY SOLD OF SEB POWER SYSTEM IN 1980

Tariff Classification	Number of Consumers	%	Energy Sold (MWh)	%
A. Flate Rate: Offices, Halls, Clinics	3,717	5.0	19,964	5.9
B. Cinema-merged with Tariff	-	-	-	-
C. Charitable Organisations: Hospitals, Schools, Hostels	1,042	1.4	9,004	2.7
D. Industries & Hotels	2,817	3.8	94,673	28.2
E. Domestic & Households	56,846	77.2	110,363	32.9
F. Commercial, Shops & Cinemas	6,237	8.5	38,307	11.4
G. Central Air-conditioning	2,178	3.0	49,617	14.8
H. Public Lighting	370	0.5	6,996	2.1
I. Armed Forces	417	0.6	6,810	2.0
Total	73,624	100	335,734	100

Source; Ref. 1

Table 18 COMPOSITION OF TOTAL ENERGY SOLD OF SESCO POWER SYSTEM IN 1980

Tariff Classification	Number of Consumers	%	Energy Sold (MWh)	%
Domestic	56,943	78.2	83,359	27.3
Commercial				
Low Voltage	15,299		143,861	47.2
High Voltage	1		2,636	0.9
Sub-total	15,300	21.0	146,497	48.1
Industrial				
Low Voltage	440		52,770	17.3
High Voltage	4		18,118	5.9
Sub-total	444	0.6	70,888	23.2
Street Lighting	175	0.2	4,194	1.4
Total	72,862	100	304,938	100

Source; Ref. 5

Table 19 ELECTRICITY TARIFF IN SEB POWER SYSTEM (1/3)

Tariffs	Monthly Rate
A. Flat Rate Lighting (Fans, heating and office apparatus of offices, halls, clinics, museums, libraries, community/sport centers)	M$0.35/unit Minimum charge: M$10.00
B. Cinemas (Abolished and merged with commercial tariff)	
C. Charitable Organisations (Hospitals, schools, mosques, temples, schools and government hostels)	100 units : M$0.25/unit 400 units : M$0.17/unit Balance : M$0.15 Minimum charge: M$10.00
D. Industry	
D1 - Light industry below 500 ps or 370 kW	2,000 units : M$0.20/unit 13,000 units : M$0.17/unit Balance : M$0.15 Minimum charge: M$2.00/ps (0.75 kW) of connected load but not less than M$10.00
D2 - Heavy industry for load connected above 500 ps or 370 kW (Maximum Demand Power Tariff)	(1) For each kW of maximum demand per month: M$10.00 (2) For all units: M$0.12/unit Minimum charge: M$2.00/ps (0.75 kW) of connected load but not less than M$1,000 (3) For supplies taken at high voltage or extra high voltage, the units recorded will be reduced by 2% for billing purposes. (4) This type of industrial consumers is required to provide a space on their premises for installation of substations.

Source; Ref. 2

Table 20 ELECTRICITY TARIFF IN SEB POWER SYSTEM (2/3)

Tariffs	Monthly Rate
E. Domestic and Household	40 units : M$0.25/unit 160 units : M$0.17/unit Balance : M$0.15 Minimum charge: M$5.00
F. Commercial (Restaurants, shophouses, cinemas, markets, funfares, clubs, and associations)	100 units : M$0.30/unit 900 units : M$0.17/unit Balance : M$0.15 Minimum charge: M$50.00/month
G. Air-conditioning (Only applies to central plants)	Flat rate : M$0.20/unit Minimum charge: M$50.00/month
H. Public Lighting	
H1 - Street lighting	From dusk to dawn, 12-hour basis, 100 W or pro-rate per month: M$5.40/month or M$0.15/unit. Initial charge for use of SEB poles for mounting of light fittings per pole (payable once only): M$25.00 The 6-hour basis of dusk to midnight is abolished.
H2 - Temporary festivals/ decorations, staircases, elevators and playgrounds	Flat rate : M$0.17/unit Minimum charge: M$10.00/month
I. Armed Forces	500 units : M$0.35/unit Balance : M$0.20 Minimum charge: M$10.00

Source; Ref. 2

Table 21 ELECTRICITY TARIFF IN SEB POWER SYSTEM (3/3)

Meter Rentals; Single Phase: M$0.50/month
Three Phase : M$1.00/month

Fuel Oil Variation Charge;

This Clause shall apply to all tariffs, with the exception of Tariff A and up to the first 200 units of Tariff E.

For every dollar or pro-rata for every part of a dollar increase in the average cost to the Board of fuel having an average calorific value as received of 18,500 BTU/lb consumed at the Board's major generating stations above M$258/ton or below M$252/ton, the consumer shall pay an increased or decreased charge of 0.040 cent per unit, provided always that this charge shall only apply in the proportion that the units generated by fuel bears to the total units generated by the Board at all the Board's major generating stations supplying energy to Kota Kinabalu, Sandakan, Tawau, Lahad Datu and Labuan during the month concerned.

In the event of fuel having a calorific value either more or less than 18,500 BTU/lb the price per ton will be adjusted by simple inverse proportion to that value, provided that if the calorific value is more than 18,200 BTU and less than 18,800 BTU no adjustment in the price per ton shall be made. The term "fuel" in this agreement includes cost and oil and any substance other than water 'Hydropower' which from time to time may be utilized by the Board as a source of energy for generating electricity.

Source; Ref. 2

Table 22 ELECTRICITY TARIFF IN SESCO POWER SYSTEM (1/2)

Tariffs	Monthly Rate Class I	Class II
A. Private Dwelling Premises		
For the first 30 units	M$0.30/unit	M$0.38/unit
For units excess of 30 units	M$0.18/unit	M$0.21/unit
Minimum charge	M$3.00	M$3.00
B. Commercial Premises		
(Low Voltage Supply)		
For the first 60 units	M$0.35/unit	M$0.38/unit
For units excess of 60 units but not exceeding 5,000 units	M$0.22/unit	M$0.25/unit
For units in excess of 500 units	M$0.18/unit	M$0.21/unit
Minimum charge	M$6.00	M$3.00
(High Voltage Supply)		
Maximum demand charge	M$12.00/kW	M$15.00/kW
Running charge	M$0.13/unit	M$0.15/unit
C. Industrial Premises		
(Low Voltage Supply)		
For the first 60 units	M$0.35/unit	M$0.38/unit
For units in excess of60 units but not exceeding 3,000 units	M$0.22/unit	M$0.25/unit
Maximum charge	M$6.00	M$6.00
(High Voltage Supply)		
Maximum demand charge	M$12.00/kW	M$15.00/kW
Running charge	M$0.09/unit	M$0.11/unit
Minimum Charge	M$800.00	M$800.00
D. Street Lighting		
Inclusive of all maintenance charge	M$0.35/unit	M$0.38/unit
Minimum charge	M$6.00	M$6.00

Remarks; Class I :
Class II:

Source; Ref. 8

Table 23 ELECTRICITY TARIFF IN SESCO POWER SYSTEM (2/2)

All tariffs are subject to the following clauses:

(a) Fuel Cost Variation Charge

For every dollar or pro-rata every part of a dollar increase or decrease in the cost to the Sarawak Electricity Supply Corporation:-

(i) of fuel oil having a calorific value as received of 19,000 British Thermal Units per pound consumed at the Sarawak Electricity Supply Corporation's generating station in Kuching above M$290/ton or below M$280/ton; or

(ii) of diesoline having a calorific value as received of 19,400 British Thermal Units per pound consumed at Marudi generating station above M$358/ton or below M$348/ton,

the consumer shall pay an increased or decreased charge of 0.0278 cent per unit during the month concerned.

In the event of fuel or diesoline having a calorific value either more or less than the calorific values as stated in paragraphs (i) and (ii) above, the price per ton will be adjusted by simple inverse proportion to that value:

Provided that if the calorific value is within 1.5% more or within 1.5% less than the calorific value stated in paragraphs (i) and (ii) above no adjustment in the price per ton shall be made.

(b) Low Power Factor Cost

The consumer shall use his best endeavours to obtain the highest power factor possible in the operation of his electrical installation. If the average power factor in any month is found to be below 0.85 lagging a supplementary charge of one and half percent (1.5%) of the bill for that month for each one hundredth part (0.01) below 0.85 lagging power factor shall be added to the bill for that month.

Source; Ref. 8

Table 24 REVENUE AND EXPENDITURE OF SEB IN 1980

Unit: M$ x 10^3

Item		Amount
1.	Revenue (A)	
	(1) Operating Revenue	
	Revenue from sales of electricity	70,937
	Others	566
	Sub-total	71,503
	(2) Non-operating Revenue	4,505
	Total	76,008
2.	Expenditure (B)	
	Generation	69,029
	Distribution	10,291
	Administration	15,403
	Loan interest	4,833
	Total	99,556
3.	Balance of Revenue (A) - (B)	-23,548

Source; Ref. 2

Table 25 REVENUE AND EXPENDITURE OF SESCO IN 1979

Unit: M$ x 10^3

Item		Amount
1.	Revenue (A)	
	(1) Operating Revenue	
	Revenue from sales of electricity	57,219
	Others	-
	Sub-total	57,219
	(2) Non-operating Revenue	5,382
	Total	62,601
2.	Expenditure (B)	
	Generation	26,488
	Distribution	4,056
	Service maintenance	831
	Training and welfare	1,156
	Administration	2,939
	General expenses	2,296
	Other expenses	409
	Loan interest	5,588
	Total	43,763
3.	Balance of Revenue (A) - (B)	18,838

Source; Ref. 6

Table 26 COMPOSITION OF SEB'S EMPLOYEES AS OF DECEMBER 31, 1980

	Number of Employee	Proportion (%)
Managerial and Professional Group	76	5.3
Executive and Sub-Professional Group	41	2.9
Supervisory Group	-	-
Clerical Group	388	27.2
Technical Staff	597	41.8
Industrial and Manual	200	14.0
Apprenticeship Scheme	126	8.8
Total	1,428	100.0

Source; Ref. 1

Table 27 COMPOSITION OF SESCO'S EMPLOYEES AS OF DECEMBER 31, 1980

	Number of Employee	Proportion (%)
Managerial and Professional Group	72	7.1
Executive and Sub-Professional Group	39	3.9
Clerical and Technical Group	454	44.6
Subordinate and Manualf Group	453	44.4
Total	1,018	100.0

Source; Ref. 5

Table 28 FUTURE POWER DEMAND IN SABAH PROJECTED BY SEB

Year	Energr (GWh)	Max. Power (MW)	Power Factor (%)
1965	44.8	10.6	48.2
1970	87.9	20.0	50.2
1975	197.6	40.2	56.1
1979	359.1	69.2	58.1
1980	386.1	79.0	55.8
1985	761.0	162.0	56.5
1990	1,636.0	344.0	58.2
1995	3,094.0	620.0	59.2
2000	5,257	1,035.0	61.2

Remarks; The values were revised by SEB on June, 1982.

Table 29 FUTURE POWER DEMAND IN SARAWAK PROJECTED BY SESCO

	Minimum Forecast (1)			Maximum Forecast (2)		
Year	Energy (GWh)	Max. Power (MW)	Load Factor (%)	Energy (GWh)	Max. Power (MW)	Load Factor (%)
1975	176	37	57.4	-	-	-
1979	318	69	54.4	-	-	-
1980	361	74	55.7	361	74	55.7
1985	812	160	57.9	3,164	475	76.0
1990	1,413	274	58.9	4,776	749	72.8
1995	2,243	425	60.3	5,608	900	71.1
2000	3,260	600	62.0	6,623	1,075	70.3

Remarks; (1): Normal growth of the existing staitons

(2): Minimum forecast plus the following project in Bintulu

- Aluminium smelter
- Iron ore direct reduction plant
- Electric arc steel plant

Soruce; Refs. 5 & 13 (Vol. II, Annex 3/2)

Table 30 FUTURE POWER DEMAND OF MAJOR POWER STATIONS IN SABAH

Station	Power Demand (MW)				
	1979	1985	1990	1995	2000
Kota Kinabalu	37	73	148	276	460
Sandakan	16.5	31	54	100	168
Tawau	9.5	19	36	67	112
Labuan	5.1	21	69	127	213
Lahad Datu	2.2	5	9	17	28
Kudat	1.3	3	5	9.3	16
*Keningau	1	3	5.1	9.5	16
Total	72.6	155	326.1	604.8	1,013

Remarks; The values were revised by SEB on June, 1982.

* Keningau station, which trends to grow in the same pace as Kudat station, is included.

Table 31 FUTURE POWER DEMAND OF MAJOR STATIONS IN SARAWAK

Station	Power Demand (MW)				
	1979	1985	1990	1995	2000
Kuching	38.9	85	142	213	295
Sibu	12.6	24	40	67	101
Miri	8.2	18	32	52	78
Bintulu	2.0	11	26	47	69
Sarikei	1.3	3	5	9	15
Energy-intensive Project[/1]	-	328	491	495	496
Total	63	469	736	883	1,054

Remarks; Aluminium smelter, iron ore, direct reduction plant, electric arc steel plant, deepwater port, Urea/ammonia plant.

Source; Ref. 11

Table 32 EXPANSION PROGRAM OF GENERATING FACILITIES IN SEB

Year	Station	Capacity to be Installed in Major P/S (MW)	Type	Total Capacity (MW)	Maximum Demand (MW)
1980				144.1	79
1981	Kudat	0.75 x 1	D	153	88
	Tawau	5.4 x 1	D		
	Lahad Datu	2 x 1	D		
1982	Kota Kinabalu /1	14 x 2	GT	232	105
	Sandakan	8 x 2	D		
	Labuan	5.5 x 1	D		
	Kudat /1	0.75 x 1	D		
	Keningau	0.75 x 1	D		
	Keningau	0.5 x 1	D		
	Kota Belud	0.5 x 2	D		
	*Beaufort	0.5 x 2	D		
	Tenom	0.5 x 2	D		
	Semporna	0.5 x 1	D		
	Ranau	0.5 x 1	D		
	Tawau	8 x 2	D		
	Labuan	1 x 1	D		
1983	Labuan	8 x 1	D	245	121
	Lahad Datu	2 x 2	D		
	*Tenom	0.5 x 2	D		
1984	Sandakan	8 x 2	D	330	140
	Kudat	1.5 x 2	D		
	Pangi	22 x 3	H		
	Kota Belud	0.5 x 1	D		
1985	Kota Kinabalu	12 x 4	D	377	162
	Kota Belud	0.5 x 1	D		
	Ranau	0.5 x 1	D		

Remarks; /1: Replacement
GT: Gas turbine, D: Diesel, and H: Hydropower
*: Will be closed in 1985.
The values were revised by SEB on June, 1982.

Source; Refs. 1 & 2

Table 33 EXPANSION PROGRAM OF GENERATING FACILITIES IN SESCO

Year	Name of Station	Capacity to be Installed (MW)	Type	Total Capacity (MW)	Maximum Demand (MW)
1980				147.9	74
1982	Kuching	12 x 1	GT	159.9	86
1982	Miri	8 x 2	GT	175.9	101
1983	Sibu	8 x 1	D	183.9	118
1984	Kuching	12 x 1	GT	195.9	137
1985	Batang Ai	23 x 4	H	287.9	160

Remarks; GT: Gas turbine, D: Diesel, and H: Hydropower

Source; Refs. 5 & 6

Table 34 EXPANSION PROGRAM AND FEATURES OF RAJANG RIVER BASIN IN SARAWAK

Project		Pelagus (Raja 284)	Bakun (Balu 037)	Muru 040	Bela 010
Name of River		Rajang	Balui	Murum	Belaga
Mean Discharge	m^3/s	2,000	1,560	310	230
Mean Net Head	m	39	159	291	112
Max. Active Storage Volume	$10^9 \times m^3$	3.0	27.1	6.0	6.8
Reservoir Area	km^2	330	730	210	390
Installed Capacity	MW	770	2,580	940	260
Energy	GWh	5,600	18,100	6,600	1,800
Capital Cost	$10^6 \times$ M$	1,480	2,690	1,080	730
Energy Cost	M$/kWh	4.1	2.3	2.3	5.3
Commenced Year	1st stage	1990	1995	2004	2009
	2nd stage	-	2001	-	-

Remarks; Data on June, 1982

Table 35 RURAL ELECTRIFICATION PLAN IN SEB POWER SYSTEM

Year	Area	Population (No.)	Population (%)	Households (No.)	Households (%)	Households with Electricity (No.)	Households with Electricity (%)
1970	Rural	545,665	77.2	99,212	83.5	7,480	7.5
	Urban	107,599	22.8	19,563	16.5	17,606	90.0
	Total	653,264	-	118,775	-	25,086	-
1975	Rural	691,792	83.5	125,780	83.5	23,170	18.4
	Urban	136,413	16.5	24,802	16.5	22,321	90.0
	Total	828,205	-	150,582	-	45,492	30.2
1977	Rural	750,611	82.4	136,474	82.4	28,566	20.9
	Urban	160,051	17.6	29,100	17.6	26,190	90.0
	Total	910,662	-	165,574	-	54,756	3.3
1980	Rural	803,632	80.2	146,115	80.3	42,850	29.3
	Urban	197,697	19.8	35,945	19.7	32,350	90.0
	Total	1,001,329	-	182,060	-	75,200	41.3
1985	Rural	997,943	78.6	181,444	78.6	69,777	38.4
	Urban	271,537	21.4	49,370	21.4	44,433	90.0
	Total	1,269,480	-	230,814	-	114,210	49.5

Source; Ref. 16

Table 36 RURAL ELECTRIFICATION PLAN IN SESCO POWER SYSTEM

Year	Area	Population (No.)	Population (%)	Households (No.)	Households (%)	Households with Electricity (No.)	Households with Electricity (%)
1970	Rural	825,132	84.5	150,024	84.5	6,590	4.4
	Urban	151,137	15.5	27,479	15.5	23,857	86.8
	Total	976,269	100	177,503	100	30,447	17.2
1975	Rural	933,600	84.5	169,700	84.5	15,641	9.2
	Urban	171,000	15.5	31,100	15.5	30,167	97.0
	Total	1,104,600	100	200,800	100	45,800	22.8
1977	Rural	980,900	84.5	178,300	84.5	20,600	11.6
	Urban	179,700	15.5	32,700	15.5	32,046	98.6
	Total	1,160,600	100	211,b00	100	52,624	24.9
1980	Rural	1,045,900	83.7	190,200	83.7	34,100	17.9
	Urban	203,900	16.3	37,000	16.3	36,500	98.6
	Total	1,249,800	100	227,200	100	70,600	31.1
1985	Rural	1,183,300	83.7	215,100	83.7	54,100	25.2
	Urban	230,700	16.3	41,900	16.3	41,500	99.0
	Total	1,414,000	100	257,000	100	95,600	37.2

Source; Ref. 16

Table 37 HYDROPOWER POTENTIAL IN SABAH

Regional Location	Name of River	Installed Capacity (MW)	Energy Output (GWh/y)
Tanom Pangi	Padas	66	464
Sook	Padas	44	220
Rayok	Padas	65	-
L. Halogilat	Padas	144	990
U. Halogilat	Padas	98	-
Papar	Papar	35	171
Moyong	S. Moyong	7	-
Tamparuli	S. Turan	35	-
Balat	S. Kinabatangan	71	342
Deramakot	S. Kinabatangan	78	387
Milian	S. Milian	50	236
Kuamut	S. Kuamut	46	241

Source; SEB

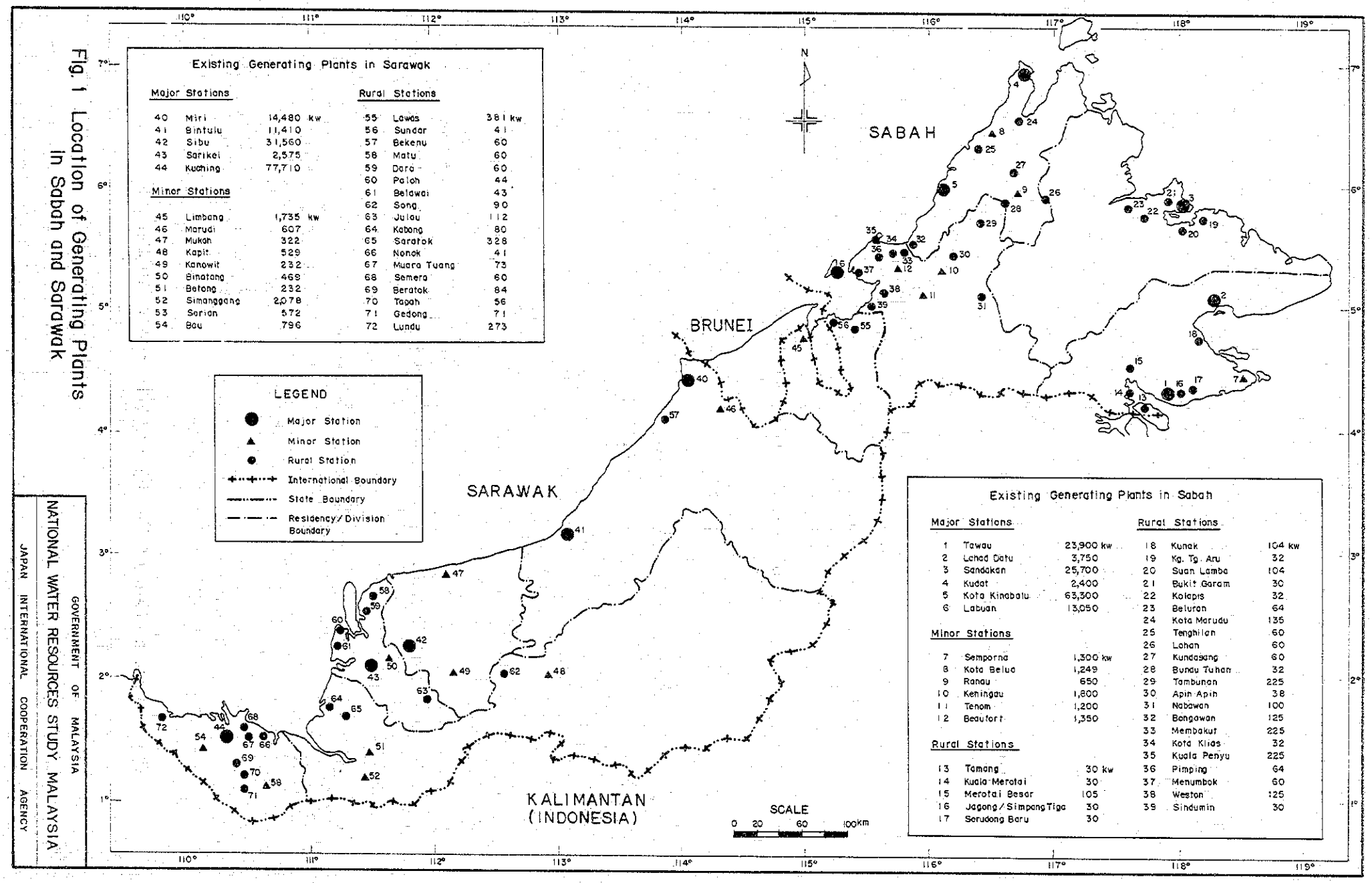
Table 38 BEST HYDRO-ELECTRIC PROJECT IN SARAWAK

Name of River	Dam Height (M)	Active Storage (MW)	Installed Capacity (MW)	Energy (GWh/y)	Project Cost (M$ x 10^6)
S. Limbang	113	1,201	258	1,129	447
S. Tutoh	131	550	538	2,357	739
B. Baram	181	24,682	2,078	9,101	2,082
S. Murum	128	3,621	1,548	6,779	1,249
S. Belepeh	113	1,052	194	148	346
S. Balui	181	26,994	4,534	19,860	3,525
S. Linau	148	4,416	568	2,487	824
B. Belaga	146	17,623	524	2,294	874
B. Rajang	92	17,691	2,722	11,921	2,050
B. Baleh	117	4,074	1,406	6,610	1,323
S. Katibas	155	6,491	315	1,378	739

Source; Ref. 13

FIGURES

Fig. 1 Location of Generating Plants in Sabah and Sarawak



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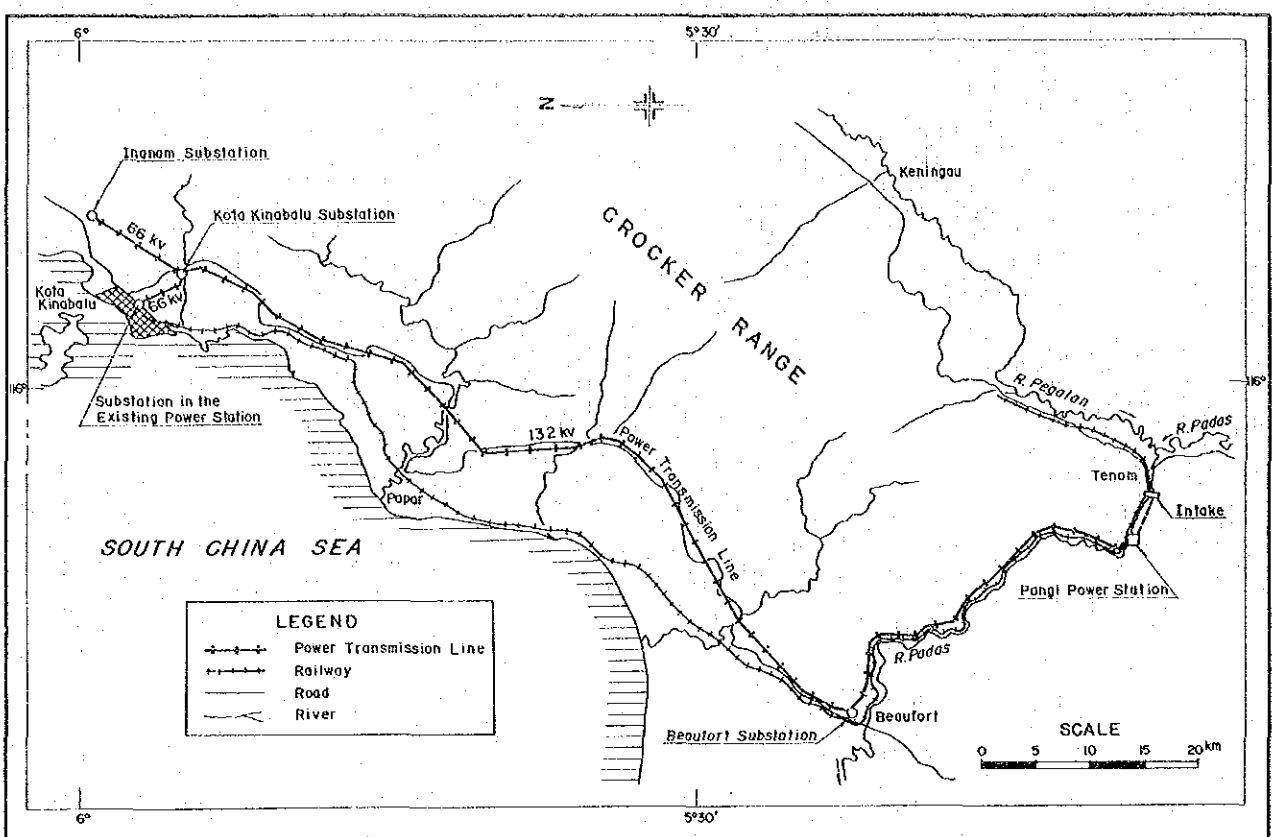

Fig. 2 General Map of Tenom Pangi Hydro Power Project

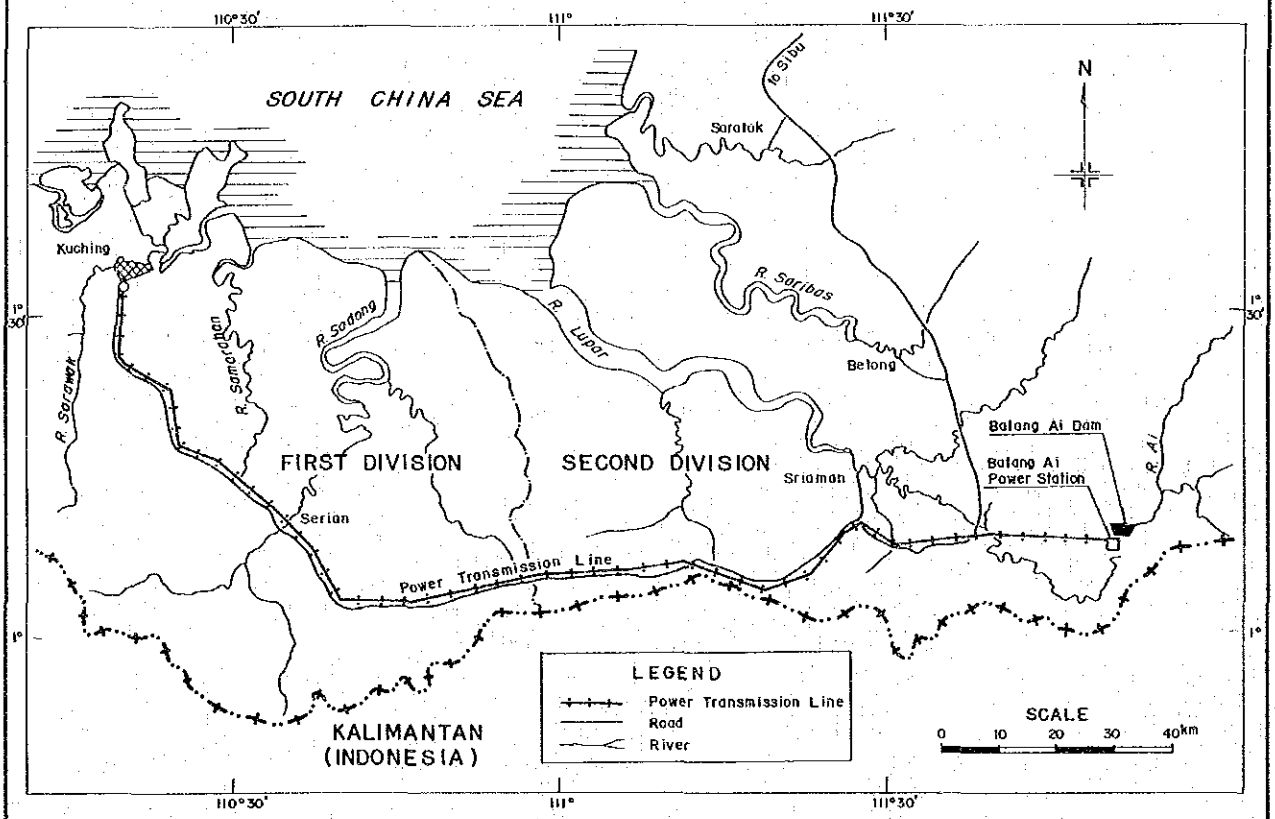

Fig. 3 General Map of Batang Ai Hydro Power Project

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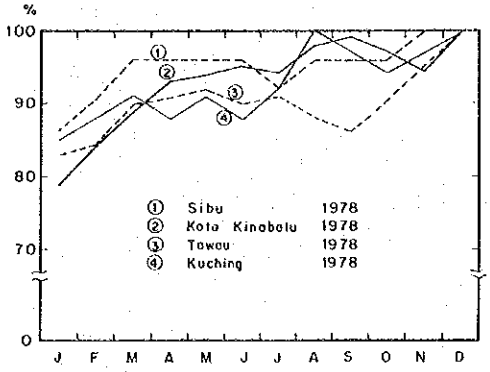

Fig.4 Monthly Maximum Power Demand in % of the Annual Maximum Demand

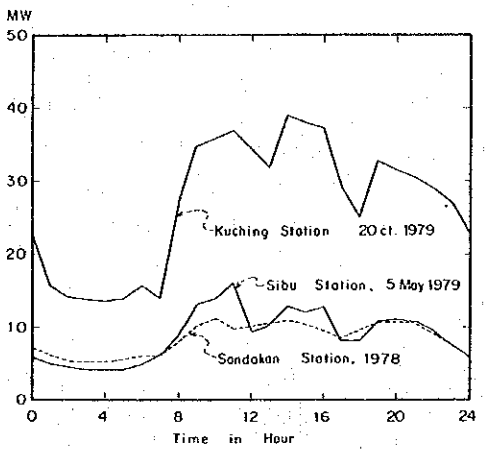

Fig. 5 Typical Daily Load Curves of Major Stations

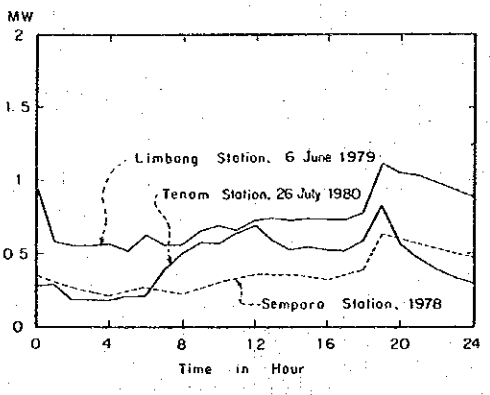

Fig.6 Typical Daily Load Curves of Minor Stations

Source : Refs. 1 and 2

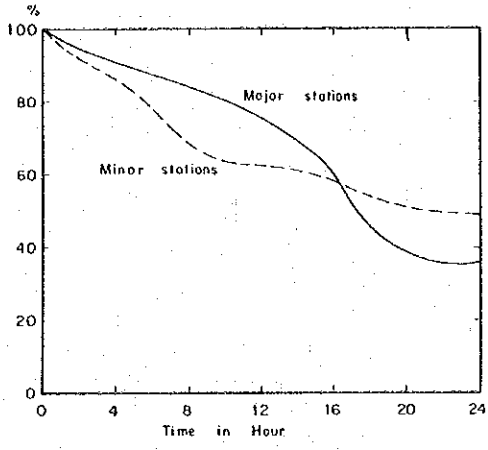

Fig.7 Typical Load Duration Curves

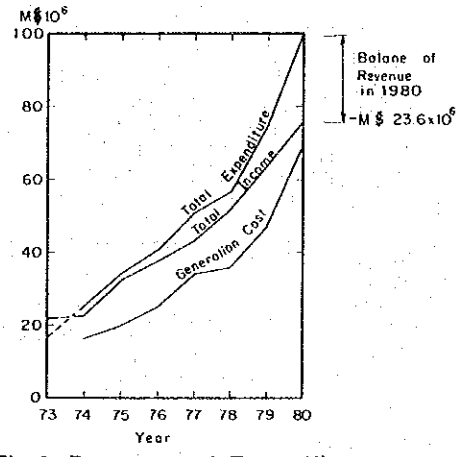

Fig.8 Revenue and Expenditure of SEB

Source : Refs. 2 and 4

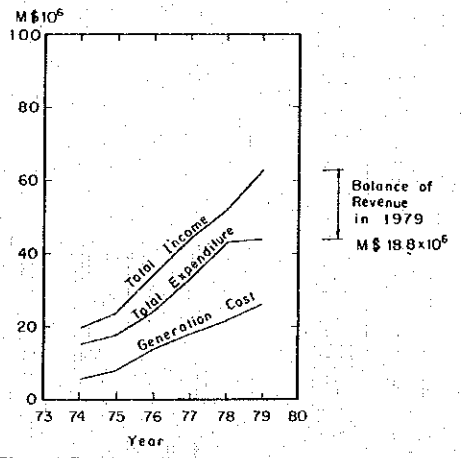

Fig.9 Revenue and Expenditure of SESCO

Source : Refs. 1 and 3

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Fig. 10 Organization of SEB

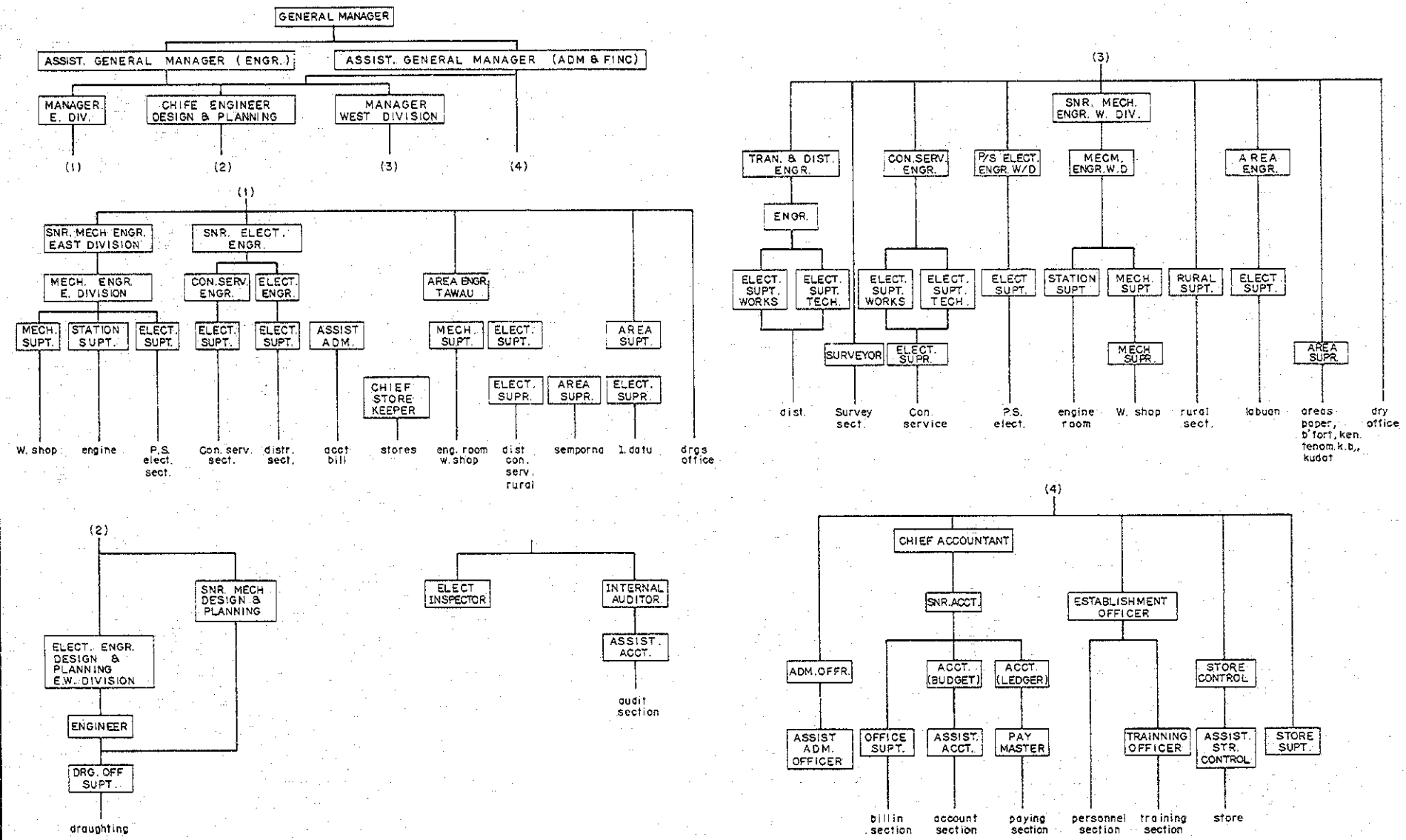

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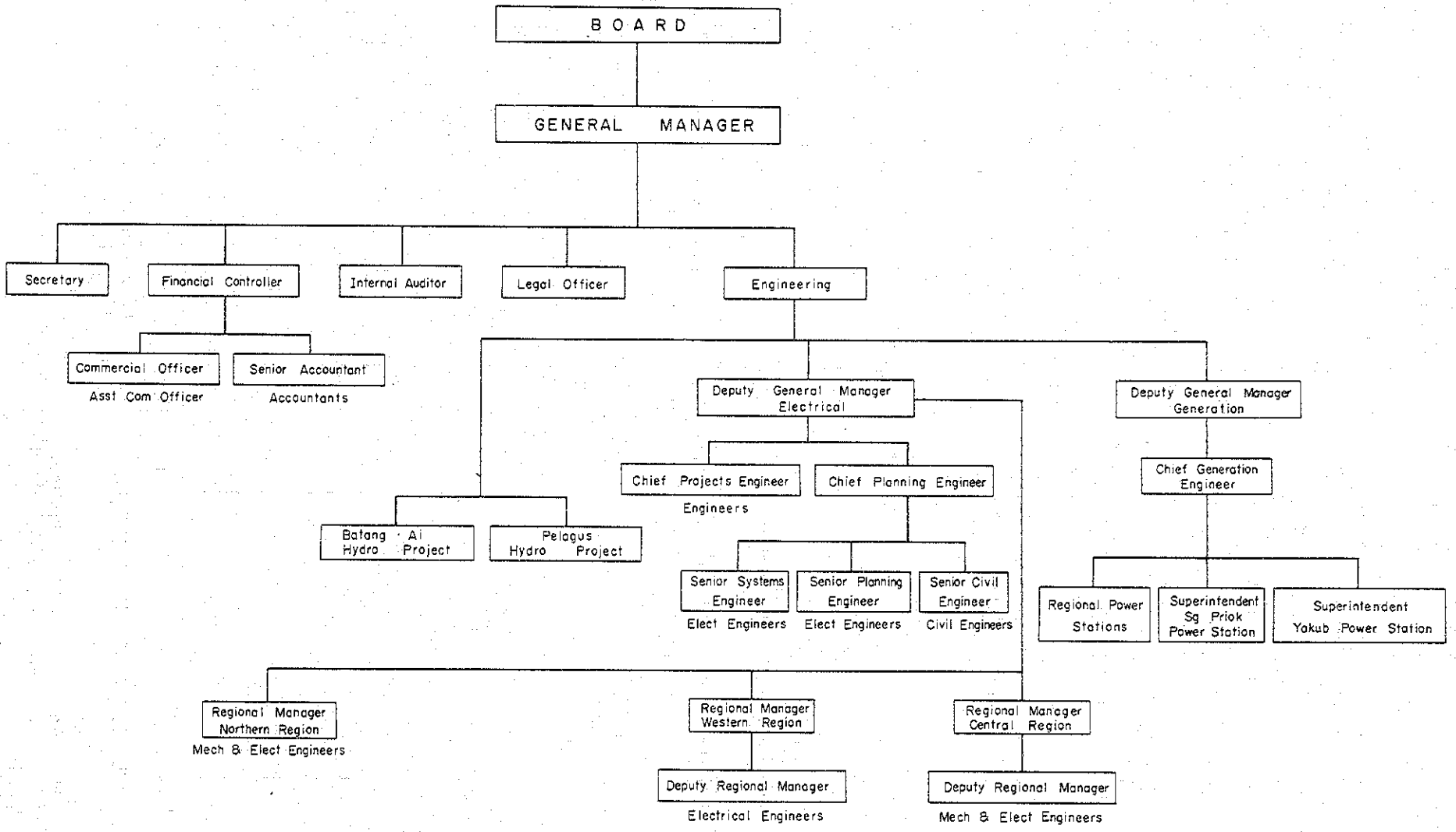
Fig. II Organization of SESCO



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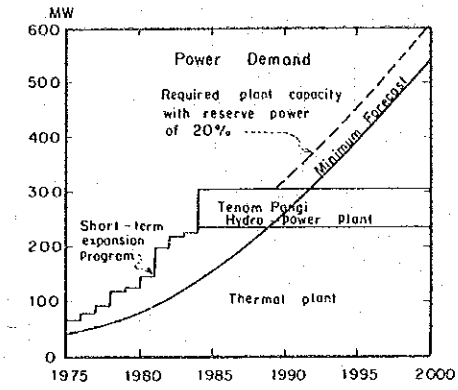


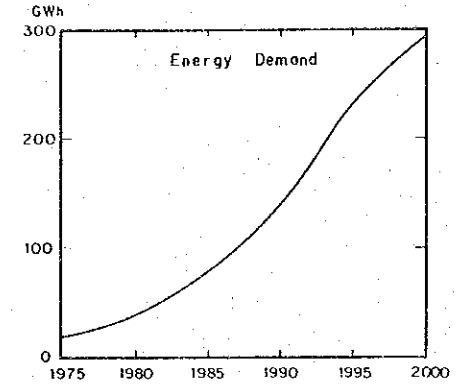
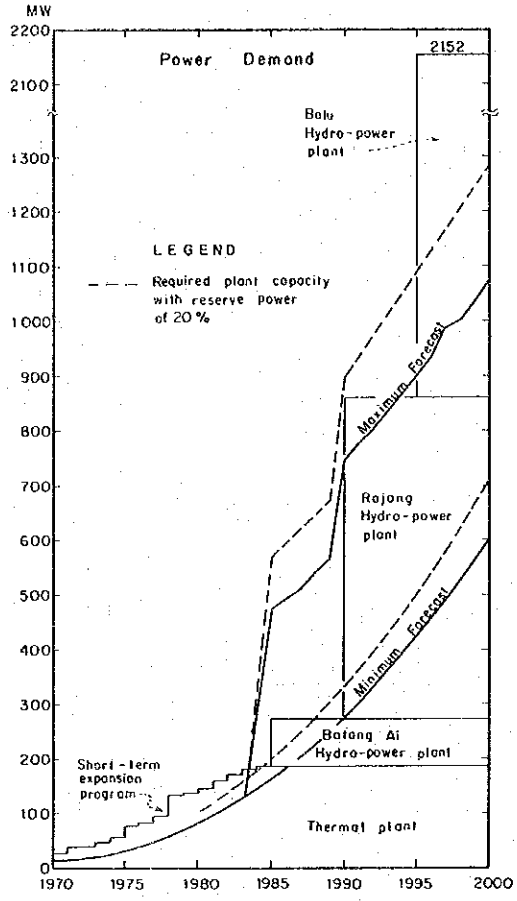


Fig.12 Power Demand Projected by SEB

Source: Refs 4 and 20



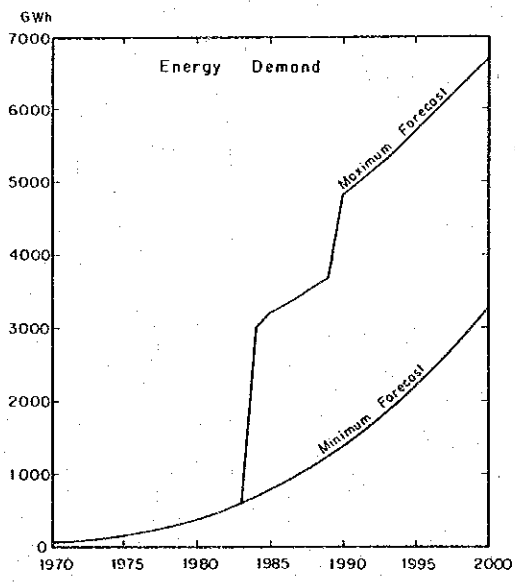


Fig.13 Power Demand Projected by SESCO

Source ; 11-13

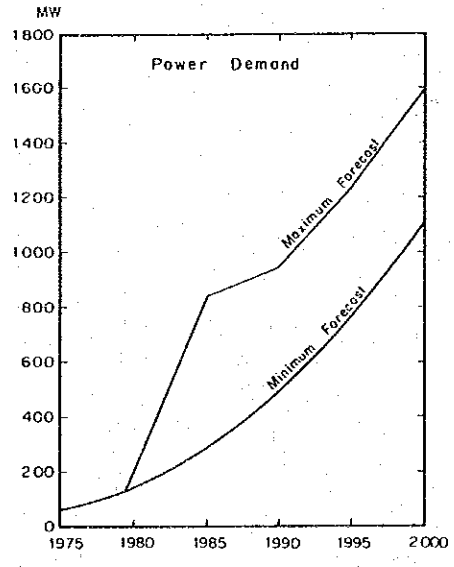


Fig. 14 Total Power Demand Projected For SEB and SESCO

Source ; Compiled by the JICA study

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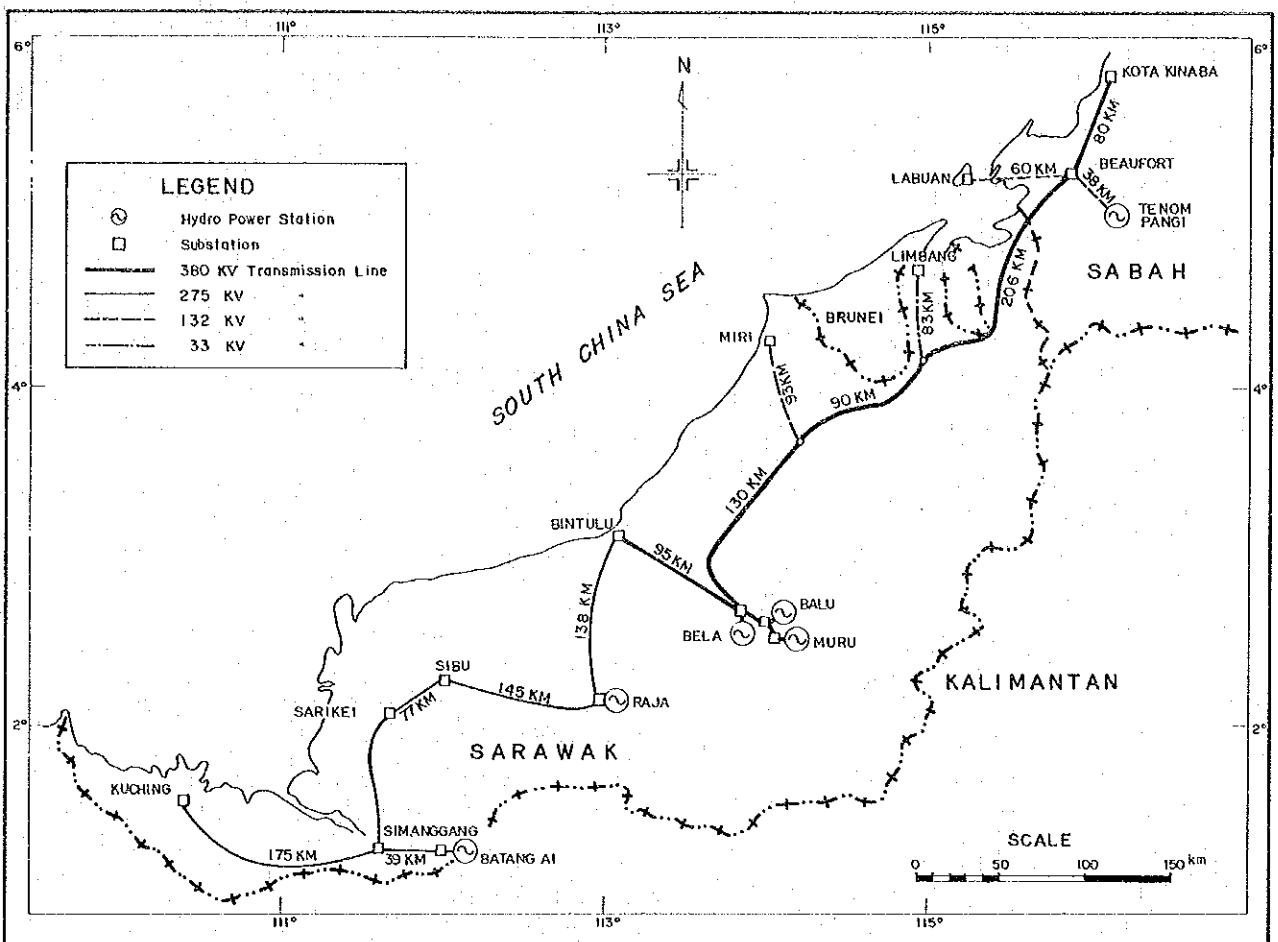

Fig.15 Interconnection Transmission Line System of SEB and SESCO Power System

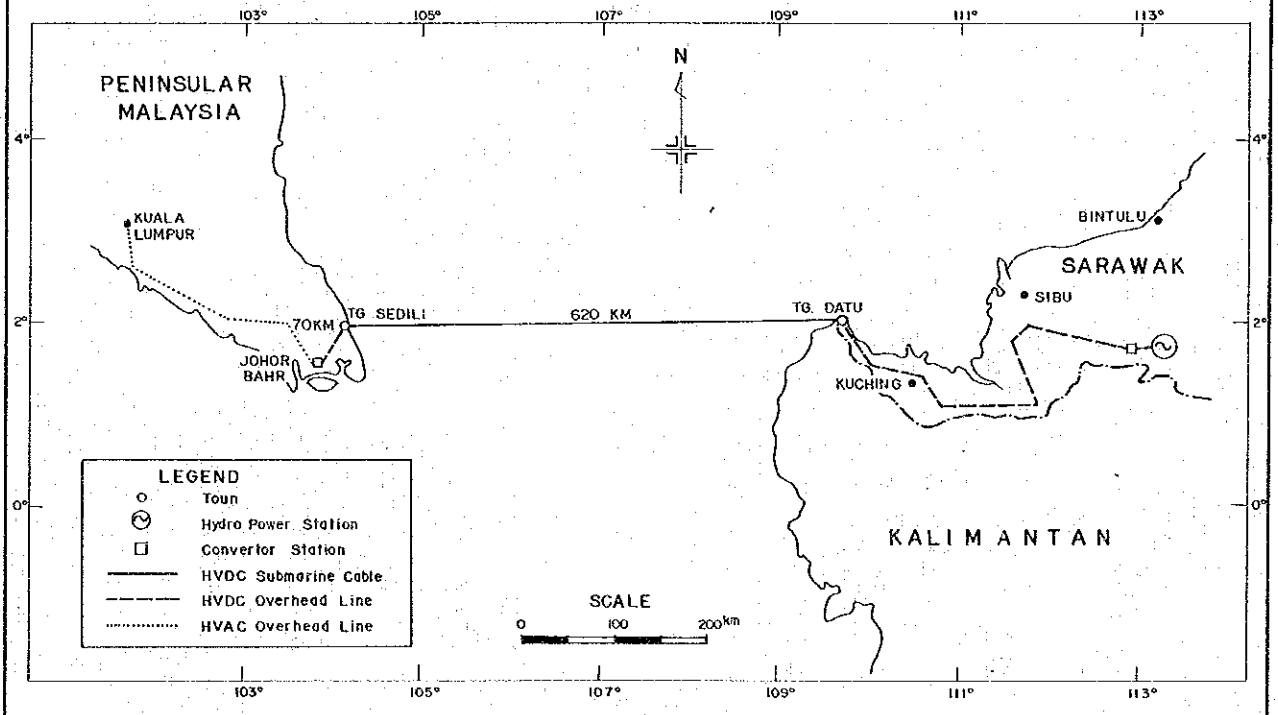

Fig.16 HVDC Submarine Cables Transmission System

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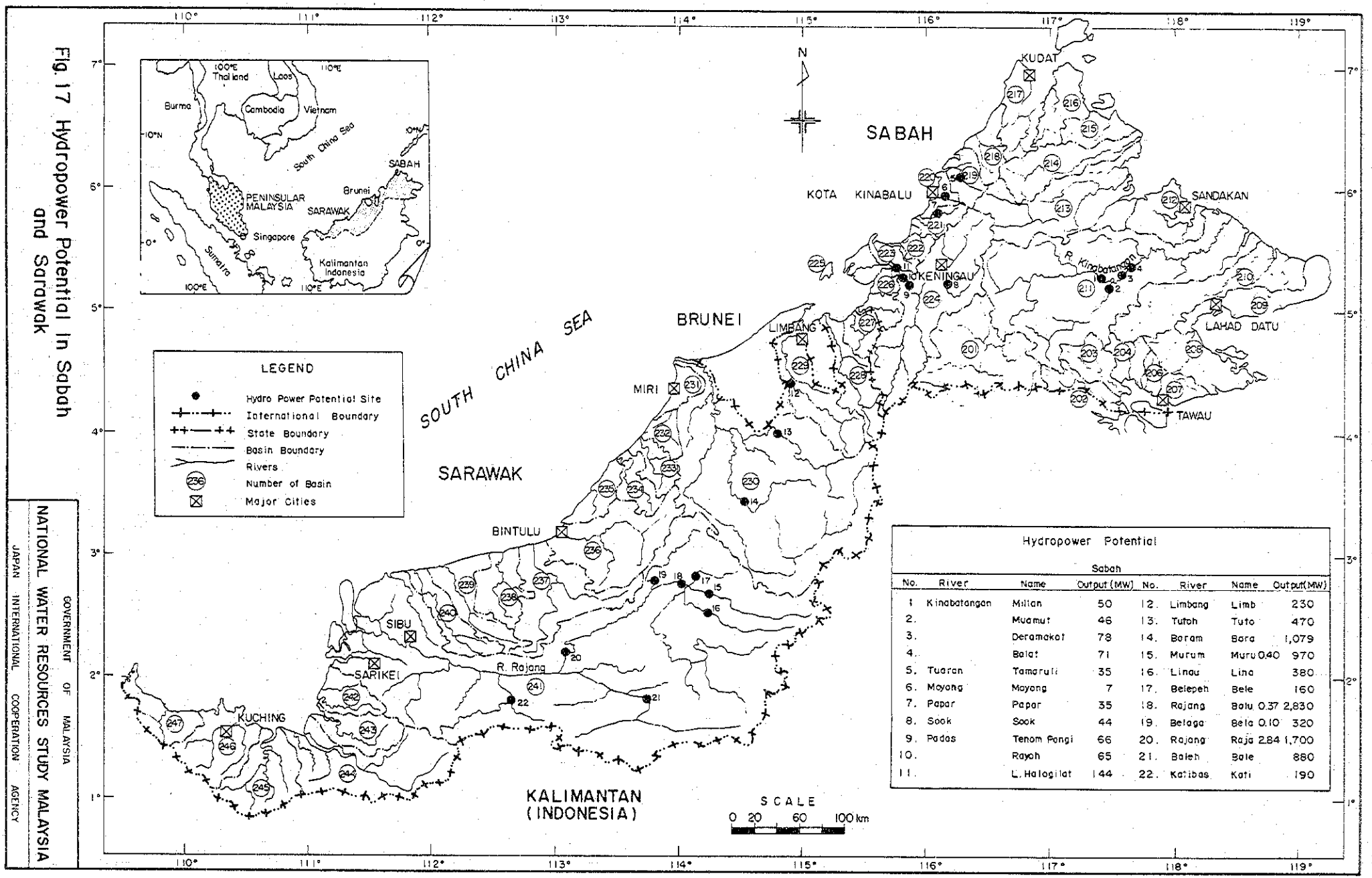
Fig. 17 Hydropower Potential in Sabah and Sarawak



Hydropower Potential

Sabah

No.	River	Name	Output (MW)	No.	River	Name	Output (MW)
1	Kinabatangan	Milian	50	12.	Limbang	Limb	230
2.		Muamut	46	13.	Tutoh	Tuto	470
3.		Deramakot	78	14.	Baram	Bara	1,079
4.		Balat	71	15.	Murum	Muru 0.40	970
5.	Tuaran	Tamaruli	35	16.	Linau	Lina	380
6.	Moyang	Moyang	7	17.	Belepeh	Bele	160
7.	Papar	Papar	35	18.	Rajang	Balu 0.37	2,830
8.	Sook	Sook	44	19.	Belaga	Bela 0.10	320
9.	Padas	Tenom Pangi	66	20.	Rajang	Raja 2.84	1,700
10.		Rayoh	65	21.	Baleh	Bale	880
11.		L. Halogilat	144	22.	Katibas	Kati	190

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