THE REPUBLIC OF INDONESIA

STUDY ON LONG-RANGE ELECTRIC POWER DEVELOPMENT PROGRAM IN EAST JAVA

MARCH 1972

PREPARED FOR

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

BY

ELECTRIC POWER DEVELOPMENT CO., LTD.

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PREFACE

The Government of Japan, in response to the request of the Government of Indonesia, undertook to conduct a survey on the long-range power program in the East Java, Indonesia and entrusted the execution of the survey to the Overseas Technical Cooperation Agency.

Being cognizant of the importance of the East Java, from the stand point of its location in the whole Indonesia, and of the economic and social importance of the power enterprise, the Agency organized a survey team comprising five members, headed by Mr. Hamaaki Aoki and sent it to Indonesia for a period of 75 days from August 28 to November 10, 1971.

Thanks to the kind cooperation of the Government of Indonesia, the survey could have been carried out satisfactorily and the team could collect the necessary data and materials for projecting the long-range power program. Through analysis and modification of the above data and materials, the Report, the outline of which are under-mentioned, has been prepared and now is ready for presentation.

(1) The demand for power is forecasted to increase at the rate of 15% till 1980 and thereafter of 12% till 1985, on the basis of the relation between per capita GDP and per capita electricity production of countries of the world.

(2) On the assumption of the above demand forecast, both hydro and thermal power supply are planned, paying the fullest attention to the economic analysis – cost-benefit analysis.

(3) On the other hand, the transmission and distribution lines are planned out in accordance with the above. The financial program are also considered to facilitate the implementation of program.

It is my sincere hope that the Report which covers various cases in detail be conducive to working out the long-range power program in Indonesia and to the economic growth of the country. I shall be very happy if the friendship and economic relationship between Indonesia and Japan is promoted on this occasion.

Finally, I wish to take this opportunity to express my heartfelt gratitude to the officials of the Government of Indonesia for their whole hearted support extended to the team in the execution of the survey.

March 1972,

Keiichi Tatsuke,
Director General,
Overseas Technical Cooperation
Agency

Letter of Transmittal

Mr. Keiichi Tatsuke, Director General
Overseas Technical Cooperation Agency

Dėar Sir:

Submitted herewith is the report on the Long-Range Electric Power Development Program in East Java, the Republic of Indonesia.

The Overseas Technical Cooperation Agency (hereinafter called OTCA), for the purpose of formulating a long-range electric power development program for the province of East Java, the Republic of Indonesia, organized and sent an engineering team consisting of five experts of Electric Power Development Co., Ltd. (hereinafter called EPDC) to the Republic of Indonesia from August to November 1971.

Before return to Japan from the Republic, the team submitted to the Government of the Republic, an interim report which was prepared based on the investigations conducted at the site, and data and information made available by the Government of Indonesia, as well as, international organizations, such as, International Bank for Reconstruction and Development, Asian Development Bank, and Economic Commission for Asia and the Far-East.

Upon return to Japan, the studies that had been made during the team's stay in the Republic, were amplified and refined by employing digital computors, as well as, by mobilizing experts from the engineering staff of EPDC.

Economy of the Republic, once stagnant till near the end of the 1960's, has become stable and began steady growth in the last few years. Therefore, in East Java too, expansion and reinforcement of electric utility industry is a requisite to support the economic growth of the region. The capital investment requirement estimated by the team for the electric power development of the region is US$ 180 million for the period of 1973 to 1984, which, as stated in the Report is deemed proper in view of the total capital investment projected by the Government of Indonesia in the power sector of the entire Republic.

In closing, it is wished to express the heartfelt gratitude to the officials concerned of Perusahaan Listrik Negara, Departemen Pekerdjaan Umum dan Tenaga Listrik, Badan Perantjang Pembangunan Nasional, the Embassy of Japan to Indonesia, the Government of Japan, and the OTCA, as well as, ECAFE, IBRD and ADB for their generous assistance and cooperation in performing the studies.

Yours respectfully,

H. Aoki

Hamaaki Aoki, Chief
Japanese Survey Team
for Long-Range Power
Development Program in
East Java

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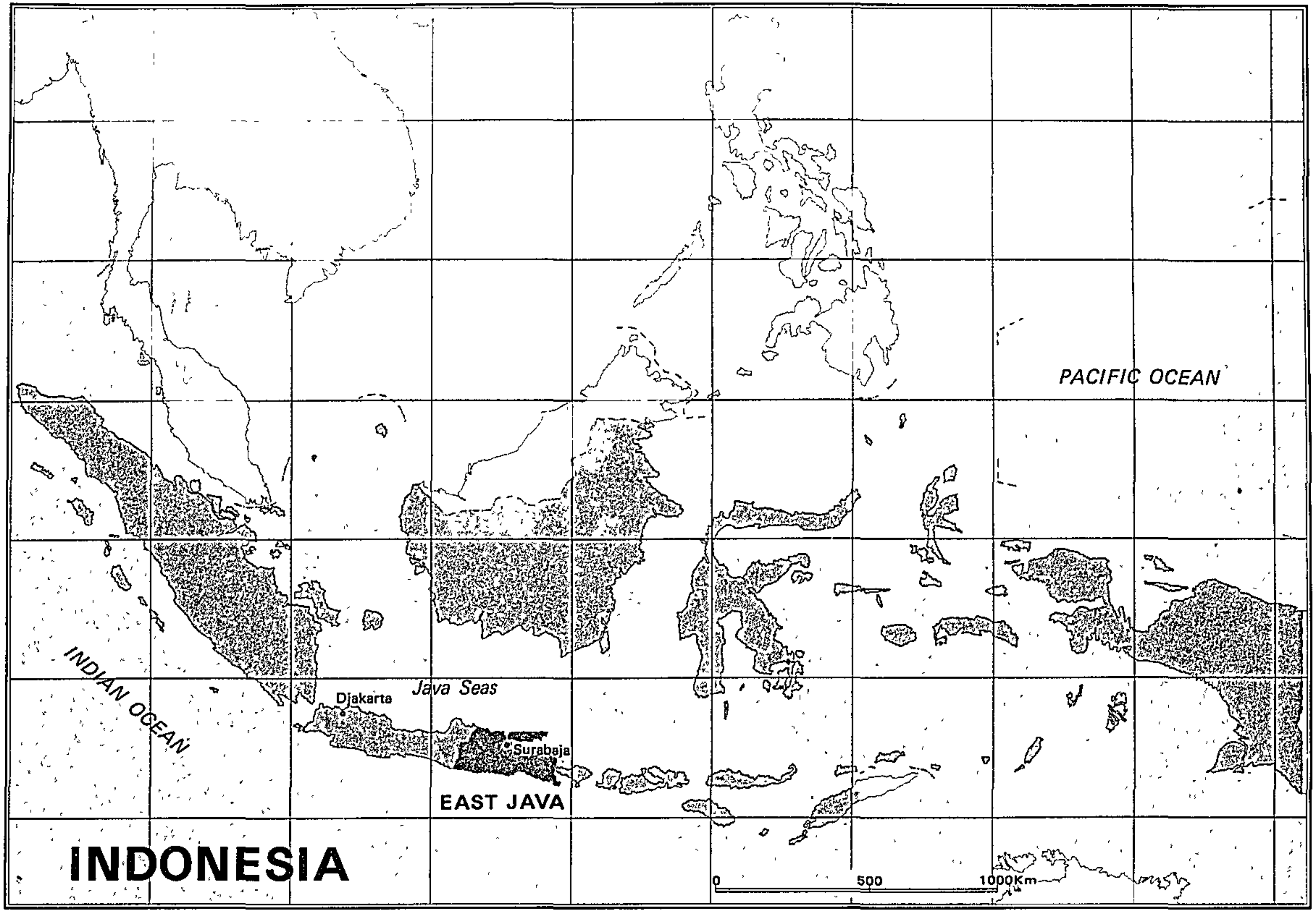
survey team

hamaakı aoki
tsutomu kidahashı
shoetsu hayashı
masahıko ikeda
takuya takaoka

photograph=yasushı nagao; printıng=nanaei kogyo co ltd.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INDIAN OCEAN
Djakarta
Java Seas
Surabaja
EAST JAVA
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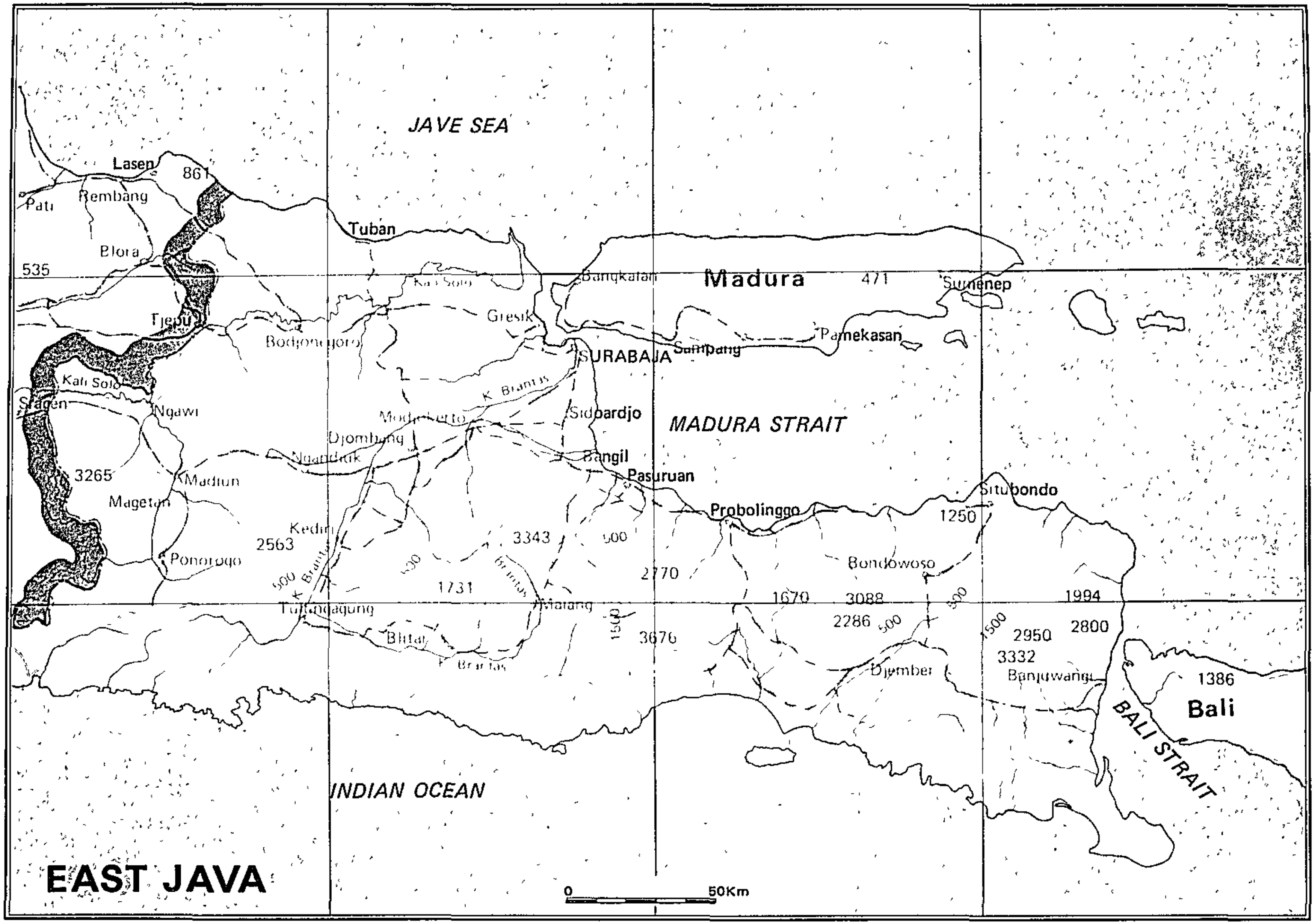
INDONESIA


EAST JAVA
JAVE SEA
Madura
MADURA STRAIT
INDIAN OCEAN
BALI STRAIT
Bali
1386
Lasen
861
Pati
Rembang
Blora
535
Tuban
Tjepu
Bodjonegoro
Kali Solo
Sragen
Ngawi
Gresik
SURABAJA
Bangkalan
Sampang
Pamekasan
Sumenep
471
K. Brantas
Modjokerto
Djombang
Nganduk
Sidoardjo
Bangil
Pasuruan
Probolinggo
Situbondo
1250
3265
Madiun
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2563
Kediri
500
Tulungagung
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3343
Malang
Blitar
Brantas
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2286
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Banjuwangi
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I

PRINCIPLES OF STUDY

Relation to Economy
The long-range electric power demand forecast was computed statistically and solely based upon the prospected future economic situation of the Republic. Therefore, it is a requisite that the power industry in East Java be developed in compliance with the implementation program established in the Report in order to keep abreast of the economic development in the region; the economy of East Java being completely integrated in the economy of whole Java, the most important island of the Republic.

It should be recognized that the *Demand* is different from the so-called *Load* in nature. If the power industry is not developed keeping pace with growth in demand, the *Load*, or the number of customers, will not increase corresponding to the increase in the *Demand*, with the result that a great number of people will remain to suffer from the shortage of power supply.

Method of Program Formulation
The analytical method was used to formulate the implementation program of power facilities classifying the demands according to the sectors and locations based on the macro demand forecast, with which the result of the analytical method is consistent and highly correlated. Especially the analytical method gives a basis to formulate the development program of transmission and distribution facilities.

Investment
The implementation program was also formulated as much from the economical point of view as possible. Construction cost, or initial investment, is one of the most important factors in formulating the program. The record of the past construction cost in the Republic is very high. Therefore, the construction cost, that of the thermal power plants for instance, obtained in the Republic were modified to come into a reasonable range. The investment prepared in the Report was checked with the total investment plan of the Government.

II

CONCLUSION AND RECOMMENDATION

1. Electricity Demand

(1) The power demand in East Java has been suppressed by the shortage of power supply capability of PLN. The per capita energy production was 16 kWh in 1970, and the electrification ratio in terms of the number of electrified households as against the total in East Java was somewhere between 4 and 5 percent. The potential demand unserved by the PLN power supply network is very large.

(2) Two approaches were employed in estimating the future demand in East Java in the years of 1970 to 1985. One was a macroscopic approach projecting the growth of energy consumption in relation to the development of national economy which was forecasted by the Government of Indonesia; and the other was an analytical method which was based on detailed examination of the present situation of sectorial as well as regional electricity demand.

(3) In both approaches, the demand estimate was based on the following presuppositions:

i. The political situation of the Republic will be stable, and the national economy will develop steadily.
ii. The present power rate schedule of demand suppressing nature will be revised based on cost method to a schedule which will create new demands.

(4) The macro forecast was established based on the relation between per capita GDP and per capita electricity production of countries of the world. It forecasts the annual average growth rate of demand in East Java to be 19 percent at the maximum and 14 percent as the most probable till 1980, and thereafter, to be 13 percent at the maximum and 11 percent as the most probable.

(5) In the analytical method, East Java was divided into five areas. The sectorial demands of residential, commercial and industrial were estimated for the five areas. The demands in residential and commercial sectors were obtained from the scheduled electrification ratio, as well as, the growth of population in the areas. The demand of industrial sector in the future was considered as a sum of increase of demand of the present customers and estimated demand of big waiting customers. Two separate estimates, high and low, were prepared for the demands of three sectors. The total estimate of the three sectors of the five regions give the annual average growth rate to be 17 percent for the high and 12 percent for the low, giving an average of 15 percent.

(6) Studies by analytical method on the residential sector were performed on the assumption that the present electrification ratio of 4 to 5 percent in all East Java would be raised to the current electrification ratio of about 20 percent in Surabaja and its vicinity in 1990.

(7) The forecast established in the Report predicts that the electricity demand will grow at an annual rate of 15 percent till 1980, and thereafter at 12 percent. The peak demand and energy requirement in 1980 will be approximately 280 MW and 1,700 million kWh respectively, which are 4 times greater than the present figures. Per capita energy production will be 50 kWh. In 1985, 500 MW and 3,000 million kWh are projected respectively

in peak demand and energy requirement.

(8) A power demand forecast is based on various assumptions, therefore, should be reviewed periodically. This Report describes, in addition to the results, the method and steps of estimation, as well as, development planning into such detail that the Republic's engineers or PLN staff could review the forecast and development program during the course of implementation.

2. **Power Development Program**

(1) The power supply requirements obtained from the forecasted demand will increase by 230 MW by 1980 and 470 MW by 1985, both including a 10 percent reserve. It will be in 1976 that an additional power source will become necessary after Karangkates 1st stage begins operation in 1974.

To cope with the projected shortage in power supply capability in 1972 and 1973, gas-turbine unit should be installed, if such is available within the country without purchasing a new unit.

(2) In formulating the power development program, economy was primarily considered among other factors. It was attempted to introduce as large unit capacity as permissible having regard to system reliability in order to reduce the energy cost. Tentative calculation ; revealed that the energy produced by a 75 MW capacity unit was 5 percent less in cost than that of a 50 MW unit, and if a 125 MW unit was used the energy cost would be reduced by 10 percent.

(3) Evaluation of proposed hydro power projects was performed in the light of the following three criteria:

i. benefit cost ratio of the project,
ii. characteristic of electricity to be produced by the project as against system requirement, and
iii. energy cost of the system as a whole including the project.

(4) Since the hydro power projects proposed have been evaluated with various criteria, it is advisable that the Government establish a standard evaluation method as soon as possible. The Report adopted the benefit-cost ratio method and describes its details.

(5) The system load factor of East Java as a whole today is as high as 70 percent annually, and is expected to continue to be the same until about 1980. Aside from Karangkates 1st stage, no peaking capacity will be required in the 1970's.

(6) In view of the system requirement, the alternative plans proposed for the 2nd stage program of Karangkates project including the construction of Lahor dam and installation of the third unit were not considered except for one that would contribute to the augmentations of both kW and kWh. Karangkates 2nd stage, when evaluated by the method stated in (4) above, is eligible because it gives a B/C value of over 1.0, provided that funds are to be raised at an annual interest rate of less than 4 percent. Therefore, it is considered as one of the power sources for alternative development plans.

(7) Wlingi project, low in benefit-cost value, is not justifiable from the

economic point of view at the present stage of the studies. This is attributable to the reason that the project was evaluated for power only despite the fact that it is multipurpose including sediment control and irrigation. Although an eligibility is not given in the Report, the project is thought to deserve reconsideration by allocating the cost to its respective purposes when the master plan of the Brantas river basin development is established.

(8) Six alternative plans were prepared by arranging thermal units of 50 MW, 75 MW and 125 MW and Karangkates 2nd stage of 35 MW that were judged to be eligible in the evaluation. Of the six, four plans are composed of thermal power plants only and the remaining two include Karangkates 2nd stage project. As a result of comparative studies between the six plans, a combination of four 50 MW units, two 75 MW units and one 125 MW unit, in the order of implementation, (designated as Plan T-C) was judged to be the most proper from the economical as well as technical point of view, and therefore, selected as the implementation program. With the program implemented, the energy production cost will be reduced to 8.1 mills. (Rp 3.4) per kWh in 1980, and to 7.9 mills. (Rp 3.3) per kWh in 1985. It is expected to further decrease to 7.4 mills. (Rp 3.1) per kWh ultimately after 1985.

(9) The alternative plans that include Karangkates 2nd stage proved to be not economical, compared with the other plans, during the period which the present study covers.

(10) The first 50 MW unit should be in operation by 1976, and the second 50 MW unit by 1978. In consideration of the time limitation, it is considered most appropriate to install these two units in the premises of Tandjung Perak thermal power plant. Arrangement of financing, as well as, detailed investigations and designs for the construction of these two units are urgent requirements.

3. Transmission and Distribution Systems Development Program

(1) In line with the power development program described previously, 150 kV transmission lines, 650 kilometers-circuit in total, and 70 kV transmission lines, 940 kilometers-circuit in total, are scheduled in the Report to be constructed by 1985.

(2) Transformers scheduled to be installed by 1985 are 150 kV transformers, 70 kV transformers, and distribution transformers, respectively 490 MVA, 450 MVA and 340 MVA in total capacity. At present, most of the industrial customers receiving electricity at low voltages are using distribution transformers exclusively for their own use. According to the schedule, the number of distribution transformers will be saved by utilizing these transformers in common among low voltage customers taking advantage of diversified loads.

(3) Transmission lines to connect the proposed thermal power plants will be 150 kV double-circuit in order to maintain high reliability. A 150 kV grid system will be created covering the major load centers of Gresik, Surabaja and Pasuruan. The transmission line to be completed in 1973 between Karangkates power plant and Waru II substation will be effectively utilized to supply power to Pasuruan and Malang. 150 kV transmission lines will be expanded from the grid system to the regions where 70 kV lines will have become short in capacity in around 1980.

(4) The East Java system to be established by interconnecting the currently independent systems in East Java will be interconnected to the prospected Central Java system in 1985 in order to have the reserve capacity in common between the two systems and to improve the system's reliability taking advantage of the unit capacity merit expected from the operation of a 125 MW thermal unit to be constructed in the same year.

(5) 70 kV transmission lines will serve as sub-transmission lines to electrify rural areas at a quick tempo with less expensive single-circuit structures. The 70 kV lines will comprise local loop systems by about 1980 for the higher reliability.

(6) Except the systems now under construction, no 30 kV and 25 kV systems will be constructed.

(7) The proposed distribution systems are all 20 kV - 220/380 V. Even when the 20 kV voltage can not be used due to connections with the existing low voltage systems, the equipment and structures will be designed at 20 kV for future expansion.

(8) A trans-island system interconnection is expected to bring about great economical effect in consideration of the merit of large unit capacities in the future and the saving of reserve capacity as a whole, as well as, the high reliability to be attained by the interconnection. The implementation of the trans-island interconnection may be projected at the time when the power demand in Java reaches a level of 3,000 MW probably in the 1990's. The voltage of the interconnection line should be 330 kV or 380 kV instead of 220 kV and 150 kV.

(9) A voltage immediately higher than 70 kV is 150 kV. A 150 kV system is in operation in West Java, and another 150 kV system is under construction in East Java. The voltage of 150 kV will be sufficiently high in the East Java system even when the system is interconnected with Central Java system. The 150 kV voltage is high enough to deny the adoption of a higher voltage in the foreseeable future in East Java.

4. Financing Program

(1) The total capital investment requirement for the implementation of the proposed power development program and associated development of transmission and distribution systems (excepting the rehabilitation and expansion program of distribution facilities currently undertaken by PLN) is US$ 180 million over the period of twelve years from 1973 to 1984. The facilities to be constructed under the development program will come into operation during the period of 1975 to 1985. Of the total, 82 percent is foreign currency requirement.

(2) The sectorial distribution of the capital investment will be US$ 80 million, 23 million, 10 million and 67 million respectively for generation, transmission, transformation and distribution. In the first six years until 1978, 36 percent of the total, or US$ 11 million annually on the average, will be required. In the last six years, the annual capital investment requirement will be US$ 19 million.

(3) According to the projection made by the Government, US$ 430 million is expected to be invested in the electric power sector during the

period of 1974 to 1978, averaging US$ 80 million annually. The capital investment requirement of the Report corresponds to about one eighth of the projected investment of the Republic. In the following five years of 1979 to 1985, it is prospected that one fifth to one sixth of the Republic's investment in the electric power sector will be directed to East Java. This prospect is believed to be reasonable and justifiable in view of the economic position of East Java.

5. Formulation of Long-Range Development Program

The Government of the Republic has undergone in preparing the long-range power development program, an improper procedure dismembering the island of Java into three districts, West, Central and East. Separation of studies by the dismemberment causes to generate the following defects.

i. The growth of economy and power demand of the island as a whole is projected in a localized manner without consensus in principle and cognition of planning which are the bases to forecast the future economy and power demand and to formulate a program.
ii. Dismemberment of long-range program is against the principle of economy. Elementary knowledge of economy would have predicted that the maximum benefit of a total would not always equal to a sum of maximum benefits of parts. The most economical investment conceivable within a district is not economical when viewed from the stand point of entire Java.

Therefore, it is advisable to establish a long-range power development program of Java as a whole based on thorough cognition and understanding of the power industry of the island. Investigations of individual projects may be conducted separately in the respective districts.

II

NATURAL ENVIRONMENT

1. Indonesia

The Republic of Indonesia extends for more than 1,700 kilometers across the equater between Asia and Australia, comprising islands of various sizes. They are Sumatra, Java, Bali, Kalimantan (in part), Sulawesi, Halmahera, Lombok, Sumabawa, Flores, Timor (in part), the Moloccas, West Irian and hundreds of smaller islands of the Indonesian archipelago. The Indonesian islands constitute one of the most volcanic areas in the world. All the large islands are crossed by volcanic ranges. The highest peaks are Mount Kerintji in Sumatra (3,805 meters), Mount Semeru in Java (3,675 meters) and Mount Rantekombala in Sulawesi (3,455 meters). The total area of the Republic is 1,904,000 square kilometers, and the inhabitants are estimated at about 124,000,000.

2. Java

Fourth in area but the most important of the islands of the Republic, Java is separated from Sumatra on the west by the Sunda strait, 20 to 80 kilometers wide, and from Bali on the east, by the Bali strait, 2.5 kilometers wide. It is 970 kilometers long and 203 kilometers wide at greatest dimension and its area including the island of Madura is 132,174 square kilometers. Java lies between 5°52' and 8°47' south and 105°13' and 114°37' east.

Population

Population of Java is estimated to be 80,187,000 in 1971 which constitutes almost 65 percent of the Republic's population. In Java is the Republic's capital, Djakarta, as well as cities of Surabaja, Bandung, and Semarang. The population consists principally of three ethnic-linguistic groups. Approximately two-thirds of Java's population are the Javanese living in the central and eastern part of Java. The second largest group is Sundanese of the western third of the island. The Madurese live in the far eastern end of Java along the north coast and on the island of Madura. In addition to the above three, there are some 1,000,000 persons of Chinese origin, mostly in urban commercial occupations, and about 50,000 persons of Arab extraction. The population is found dense in the intra-volcanic basins and relatively scarce in the flat plain.

Topography

The volcanic range running from west to east forms the axis of the island, and is flanked in the north by lowlands and in the south by limestone ridges. There are over 100 volcanoes in the island, and 13 are thought active, yet serious eruptions are few. The big rivers are seen in the north flowing on a gentle slope, and the southern streams are rapid and short in length. In the wet season most of the rivers are navigable by small boats. However, they are mainly used to supply water for irrigation.

Geology

The plains in the north are formed of alluvial deposits and volcanic deposits, and in some part they are marine sand and clay. The plains are separated from the central volcanic high lands by faults. The central volcanic mountains rest on highly folded Tertiary rocks underlain by Cretaceous sandstones. The later Tertiary strata yields marls, breccias and limestones and cover 38 percent of the islands. The famous ape-man fossil named Pithecanthropus was found in the Pleistocene, which overlies fresh water Pliocene strata. Much marine pleistocene material can be found at an elevation about 100 meters above sea level. Volcanic rocks, such as andesites and basalts, cover 28 percent of the islands.

Climate

In spite of its subequatorial location, the temperature is not extremely high, averaging 25.5° to 26.5°C, since the mountains, sea breezes and thunder showers in the wet monsoons relieve the heat. The relative humidity is high through the island ranging from 65 percent to 90 percent. Notably high is the humidity in the transition period between dry and wet monsoon. Java has a northwest monsoon from December through March, bringing much rain and clouds especially in the north, while from April to October it has a southeast monsoon bringing some rain to the south coast of the island. Afternoon thunderstorms are frequent in the mountains and at night during the wet northwest monsoon. Annual precipitation is over 1,500 mm in the plains and more than 2,500 mm in the mountains. February is usually the most rainy month, and September the driest.

Vegitation Vegetation is diversified into more than 5,000 species of plants. Valuable in the hydrological function, dense rain forest abounds on the damp slopes of the mountains. The lowlands are entirely cultivated. However, soil composition and degree of fertility vary considerably, depending on whether the sediments are of recent volcanic origin or limestone.

3. East Java

In East Java, which is the target area of the Report, low lands extend to the north in the portion west of Pasuruan, while a peninsula with Tengger and Idjen volcanic mountains tapers eastward. The two biggest rivers in Java, the Bengawan Solo and the Brantas, are in East Java, providing irrigation water over a vast area and hydropower potentials along their courses. However, heavy rains in wet season cause occasional demages to agricultural fields, households and highways along the rivers.

Although located in central Java, Tjepu near to the border of east Java is the most important center of oil wells in Java. Oil is also drilled near Surabaja at Wonokromo. Sulphur is obtained from Mount Welirang near Tretes. Iodine springs occur in Modjokerto. Salt is produced, as a government monopoly, on the island of Madura, as well as on the north coast of Java near Surabaja.

Surabaja, capital of East Java with a population of over 2,100,000 is on the north coast opposite Madura on the Kali Mas river, a branch of the Brantas. It is an important naval base, trade and industrial center with a modern harbor at Tandjung Perak where there are drydocks for ships up to 15,500 tons. Ports at Probolinggo and Panarukan are also important to export sugar and tobacco produced around Djember.

Surabaja

IV

NATIONAL ECONOMY

1. Population

Distribution

East Java was populated by approximately 21,823 thousand in 1961. High concentration can be seen in large cities as well as on stretched slopes of volcanoes where high fertility soil of recent volcanic origin and natural irrigation with heavy rainfalls in mountains enable farming of relatively high productivity with primitive farming technic. The population density was 477 per square kilometer in Java and 455 in East Java.

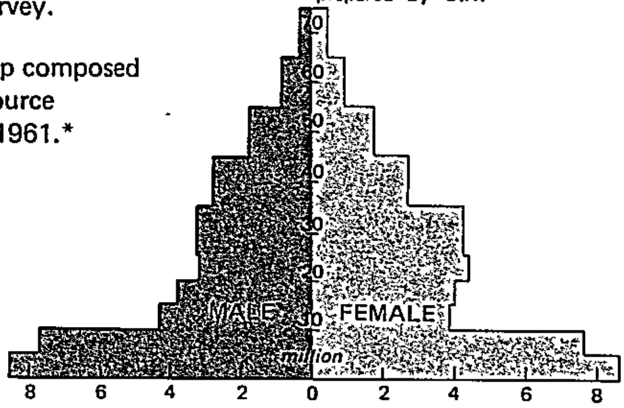
Past Growth

The population in Java was 9.6 million in 1850, 28.4 million in 1900 and 41.7 million in 1930, with an average annual growth rate of 1.85 percent. The census in 1961* reported the population in Java to be 63.06 million. The present population in Java is estimated to be 80,187,000 based on the 1961 census and from the annual growth rate of approximately 2.5 percent per annum which has been obtained from sampling survey.

* In 1961, population was estimated by revising the 1930 census based on sampling survey of births, deaths and migration and taking into account the Asia statistics prepared by U.N.

The census also showed that the 0 to 9 years age group composed 34 percent of the total in the Republic. Another source gives the annual infant death rate of 81.7 in Java in 1961.*

* The annual infant death rate is the number of deaths under 1 year of age, excluding foetal deaths, per 1000 live births which occurred during the same time period. Computed in Statistical Office of the U.N.



POPULATION BY AGE GROUP AND SEX

Over Population

The population in Java was tripled during the latter half of the 19th century. In the same period, area of cultivated land was expanded near to the fullest keeping pace with the increase in population. In 1920's, the expansion of cultivated land reached its limit in area. Thence, the population growth surpassed the increase in cultivated area, even though efforts were made by the Government to expand arable lands by introducing modern irrigation technic. Rice is grown in terrace fields, at some places to an elevation of 1,200 meters above sea level which is the circumscription in elevation for rice to grow.

Concentration into Cities

The agricultural sector yielded surplus population since 1930's. Such surplus population was estimated by a study group in the University of Indonesia in 1957 to be 37 percent based on the optimum population assumed in relation to the then arable area in Java. Migration from the rural area to urban area was the natural consequence. Yet, industries are not developed to a degree to absorb such migrated population. Chances are few for the immigrants to find jobs in cities. Disguised employment is common in large cities..

Table IV - 1 POPULATION INCREASE IN MAJOR CITIES

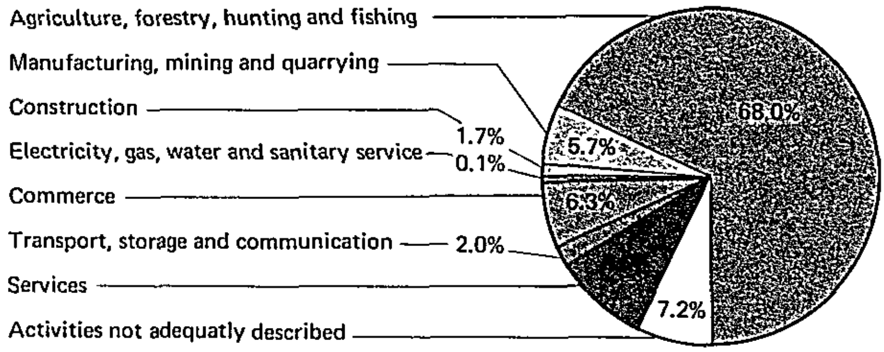
(thousands)

	1930	1955	1961
Djakarta	533	1,870	2,974
Bandung	167	588	681
Semarang	218	375	503
Jogjakarta	137	275	313
Surabaja	342	936	1,008

Source: Biro Statistik

Unemployment Although the Republic is an agricultural country, population engaged in the tertiary industry is large with the disguised employment classified in this category. Many of those flowing into cities from rural area will find their jobs as retailers, couriers, peddlers, betja drivers or home laborers. Revealed unemployment was 5.4 percent in 1961. In 1958, ILO estimated the hidden unemployment to be 33 percent based on the working hours and working days.

Countermeasure To cope with the over population in Java, forced transmigration to outer islands had long been a policy of the Government with little effects. At present, a different approach is being tried. The availability of employment activities and opportunities are expected to create incentives for transmigration movement. Dissemination of birth control has been pushed forward by the Government since 1969 as one of the programs of the Five Year Plan. Yet, no effects are seen at present.



Economically active-34,578 thousand

Population by Industry in 1961

Education Education remains still low. Two shift schooling in one school building is common due to shortage of buildings and teachers.

Table IV - 2 SCHOOLING BACKGROUND IN SURABAJA

Last schooling	Percentage
Kindergarten	7.45
Primary school (6 years)	73.43
Secondary school (3 years)	13.43
High school (3 years)	3.76
University (3 to 7 years)	0.54

Source: Report on Preliminary Survey of Development Potential of the City of Surabaja, by W.D. Scott and Co Pty. Ltd.

Surabaja is the center of secondary and high school levels of technical education in East Java.

2. Agriculture

Farming Pattern Of the total economically active population, approximately 70 percent is engaged in agriculture, including forestry, hunting and fishing, producing over 50 percent of G.D.P. However, more than 75 percent of the agricultural products are consumed without appearing in the market, and the self-supporting livelihood is general among more than a half of the total population keeping themselves away from the circulation of currency.* Nevertheless, rubber, palm oil, copra and tea, once estate products, are the major export items produced primarily by small farmers, composing about 60 percent of the total exports.

* Report of FAO Survey Team to Indonesia, February 1967.

Land Use

Until the 19th century, farming in Java was mainly on volcano slopes where fertile soil and natural irrigation prevail. The increase in population, which has become remarkable since the latter half of the 19th century, necessitated the expansion of agricultural field into the lowlands of the island. Today, despite the mountainous topography, the land brought under cultivation occupies two thirds of the island, which is 62 percent of the cultivated area in Indonesia as a whole. Moreover, variety of crops, shown in the table below, reveals effective utilization of rich soil.

Table IV - 3 AREA BY CROPS IN JAVA (1964)

Crops	Area in %
Food products	90.8
Rice	45.2
Maize	26.7
Cassava	12.1
Sweet potatoes and yams	4.0
Peanuts	2.9
Soybeans	4.6
Others †	5.3
Commercial products	9.2
Coconuts	4.8
Coffee	0.5
Tobacco	1.5
Kapok	1.2
Tea	0.6
Sugar cane	0.3
Others ††	0.2

† other potatoes and beans
†† pepper, glove, nutmeg, etc.

Utilization factor of cultivated land is 123 percent in Java and 137 percent in East Java.* Per capita area under cultivation is decreasing as is illustrated by *Sawah* (irrigated paddy field) shown below.

* Biro Pusat Statistik, 1963.

Table IV - 4 SAWAH AREA

	Sawah area † (hectares)		Sawah area per capita †† (hectares)	
	Java	Outer islands	Java	Outer islands
1954	3,897	1,572	0.071	0.054
1956	4,076	1,625	0.072	0.053
1958	4,124	1,790	0.069	0.056
1960	4,006	1,970	0.065	0.059
1962	3,703	2,333	0.057	0.061
1964	3,259	2,189	0.049	0.059

Source: Biro Pusat Statistik, 1963, 1964–1967
† Figures represent cropping area including second cropping.
†† Quotient of sawah area divided by the population.

Farming Unit According to the agricultural census in 1963, the cultivated area per farming household was 0.7 hectares in Java, almost one half of the area in 1922. This was due to the equal division of land inheritance and also to the basic shortage of land in the island.

Table IV - 5 FARMING HOUSEHOLD BY CULTIVATED AREA IN JAVA

Cultivated area (hectares)	Number of households	Percentage
0.10 – 0.49	4,152	52.2
0.50 – 0.99	2,148	27.1
1.00 – 1.49	858	10.8
1.50 – 1.99	351	4.4
2.00 – 2.99	274	3.4
3.00 – 3.99	89	1.2
4.00 – 4.99	36	0.5
5.00 and more	34	0.4

Source: Biro Pusat Statistik, Sensus Pertanian 1963

Estate Although the cultivated area per household has become small, more commercial products are produced by small farmers, while production of estate agriculture has remained almost the same due to changes in external conditions. They were the confrontation with Malaysia since 1963 and the fall in the world market prices of rubber and tea. Under such external condition, the estates had to reduce the cropping area when stock of products accumulated. In 1940, the estates produced 63 percent of the agricultural products exported, and in 1966 it was 44 percent.*

Biro Pusat Statistik, Statistic Pocketbook of Indonesia 1963, 1964 – 1967.

Table IV - 6 AGRICULTURE PRODUCTION (in 1960 price)

(Rp. 1,000,000,000)

	1960	1961	1962	1963	1964	1965
Food production	132.0	129.6	140.1	128.1	137.5	142.3
Commercial production	38.6	38.3	40.6	43.9	44.5	44.6
Small farmers	26.9	26.6	30.1	32.2	32.1	32.7
Estate	11.7	11.7	10.5	11.7	12.4	11.9
Stock farming	18.1	18.7	18.6	18.5	19.3	19.5

Rubber, once a primary export item, is less expected today since the investment for replantation of young trees has been neglected. Sugar cane of estate agriculture and food products of small farmers came into conflict in their lands, as the increase in population required larger area of land for food products. Recovery of the estates thus deteriorated has been retarded attributable to the escape of farmers from modern agricultural technic and the shortage of funds to finance the maintenance of estates.

In the Five Year Plan, it is scheduled to invest Rp. 236,000 million, which is 30 percent of the total investment under the Plan, in the field of agriculture in order to raise the productivity of farms principally in Java. Prior to the Five Year Plan, successful results of *Demonstrasi Masal* (Action Program on Intensification) to intensify the rice cropping encouraged the Government to launch *BIMAS* (*Bimbingan Masal* - Mass Guidance) program. BIMAS program is a package deal providing by the Government to the farmers technical guidance, fertilizers, improved plant seeds, insecticide, farming equipment and credit. The repayment to the Government will be made by the farmers by delivering a quarter of the increment of rice yield.

Price

FAO Survey Team to Indonesia in 1967 reported that the producer price of rice was, at most, 60 percent of the consumer price. This is partly attributable to the seasonal fluctuation in price. With 100 as the annual average, the price of rice in Java goes down to 82 in April to June, the harvest season, and goes up to 118 in October to December.* Further, the price differentiates from one city to another. All these prove that the collection and distribution system including rice cleaning mills is not fully developed.

* Malaya Economic Review Vol. XIII No. 2 "Rice Price, Marketing and Food Policy in Indonesia" by Mubyarto.

Food Supply

Changes in the food supply pattern are shown in the table below.

Table IV - 7 FOOD SUPPLY PER CAPITA

(kilograms)

	Java			Outer islands		
	1955	1960	1964	1955	1960	1964
Rice	80.4	79.9	63.2	95.9	108.7	107.6
Maize	25.6	28.2	40.2	16.7	19.5	22.6
Cassava	117.1	140.4	134.5	94.0	80.5	85.9
Sweet potatoes	18.1	22.7	33.9	29.9	37.9	45.3
Peanuts	2.8	3.0	2.6	0.9	1.0	1.5
Soybeans	5.1	5.8	4.5	1.2	1.5	1.6

food supply = production – seeds
Source: Biro Pusat Statistik, Statistical Pocketbook of Indonesia 1964 – 1967.

The agricultural production per hectare is increasing in Indonesia as a whole. However, the table above shows the lack of proper distribution of the products. The elasticities of demand for food also reveal that the pattern of demand is strongly influenced by the pattern of production of the area.

Table IV-8 ELASTICITY OF DEMAND AGAINST INCOME

(November 1964 to February 1965)

	Urban area			Rural area		
	Low income class	High income class	Expenditures per capita (Rp)	Low income class	High income class	Expenditures per capita (Rp)
West Java						
Rice rationed						
Rice not rationed	0.86	0.45	559	0.8	0.55	696
Maize	0.1	1.0	13	–0.2	0.	12
Cassava	0.8	–2.5	17	–0.06	0.44	22
(total)	–	–	(697)	–	–	(754)
Central Java						
Rice rationed	–0.1	–1.1	87	2.0	0.25	12
Rice not rationed	0.9	0.47	347	1.06	0.65	271
Maize	0.	0.1	12	–0.3	–0.3	74
Cassava	0.3	0.	16	–0.2	0.5	33
(total)	–	–	(462)	–	–	(391)
East Java						
Rice rationed	0.75	–1.0	49	1.5	–0.15	17
Rice not rationed	0.85	0.45	265	1.2	0.9	174
Maize	–0.8	0.4	15	–0.2	–0.27	67
Cassava	0.1	0.5	12	–0.1	0.	24
(total)	–	–	(441)	–	–	(282)

Table IV-8 ELASTICITY OF DEMAND AGAINST INCOME (Continued)

(November 1964 to February 1965)

	Urban area			Rural area		
	Low income class	High income class	Expenditures per capita (Rp)	Low income class	High income class	Expenditures per capita (Rp)
Outer Java island						
Rice rationed	0.6	1.05	68	0.5	1.1	25
Rice not rationed	0.7	0.45	444	1.0	–0.4	482
Maize	–0.55	1.8	16	–1.2	1.6	19
Cassava	–2.3	2.0	34	0.33	1.0	44
(total)	–	–	(562)	–	–	(470)

Source: A.D.B., The Report of the Asian Development Bank Technical Assistance Mission to Indonesia to advise on the Production and Availability of Foodstuffs in Indonesia, Vol. 11, 1967.

Table IV - 9 AREA UNDER PRINCIPAL CROPS

(thousand hectares)

	1963	1964	1965	1966	1967	1968
Rice	6,731	6,980	7,426	7,691	7,516	8,040
Maize	2,559	3,646	2,537	3,778	2,547	3,241
Sugar cane †	121	100	110	112	114	109
Sweet potatoes and yams	484	620	416	402	360	406
Cassava	1,558	1,579	1,730	1,513	1,524	1,490
Soybeans	539	571	578	605	589	678
Groundnuts	352	373	348	388	351	396
Tea	140	138	134	120	113	111
Coffee	271	296	300	319	329	339

† Crop year

Table IV - 10 PRODUCTION OF PRINCIPAL CROPS

(thousand metric tons)

	1963	1964	1965	1966	1967	1968
Rice	11,686	12.387	13,043	13,442	13,716	14,947
Maize	2,358	3,768	2,399	3,216	2,369	3,102
Sugar cane †	7,037	6,933	7,321	7,569	7,743	7,158
Sweet potatoes and yams	3,070	3,958	2,847	2,476	2,143	2,302
Cassava	11,679	12,262	11,274	13,353	10,747	11,268
Soybeans	350	392	396	416	419	381
Groundnuts (in shell)	392	436	396	263	241	289
Coconuts (million nuts)	6,237	...	...	...	...	...
Copra	1,386	1,193	1,214	1,189	1,248	1,275
Palm oil	148	161	157	174	174	188
Palm kernels	33	34	33	35	35	40
Tea	78	87	89	89	84	87
Coffee	146	88	112	110	162	157
Rubber	582.3	648.7	705.8	729.4	688.2	722.3

† Crop year

3. Forestry

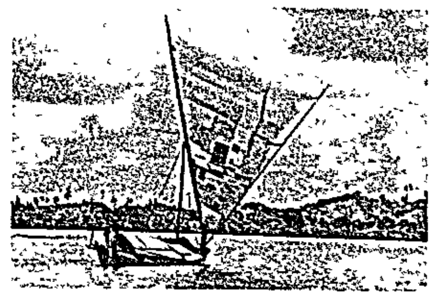
The forest resources are abundant in Indonesia. It is estimated that approximately 122 million hectares, 64 percent of the total area of the country, is forest land. However, the forestal details are unknown except one sixths of the total forest area. It is said that, of the 122 million hectares, 48 million hectares are forest reserve and 30 million hectares are precipitous. Of the remaining, 18 million hectares will have to be converted to farm land and 24 million hectares will remain as timber land. Java lacks timbers and the present forest should be preserved for flood control and protection against erosion of soil.

Inter-island transportation is poor. In 1966, transportation cost from Kalimantan to Java of timbers, costing Rp 2,000 to 3,000 per cubic meter in Java, was Rp 1,200.* The poor inter-island transportation hinders the balanced distribution of the products. However, it is noteworthy that, of a total intended private foreign capital investment of US$ 1.3 billion approved to date, more than a third or US$ 340.0 million is in forestry.*

* IBRD

* IBRD

4. Fishery



Indonesia is rich in marine products with extensive continental shelves around the islands where abundant plankton is found drifting. The annual marine catch is said to be about 700,000 tons in the latter half of the 1960's. The report of FAO estimates that a catch of up to 4.5 million tons a year would be possible in the neighboring waters.

The per capita calory intake, 1957 calories per day on average in the years of 1961 to 1963, is low as compared with the countries of the Far East. Especially, the intake of animal protein is only 4.5 grams, and a half of which is from fish. Therefore, the fishery in Indonesia is thought important from the stand point of nourishment in consideration of less hopeful stock-farming.

The total fish catch landed in Java in the year of 1966 was only 2.3 kilograms when divided by the number of population, which implies the absence of developed distribution system on the island, including inadequate storage and freezing as well as salting and drying facilities. Besides, there are considerable obstacles arising from poor inter-island transport.

5. Mining

According to data available, the mineral deposits of oil, tin, bauxite and nickel are abundant, while there are some lead, zinc and coal deposits. In addition to the above, deposits of copper, iron, manganese, gold, silver, sulphur and diamond are attracting the world's attention recently.

Table IV - 11 MINING PRODUCTION

(thousand metric tons)

	1958	1960	1962	1964	1966	1968
Coal	603	658	471	446	321	176
Natural gas † (million cu.m.)	2,693	3,137	3,491	3,524	3,162	4,287
Crude oil	16,310	20,606	22,747	22,824	23,244	34,907
Manganese (Mn content)	23.3	5.7	25.0	2.7	107.0	–
Tin in concentrates	23.6	23.0	17.6	16.8	12.7	16.9
Beauxite ††	344	396	461	648	701	879

† Including gas repressured and wasted.
†† dried equivalent of crude ore.
Source: Statistical Yearbook for Asia and the Far East 1969, ECAFE

The geological conditions of Indonesia are not fully investigated, and the data on mineral resources are insufficient, which hampers formulation of concrete development program. On this account, the Government has not stressed strongly the need to develop its mineral resources, although the international market is following closely their developments.

The development of mineral resources requires a large amount of speculative capital investment. Foreign capital and technic have been introduced on a contract-of-work basis and production-sharing basis, recently both through international tenders. In 1968, the annual crude oil production under foreign capital amounted to 82 percent of the total.

The distribution of oil field is localized as in the case of other resources. Of the total, 95 percent of the crude oil is produced in outer islands, while 65 percent of the total population is in Java.

Table IV - 12 DISTRIBUTION OF CRUDE OIL PRODUCTION

(thousand barrels)

	1964	1965	1966	1967	1968
Sumatra	152,130	163,806	158,223	175,997	210,246
Java	920	752	618	537	483
Kalimantan	15,929	11,738	11,051	9,018	8,572
West Irian	789	710	632	586	562

Source Indonesia Perspectives (February 1970)

The tin production of Indonesia, the largest in the world before World War II, is now fourth following Malaysia, Bolivia and Thailand, producing 7.9 percent of the world total. The official figures recorded on hard mineral mining show investment to date has been mainly in exploration activities.

6. Transportation

Overland Transportation

Major load of the overland transportation is primary goods fluctuating seasonally in traffic. In Java, most imported goods are unloaded at Djakarta and Surabaja except bulky cargoes, such as construction materials, machines and equipment. Export is also made through the same ports except the agricultural products in bulk.

The overland transportation network can be divided into three zones: west, central and east with centers of Djakarta, Semarang and Surabaja respectively. The trunk line, both railways and highways, is between the three cities along the south coast of Java. In east Java, transportation network is spreading from Surabaja to Madiun, Kediri, Malang and Djember which, located between volcanoes, are the collecting and distributing centers of agricultural products.

Highways

The highways are classified into six, and the road load is limited according to the class. Improvement of road conditions is being carried out extensively under the Five Year Plan. However, the loading gauge of bridges is the bottle neck in increasing the transport capacity.

Vehicles are old. In addition, the load limit per axle, stipulated according to the highway classification, restricts the transport capacity of one vehicle. Due to the seasonal fluctuation in traffic, transportation business is small in scale. Consequently, transport of materials and products is carried out by the enterprises buying and selling same. The price of fuel gasoline of vehicles is uniformly 25 rupiahs per litre in Indonesia.

Railways

Railway service is available with narrow gauge in Java and Sumatra. The rolling stock is also aged, 40 years or older, with a few exceptions. The investment by the Government to maintain the railway service is predicted to be guided on particular lines in order to avoid twofold investment in the same field of services, railways and highways, with emphasis on the lines between large cities in addition to those conveying particular materials and products in bulk.

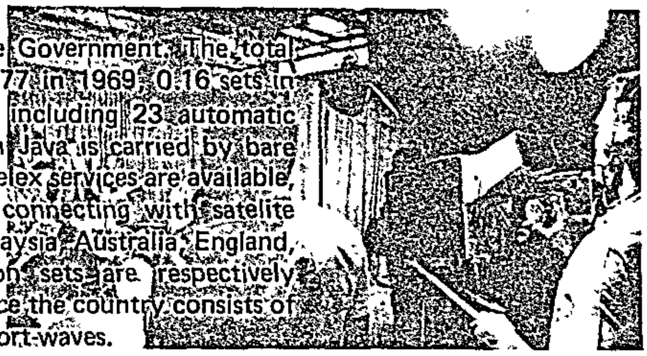
Marine Transportation

The marine transportation service has shown a chronic deficit in the international balance of payment together with insurance. This is due to the extremely low loading rate of Indonesian ships.

There are 55 domestic regular lines with a total displacement tonnage of 392,000 tons. Of the 55 lines, 40 are concentrated in west Indonesia including Singapore. The ship's burden is small in the east. The rate of shipping operation is low with the annual transportation efficiency of 5.4 tons per displacement ton in 1969, which stems from the obsolescence of not only vessels but of the port facilities and related overland transportation. The freight is uniform according to the goods. Related to the development of agriculture and industries of the country, reinforcement of the marine transport capacity is one of the most difficult tasks in the future.

7. Communication

The public telecommunication is operated by the Government. The total number of telephone sets in Indonesia was 181,377 in 1969, 0.16 sets in every 100 persons, with 536 exchange stations including 23 automatic stations. The long distance call between cities in Java is carried by bare conductors of 3 and 12 channels. Telegraphic and telex services are available, mostly concentrating in Java. An earth station connecting with satelite stations provides telephone channels to Japan, Malaysia, Australia, England, West Germany and Spain. Radio and television sets are respectively 4,500,000 and 46,000 in approximate number. Since the country consists of many islands, the radio broadcasts are mostly on short-waves.



8. Manufacturing

The contribution by the manufacturing sector to GDP remained almost static in the last decade.

Table IV - 13 MANUFACTURING PRODUCT AT 1930 MARKET PRICE

(billion rupiahs)

	1960	1962	1964	1966	1968
G D P	390.2	420.2	425.3	441.9	477.8
Manufacturing product	32.6	37.1	35.9	36.3	40.8
Rate of contribution (%)	8.4	8.8	8.4	8.2	8.5

Source: Statistical Yearbook for Asia and the Far East 1969 ECAFE

In the past five years, the manufacturing product has grown at less than 7 percent a year as compared with the growth of mining and forestry at 25 percent and 9 percent respectively. The Five Year Plan puts primary

emphasis on agricultural development and for this period assigns the industrial sector only a supporting role. This is specifically the case with respect to industry in the public sector, for which the plan emphasized the rehabilitation of existing production capacity. This supporting role is further underlined by the preferential treatment to be accorded among others, to private sector industries that are designed to complement agricultural sector development, i.e., industries that manufacture farm inputs or process agricultural outputs. Priority is also to be given to industries that produce import-substitutes. Of 335 approved foreign investments in 1969 and 1970, 184 are in manufacturing industries, mainly food, beverages,
IBRD tobacco, chemicals and rubber.* According to the industrial census in 1964, of 33,627 manufacturers, 24,194 were in Java, 75 percent of the total. Whereas, manufacturers operating without motive power concentrated in Java at a higher rate of 92.5 percent.

Table IV - 14 NUMBER OF MANUFACTURERS BY REGION

(large- and middle-scale manufacturers only)

	1959	1960	1961	1962
Djakarta	1,494	1,707	1,709	1,747
West Java	1,814	2,037	2,168	2,183
Central Java	2,658	3,182	3,055	3,104
Jogjakarta	455	534	556	515
East Java	2,477	2,702	2,953	3,342

Source. Biro Pusat Statistik, Sensus Perindustrian 1964

In East Java, the manufacturers were mainly centered around Bodjonegoro, Madiun, Ponorogo, Surabaja and Malang, respectively 785, 737, 633, 1,177 and 538 in number.

Table IV - 15 MANUFACTURING PRODUCTION IN 1961

(Million rupiahs)

	Product		Added value	
	1958	1961	1958	1961
Manufacturing	26,456	56,673	10,021	28,287
Food	2,336	4,629	1,067	1,837
Beverages	390	946	250	781
Tobacco	6,065	15,109	2,478	9,788
Textiles	2,324	5,443	563	2,280
Clothing	117	289	43	93
Wood	217	470	91	146
Furnitures	102	208	57	120
Paper, paper products	210	551	135	370
Printing, publishing	1,120	2,998	526	1,520
Leather, leather products	466	1,285	210	600
Rubber products	4,701	8,114	1,256	2,312
Chemicals	4,385	9,113	1,067	3,552
Non-metalic mineral products	430	1,427	181	1,046
Metal products	632	1,627	191	792
Machinery (non-electric)	263	649	105	301
Electric machinery	422	889	287	531
Transport equipment	2,000	2,371	1,350	1,852
Miscellaneous manufacturing	276	555	164	366

Source: Nugroho: Indonesia, Facts and Figures, Djakarta 1967

9. Banking

Financing System

The Bank Law was enacted in January 1968 as the first financing regulation since independence of the Republic, with the purpose to reorganize the financing system. The Bank Indonesia, the central issue bank of the Republic, is guiding directly or indirectly six national banks, National Development Bank, and city banks. The National Development Bank provides middle and long term loans, and the national banks short term loans. However, the tendency is that the long term loans will also be furnished by the national banks.

Loan Policy

The ratio of deposit money against money supply is increasing, about 40 percent in September 1969. The Bank Indonesia has been guiding the national banks through the release of funds with a target to allocate to the government sector 60 percent of the total amount to be loaned out based on the fund on hand. Emphasis is also put on the production sector and export-import sector, with a target of respectively 50 percent and 20 percent of the total loan.

Interest

The money is dear, with loan interest rates of 1.0 to 2.5 percent per month variable in line with the order of priority given by the Five Year Plan, and 2.0 to 4.0 percent for businesses dealing in luxurious goods and services. Interest rate on time deposit was raised in 1968 to 2.0 percent per month in order to stabilize rupiah currency on the international exchange market. However, an increase in financial cost at city banks resulted in the inducement of private capital from city banks to national banks; national banks enjoying subsidy for payment of interest from the Bank Indonesia.

Local Banks

Peculiar in the Republic are the banks belonging to local autonomies. Their activities include, in addition to the ordinary functions, loans in kind of seeds and collection of harvest.

10. Export

Since 1966, export of the Republic has been steadily increasing. Although data are lacking on 1970 and 1971, it is believed that the steady growth has continued to date and will continue into the future.

The export of the Republic tends to be monocultural largely depending on the production of oil, rubber and tin, the total share of the three being 60 to 70 percent in value. This trend is believed much outstanding in 1971, due to the increases in crude oil prices.

11. Import

The fluctuation in imports clearly reflected the climate of economy. Demand for imports is great. However, the amount of imports had been determined by the availability of foreign exchange. Therefore, the amount of imports fluctuated greatly up until 1967 reflecting foreign exchange gains through exports which consist of primary goods and losses due to debt payments. Today, a large portion of foreign exchange is supplied by aid and foreign capital investment.

Food was the principal import, and recorded almost one half of the total imports in 1968. In 1969, import of materials and equipment for investment purposes increased drastically, while that of food decreased owing to the increased agricultural yield in 1968. It is prospected that the trend which appeared in 1969 will continue in the years to come. An estimate by IBRD shows the import of materials and capital goods increased by 48 percent in 1970 over the previous year.

All imports of materials and equipment under development budget are exempted from import taxes and duties.

Table IV - 16 EXPORT STRUCTURE

(million $ in FOB price)

	1966	1967	1968	1969 (estimate)
Oil †	215	244	303	358
Group A	376	363	377	399
Rubber	223	189	175	197
Tin	31	32	49	60
Coffee	33	45	44	45
Copra	15	18	40	31
Palm oil	30	28	25	25
Palm kernels	7	.4		
Tobacco	24	29	30	30
Pepper	13	18	14	11
Group B	114	66	82	92
Over price ††	–	96	110	131
Error	9	–	–	–
Total	714	769	872	980

Source: Statistical Yearbook for Asia and the Far East 1969, ECAFE

† Export and import of oil is controlled by PERTAMINA, a government organization, with privileges to stay outside the concentration of foreign exchange by the Government. In this sense, oil is separated from other export and import items. Other items are divided into Group A and Group B; Group A including the traditional 9 export items of rubber, tin, coffee, copra, palm oil, palm kernels, tobacco, pepper and diamond, and Group B all the others.

†† There are check prices for Group A and B items. Foreign exchange receipts exceeding the check price is called DP (overprice).

Table IV-17 IMPORT STRUCTURE IN CIF

(million US$)

	1964	1965	1966	1967	1968	1969
Consumer goods	298.8	230.6	304.6	322.2	456.0	305.0
Materials	174.0	226.6	183.9	238.7	320.0	425.0
Capital goods	229.0	220.8	200.0	173.8	145.0	195.0
Total	701.8	738.0	688.5	734.7	921.0	925.0

Source: IBRD.

12. Balance of Payments

The current account deficit in goods and services has been chronical since 1960 partly due to large deficit in transportation which is expected to continue in the future along with the envisaged increase in external trade. Besides, the demand for imports is great due to shortage of products both in agricultural and manufacturing fields.

Foreign capital investment is being introduced to increase the product of import substitutes. Project aid in a huge amount aims at the rehabilitation of infrastructure. The current deficit is presently offset by aid and foreign capital investment received within a frame work of future debt service payment.

The exchange rate was raised from Rp. 378 per US dollar to Rp. 415 per US dollar recently following the proclamation of 10 percent import surcharge of the United States. Recently, it was again devalued along with the multirateral realignment of currency values with the constant exchange rate against US dollar.

Table IV - 18 BALANCE OF PAYMENTS (million US$)

	1963	1964	1965	1966	1967	1968
Goods and services	–228	–230	–248	–132	–282	–251
Export and import f.o.b.	54	42	24	110	–35	41
Transportation	–47	–52	–79	–88	–99	–109
Investment income	–98	–93	–95	–47	–63	–78
Other	–137	–127	–98	–107	–85	–105
Private capital	10	25	18	34	84	26
Official transfer payments and miscellaneous capital	113	103	253	96	219	217
Monetary movements	142	88	12	11	9	12
Net IMF position	20	–	–	–	–14	15
Short-term liabilities	60	50	–	6	9	–3
Short-term assets	54	5	12	5	14	–
Monetary gold	8	33	–	–	–	–
Net errors and omission	–37	14	–35	–9	–30	–4

Source: Statistical Yearbook for Asia and the Far East 1969 ECAFE.

13. National Budget

Since 1967 the national budget consists of the routine budget and development budget. The routine revenue is mostly composed of taxes. The income tax is progressive from 15 to 50 percent with credit of Rp. 24,000 for a tax payer, Rp. 18,000 for its spouse and Rp. 6,000 per dependent. The export tax is collected through foreign exchange banks. Revenues from oil sector are increasing as the production grows. The non-tax profit comprises profits from state enterprises and central bank and gains from foreign exchange fund. Including most part of the subsidies to autonomous expenditures, total personnel expenditures are extremely large.

The counterpart funds are the major resources of the development budget. Although small in amount, surplus yielding from the routine budget since 1969 has been transferred as another source of the development budget, indicating the recent sound finance of the Republic.

Table IV - 19 1970 NATIONAL BUDGET (billion rupiah)

	Budget †	Performance ††
Routine Revenue	320.5	344.4
Taxes on Income	117.1	121.4
Income tax	13.2	13.3
Corporate tax (non-oil)	21.2	20.6
Corporate tax (oil)	61.5	68.5
Withholding tax	20.9	18.8
Other	0.2	0.2

Table IV-19 1970 NATIONAL BUDGET (Continued)

(billion rupiah)

	Budget †	Performance ††
Domestic Consumption Tax	96.4	90.1
Sales tax	19.0	16.5
Excises	39.5	37.6
Other oil revenues	33.6	31.6
Miscellaneous	4.3	4.1
Taxes on International Trade	104.5	123.2
Import duties	78.0	75.0
Sales tax on imports	19.5	22.9
Export tax	7.0	25.3
Non-tax Revenues	2.6	9.7
Routine Expenditures	283.4	310.7
Personnel Expenditures	119.4	137.5
Material Expenditures	69.4	58.9
Subsidies to Autonomous Regions	53.2	76.5
Debt Service Payments	31.4	26.1
Other Routine Expenditures	10.0	11.7
Development Budget Resources		
Routine Revenue	320.5	344.4
Routine Expenditure	283.4	310.7
Surplus on Routine Budget	37.1	33.7
Transfer of Counterpart Funds	45.6	73.2
Total Rupiah Development Resources	82.7	106.9

† Budget plan as submitted to the Diet
†† Estimate made at the end of the third quarter of fiscal 1970

14. Summary

The past economic activities of the Republic is summerized in the Five Year Plan as follows: *"During the last decades the economy was the servant of politics. Rational economic principles were ignored. Domestic and foreign resources were squandered. The direct result was a decline in the economy accompanied by hyperinflation, which became more and more critical. Shortages were felt in many sectors, such as food, textiles, tools for production, spare parts, raw materials, etc. The irrigation system, plantations, mines, factories, road networks, electricity, drinking water, railways, airport, harbor and telecommunication facilities were virtually neglected."*

Today, it is true to say *Kabinet Pembangunan* (Development Cabinet) is undertaking the most painstaking task with great effort to rehabilitate the country, with assistance by IMF, IBRD and developed countries of the world. To date, its target has been accomplished to a large degree.

The legal system of the Republic is based on the customary law that has been formulated and compiled in line with the principle of cooperative community to create an economic system guaranteeing the preservation of democratic economy. The cooperative community has been existing since long time ago before the invasion of Portuguees in 15th century. The constitution also provides that the economy as a whole shall be organized as a joint enterprise based on *Azas Kekeluargaan* (principle of cooperative community). The cooperative community has been developed from a small unit of farming community, its principle still dominating the rural life.

Endowed with the favorable natural condition, the farmers would be rich if not overpopulated as it is. However, situated partly outside the circulation of currency, the living standard in rural area is not so low as what is shown by the indications of available statistics. This, however, will restrain in the near future the growth of domestic demand for manufacturing products.

Small scale farming is vulnerable to the natural calamities especially when it is not equipped with modern facilities. Flood is frequent in Java. According to the agricultural census in 1963, 59 percent of farmers in Java owned their lands. However, a survey made in west Java by K. J. Pelzer revealed that 92 percent of total farmers are tenant or farming laborers; 44 percent without land, 25 percent farming common land of village and 23 percent landed with less than one hectare. It can readily be imagined that the farmers in Java have lost their lands as forfeited mortgages.

Since Ordinance No. 19* was promulgated in 1960, it has been an urgent need to establish fluid circulation system of goods and capital. A large portion of the development budget has been appropriated for rehabilitation of transportation facilities. Also, expected is much from the enhancement of education which, lying behind all the economic activities, will boost the growth of national economy.

* An ordinance that provides separation of manufacturing, agriculture and commerce from each other which, once, were administered integrally under the control of big eight companies.

Table IV - 20 EXPENDITURE ON GROSS DOMESTIC PRODUCT AT CONSTANT 1960 MARKET PRICES

(billion rupiahs)

	1963	1964	1965	1966	1967	1968
Private consumption expenditure	345.0	347.7	356.0	350.8	381.7	401.7
General government consumption expenditure	34.0	40.0	29.0	40.3	36.2	36.2
Gross domestic capital formation	30.6	34.8	36.2	40.7	33.2	47.2
Exports of goods and non-factor services	48.7	54.5	56.2	55.6	55.5	61.6
Less: imports of goods and non-factor services	47.5	51.7	47.5	45.5	58.3	68.9
Gross domestic product at constant market prices	410.8	425.3	429.9	441.9	448.3	477.8
National income †	358.2	370.8	374.9	385.1	390.9	416.7

† Extrapolated by index of GDP at constant prices.

V

FUTURE GROWTH OF ECONOMY

Population: 124 million (1970) in the Republic
Annual growth rate (Estimated) 2.5 percent

Gross Domestic Product: (Estimated) US$ 90 Per Capita (1970)
US$ 1.00 = Rp 378

According to the survey made by the Central Statistics Bureau, the growth of gross domestic product in 1969 was approximately 5 percent at constant prices over the previous year. Not fully reliable production data indicate that the growth of gross domestic product in 1970 was 7 to 8 percent. The significant growth in agriculture, industry, mining and construction must have been observed.

Growth of Economy

According to the future projection contemplated by the Government for the period from 1970 to 1980, 7 to 8 percent growth rate of gross domestic product is prospected as the optimum growth of her economy, increasing the importance of mining and industry at sectorial structure from 15 percent in 1970 to 20 to 25 percent in 1980, while importance of agriculture sector is expected to decline in percentage. Capital investment, as a matter of course, is expected to be promoted at a rate of about 10 to 20 percent of GNP, reflecting the change in structure of gross domestic product. The investment will be with foreign aid in order to make up the deficit of resource gap.

Growth of Electric Power Sector

For the period of the first Five Year Plan, 1969-1973, power sector program is estimated to involve expenditures of approximately US$ 300 million, majority of this from foreign aid. Evolving this, budgetary expenditures for electric power sector is roughly estimated at US$ 400 to 450 million for 5 years from 1974 to 1978. Furthermore, an increase can be expected for the power sector in the further future.

Present level of budgetary expenditure seems low in relation to the potential electricity demand and its growth. Per capita annual production, only 16 kWh in the Republic in 1970 compared with 100 kWh in developing ECAFE region is among the lowest in the region, because of the poverty in the facilities of electric power industry in the Republic.

VI

ENERGY RESOURCES FOR ELECTRICITY GENERATION

1. Resources.

Coal

Although the Republic has bituminous coal deposits of the second largest in Asia following India, the annual coal production has decreased sharply since World War II and has not recovered to the pre-war production level of two million tons a year. Because of the notable increase in wages, decrease in demand and unlikelihood of full mechanization, coal prices are anticipated to rise significantly. Neither constant production in large quantity at low cost nor regular consumption of coal can be expected.

Nuclear Fuel

Although thorough exploration has not been performed, Indonesia can not be considered as an area abundant in uranium deposits. Natural uranium has been sold on the world market for years, yet enriched uranium is available only under certain conditions from limited sources. Arrangements for such supply can be made either through the International Atomic Energy Agency or through bilateral agreement. As a tendency of the world today, the use for power reactor and fuel cycle optimization are being encouraged.

Geothermal Energy

Java, a volcanic island, may offer an opportunity for the development of geothermal energy. Exploration is to be carried out as one of the long term developments of energy. Therefore, no economic appraisal is possible until a commercial field of geothermal steam is well defined.

Hydro-power Resources

Endowed with much rainfall in the mountains, the hydro-power resources of the Republic have been and are being developed along with the increase of electric power demand. On the other hand, the shortage of foodstuff, especially of rice, is the acute problem of the Republic, and the Five Year Plan gives the first priority to the solution of this problem. Therefore, much is expected from the river basin development to improve the irrigation systems and to reinforce flood control system. In order to economize the development, multipurpose projects combined with power generation are underway at several locations.

In addition, there are several projects to construct small hydro power plants to promote electrification of the Republic. Thus, the hydro-power development in the Republic is contemplated from various points of view.

Fuel Oil

In crude oil production, the Republic ranks twelfth in the world and the top in Asia. In the light of air pollution and ecological needs, low-sulphuric crude oil produced in the Republic has come to attract the attention of the world-wide cosumers, and a corresponding increase in demand has been noted.

In 1970, the Republic produced 849,000 barrels of crude oil per day. Of these, 621,000 barrels per day were exported. According to an estimate made in 1970 the domestic consumption was 135,000 barrels per day which was only 16.3 percent of the total production.

Following the OPEC countries who raised the price of crude oil in February 1971, the Government hiked the price of its crude oil by US$ 0.51 per barrel, resulting in an increase to US$ 2.21 per barrel in FOB price.

Oil production is monopolized by the Pertamina, a government owned organization, responsible for prospecting, production, refinery, transport and distribution including retail sale.

Table VI-1. DEMAND AND PRODUCTION OF CRUDE OIL.

	1965	1966	1967	1968	1969	1970	
Production							
Million tons per year	24.3	22.8	25.4	29.8	36.4	41.6	
Thousand barrels per day	485.0	455.0	512.1	600.3	742.5	849.0	
Demand							
Million tons per year	7.9	6.1	5.7	6.5	6.2	6.8	(est.)
Thousand barrels per day	158.0	122.0	113.0	130.0	124.0	135.0	(est.)

Table VI-2. OIL PRICES IN THE REPUBLIC

(rupiah per liter)

Residual Fuel Oil	6.0
Inland Diesel Oil	8.0
High Speed Diesel Oil	12.5
Kerosene	10.0
Gasoline (regular)	24.0

Table VI-3. TRANSPORTATION COST OF OIL IN EAST JAVA

(rupiah per liter)

Destination	Transportation	Cost
Perak (thermal)	boat	0.25
Ngagel (diesel)	boat	0.25
Banjuwangi	train	2.20
Situbondo	train	2.10
Djember	train	1.90
Madiun	train	1.80
Lumadjang	train	1.60
Malang	train	1.20
Madura	truck car	2.63
Patjitan	truck car	3.20

2. Overall appraisal

Coal Construction of coal-burning thermal power plant may provide employment opportunities in the field of coal mining. However, the following conditions should be duly taken into account in contemplating a coal-burning thermal power plant project.

i. Fuel cost at power plant should be reasonable as compared with other fuel, i.e., oil
ii. Stable production and supply of coal must be ensured at least for a life time of power plant
iii. Stable chemical component of coal to meet the design criteria of boiler must be strictly observed. (High technical level is required in coal-dressing and quality control at coal mine).

The fact that coal production has been decreasing year by year and the cost has been rising in these years in the Republic gives a negative ground to qualify coal, as compared with oil, for use at power plants. Further, a coal burning power plant is generally higher in construction cost than an oil burning plant by about 20 percent including additional facilities, such as coal landing crane, conveyors and crushers. Coal as fuel of a thermal power plant is much inferior to oil from the economical point of view. Therefore, even though coal is indigenous, no chance will be given for coal to be used as fuel of a thermal power plant. Combined use of oil and coal, as in the case of Tandjung Priok and Tandjung Perak power plants, is not conceivable for that the power plant should be equipped with additional facilities to burn both coal and oil.

Nuclear Fuel

At the present stage of the power industry in the Republic, neclear fuel can not be taken into account even in the long-range development grogram.

Nuclear fuel would have to be imported from abroad, and the Government has no way to command the determination of its price, while oil is indigenous and abundant in the Republic. The cost of nuclear power is not very attractive when compared with oil fueled thermal power. Much improvements should be made on nuclear power plant before it becomes competitive with oil fueled power plant.

The smallest unit capacity of nuclear power generation, when considered on a commercial basis, is 500 MW which, if put in the present system of Java (350 MW in system capacity today), would require, as a reserve, installation of another 500 MW capacity with use of any resources because regular maintenance and re-fueling of nuclear reactor take considerably a long time. A nuclear power plant on a commercial basis is too large in capacity for the system in Java, requiring a large amount of advanced investment.

Hydro Resources

The water resources are as important as oil for power industry to meet the growth in power demand. However, the water resources should also be utilized for the purposes of irrigation and water supply to industries and municipalities, contributing to the betterment of living conditions and standard. Therefore, the development of water resources should be contemplated in the form of multipurpose project duly taking into consideration their uses and the allocation of development cost. Micro hydro power plant is another means to utilize water resources, but its economic justification is dubious.

Fuel Oil

The Republic has large oil deposits, and its production is increasing. The export of oil, increasing as well, is the main source of foreign exchange. However, the domestic consumption remains low, and the oil refining capacity has been 260,000 barrels per day for these ten years at approximately 80 percent plant factor. As industrialization progresses, oil consumption will increase. Especially in the Republic, the expansion of power industry will require more and more fuel oil.

Well organized distribution system of fuel oil is necessary to supply less expensive power. Although the price structure of fuel oil is not included in the scope of the Report, it is advisable to rectify and strengthen oil distribution system as soon as possible.

There is no quantitative discount in price of fuel oil. A power utility organization is purchasing fuel oil for power generation at the same price as that of small town shop, which is quite absurd in the light of the principle of economy. Being a public utility, the power industry could be duly privileged with quantitative discount on fuel oil. In order to foster the growth of power industry, which will greatly contribute to the industrialization of the country, due consideration should be made in this regard.

The extraordinary high transportation cost of fuel oil due to poor inland transportation system will cause to abolish the existing diesel power plants that are located inland, by constructing transmission lines connecting from a large capacity thermal power plant where fuel oil is available at low price.

VII

PRESENT SITUATION OF ELECTRIC SUPPLY IN EAST JAVA

1. General.

Electric Utility

The electric utility industry is undertaken by Perusahaan Listrik Negara (PLN), which belongs to the Ministry of Public Works and Electricity, with its head office in Djakarta and 15 Exploitasi (local offices) to cover the whole Republic. East Java, an administration district, falls in a territory of Exploitasi IX which has 15 branches (3 generation and transmission branches, 11 distribution branches and one workshop) and is engaged in and responsible for the operation and maintenance of existing power facilities, power sales and expansion works of the distribution networks within the territory. Its service territory covers an area of 48 thousand square kilometers and contains an estimated population of 27 million which is one third of the total in Java. Besides Exploitasi IX, there are project offices in East Java, other organizations under PLN head office, and the Ministry of Public Works and Electricity which undertake the construction of transmission facilities and hydro power plants. Fig. VII-1 gives the organization chart of PLN.

The power supply in East Java is being made by Kalikonto system which, a major system in East Java, covers cities of Surabaja and Malang, and Madiun system around Madium city and several other systems of small scale. Yet, all these systems are not interconnected. The number of consumers was 207 thousand in 1970, and the total contract capacity 136 thousand kVA. The present electrification ratio in terms of the number of households is somewhere between 4 and 5 percent on the average in East Java. The annual energy production was 421 million kWh, and the per capita value was 16 kWh in 1970, which, almost the same as that of Java as a whole, was very low when compared with the average of 100 kWh in ECAFE countries.

Of the sold energy, 86 percent was consumed by Kalikonto system, and 6 percent and 8 percent respectively by Madiun system and others. Consuming 50 percent of power in East Java, Surabaja is an industrial and trade center of East Java. The energy consumed by residential, industrial and commercial sectors were respectively 77, 17 and 6 percent in 1971 reflecting the retarded development of industry. However, most of the large enterprises are equipped with their own generating units partly bacause PLN power rate has been high for industrial use. If these are included in PLN system, the industrial energy consumption would be larger than the above. (See IX-4.3 Privately owned generating facilities).

The past growth of energy consumption in East Java was slow due to the resourceless economic policy, exasperated inflation and insufficient power supply facilities. With the rehabilitation under the new regime, however, the economy has been stabilized, and the energy consumption started increasing in 1968 when the Five Year Development Plan was launched, with a growth rate of 7 percent from 1968 to 1969 and 14 percent from 1969 to 1970. (Fig. VII-2) If the stable political landscape continues in the future and the present impellent of the Government for economic development is maintained, assisted by foreign aid, the energy demand is expected to grow considerably necessitating the corresponding expansion of the power supply facilities.

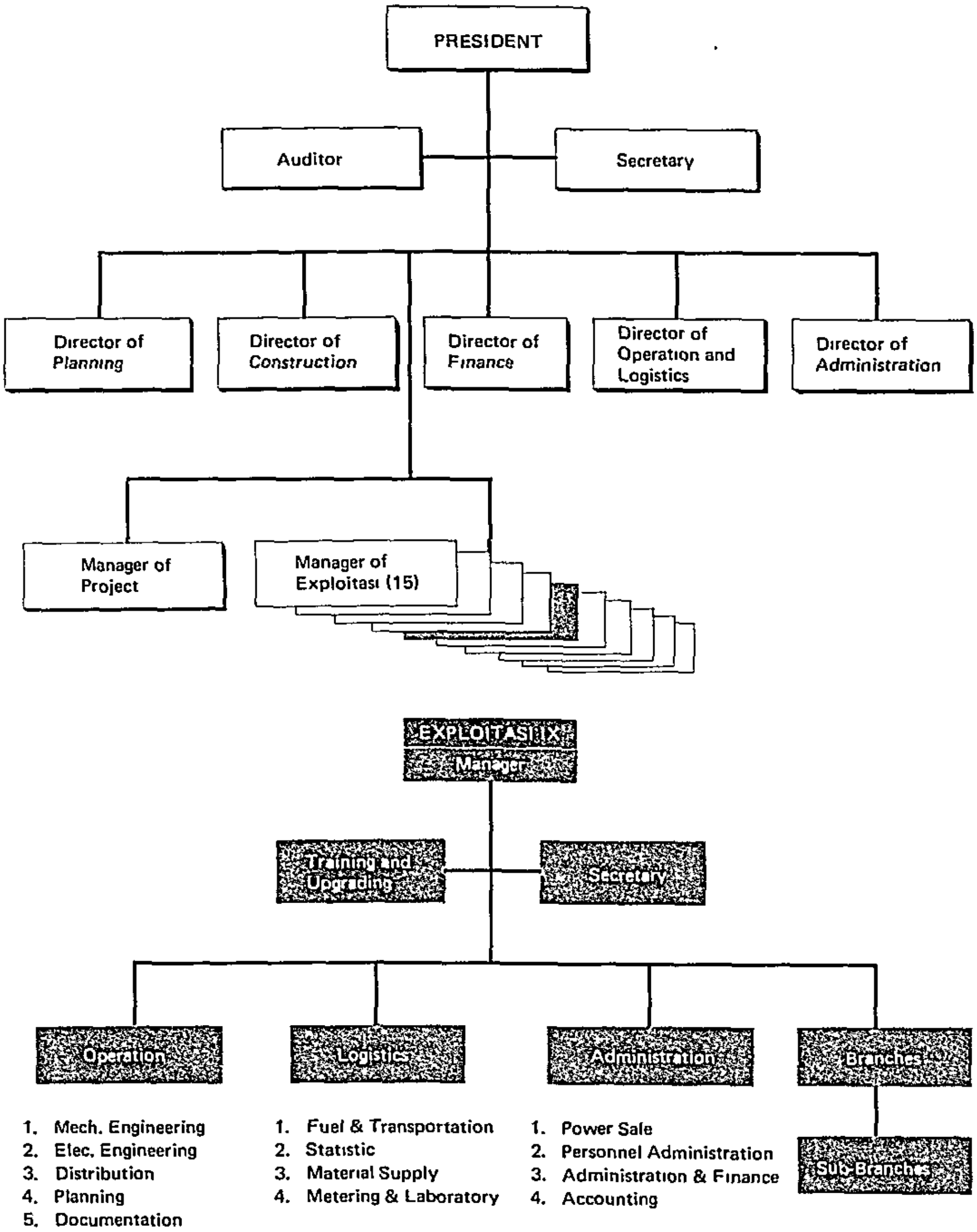


Fig. VII-1 ORGANIZATION CHART OF PLN

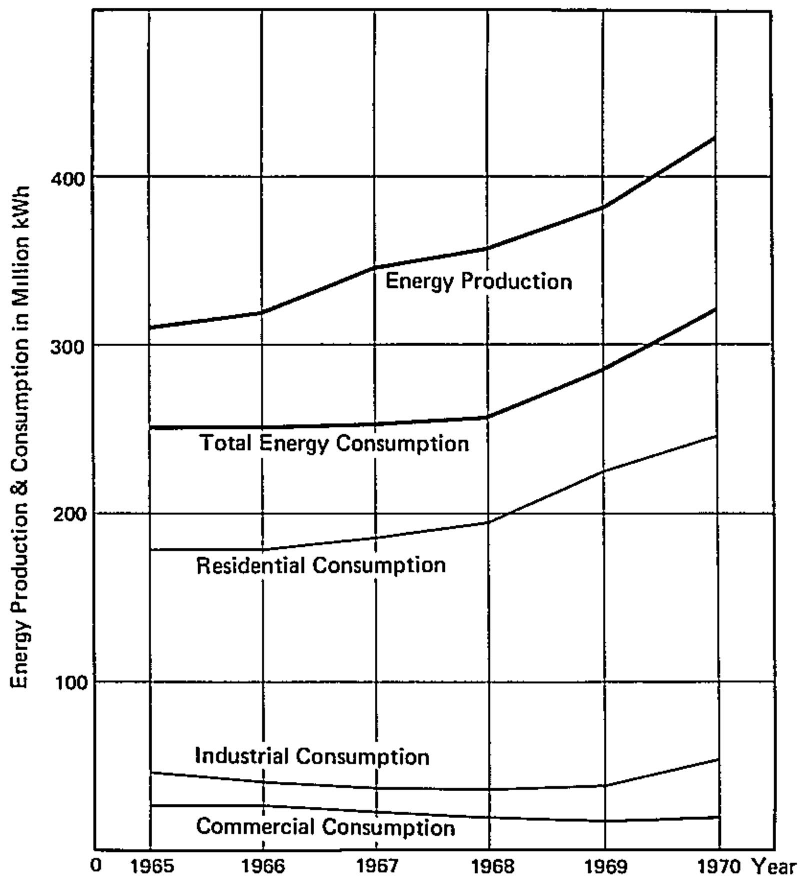


Fig. VII-2 ENERGY PRODUCTION & CONSUMPTION

2. Power Supply Facilities

2-1. Generating Facilities

Kalikonto System

The generating facilities in East Java are enumerated in Table VII-1. The total installed capacity in 1970 was 113 MW, which was a little less than 20 percent of the whole Indonesia. The component ratios of hydro, thermal and diesel are 40:45:15.

The major generating facilities of Kalikonto system are Perak thermal power plant, completed in 1964, and Mendalan and Siman hydro power plants with regulating ponds on the Kalikonto river. The Mendalan power plant, completed in 1930 and additional units installed later on, has an installed capacity of 23 MW with 4 units. However, one of the 4 units was designed as a reserve, and the intake and headrace have a capacity to conduct water for 3 units only. The maximum output is lower than the installed capacity. Siman power plant was designed in the same manner. The total output of Mendalan and Siman power plants is 25 MW as against the total installed capacity of 33.8 MW. Sengguruh hydro power plant, 2.6 MW in installed capacity, is operated with the primary purpose of irrigation, producing energy mainly in dry season. This power plant will be abolished in 1973, submerged by water to be stored in Karangkates reservoir. Energy production of Mendalan and Siman power plants will be increased by about 31.4 million kWh when Seloredjo dam, now under construction, is completed on the upstream in 1973. Diesel units are all old and supplying power during peak load hours. The dependable peaking capacity and annual energy production are considered to be 81 MW and 415 million kWh respectively. The biggest thermal power plant in East Java and the only plant constructed after 1955, Perak thermal power plant started commercial operation in 1964 with 2 units of 25 MW capacity. Since there are only a few power plants that can produce energy corresponding to load fluctuation in the system, Perak is being operated to follow the load fluctuation. This power plant was designed and equipped to burn both oil and coal. But, coal was never used, and its equipment has remained useless.

Madiun System and Others

In Madiun system, there are two major hydro power plants, Giringan and Golang, and Ngebel power plant which is operated using irrigation water. The facilities are old, and the total output of the three is 4 MW. The generating facilities of other systems are all diesel driven units of small capacity, about 200 kW in average unit capacity. The generating facalities in East Java are generally very old, and there are no recent additions. Although maintained with great care, the facilities are so obsolete that spare parts are not available, with the result that the output is far less than the nominal capacities.

Seloredjo and Karangkates

In East Java are two hydro power plants under construction, Seloredjo (otherwise known as Kalikonto) and Karangkates. They are expected to be put in operation in 1973 and 1974 respectively. The construction of the two were commenced as reparation works of Japanese government as a part of so-called 3-K's project, but, suspended due to the chaotic political and economic situations in 1965. The construction works were resumed in 1968 with yen credit. Seloredjo project, located upstream of Mendalan and Siman power plants, is multipurpose including flood control, irrigation and power generation. The installed capacity is to be 4.5 MW and the annual energy production is estimated to be 55 million kWh including the downstream increment. The dam has been completed, and the power plant will start operation by the end of 1973. Karangkates project is a key project in the Brantas river basin development. It is also a multipurpose project. The reservoir will impound 253 million cubic meters of effective storage, and the power plant will have an ultimate installed capacity of 105 MW by three units, of which two are being installed in the first stage. The dam will be completed by the end of 1971 and start storing water in 1972. Commercial operation of the power plant is expected within 1973 to supply East Java system 340 million kWh annually, which will correspond to seventy percent of the present total output in East Java. This will be a great incentive to the growth of demand so far supressed by the shortage of power supply capability.

Diesel and Gas Turbine

To cope with the shortage of electricity in 1972 and 1973, that is before completion of Karangkates, PLN is undertaking the installation of diesel units, 4.8 MW in total capacity and a gas turbine unit of 12.5 MW, all to be completed within a period of 1970 to 1973. The gas turbine unit presently in operation at Palembang will be transferred to East Java by mid 1972, but the details are unknown.

2-2. Transmission and Distribution Facilities

Table VII-2 and Fig. VII-3 give the outline of transmission line in East Java.

Kalikonto system consists of a 70 kV system which, constituting a loop, links Perak power plant in Surabaja and Mendalan and Siman hydro power plants in south and transmits power to Surabaja, Pasuruan, Malang and

Table VII-1 GENERATING CAPACITY

	Kalikonto System				Madiun System				Others		
	Power Plant	Installed Capacity (kW)	Dependable Peaking Cap. (kW)	Annual Energy Production (million kWh)	Power Plant	Installed Capacity (kW)	Dependable Peaking Cap. (kW)	Annual Energy Production (million kWh)	Installed Capacity (kW)	Dependable Peaking Cap. (kW)	Annual Energy Production (million kWh)
Hydro		36,400	25,000	138		7,900	4,100	22			
	Mendalan	23,000)	25,000)	120	Giringan	3,200	1,800)	22			
	Siman	10,800)			Golang	2,700	2,300)				
	Sengguruh	2,600	–	18	Ngebel	2,000	–				
Thermal		50,000	50,000	285							
	Perak	50,000	50,000	285 †							
Diesel		9,200	5,500	10		2,100	1,100	3	7,000	6,500	30
	Ngagel	8,000)	5,500	10	Madiun	2,100	1,100	3			
	Malang	1,200)									
Total		95,600	80,500	433		10,000	5,200	25	7,000	6,500	30

† Plant Factor: 65%

Table VII-2. TRANSMISSION FACILITY

(at the end of 1970)

Item	Kalikonto system	Madiun system	Total
Transmission Line			
70 kV	323.0 Km		
30 kV	205.7 Km		
25 kV		57.0 Km	
Substation			
Power Transformer	225.091 MVA	17.490 MVA	242.581 MVA
No. of Transformer	47 pcs.	16 pcs.	63 pcs.

Table VII-3. DISTRIBUTION FACILITY

(at the end of 1970)

		Kalikonto system	Madiun system	Others	Total
Line					
H.V.	(Km)	852.3	78.8	87.9	919.0
L.V.	(Km)	1,316.2	187.8	236.4	1,740.4
Transformer					
Capacity	(MVA)	104.3	6.4	10.0	120.7
No. of transformer		1,050	89	110	1,249

Modjokerto, and 30 kV system connected to the 70 kV system to supply power to Kediri, Blitar, Probolinggo and Letjes. Madiun system, 25 kV in voltage, is small in scale connecting Giringan, Goland and Ngebel hydro power plants with the load center at Madiun and its surrounding where the demand is about 4.5 MW at the maximum.

Transmission Line The 70 kV transmission lines are single circuit except the section between Sawahan and Mendalan and localized short sections where two circuits are installed. However, all the single circuit lines are installed on double circuit steel tower structures, except the underground feeders from Perak power plant.

Substation In Kalikonto system Petersen grounding system is used with Petersen coils installed at Perak, Mendalan and Siman power plants and Sawahan and Bangil substations. Old substations have their transformers indoors. The power transformers of major substations are equipped with on-load tap changers of manual operation type to regulate the voltage, but with no static condenser. Consequently, the operating voltage is low, e.g., 65 to 68 kV at Bangil and Blimbing substations. The tap widths are 79,800 to 60,200 V for the transformers of recent installation.

Load Dispatching and System Operation The load dispatching center of Kalikonto system is in the head office of PLN-Exploitasi IX in Surabaja. The duty is light. Operational data are recorded there with one hour interval, and load dispatching orders are placed to major power plants and substations as necessary. In addition to public telephone system, radios are used for communication, but the readability is not sufficiently high for system operation.

Interconnection and Reinforcement In line with the construction of Karangkates and Seloredjo hydro power plants, a 150 kV single circuit line on double circuit structures is under construction from Karangkates to Waru II substation, 110 kilometers in distance. The interconnection of Kalikonto and Madiun systems has been decided to be made by a 110 kilometers long 70 kV line to form East Java system. At the same time, Kalikonto system will be reinforced by installing the second circuit to the present single circuit 70 kV line for a distance of 86 kilometers, as well as, by extending the line for 55 kilometers. In 1971, the present 20 kV transmission line between Sawahan and Gresik will be raised to 70 kV to increase the demand of that region.

The 70 kV installation of Waru II substation is near completion. Scheduled reinforcement includes the installation of two transformers (39 MVA x 2 units) and static condensers at Waru II substation, the construction of New Madiun, Probolinggo and Gresik substations, all 70 kV in voltage, and the extension of 30 kV and 25 kV systems to meet the increasing demand.

Distribution Facilities

Table VII-3 gives the outline of the distribution facilities. The distribution system consists of 6 kV lines and 127/220 V lines.

Step-down of distribution voltage is made by transformers housed in buildings with a few exceptions of pole transformers. The high voltage distribution lines are mostly underground cable, and the low voltage are overhead lines. The standard distribution unit in PLN is shown in the following table in comparison with the existing unit.

	Standard distribution unit	Existing distribution unit on average
Distribution transformer	100 kVA x 1 pcs	96 kVA
High voltage line per unit	600 m	740 m
Low voltage line per unit	2,800 m	1,400 m

The existing distribution facilities are very old and require large scale repair works. The number of distribution units were increased by 41 in 1968 and by 67 and 32 respectively in 1969 and 1970. In the years of 1971 to 1973, 100 units are scheduled to be augmented annually.

3. Power Demand and Supply

Energy Consumption

The energy sold by district branches is shown in Table VII-4 for the years of 1969 and 1970. The total energy sold in 1970 was 321.7 million kWh which was an increase of 8.8 percent over the previous year. Consumption of energy is concentrated in the branches of Surabaja (north and south), Malang and Pasuruan comprising nearly 80 percent of the total. The component ratio of industrial sector is high in Pasuruan branch implying that the industrial district prospected between Surabaja and Pasuruan will grow with Pasuruan as its center. Table VII-5 gives the number of customers, per customer energy consumption and contracted VA, indicating that the average consumption per residential customer is high, 1,250 kWh in East Java and 1,560 kWh in Surabaja, including the consumption of U-1, U-2 and U-3 tariff classes which are for governmental uses. If the governmental uses are deducted, it is 880 kWh in East Java. The contracted VA per residential customer of 380 VA on the average is low. This means only 3A at 127 V. The large energy consumption with low contracted VA is indicative of long lighting hours, which in turn implies the large component ratio of the customers who are tariffed with flat S-1 rate. The large industrial

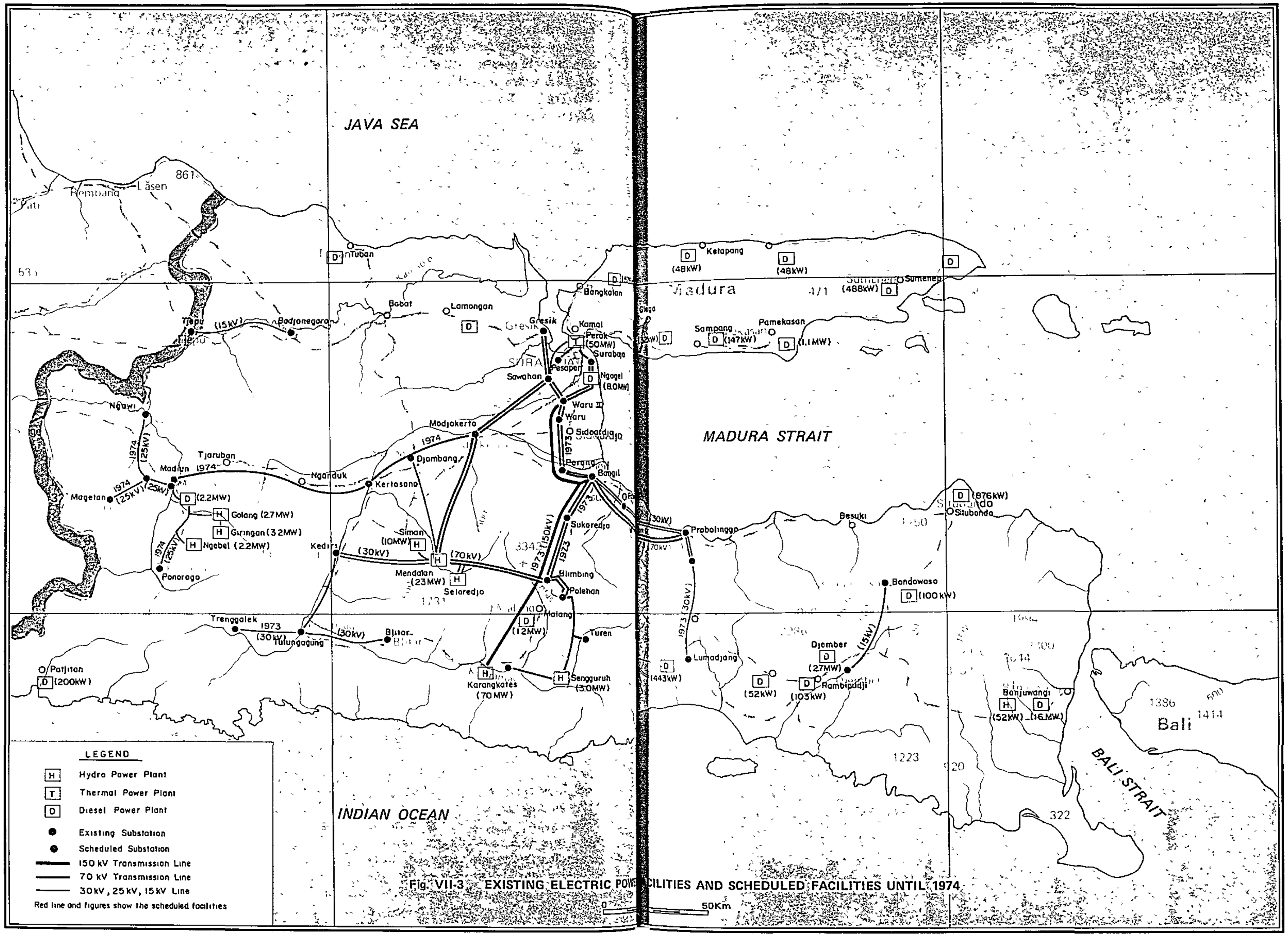


Fig. VII-3 EXISTING ELECTRIC POW CILITIES AND SCHEDULED FACILITIES UNTIL 1974

Table VII-4 ENERGY SOLD

(million kWh)

	1969				1970				1969 / 1970 (%)			
	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total
Surabaja	119.4	21.2	10.8	151.5	125.1	24.2	11.5	160.7	4.5	14.0	6.0	6.0
Malang	40.0	5.0	2.5	47.5	42.7	5.9	2.4	51.0	6.8	18.0	−3.4	7.2
Pasuruan	18.6	7.3	0.9	26.8	19.1	15.8	0.9	35.8	3.0	117.0	5.0	34.0
Kediri	14.6	2.7	1.3	18.6	15.2	3.6	1.5	20.3	4.5	31.7	17.7	9.1
Modjokerto	6.4	0.9	0.6	7.9	6.6	1.0	0.6	8.3	3.6	11.8	12.3	5.8
Madiun	15.0	2.4	0.8	18.2	15.4	2.5	0.8	18.7	3.0	3.1	–	2.9
Djember	10.2	0.4	1.0	11.6	10.6	0.6	1.0	12.2	3.3	45.5	0.8	4.7
Banjuwangi	4.1	0.6	0.3	5.0	4.4	0.6	0.4	5.5	8.0	2.2	15.1	9.6
Situbondo	2.4	0.2	0.1	2.7	2.5	0.2	0.2	2.8	4.1	6.3	9.5	5.5
Pamekasan	5.9	0.1	0.3	6.3	6.0	0.1	0.3	6.0	2.3	57.5	20.0	3.8
East Java	236.5	40.7	18.5	295.8	247.7	54.3	19.7	321.7	4.7	33.5	5.9	8.8

Table VII-5 NO. OF CUSTOMER AND CONTRACTED VA IN 1970

	No. of Customer (thousand)				Contracted VA/Customer (VA)				Energy Consumption/Customer (kWh)			
	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total
Surabaja	80.0	0.89	4.0	84.9	510	29,400	1,620	865	1,560	27,300	2,870	1,880
Malang	36.7	0.25	1.2	38.2	365	26,000	1,420	565	1,160	23,600	1,950	1,340
Pasuruan	15.6	0.12	0.53	16.3	300	65,500	1,260	800	1,220	135,000	1,720	2,200
Kediri	15.8	0.13	1.0	16.9	240	23,000	1,020	460	970	28,200	1,500	1,200
Modjokerto	7.1	0.10	0.39	7.5	220	81,000	1,040	370	935	10,200	1,620	1,100
Madiun	16.0	0.05	0.62	16.7	220	54,000	1,060	410	960	51,600	1,260	1,120
Djember	10.0	0.04	0.58	10.6	340	17,300	1,380	450	1,050	16,800	1,730	1,150
Banjuwangi	5.8	0.01	0.20	6.1	190	42,900	1,370	330	760	44,100	2,060	900
Situbondo	2.8	0.0	0.12	2.9	200	18,200	1,100	290	900	18,900	1,350	970
Pamekasan	7.1	0.01	0.20	7.3	200	11,100	1,020	250	850	8,220	1,730	890
East Java	196.9	1.5	8.9	207.4	380	31,300	1,400	650	1,250	35,200	2,210	1,550

customers of more than 200 kVA in contract capacity number 35 in East Java, averaging 430 kVA in contract capacity per customer. Other industrial customers are far small, 35,200 kWh in annual average consumption per customer and 31 kVA in average contract capacity.

Maximum Demand The maximum peak demands in 1969 and 1970 are shown below.

(MW)

	1969	1970
Kalikonto system	53.0	60.0
Madiun system	3.7	4.0
Other system	5.1	5.4
Total	61.8	69.4

Since the fluctuation in temperature and daylight hours are small, there is no seasonal fluctuation in peak demand.

Load Curve Fig's. VII-4 and VII-5 show the daily load curves of Kalikonto system of Wednesday and Sunday in September 1971. The curves are typical of a system where lighting is a major component. During the day time, the load is small due to small scale and number of industries and early office hours of 7:00 to 14:00 or 15:00 hours. The peak load appears at around 19:00 hours of the day, and the minimum load between 12:00 and 14:00 hours. The relatively large midnight load implies many flat-rate tariffed customers. The daily load factor is within the range of 74 to 78 percent. The peak lasts for about four hours. In the daytime, the Sunday load is lower than the Wednesday load by an equivalent of industrial load. However, they are the same in midnight and peak hours. The daily load curve of Madiun system is similar to that of Kalikonto. It is expected in the future that

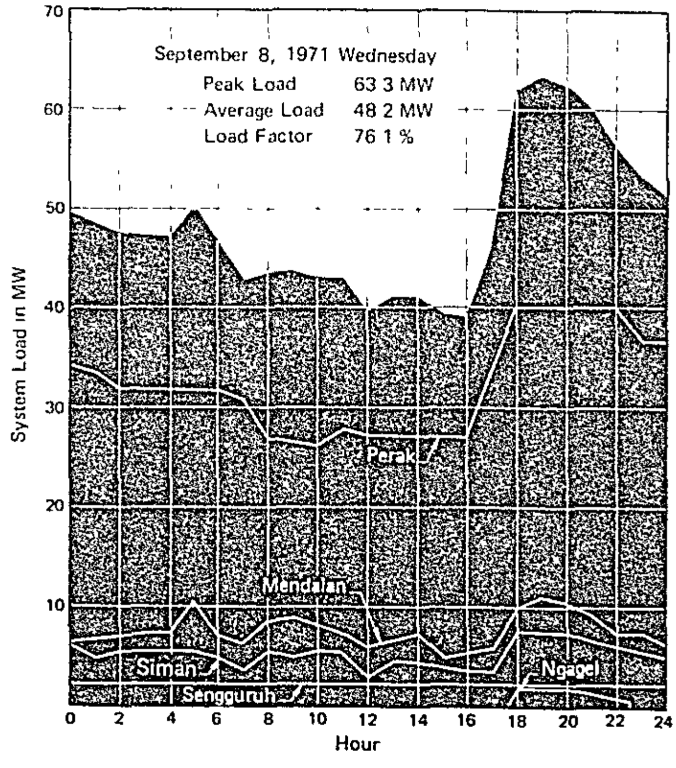


Fig. VII-4 DAILY LOAD CURVE OF KALIKONTO SYSTEM the number of flat-rate tariffed customers will decrease in the residential sector, and meter-rate tariffed customers will increase in its stead, and that the industrial load will increase remarkably, with the result that the secondary peak will appear in the daytime.

4. Power Rate

The energy demand is largely influenced by the power rate. The present power rate schedule adopted by PLN is based on the tariff-bearing capacity of customers; a very low rate for residential customers which constitutes 80 percent of the total customers, and a higher rate for commercial and industrial sectors. But, if averaged, the rate is considerably low, breaking the cost level. The deficit is being supplemented by government subsidy. As sound development of the power industry can not be expected with such power rate, it has been advised to set up rates of service based on the cost-method. The modification of rate schedule in 1968 is said to have been a step toward the cost method. It brought a minor renovation in the rate of industrial sector, but fundamentally the rate remained the same. Table VII-6 shows the power sales revenues of Exploitasi IX by the customer class in 1970 and the unit sales price.

The residential consumers of Tariff S-1 class which comprises 80 percent of the total consumers are using electricity on a flat rate, and its annual energy consumption per consumer amounts to about 700 kWh as against the average contract capacity of 118 VA. This means that, if electricity is consumed at the contract capacity, lights are put on for 16 hours a day, which reveals one of the defects of the flat rate. This is also reflected in the daily load curve in terms of the relatively large midnight load keeping the system load factor at a high level in spite of the small industrial load.

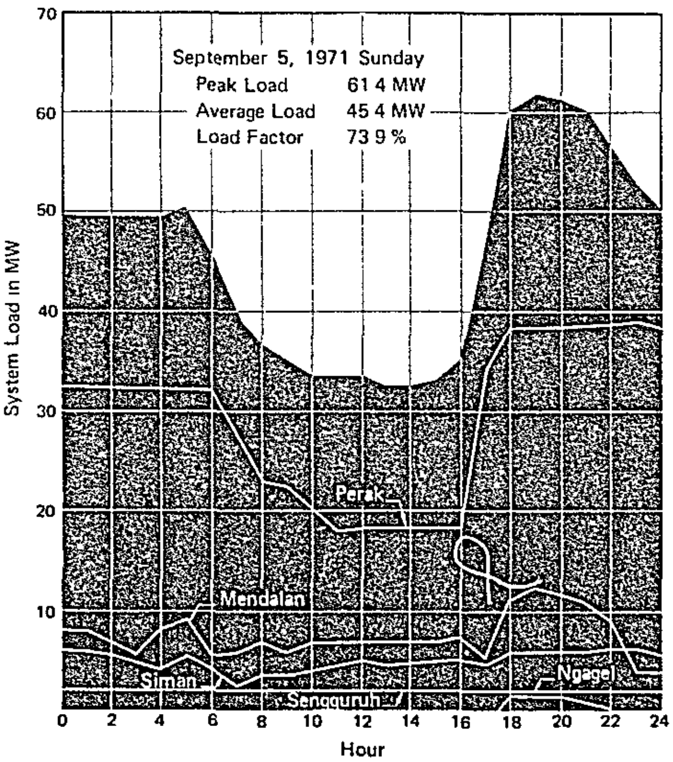


Fig. VII-5 DAILY LOAD CURVE OF KALIKONTO SYSTEM

Table VII-6 REVENUE OF ENERGY SALES 1970

Tariff Schedule		No. of Customer	Consumption (thousand kWh)	%	Revenue (thousand Rp)	%	kWh/Customer	Unit Revenue Rp/kWh	Unit Revenue mill/kWh †
S-1	Small Household Flat Rate	167,405	116,650	36.4	337,000	15.3	697	2.89	6.96
S-2	Social Building	1,320	7,540	2.3	26,200	1.2	55,715	3.48	8.38
R-1	Small Household	23,700	38,780	12.1	323,400	14.6	1,640	8.34	20.1
R-2	Household	1,420	8,430	2.6	95,100	4.3	5,930	11.28	27.2
K-1	Commercial	7,970	11,330	3.5	179,000	8.1	1,420	15.80	38.1
K-2	Large Shop Restaurant	930	7,540	2.3	179,000	8.1	8,120	23.74	57.2
K-3	Temporary Use	–	780	0.2	17,500	0.8	–	22.43	54.0
U-1	Street Lighting	230	6,080	1.9	15,900	0.7	26,600	2.62	6.31
U-2	Government Office	2,280	29,940	9.3	293,600	13.3	13,140	9.81	23.6
U-3	State Enterprise	575	5,410	1.7	59,800	2.7	9,395	11.05	26.6
P & Ch	Industry	1,540	88,990	27.7	684,100	30.9	57,780	7.69	18.5
	Total	207,360	321,470	100	2,210,600	100	1,550	6.88	16.6

† Conversion Rate: 1 US$ = 415 Rp.

The average unit sales price of Tariff S-1 class is Rp.2.89/kWh, or 7 mills/kWh, while its average price is Rp.6.88/kWh, or 16.6 mills/kWh. This is to say, the monthly expenditure for electricity of one household is approximately Rp.170 on average. On the other hand, commercial customers to whom tariff schedule of K-1 and K-2 are applied are paying two to three times of the average power rate. On this account, the commercial load increased little in the past.

While the power rate of residential sector is very low, a high connection fee is charged to new subscribers. A contract for a 500 VA capacity which is the average size of residential customers around Surabaja requires a connection fee of Rp.20 per VA. In addition, there is a line-extension burden charge which is about Rp.40,000 on the average, totaling Rp.50,000. The average household income is about Rp.10,000 per month in East Java.

For the industrial sector, there is a penalty charge (or block rate) of Rp.20/kWh for on-peak energy while the off-peak rate is Rp.5.5/kWh. Therefore, many factories have their own generating equipment to escape from the penalty, receiving electricity from PLN during off-peak hours only. Since 1970, a special rate was introduced to give a favor to large industrial customers of more than 500 kVA in contract capacity. To illustrate, a paper mill having a contract capacity of 3,000 kVA in Letjes is tariffed Rp.5.5 per kWh of a straight line rate, exempted from penalty charge. With this tendency strengthened, it is expected that the generating units of factories will be replaced by PLN power supply, and accordingly merit of large capacity unit can be expected.

Outstanding fee is another problem of PLN operation. Although no precise data were made available in this regard, it is said that such accrued income amounts to 20 to 25 percent of the total amount billed. Indications were given during the survey that the military and government sectors are the large sources of this receivables. Square deal should be established immediately. Involving the problems described in the above, the present power rate schedule requires among others, the raise of power rate based on the cost method, the transfer from the flat rate to the flat-and-meter rate, and the favorable treatment of commercial and industrial customers. A report is expected from a French team which is undertaking a study on the future power rate schedule of the Republic.

VIII

LONG-RANGE DEMAND FORECAST

In installing new power generation, transmission and distribution facilities, a plan should be established at least ten years in advance of the actual installation. Careful studies and considerations should be given in the planning to the costs of alternative sources of power, the fixed and variable costs of the alternative plans, and the steps to be taken to finance the projects. For long range planning to meet the need of an expanding economy, especially *where important and rapid changes may be expected as in the case of developing countries,* it is logical to base the long-range forecast of power demand on the probable expansion of the economy, because the growth of national economy is much interdependent with the growth of its electric power system. In this connection the relation between electric energy production and national economy, as well as, drawing on the experiences of many other countries should be used as guidance.

1. Basis

The long-range forecast is based on an application of the above mentioned concept. The per capita kWh production and per capita gross domestic products in 97 countries in 1966 were plotted on a graphic chart. The relationship obtained from the chart indicates that the rate of growth in per capita energy production greatly exceeds that of per capita gross domestic product, but the former growth rate slowly declines at higher levels of gross domestic product.

2. Present Situation of the Republic's Power Industry

The relationship between the Republic's per capita energy production and its per capita gross domestic product at 1960 market prices indicate stagnant economic activities in the years of 1960 to 1969. The Republic, when plotted in the chart, is placed considerably below the *average curve**. The per capita energy production of 16 kWh in the Republic in 1970 is lower than the *average curve* by 47 kWh which can be considered as the *potential power demand* of the region. In other words, a consumptive power equivalent to about 30 kWh is left *out of service.* As a matter of fact, many factories in East Java do not rely on the power supply from PLN, and the aggregate installed capacity of their generating facilities amounts approximately to 130 MW. Rough estimation revealed the resultant peak loads of these facilities to be 50 MW, which is approximately on a par with the peak demand of 70 MW of the whole system owned by PLN in East Java.

* Per capita GDP (1970) was estimated as US$ 90, and per capita energy production (1970) as 16 kWh in Indonesia, 16 kWh in East Java and 20 kWh in Java

Such situation is due to not only the stagnant economic activities in the past and the momentum of being stagnant but also, it would be seen if careful consideration is made, that there are a number of factors which are common to cause many other countries to deviate in growth of power production upward or downward from the *average curve.*

Shortage of Power Supply Capability

Unfortunately, PLN has not had sufficient funds to expand its facilities corresponding to the increase in power demand. The shortage of facilities to produce, transmit and distribute energy to the consumers has resulted in deterioration of energy supply in quality as well as quantity. As a consequence, many factories are equipped with their own generating units; the factories otherwise would be large consumers of PLN system.

Power Rate

If the per capita gross domestic product is constant, the per capita energy production tends to increase as the power rate decreases, and vice versa, with a larger fluctuation in the former than the latter in general practice. The present power rate of the Republic which, seem to have been deter-

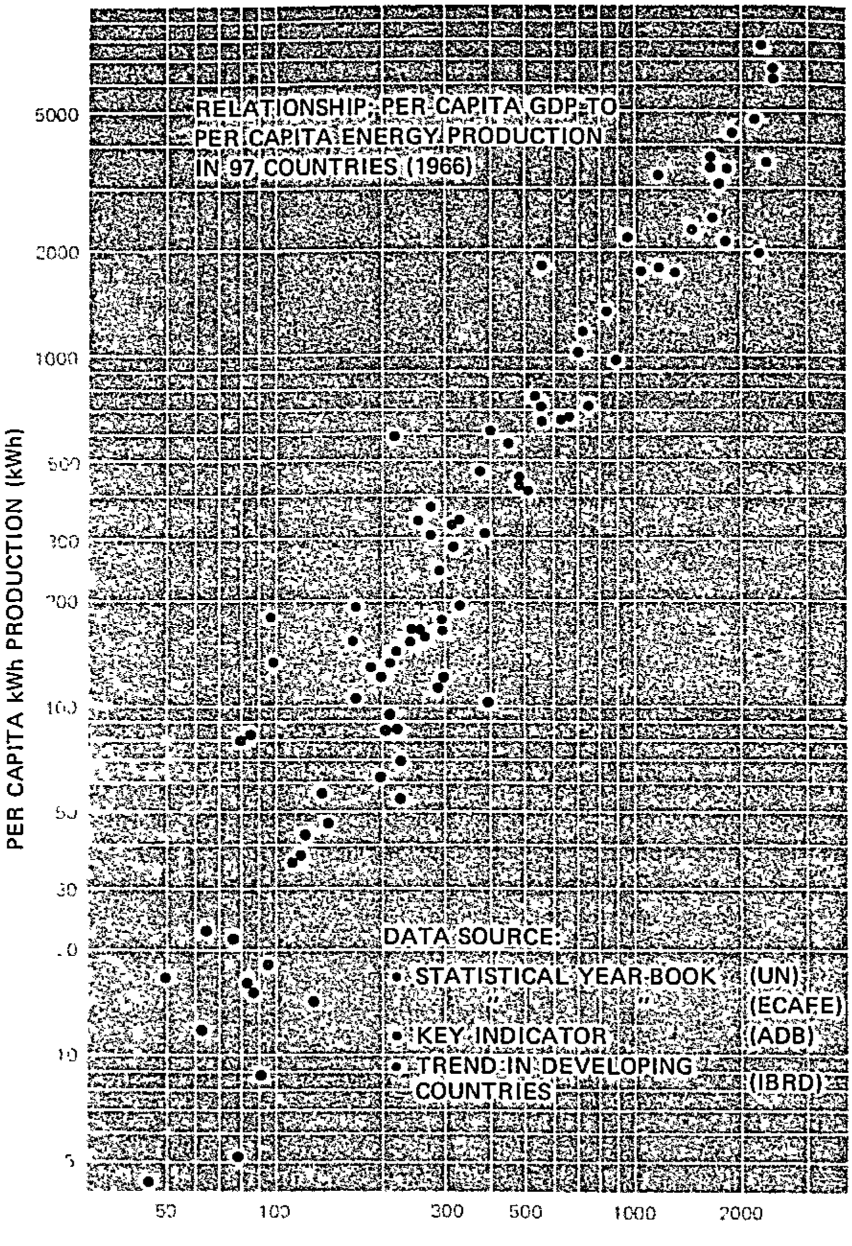
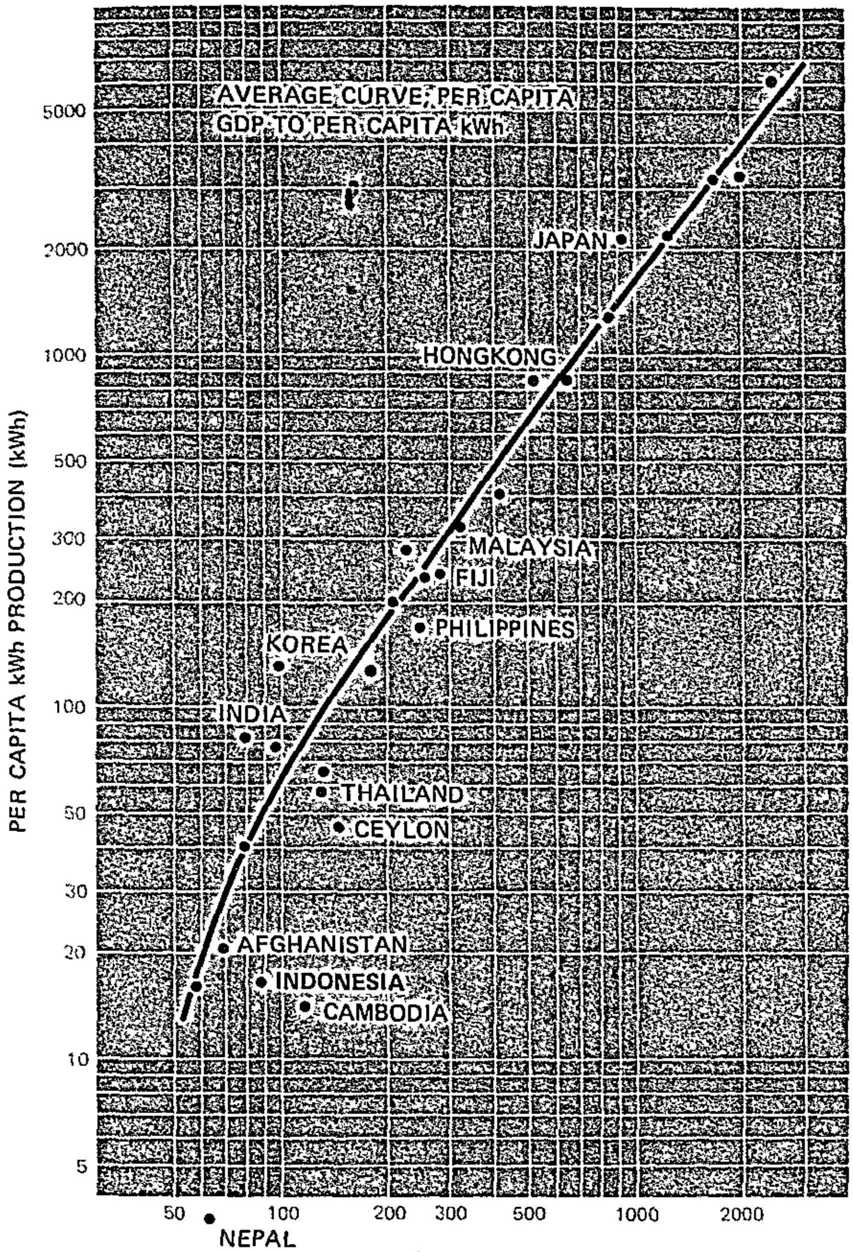


Table VIII-1 PAST RELATIONSHIP OF PER CAPITA GDP TO PER CAPITA ELECTRIC

		1960	1961	1962
GDP at 1960 market prices (billion rupiahs)		390.2	412.6	420.2
Electric energy production (million kWh)		1,161	1,206	1,445
Population	(million)	93.5	95.6	97.8
GDP per capita	(thousand rupiahs)	4.17	4.32	4.31
Electric energy production per capita (kWh)		12.4	12.6	14.8

Source: Statistical Year Book 1969, ECAFE.



ENERGY PRODUCTION IN INDONESIA

1963	1964	1965	1966	1967	1968	1969
410.8	425.3	429.9	441.9	448.3	477.8	–
1,548	1,506	1,584	1,667	1,676	1,763	–
100.0	102.4	104.9	107.4	110.1	112.8	–
4.11	4.17	4.10	4.11	4.07	4.22	–
15.6	14.7	15.1	15.5	15.2	15.6	15.7

mined by political and social requirements in addition to economic factors, is higher for industrial use; the industrial consumers being disadvantaged over the residential consumers, and appears to have suppressed the increase of consumption.

Therefore, if the power rate is lowered to the possible extent, the energy consumption of PLN system is expected to increase*. The fuel oil price, which is presently fixed without the provisions of quantitative discount, would also help lower the rate if a policy is adopted to priviledge the utility industry with quantitative discount. Installation of larger capacity units at either hydro or thermal power plant is also an approach to reduce the power cost.

* The power rate and accounting system of power utility of the Republic are being studied by a French team as a part of the organizational studies on the Republic's power utility

3. Assumptions for Forecast

In order to plot the future per capita energy production of the Republic on the graphic chart, the gross domestic product should firstly be projected for the years 1980, 1985 and 1990. The projection is prepared by the Republic up until 1980 with the purpose to estimate the future fixed capital facilities and the savings for investment requirement of the Republic. The projections adopted in the Report were as follows:

Per capita GDP (1970):	US$ 90
Per capita kWh (1970):	16 kWh in the Republic
	16 kWh in East Java
	20 kWh in Java

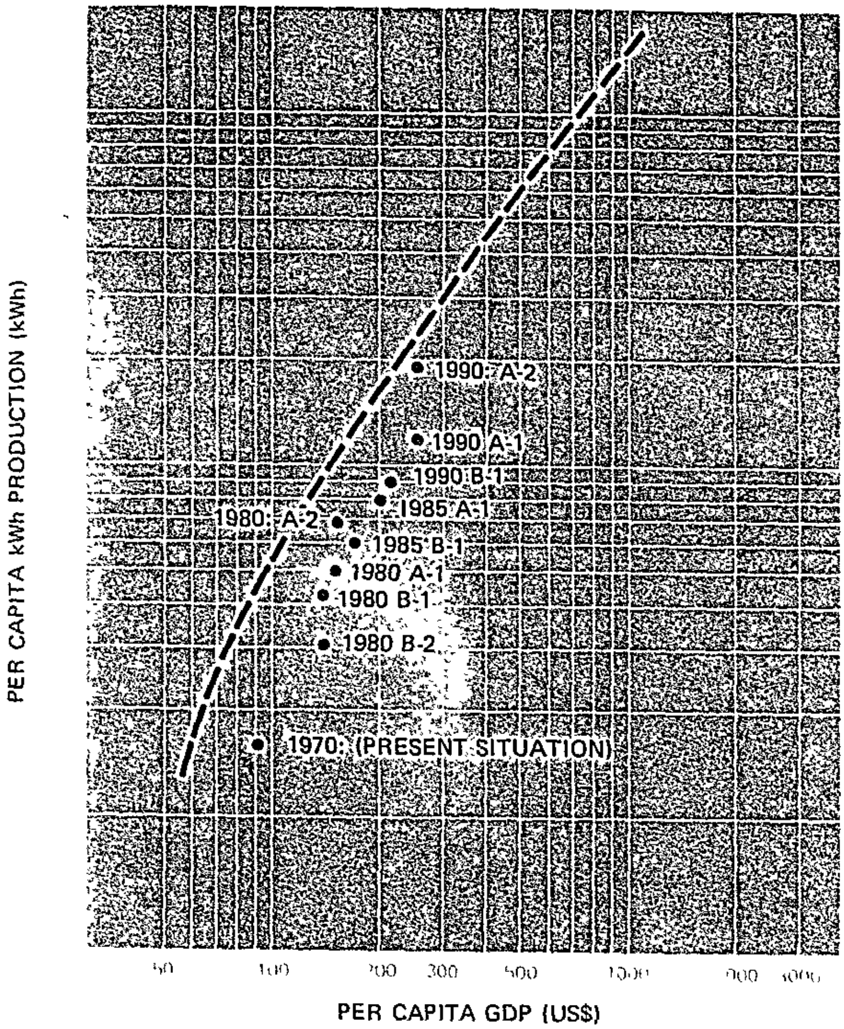
The per capita GDP and per capita energy production in East Java in 1970 were estimated as respectively US$ 90 and 16 kWh; this means that the economic feature in East Java is on the average of whole Indonesia.

Growth rate of GDP (1970 - 1990)

Case A:	8 percent
A-1:	per capita kWh production to follow the trend of developed countries
A-2:	per capita kWh production to reach the world average in 2000 (30 years from 1971)
Case B:	7 percent
B-1:	per capita kWh production to follow the trend of developed countries
B-2:	per capita kWh production not to increase till 1974 (for 4 years from 1971) and to start following the trend of developed countries in 1975

The largest growth of energy production is expected in Case A-2, and the least in Case B-2. According to the estimate by the Republic, the growth rate of the Republic's gross domestic product is set at 7 to 8 percent, which in turn provided a ground to prospect, in relation to the *average curve*, that the probable growth would be the mean of Case A-1 and Case B-1.

However, the prospect of the growth in energy production to follow the trend represented by the *average curve* may be considered still conservative because the present energy production is low in relation to the gross domestic product and that the social capital is likely to be guided, as in the case



of other ECAFE countries, intensively to the investment in the power industry to give incentives to the investment of private capital.

4. Future Energy Demand at Generating End

Based on the assumptions given above, the future demand is estimated as follows:

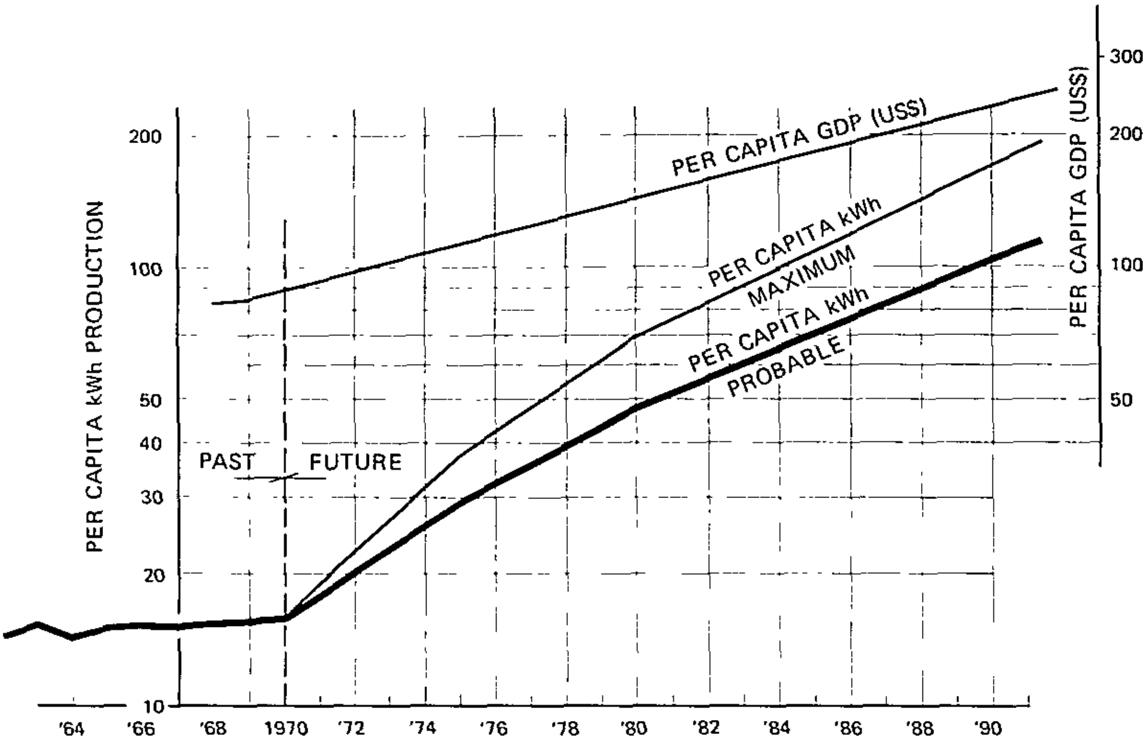
Table VIII-2. PER CAPITA KWH

	1970 (actual)	1980	1985	1990
Case A-1	16	50	80	120
Case A-2	16	70	–	190
Case B-1	16	42	60	90
Case B-2	16	30	–	–

Table VIII-3. ENERGY DEMAND

(million kWh)

	1970 (actual)	1980	1985	1990
Case A-1	430	1730	3130	5300
Case A-2	430	2420	–	8400
Case B-1	430	1450	2340	3980
Case B-2	430	1040	–	–
the Probable	–	1590	2735	4640
the Largest	–	2420	–	8400
the Smallest	–	1040	–	–



PER CAPITA ENERGY & GDP by YEAR

Table VIII-4. TOTAL ENERGY DEMAND AT GENERATING END

(million kWh)

	1970	1980	1985	1990
Probable	430	1590	2735	4640
Maximum	430	2420	–	8400

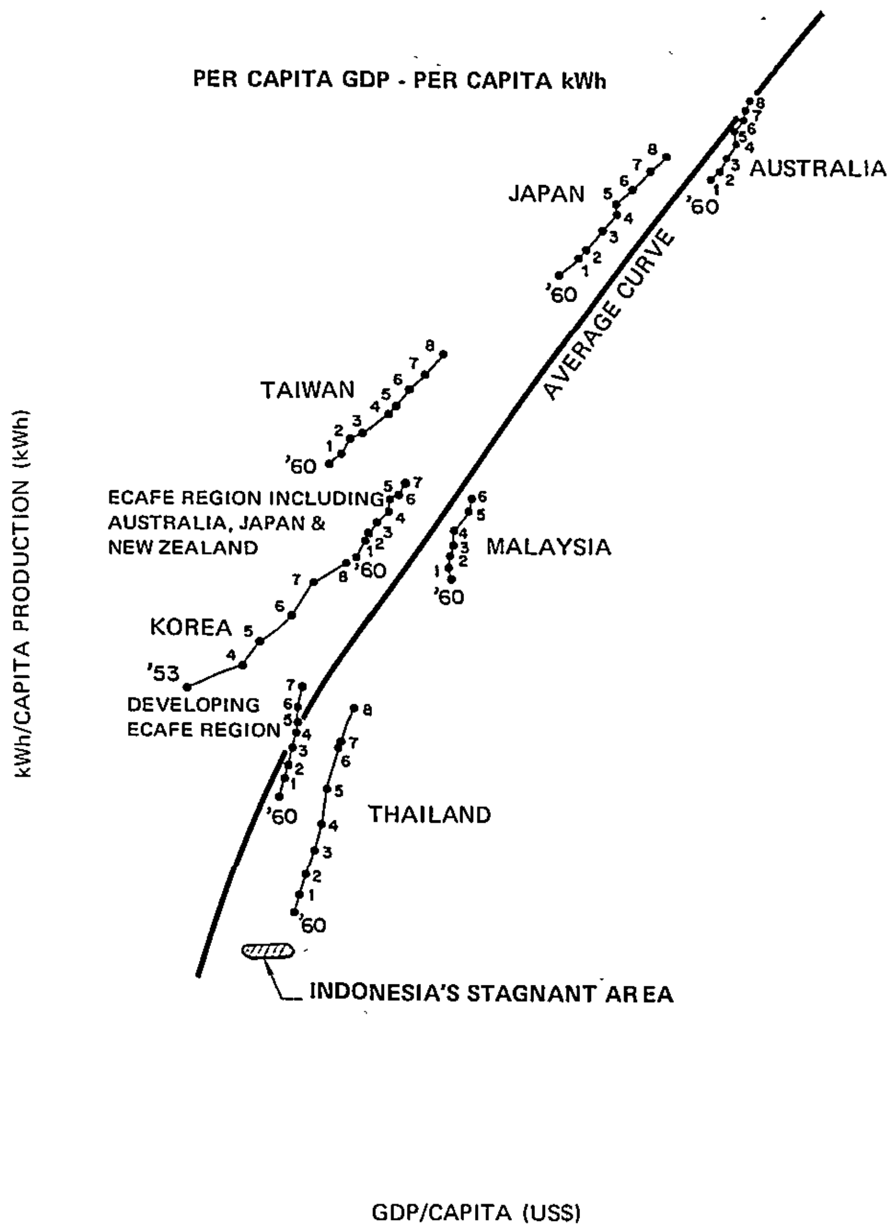
Table VIII-5. GROWTH RATE OF ENERGY DEMAND AT GENERATING END

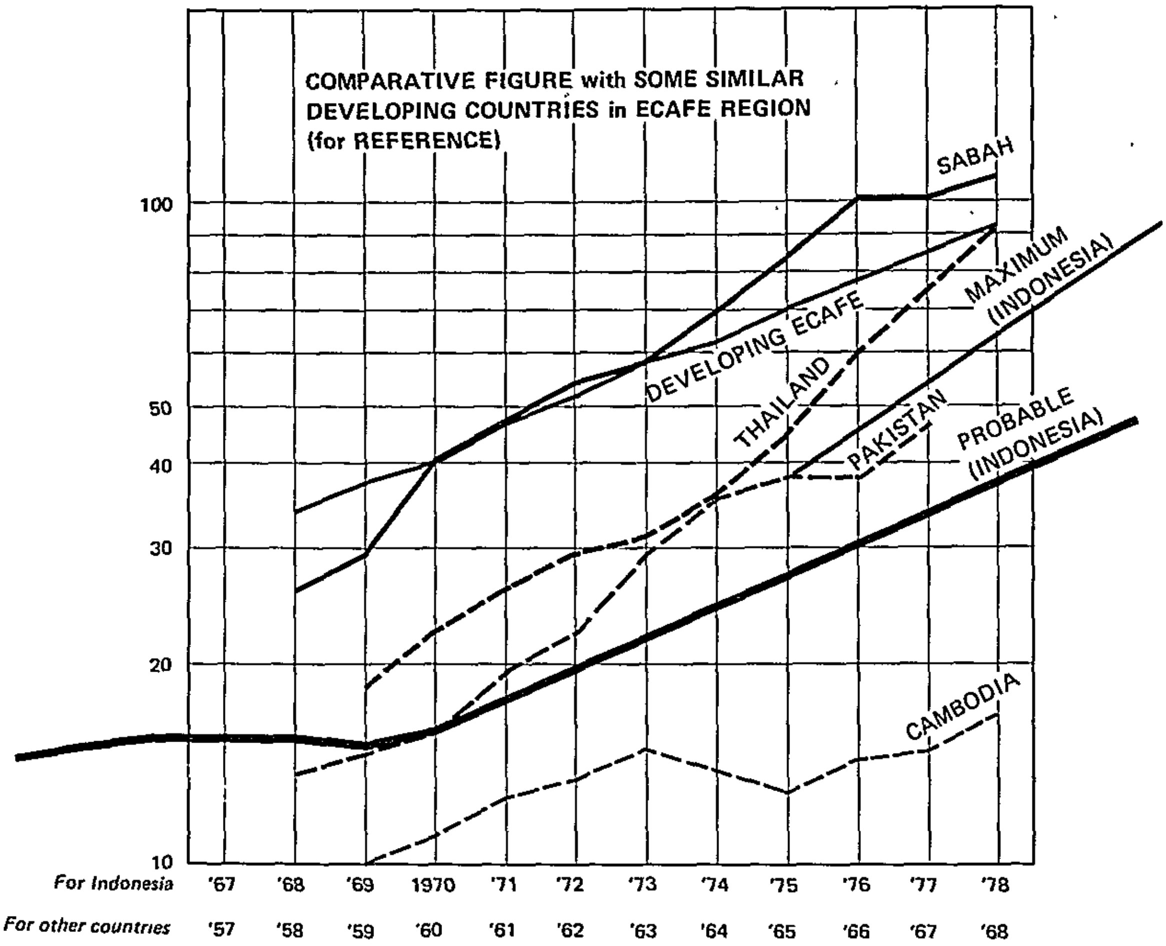
(percent)

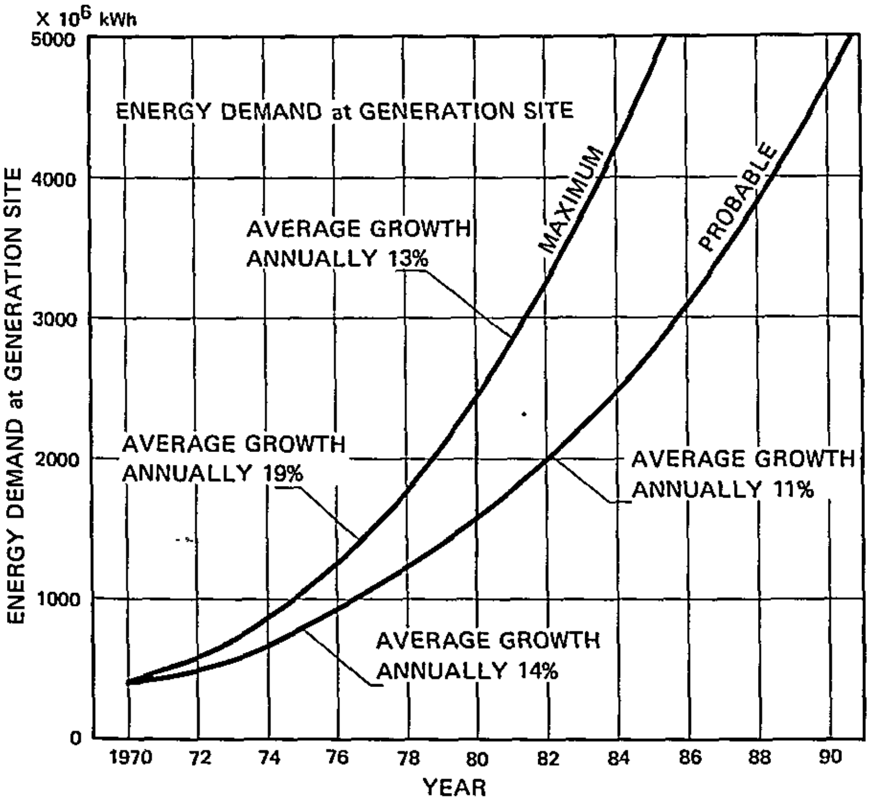
	1971 - 1980	1981 - 1990
Probable	14	11
Maximum	19	13

5. **Conclusion**

If it is expected that the power industry will grow hand in hand with the natioanl economy as a whole, the load forecast should not be smaller than the prospected power demand. If it is smaller, shortage in power supply capability will hamper the growth of economy. Therefore, funds should be raised for the power industry to invest in the expansion and reinforcement of the power supply facilities to meet the load forecast established based on the probable energy demand. For this reason, the *minimum load* prospected in Case B-2 (per capita energy production will not increase until 1974 and start increasing in 1975 following the world trend) should be eliminated from the study in formulating the long-range power development program.




COMPARATIVE FIGURE with SOME SIMILAR DEVELOPING COUNTRIES in ECAFE REGION (for REFERENCE)
SABAH
MAXIMUM (INDONESIA)
DEVELOPING ECAFE
THAILAND
PAKISTAN
PROBABLE (INDONESIA)
CAMBODIA
100
50
40
30
20
10
For Indonesia '67 '68 '69 1970 '71 '72 '73 '74 '75 '76 '77 '78
For other countries '57 '58 '59 '60 '61 '62 '63 '64 '65 '66 '67 '68


X 10^6 kWh
ENERGY DEMAND at GENERATION SITE
MAXIMUM
PROBABLE
AVERAGE GROWTH ANNUALLY 13%
AVERAGE GROWTH ANNUALLY 19%
AVERAGE GROWTH ANNUALLY 11%
AVERAGE GROWTH ANNUALLY 14%
ENERGY DEMAND at GENERATION SITE
5000
4000
3000
2000
1000
0
1970 72 74 76 78 80 82 84 86 88 90
YEAR

IX

LOAD FORECAST BY ANALYTICAL METHOD

1. Relation to Macro Forecast
In formulating the long-range power development program, projection of the future power demand is the basis to determine all others. Therefore the future demand was estimated by analytical approach analyzing each component sector of consumers, i.e., residential, commercial and industrial, in addition to the macro forecast which seized the growth of power demand in the light of probable economic growth. An estimate established based on the two approaches of different direction is believed to have much adequacy. The results obtained through the analytical method was essentially used to set up the expansion program of the power facilities, especially transmission and distribution lines.

2. Presuppositions
Suited in its nature for a short-range forecast, the analytical method was applied for a period of 10 years covering until 1980, and performed on the following presuppositions:

i. The political climate of the Republic will remain stable, and the economy will be rehabilitated and continue to grow steadily.
ii. The power rate, which is of a demand-suppressing nature, will be modified to demand creating type attractive to big consumers.
iii. The present electrification ratio of 4 to 5 percent in East Java will be raised to 20 percent in 1990. (This means that 13 percent in 1980 is necessary to raise it to the present level of Surabaja and its vicinities in 1990.)

If the above presuppositions are not fulfilled, the projection will, needless to say, be fallible. Presupposition (i) is judged reasonable from the present political situation. A French team is working on the renovation of power rate schedule, and is expected to advise a schedule with the same target of presupposition (ii) and gradual steps in transition. Solely dependent upon the Government and PLN, the achievement of electrification target in presupposition (iii) would involve herculean difficulties in terms of finance and man-power without a powerful and intensive back-up of the Government and volitional execution of PLN. In this respect, the load forecast of the Report imposes a task on the Government and PLN in promoting electrification. However, in view of the administration and policy execution of the present Government, the three presuppositions at the present moment are believed practicable.

The extension program of transmission and distribution facilities now under way schedules the interconnection of Kalikonto system with Madiun system by 1974. The plan proposed in the Report anticipates the interconnected system will incorporate Djember and Bondowoso systems, now isolated respectively depending upon diesel units, in 1975 and Situbondo by 1976. The forecast of the Report is primarily directed to the projects to be completed after 1975 when the 1st stage Karangkates starts commercial operation and East Java system has been established leaving a few small systems isolated. Therefore, the Report in forecasting the demand regards East Java as a territory of integrated East Java system.

3. Method of Forecast
The method of forecast adopted in the report was as follows:

(1) To estimate the population and number of households in the five

areas which has been set up by arranging the 11 distribution branches in East Java,

(2) To obtain kWh requirement of residential sector by multiplying the average usage by the number of customers which was calculated from the presupposed electrification ratio,

(3) To obtain kWh requirement of commercial sector by multiplying the average usage by the number of commercial customers that has been obtained based on the number of residential customers,

(4) To estimate the industrial load by adding prospected load of the big waiting customers to the estimated future load of present customers,

(5) To make two estimates, high and low, for the average usages of residential and commercial sectors and for the big waiting consumers' energy requirement; thereby to understand the effect on the forecast by variation in usages and requirement,

(6) To find the total energy requirement of East Java by aggregating kWh's of sectors and areas, and to estimate energy production requirement at generating end from the estimated system loss, and

(7) To calculate peak demand at generating end based on the assumed annual load factor.

4. Details of Forecast

4-1 Residential Load

Area The 11 branches in East Java were arranged into five areas, in consideration of similarity in terms of location, past trends in load growth, demand structures, sizes of demands, and per customer energy consumption. They are Surabaja, Malang, Pasuruan, Rural-1 and Rural-2 areas (See Table IX-1). Rural-1 includes Kediri, Modjokerto, Madiun and Djember, and Rural-2 encompasses Banjuwangi, Situbondo and Pamekasan. Bodjonegoro which presently stays outside the service territory of Exploitasi IX was considered separately until 1977, and thereafter included in Rural-2.

Population Growth Table IX-2 gives the estimated population by areas in 1970, a total of which equals the population in PLN service territory in East Java. The future population was estimated at an annual growth rate of 2.5 percent. Population growth rate will decline when birth control is generally practiced. However, it was uniformly fixed at 2.5 percent in view of the minor effect to be brought about by the decline; a decline of 0.5 percent will result in a 5 percent decrease in population in 1980. Moreover, birth control program has just been launched, and it is thought to take a long time before the program becomes effective in the Republic.

Size of Household In order to obtain the number of households from the estimated population, a household of residential customer was assumed to comprise 7 persons. The Statistical Yearbook of ECAFE indicated the household size to be 4.7 persons on the average in the years 1964 and 1965. However, in view of the actual situation the size of a residential customer is judged to be 7 persons. The change in household size is generally very gradual. Therefore, it is assumed to be static for the period of ten years.

Table IX-1 ELECTRIC SITUATION IN EACH BRANCH (1970)

	Contracted kVA				Contracted VA/Customer				kWh/Customer			
	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total
Surabaja	40,830	26,000	6,500	73,300	510	29,400	1,620	865	1,560	27,300	2,870	1,880
Malang	13,420	6,470	1,750	21,640	365	26,000	1,420	565	1,160	23,610	1,950	1,340
Pasuruan	4,670	7,610	670	12,950	300	65,500	1,260	800	1,220	135,000	1,720	2,200
Rural - 1												
Kediri	3,790	2,920	1,030	7,740	240	23,000	1,020	460	970	28,200	1,500	1,200
Modjokerto	1,580	800	410	2,790	220	8,100	1,040	370	935	10,200	1,620	1,100
Madiun	3,580	2,600	650	6,810	220	54,000	1,060	410	960	51,600	1,260	1,120
Djember	3,360	610	800	4,770	340	17,300	1,380	450	1,050	16,800	1,730	1,150
Rural - 2												
Banjuwangi	1,110	600	270	1,980	190	42,900	1,370	330	760	44,100	2,060	900
Situbondo	570	150	130	840	200	18,200	1,100	290	900	18,900	1,350	970
Pamekasan	1,430	160	210	1,800	200	11,100	1,020	250	850	8,200	1,730	890
East Java	74,300	47,900	12,400	134,600	380	31,300	1,400	650	1,250	35,200	2,210	1,550

Table IX-2 ESTIMATED POPULATION GROWTH

(thousand)

	1970	1975	1980
Surabaja	2,731	3,090	3,495
Malang	2,160	2,431	2,750
Pasuruan	1,869	2,115	2,393
Rural - 1	12,900	14,660	16,590
Rural - 2†	4,500	5,085	5,615
Total	24,160	27,381	30,843

† Population in the Bodjonegoro area is excluded.

Customer Classification In the Report, PLN power rate schedule which consists of 12 classifications of customers (See VII. 4. Power Rate Structure) was followed in classifying the customers as shown below.

Residential	:	S-1, S-2, R-1, R-2, U-1, U-2 and U-3
Commercial	:	K-1, K-2 and K-3
Industrial	:	P and Ch

U tariff customers, or the government offices, were included in the residential sector.

Electrification Ratio The electrification ratio herein referred means the ratio of the number of households served by PLN to the total households in PLN service territory. In order to raise the average electrification ratio of East Java to 13 percent in 1980, customers should be increased in the residential sector at a rate exceeding 2.5 percent for it is the rate of population growth, which, because of the large number of population of East Java, will require strenuous effort of the Government and PLN.

The electrification program at the electrification ratio of 13 percent is shown in Table IX-3.

Table IX-3 PROPOSED ELECTRIFICATION SCHEDULE

(percent)

	1970	1972	1974	1976	1978	1980
Surabaja	20.5	21.5	24	26	28	30
Malang	12	13	14.5	16.5	18.5	20.5
Pasuruan	5.8	6.8	9	11	13	15
Rural - 1	2.7	3.5	5	7	9	11
Rural - 2	2.5	3.5	5	7	9	11
East Java	5.0	6.0	7.5	9.3	11.2	13.0

In consideration of the present small power supply capability, the electrification was assumed to progress a little until 1973, and after that the number of households to be electrified will increase progressibly since the 1st Stage Karangkates will start operation in 1974.

Studies were also made with the target 1980 electrification ratios of 10 percent and 15 percent in order to understand the effect to be brought about by the change in annual electrification ratio to the concurrent future load (See Table IX-4).

Table IX-4 ALTERNATIVE ELECTRIFICATION SCHEDULE

(percent)

	1970	1972	1974	1976	1978	1980
Surabaja	20.5	21.0	22.0	24.0	26.0	28.0
	20.5	21.5	24.0	27.0	29.0	32.0
Malang	12.0	13.0	14.0	15.0	17.0	19.0
	12.0	13.0	14.5	17.5	20.5	24.0
Pasuruan	5.8	6.3	7.3	8.6	10.2	12.0
	5.8	6.8	9.0	12.0	15.0	18.0
Rural - 1	2.7	3.0	4.0	5.1	6.3	7.5
	2.7	3.5	5.0	7.6	10.2	13.0
Rural - 2	2.5	3.0	4.0	5.1	6.4	8.0
	2.5	3.5	5.0	7.6	10.2	13.0
East Java	5.0	5.6	6.5	7.6	9.0	10.0
	5.0	6.0	7.5	10.0	12.4	15.0

10% Electrification in 1980.
15% Electrification in 1980.

Number of Residential Customer

The number of residential customers in the future is obtainable from the number of households estimated in the foregoing and electrification ratio.

To see the past record since 1965, the increase in the number of customers, although steady, has been on a par with the increase in population, with a constant electrification ratio. According to the electrification program established in the Report, it should be increased at an annual rate of 6.5 percent in Surabaja area where the electrification is relatively high, and 18 percent in Rural areas, retarded in electrification.

Table IX-5 NUMBER OF RESIDENTIAL CUSTOMER

(thousand)

	1970	1972	1974	1976	1978	1980
Surabaja	80.0	88.1	103.3	117.6	133.0	149.7
Malang	36.7	41.9	49.1	58.7	69.2	80.5
Pasuruan	15.6	19.1	26.5	34.1	42.1	51.3
Rural - 1	48.9	68.1	102.2	150.2	203.0	260.6
Rural - 2	15.7	23.6	35.4	52.1	70.4	90.4
East Java	196.9	240.8	316.5	412.7	517.7	632.5

Average Residential Use per Customer

The average energy consumption per residential customer by area is shown below.

Table IX-6 AVERAGE RESIDENTIAL USE PER CUSTOMER

(kWh)

	1965	1968	1970	Average annual percent increase Actual (%)	Future (%)
Surabaja	1,300	1,270	1,560	3.8	3.8
Malang	790	905	1,160	8.0	5.5
Pasuruan	650	965	1,220	13.4	5.5
Rural - 1	720	800	980	6.3	5.0
Rural - 2	650	650	825	4.9	4.0
East Java	975	1,010	1,250	5.1	

The past increase in energy consumption is outstanding in Malang and Pasuruan. In the forecast, however, it is estimated to increase at the rates shown to the right in Table IX-4.

The energy consumption per new customer in a district where PLN service has not reached is expected to be considerably small as compared with the then probable energy consumption per customer of a district receiving energy from PLN today. Consequently, the increase in energy consumption per customer is estimated to be lowered on the average. Therefore, the estimate of per customer energy consumption was made in two ways; one on the assumption that the present per customer energy consumption on the average will remain the same into the future, and the other to increase at the present rate of growth in per customer energy consumption.

4-2 Commercial Load

Number of Commercial Customer

The ratio of the number of commercial customers as against the number of residential customers has been almost stable in each area.

Table IX-7 RATIO OF COMMERCIAL CUSTOMERS TO RESIDENTIAL CUSTOMERS

	1965	1967	1968	1970	Used for forecast
Surabaja	0.063	0.059	0.051	0.05	0.05
Malang	0.038	0.035	0.032	0.033	0.035
Pasuruan	0.049	0.037	0.032	0.034	0.035
Rural - 1	0.062	0.054	0.051	0.051	0.05
Rural - 2	0.031	0.027	0.048	0.033	0.035

The past ratios were thought to remain the same into the future, therefore, the number of commercial customers was obtained from the number of residential customers.

Average Commercial Use per Customer

The per customer energy consumption in the commercial sector had decreased from 2,770 kWh in 1965 to 2,210 kWh in 1970. This is believed due to the stagnant economic activities and the change in classification of customers made in line with the modification of power rate schedule. In 1970, however, it had increased by 2 percent over the previous year. Therefore, as in the case of residential customers, the per customer energy consumption in commercial sector was estimated in two ways; one to increase at the rate of 2 percent and the other to remain the same as that of 1970.

4-3 Industrial Load

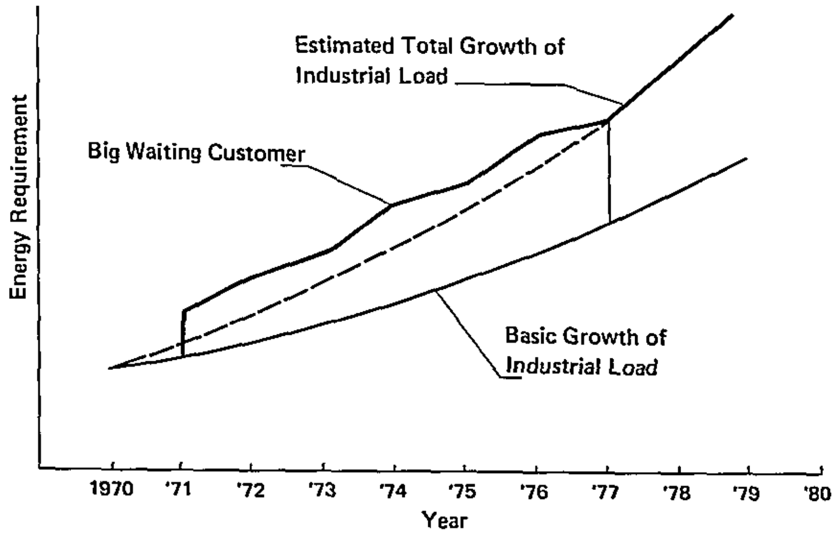
Basic Considerations

The industrial load in the future was estimated as a sum of the prospected loads of existing customers and new small scale customers described hereinunder and of big waiting customers of more than 20 kVA in contract capacity.

As described in the later paragraph "Industrial Consumption", the industrial load had increased by 7 percent from 1968 to 1969 and 33 percent from 1969 to 1970. This implies that the increase in that period included addition of new customers who had up till then been listed among waiting customers. In the present load forecast, such addition of waiting customers in the future was considered separately from the increase in demand of existing customers, which was estimated based on the past trend taking into account the prospected future economy of the area.

The timing of additions to the load of big waiting customers, who have applied in writing to PLN for power supply, was scheduled according to the current progressing stages of factory construction. However, it is also conceivable that some of the big waiting customers would cancel their applications or put off receipt of power considerably behind the schedule. In addition, the plant factor is usually low at the initial stage of operation. Therefore, two estimates were prepared; one is the forecast with one half of the increase of the other in which the big waiting customers are to be included in the load as first scheduled according to the present situation of waiting customers. No big waiting customers being in Rural-2, the rate of increase in demand of existing customers in the area was estimated for two cases; the low probable and the high probable.

All the present big waiting customers as registered with PLN will start receiving PLN power by 1974 according to the customer's schedule and by 1979 to the schedule established based on the present situation of waiting customers. However, new applications for power supply are expected to follow in the years to come maintaining the increase at the same rate of growth.



The past trend in PLN energy consumption by industries is shown below. *Industrial Consumption*

Table IX-8 ENERGY CONSUMPTION BY INDUSTRIAL CUSTOMER

(million kWh)

	1965	1966	1967	1968	1969	1970	Percent increase 1969/1970
Surabaja	25.4	25.4	24.6	23.0	21.2	24.2	14
Malang	1.8	1.9	3.1	4.3	5.0	5.9	18
Pasuruan	9.4	9.4	6.8	5.5	7.3	15.8	116
Rural - 1	5.6	6.5	4.4	4.6	6.4	7.6	19
Rural - 2	0.8	0.44	0.44	0.69	0.71	0.89	25
East Java	44.0	43.6	39.3	38.0	40.7	54.3	33

Reflecting the stagnant economy in the past, the energy consumption tended to decrease during the period of 1965 to 1968, and started increasing in 1969, along with the recovery of economic activities, by 7 percent over

1968. In 1970, the rate of annual increase reached 33 percent, attributable primarily to the large increment in Pasuruan, as well as the increases in Surabaja and Malang, respectively 13 percent and 18 percent. All these prove that the economy has become active in the recent years.

The per customer energy consumption in industrial sector is shown below.

Table IX-9 ENERGY CONSUMPTION PER INDUSTRIAL CUSTOMER

(Thousand)

	1965	1966	1967	1968	1969	1970
Surabaja	39.0	47.2	45.0	37.0	25.2	27.3
Malang	5.0	89.0	23.9	22.0	20.2	23.6
Pasuruan	120.0	96.5	66.0	52.0	64.5	135.0
Rural - 1	12.3	70.5	38.0	21.3	26.2	24.8
Rural - 2	18.3	59.5	27.4	28.2	24.1	24.6
East Java	26.7	57.5	44.0	32.7	27.6	35.2

There can be seen a big fluctuation in per customer energy consumption in some areas and years, but generally tended to increase from 1968 or 1969 to the present.

Upon these considerations, the annual growth rate of industrial load exclusive of the big waiting customers was estimated by the area shown in the following table.

Table IX-10 BASIC GROWTH RATE OF INDUSTRIAL LOAD

	Percent increase
Surabaja	10
Malang	10
Pasuruan	15
Rural - 1	20
Rural - 2	15 and 25

In the above, undervalued estimates were adopted, for they will have to cover a long period.

Big Waiting Customer

In the service territory of PLN Exploitasi IX there are 36 big waiting customers of more than 200 kVA in contract capacity as of September 1971, totaling over 100 MVA. Some of them are new customers, and the others are existing and applying for additions of contract capacity. However, the small margin of power supply capability, which will continue till completion of Karangkates 1st stage, and the insufficient transmission and distribution facilities hinder immediate power supply to these waiting customers. Large in demand, the big waiting customers, so designated by PLN, cast a trend to some extent in the future expansion program of power supply facilities. Further, the timing and size of power requirements of big waiting customers are foreseeable. Therefore, the big waiting customers were considered separately in forecasting the future industrial load.

The timing of power requirement of each customer was projected as shown in Table IX-11 based on the present situation of the customer. Generally, expansion of a factory will be decided looking into the business results

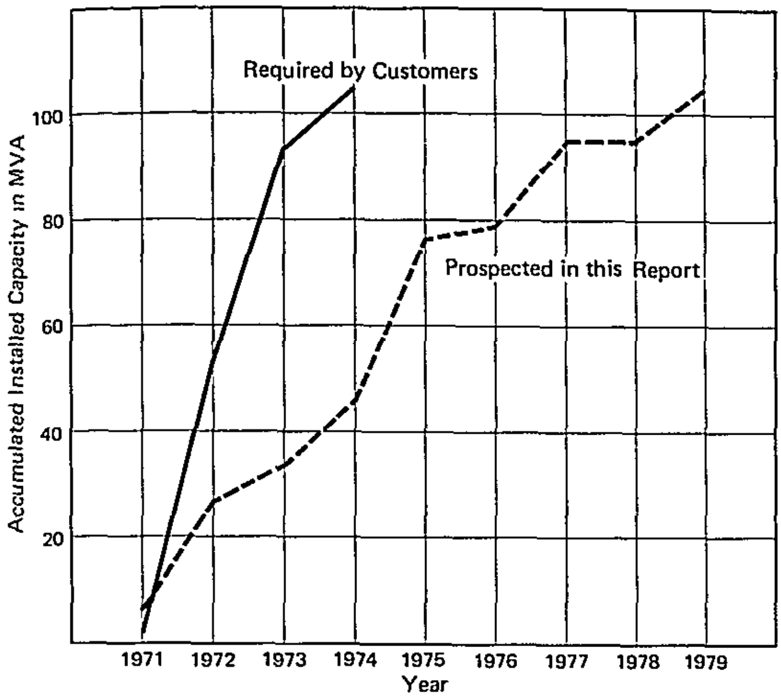


Fig. IX-1 INSTALLATION SCHEDULE OF BIG WAITING CUSTOMER

for at least one year after its first foundation, and much careful analysis will be required if it is a steel mill which requires a large capital investment. These are duly taken into consideration in projecting the timing of power requirement regardless of the dates requested in the applications. Figure IX-1 shows the difference between customer's application and our projection. Table IX-12 gives the yearly projection by the area.

The load factors and demand factors of the present big customers of PLN were made known by PLN to be respectively 0.35 and 0.68 on the average. Therefore, with a diversity factor of 1.35 in the industrial sector, the peak demand and energy requirement could be obtained as shown in Table IX-12. From the peak demand and energy requirement thus obtained, an alternative estimate was calculated as a low estimate in consideration of the probable retardation in actual power requirement of the big waiting customers described under *Basic Considerations.*

Privately Owned Generating Facilities

There are many factories that have their own generating facilities. This is attributable to the unreliable power supply due to shortage in power supply capability of PLN and the high industrial power rate which is higher than residential rate, as well as the high peak hour rate which, applied to the industrial sector, is over three times of off-peak hour rate.

The generating capacities of factories in East Java total 70 MW approximately, and if prime power replaceable by electricity is included it would amount to 174,000 HP. The distribution of such generating facilities is shown by area in Fig. IX-2. These generating facilities are mostly small in capacity and old. Tentative calculation gave the cost of a 200 kVA diesel unit as shown in Table IX-3.

The interest rate was assumed to be 10 percent per annum and the fuel to be high speed diesel. Fuel A represents fuel oil of Rp 12.75 (30.8 mills)

Table IX-11 LIST OF BIG WAITING CUSTOMERS

No.	Branch	Customer	Products	Capacity kVA †	Present status ††	Year of power supply Required	Estimated
1.	Pasuruan	Paper factory Letjes	Paper	+ 2,500	N	1972	1975
2.	Malang	Textile factory Kamadjaja	Cotton sheet	+ 700	N	1972	1974
3.	Modjokerto	Chemical factory Ajinomoto	Food	500	Y	1972	1972
				+ 1,000		1973	1973
				+ 1,000		1973	1974
4.	Surabaja	Cement factory Gresik	Cement	5,000	Y	1972	1971
				+ 10,000		1972	1972
5.	"	Abattoir Rungkut	Meat	300	Y	1972	1973
6.	"	T.L. factory Philips	Tube lamp	+ 500	N	1972	1975
7.	"	Airport Djuanda		1,500	Y	1972	1972
				+ 1,000		1973	1973
8.	"	Steel plant Saripanah	Steel	4,000	N	1973	1975
				+ 5,000		1973	1977
9.	"	Steel plant Barata	Steel	3,000	N	1972	1975
				+ 5,000		1973	1977
				+ 6,000		1974	1979
10.	"	Rolling mill Marubeni	Steel	5,000	N	1972	1975
				+ 5,000		1973	1977
				+ 5,000		1974	1979
11.	"	Pump factory Indra	Pump	+ 400	N	1972	1975
12.	"	Diesel factory Indra	Diesel	600	N	1972	1975
				+ 1,000		1973	1976
				+ 1,000		1973	1977
13.	"	Workshop Bisma		+ 500	Y	1972	1972
14.	"	Pelleting factory Peter Cremer	Cattle food	400	Y	1972	1972
15.	"	T.V. station Gunungsari		+ 650	N	1972	1975
16.	"	Glass factory Iglas	Glass	+ 200	Y	1972	1972
17.	Surabaja	Hotel Mirama		1,000	Y	1972	1973

No.	Branch	Customer	Products	Capacity kVA †	Present status ††	Year of power supply Required	Estimated
18.	"	Milk factory Nestle	Milk	400 + 400	Y	1972 1972	1972 1973
19.	"	Powder factory Asia Djaja	Food	1,500	N	1972	1974
20.	"	Carbide factory Afro-Asia	Carbide	3,000	N	1972	1975
21.	"	Steel workshop Warudjaja	Steel	500	N	1972	1974
22.	"	Bank Indonesia		1,000	Y	1972	1972
23.	"	Soda Waru	Soda	5,000	Y	1972	1972
24.	"	Steel plant Itoh	Steel	8,000	N	1973	1975
25.	"	Cattle fodder Japfa	Cattle food	1,100	N	1972	1974
26.	"	Public telephone center Perak		400	Y	1972	1972
27.	"	Beer factory Bintang	Beer	+ 1,000	Y	1972	1972
28.	"	Sandal factory Daimatsu	Sandal	500 + 500	Y	1971 1972	1971 1972
29.	"	Shipyard Gresik	Ship	2,000 + 2,000	N	1972 1973	1975 1976
30.	"	Can factory Rungkut	Can	300	N	1972	1974
31.	"	Aluminium ware Logam Djawa	Al. ware	400 + 1,600	Y	1971 1972	1972 1974
32.	"	Pump station Petrokimia		1,500	Y	1972	1972
33.	"	Pharmaceutical factory ICI	Medicine	350	N	1972	1972
34.	Malang	Textile factory Patal Lawang	Cotton sheet	4,000	N	1973	1974
35.	Pasuruan	Textile factory Grati	Cotton sheet	2,000	N	1973	1974
36.	Surabaja	Hotel Modjopahit		300	Y	1971	1971
			Total	105,500			

† + means expansion program
†† Y: under construction N: not yet started

Table IX-12 PEAK AND ENERGY DEMAND OF BIG WAITING CUSTOMER

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
Surabaja												
Required capacity	(kVA)	5,800	23,150	2,700	5,000	27,150	3,000	16,000	–	11,000	–	93,800
Accumulated total	(kVA)	5,800	28,950	31,650	36,650	63,800	66,800	82,800	82,800	93,800	–	
Peak demand	(kW)	2,900	14,500	15,800	18,300	31,900	33,400	41,400	41,400	46,900	–	
Energy requirement	(thousand kWh)	8,890	44,380	48,520	56,190	97,810	102,390	126,910	126,910	143,770	–	
Malang												
Required capacity	(kVA)	–	–	–	4,700	–	–	–	–	–	–	4,700
Accumulated total	(kVA)	–	–	–	4,700	–	–	–	–	–	–	
Peak demand	(kW)	–	–	–	2,350	–	–	–	–	–	–	
Energy requirement	(thousand kWh)	–	–	–	7,210	–	–	–	–	–	–	
Pasuruan												
Required capacity	(kVA)	–	–	–	–	2,000	2,500	–	–	–	–	4,500
Accumulated total	(kVA)	–	–	–	–	2,000	4,500	–	–	–	–	
Peak demand	(kW)	–	–	–	–	1,000	2,250	–	–	–	–	
Energy requirement	(thousand kWh)	–	–	–	–	3,070	6,900	–	–	–	–	
East Java												
Required capacity	(kVA)	5,800	23,650	3,700	12,700	29,650	3,000	16,000	–	11,000	–	105,500
Accumulated total	(kVA)	5,800	29,450	33,150	45,850	75,500	78,500	94,500	94,500	105,500	–	

1) Peak Demand = Required Capacity $\times \frac{\text{Demand Factor}}{\text{Diversity Factor}}$

2) $\frac{\text{Demand Factor}}{\text{Diversity Factor}} = \frac{0.68}{1.35} = 0.5$

3) Load Factor = 0.35

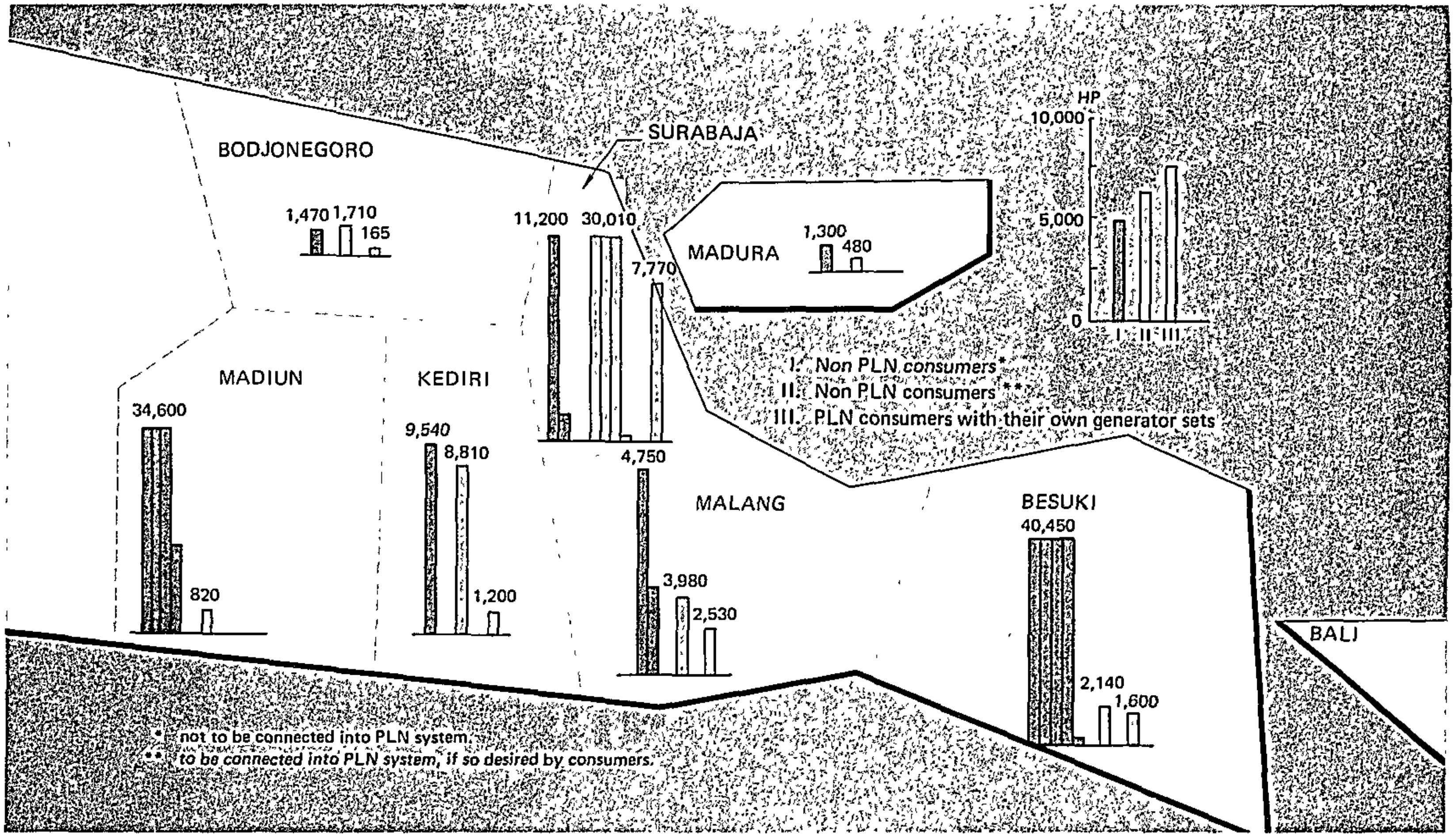


Fig. IX-2 DISTRIBUTION OF PRIVATELY OWNED POWER FACILITIES per liter available in Surabaja and Fuel B Rp 14.50 (35 mills) per liter which is the price at locations far from Surabaja.

Table IX-13 GENERATING COST OF DIESEL POWER PLANT

(mill/kWh)

		Fuel A	Fuel B
Plant factor	30 %	36.4	37.6
"	50 %	25.5	26.7

The average receipt of PLN from industrial sector is Rp 7.69 (18.5 mills) per kWh which is not expensive for the industrial customers. Of the above power cost, 50 percent is fixed cost at a 30 percent plant factor and it is 40 percent at a 50 percent plant factor. Even if its fixed cost is neglected, PLN power is advantageous compared with the fuel cost only. Therefore, it is readily conceivable that the enterprises presently operating with their own generating units will receive power positively from PLN creating large demand in the future when PLN system is reinforced with reliable power supply capability and the power rate is revised. However, since most of these industries, as shown in Fig. IX-2, are located at places where PLN system has not reached, it will take a long time before such industries can enjoy power supply from PLN. Within a reach of PLN system there is a total of 25 MW capacity owned by enterprises most of which, however, have already been registered with PLN as big waiting customers. Therefore, to avoid duplicated counting, these privately owned capacities were not considered as potential demand. But, in estimating the load growth rate, due consideration was given to them.

4-4 Load Factor and Loss Factor

Load Factor As described in *Daily Load Curve* in VII, the present Kalikonto system is operating at an annual load factor of about 70 percent and a daily load factor of 77 percent approximately. The daily load curve is expected to change its configuration in the future. The ratio of loads among residential, industrial and commerical was estimated to be 65:30:5 in 1980, while it was 77:17:6 in 1970. A large increase is expected in industrial load, which arising in the daytime will help raise the load factor of the system, the present peak being in the evening. If the penalty, or block rate, which is restraining peak demand is lifted, peak load will tend to increase, reducing the load factor. However, since most of the working hours of factories are in the daytime, the rise in peak load is considered small. On the other hand, the flat-and-meter rate expected to be applied for new residential customers and the transfer from the flat rate presently applied to the residential customers to the flat-and-meter rate will serve to lower the wasted midnight load, thereby, in combination with the generalization of home electric appliances, to reduce the load factor as a whole. Of these two tendencies pointing to the opposite directions, there is much weight in the increase of anticipated industrial load which will surpass the other loads. However, it is hard to project the general tendency exactly at the present stage. In establishing an implementation plan, the lower load factor gives a safe parameter. In the Report, it is projected that the present 70 percent annual load factor will continue into the future.

Combined Loss Factor The total of station service use at power stations and substations and of loss in transmission and distribution are very large in East Java as shown in Table IX-14.

Table IX-14 COMBINED LOSS FACTOR

(percent)

	1965	1966	1967	1968	1969	1970
Kalikonto system	23.9	23.2	28.5	30.9	26.3	24.9
East Java	20.3	22.6	28.8	28.8	24.8	23.6

As can be seen from the above, a quarter of the energy produced does not reach the consumers. Of the loss of 26.3 percent in 1969, 6.4 percent was transmission loss plus station service energy and the remaining 20 percent was distribution loss which was extremely large. As the rehabilitation of transmission and distribution facilities progress together with their expansion and if the implementation program prepared in the Report is materialized as proposed, the system loss will decrease especially in distribution systems. Therefore, it was assumed that the decrease in loss would be linear from 23.6 percent in 1970 to 18 percent in 1980 as indicated in Table IX-19.

5. Result of Forecast

Result of Forecast

The forecast obtained in the manner described in the foregoing is summarized in Table IX-15 and Fig. IX-3. The low forecast is a sum of the lower estimates made for the respective sectors, and the high forecast equals a total of the higher estimates. The actual load is expected to take place somewhere in between the low and the high.

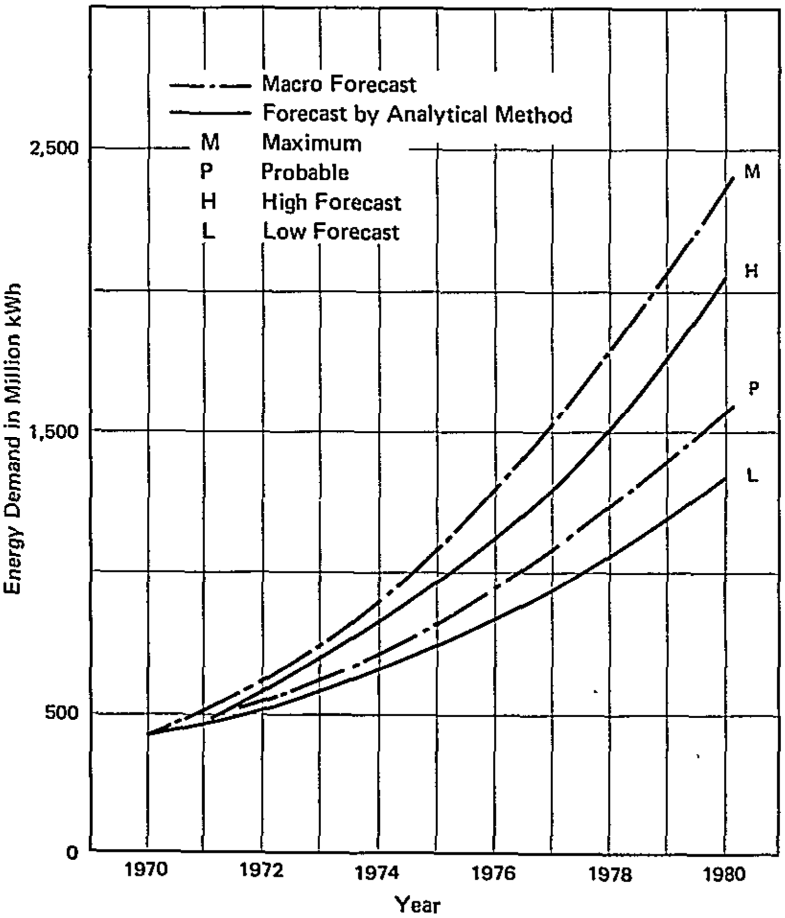


Fig. IX-3 COMPARISON OF LOAD FORECAST

The energy requirement in 1980 will be between 3.2 and 4.9 times of the present, which means an annual growth rate in the range of 12.2 to 17.2 percent. Per capita energy production will be somewhere between 39 and 60 kWh. In contemplating the implementation program, the mean value of the low and high forecasts was adopted leaving the low and high as reference values. According to the mean value, the annual energy production in 1980 will be 4.1 times of the present with an annual growth rate of 15 percent, and the per capita energy production 50 kWh.

Table IX-15 SUMMARY OF FORECAST

	1970	1975	1980	Average annual growth rate (%)
Low forecast				
Energy requirement (million kWh)	420	785	1,350	12.2
Peak demand (MW)	69	130	220	
High forecast				
Energy requirement (million kWh)	420	1,000	2,060	17.2
Peak demand (MW)	69	160	340	

Note: For details see Table IX-19 and IX-20.

Table IX-16 SUMMARY OF PROBABLE FORECAST

	1970	1975	1980	Average annual growth rate (%)
Energy requirement (million kWh)	420	890	1,720	15
Peak demand (MW)	69	145	280	15

Note: For details see Table IX-21.

Comparison with Macro Forecast

The long-range forecast established in VIII. Long-Range Demand Forecast is summerized in the following table.

Table IX-17 SUMMARY OF MACRO FORECAST

(million kWh)

	1980	1990	Average annual growth rate (%) 1971-1980	1981-1990
Probable	1,590	4,640	14	11
Maximum	2,420	840	19	13

The load growth of macro forecast is 14 percent at probable and 19 percent at maximum for the years of 1971 to 1980, which are larger than the result of the analytical approach by 2 percent in both probable and maximum values.

This gives ground to conclude that the expansion program of power facilities presupposed in the analytical approach is moderate for the country pursuing a normal economic development.

Forecast with Variable Electrification Ratio

Population and number of households in 1980 in East Java are estimated to be 34 million and 4.85 million, respectively. The variation in electrification ratio by 2 percent in 1980 equals to 100 thousand households in number.

In East Java system, residential sector is quite large. Therefore, the variation in electrification ratio will bring a large effect on the load forecast. A study was made for the cases in which the electrification will have achieved 10 percent and 15 percent in 1980 with the industrial load growth same as that in the foregoing studies.

Table IX-18 EFFECT OF ELECTRIFICATION

(million kWh)

		1975	1980	Average annual growth rate (%)
Electrification ratio	10%	790	1,580	13.4
	13	890	1,720	15.0
	15	920	1,880	16.2

The low electrification ratio of 10 percent will result in a reduction of 140 million kWh in energy demand, while the high 15 percent will bring about an increment of 160 million kWh against the 13 percent electrification ratio. Such reduction and increment correspond to 64 percent and 73 percent respectively of the annual increase in energy demand in 1980. This is to say the implementation program established based on the electrification ratio of 13 percent in 1980 will have to be advanced or postponed by about 8 months in both cases.

Table IX-19 **RESULT OF LOAD FORECAST**
13% electrification in 1980

(million kWh)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Low forecast											
Surabaja	160.5	174.1	201.5	213.8	239.5	275.8	294.5	311.7	346.8	387.6	434.5
Malang	50.9	54.9	58.8	63.1	66.7	80.2	87.4	95.0	104.1	113.7	123.9
Pasuruan	35.7	40.2	45.4	50.8	61.5	70.8	83.6	94.3	107.0	121.3	137.2
Rural - 1	59.4	69.2	83.1	98.4	125.5	153.2	183.0	214.7	249.1	286.2	326.1
Rural - 2	14.8	18.6	22.3	25.9	33.1	40.7	48.4	56.7	65.4	74.6	84.1
Total energy requirement at customer	321.3	357.0	411.1	452.0	526.3	620.7	696.9	772.4	872.4	983.4	1105.8
Loss factor (%)	23.6	23.0	22.4	22.0	21.4	20.8	20.2	19.7	19.2	18.6	18.0
Required energy production	420.5	463.6	529.8	579.5	669.6	783.7	873.3	961.9	1079.7	1208.1	1348.5
Peak demand (MW) †	68.6	75.6	86.4	94.5	109.2	127.8	142.4	156.9	176.1	197.0	219.9
High forecast											
Surabaja	160.5	183.7	234.9	255.5	294.8	361.6	393.3	424.3	496.9	578.9	683.9
Malang	50.9	57.2	64.4	72.3	90.5	103.1	116.9	132.6	152.1	173.6	198.0
Pasuruan	35.7	41.4	47.9	55.2	69.1	84.5	102.6	118.6	139.2	162.5	188.9
Rural - 1	59.4	72.1	90.5	111.8	149.4	189.9	235.8	288.8	347.8	415.7	494.4
Rural - 2	14.8	19.2	24.0	29.3	39.0	49.4	61.4	74.7	89.6	106.0	125.1
Total energy requirement at customer	321.3	373.6	461.7	524.1	642.8	788.5	910.0	1039.0	1225.6	1436.7	1690.3
Loss factor (%)	23.6	23.0	22.4	22.0	21.4	20.8	20.2	19.7	19.2	18.6	18.0
Required energy production	420.5	485	595	672	818	996	1140	1294	1517.0	1765	2061
Peak demand (MW) †	68.6	79.1	97.0	110	133	162	186	211	247	288	336

† Estimated by annual load factor of 70%

Table IX-20 **DETAILS OF LOAD FORECAST (1)**
13% electrification in 1980

(million kWh)

	1970				1971				1972				1973			
	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total
Low forecast																
Surabaja	124.8	24.2	11.5	160.5	130.9	31.1	12.1	174.1	137.4	51.5	12.6	201.5	144.1	56.5	13.2	213.8
Malang	42.6	5.9	2.4	50.9	45.6	6.5	2.8	54.9	48.6	7.1	3.1	58.8	51.7	7.8	3.6	63.1
Pasuruan	19.0	15.8	0.9	35.7	21.0	18.2	1.0	40.2	23.3	20.9	1.2	45.4	25.5	24.0	1.3	50.8
Rural - 1	47.9	7.6	3.9	59.4	55.8	9.1	4.3	69.2	66.7	11.3	5.1	83.1	78.1	14.3	6.0	98.4
Rural - 2	13.0	0.9	0.9	14.8	16.4	1.0	1.2	18.6	19.6	1.2	1.5	22.3	22.9	1.3	1.7	25.9
East Java	247.3	54.4	19.6	321.3	269.7	65.9	21.4	357.0	295.5	92.0	23.5	411.1	322.3	103.9	25.8	452.0
High forecast																
Surabaja	124.8	24.2	11.5	160.5	135.9	35.5	12.3	183.3	148.0	73.7	13.2	234.9	160.8	80.7	14.0	255.5
Malang	42.6	5.9	2.4	50.9	47.9	6.5	2.8	57.2	54.1	7.1	3.2	64.4	60.7	7.8	3.8	72.3
Pasuruan	19.0	15.8	0.9	35.7	22.2	18.2	1.0	41.4	25.8	20.9	1.2	47.9	29.8	24.0	1.4	55.2
Rural - 1	47.9	7.6	3.9	59.4	58.6	9.1	4.4	72.1	73.5	11.7	5.3	90.5	90.1	15.4	6.3	111.8
Rural - 2	13.0	0.9	0.9	14.8	16.9	1.1	1.2	19.2	21.0	1.4	1.6	24.0	25.7	1.7	1.9	29.3
East Java	247.3	54.4	19.6	321.3	281.5	70.4	21.7	373.2	322.4	114.8	24.5	411.7	367.1	129.6	27.4	524.1

Table IX-20 **DETAILS OF LOAD FORECAST (2)**
13% electrification in 1980

(million kWh)

	1974				1975				1976				1977			
	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total
Low forecast																
Surabaja	161.1	63.5	14.9	239.5	172.1	87.9	15.8	275.8	183.5	94.1	16.9	294.5	195.2	98.4	18.1	311.7
Malang	56.9	12.2	4.2	73.3	62.4	13.1	4.7	80.2	68.1	14.0	5.3	87.4	74.0	15.0	6.0	95.0
Pasuruan	32.3	27.6	1.6	61.5	36.8	32.2	1.8	70.8	41.6	40.0	2.0	83.6	46.5	45.5	2.3	94.3
Rural - 1	100.2	17.6	7.7	125.5	123.1	20.7	9.4	153.2	147.2	24.5	11.3	183.0	172.5	29.0	13.2	214.7
Rural - 2	29.4	1.5	2.2	33.1	36.2	1.8	2.7	40.7	43.2	2.0	3.2	48.4	50.6	2.3	3.8	56.7
East Java	122.9	122.4	30.6	532.9	430.6	155.7	34.4	620.7	483.6	174.6	38.7	696.9	538.8	190.2	43.4	772.4
High forecast																
Surabaja	187.0	91.6	16.2	294.8	207.4	136.8	17.4	361.6	229.9	144.3	19.1	393.3	254.0	149.6	20.7	424.3
Malang	70.2	15.8	4.5	90.5	81.2	16.7	5.2	103.1	93.3	17.6	6.0	116.9	107.2	18.6	6.8	132.6
Pasuruan	39.8	27.6	1.7	69.1	47.7	34.8	2.0	84.5	56.9	43.4	2.3	102.6	67.1	48.9	2.6	118.6
Rural - 1	121.6	19.5	8.3	149.4	157.0	22.6	10.3	189.9	196.8	26.4	12.6	235.8	242.9	30.9	15.0	288.8
Rural - 2	34.3	2.2	2.5	39.0	43.6	2.7	3.1	49.4	54.2	3.4	3.8	61.4	65.9	4.2	4.6	74.7
East Java	452.9	156.7	33.2	642.8	536.9	213.6	38.0	788.5	631.1	235.1	43.8	910.0	737.1	252.2	49.7	1,390.0

Table IX-20 DETAILS OF LOAD FORECAST (3)
13% electrification in 1980

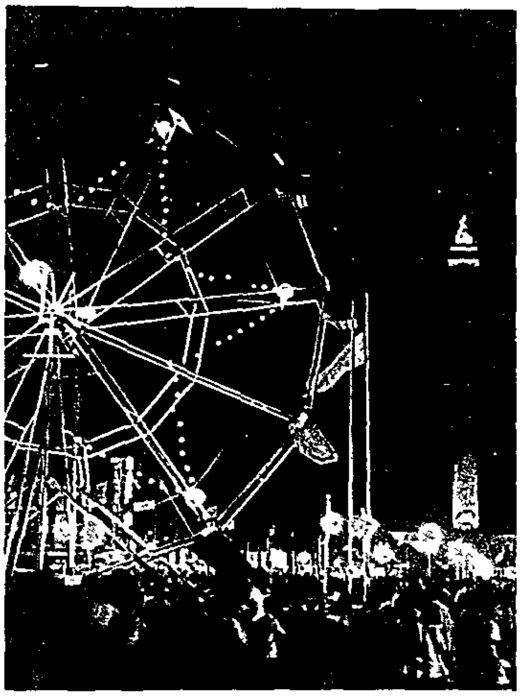
(million kWh)

	1978				1979				1980			
	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total	Residential	Industrial	Commercial	Total
Low forecast												
Surabaja	207.5	120.2	19.1	346.8	220.3	146.9	20.4	387.6	233.5	179.5	21.5	434.5
Malang	80.3	17.2	6.6	104.1	86.7	19.7	7.3	113.7	93.4	22.5	8.0	123.9
Pasuruan	51.6	52.9	2.5	107.0	57.0	61.5	2.8	121.3	62.6	71.5	3.1	137.2
Rural - 1	198.9	35.1	15.3	249.3	226.5	42.3	17.4	286.4	255.4	51.2	19.5	326.1
Rural - 2	58.4	2.7	4.3	65.4	66.6	3.1	4.9	74.6	75.0	3.5	5.6	84.1
East Java	596.7	228.1	47.8	872.6	657.1	273.5	52.8	983.4	719.9	328.2	57.7	1,105.8
High forecast												
Surabaja	280.6	194.0	22.3	496.9	302.9	251.6	24.4	578.9	341.3	326.3	26.3	693.9
Malang	122.5	21.9	7.7	152.1	139.1	25.8	8.7	173.5	157.8	30.4	9.8	198.0
Pasuruan	78.7	57.5	3.0	139.2	91.5	67.6	3.4	162.5	105.7	79.4	3.8	188.9
Rural - 1	292.3	37.8	17.7	347.8	349.0	46.2	20.5	415.7	414.4	56.5	23.5	494.4
Rural - 2	78.8	5.3	5.5	89.6	93.0	6.6	6.4	106.0	109.4	8.2	7.5	125.1
East Java	852.9	316.5	56.2	1,225.6	975.5	397.8	63.4	1,436.6	1,128.6	500.8	70.9	1,700.3

Table IX-21 **PROBABLE LOAD FORECAST**
13% electrification in 1980

(million kWh)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Energy requirement at customer											
Surabaja	160.5	178.9	218.2	234.7	267.2	318.7	343.9	368.0	421.9	483.3	559.2
Malang	50.9	56.1	61.6	67.7	78.6	91.7	102.2	113.8	128.1	143.7	161.0
Pasuruan	35.7	40.8	46.7	53.0	65.3	77.7	93.1	106.5	123.1	141.9	163.1
Rural - 1	59.4	70.7	86.8	105.1	137.5	171.6	209.4	251.8	298.5	351.0	410.3
Rural - 2	14.8	18.9	23.2	27.6	36.1	45.1	54.9	67.9	82.1	97.3	114.3
(Bodjonegoro)								(2.2)	(4.6)	(7.0)	(9.6)
Total	321.3	365.3	436.4	488.1	584.6	704.6	803.5	907.9	1,053.6	1,217.0	1,407.7
Loss factor (%)	23.6	23.0	22.4	22.0	21.4	20.8	20.2	19.7	19.2	18.6	18.0
Required energy production	421	474	562	626	724	890	1,007	1,130	1,304	1,495	1,717
Peak demand (MW)	69	77	92	102	121	145	164	184	213	244	280



X

POWER DEVELOPMENT PROGRAM
with Alternative Studies

1. Policy of Power Development Planning

Power development planning is a study to find the most economical way to develop and utilize available power resources for energy production to meet the load forecast established in VIII and IX of the Report. It includes the determination of the order of priorities of the projects proposed and their timing of implementation. Projects are being implemented to secure power supply capability against the demand until 1975. Therefore, the objective of the Report is for the period from 1975 to 1985.

Economy was primarily sought in the planning. According to the load forecast made in IX. Load Forecast by Analytical Method, the demand in the East Java system will increase at an annual rate of 15 percent. To cope with such growth in demand, the present power supply capability should be multiplied by about 5.5 times including a reserve capacity, which means an addition of 470 MW in installed capacity, and a total capital investment of US$ 180 million including related transmission and distribution facilities. Largely dependent on foreign aid and capital, the Republic should find its way to provide the largest power supply capability at the least cost by effectively utilizing its financial source. In the past, however, economization in this field does not seem to have been exercised to the fullest.

2. Process of Planning

The power development program was planned according to the following steps:

- i. To estimate the power supply requirement based on the estimated demand and the reserve capacity required.
- ii. To evaluate economic feasibility of the respective hydro power projects conceivable within the area. The evaluation was made in terms of benefit-cost-ratio based on an standard thermal plant.
- iii. To study on the conditions of locations, unit sizes and timing of in-service of the conceivable thermal power plants.
- iv. To prepare alternative plans that can secure the power supply requirement by combining hydro and thermal power plants or by arranging only thermal power plants conceived in the above.
- v. To study alternative plans from the technical and economical points of view, and select the most optimum plan. The economic study includes the trend of energy cost of the system in the future in addition to the construction cost.
- vi. To calculate the investment requirements of the selected plan, and prepare the investment program.

Fig. X-1 gives these steps in a schematic diagram.

3. Power Supply Requirement and Demand

3-1 Reserve Capacity

The power supply requirement was assumed to be a sum of the mean value obtained in IX. Load Forecast by Analytical Method and the reserve capacity. A reserve capacity is a reserve for misforecasting of load, possible outage of facilities and decrease in hydro energy production due to drought. In the Report, the reserve was assumed to be 10 percent of the peak load.

So far in East Java, the reserve capacity has been regarded as an equivalent of the maximum unit capacity of the system, which is not agreeable not

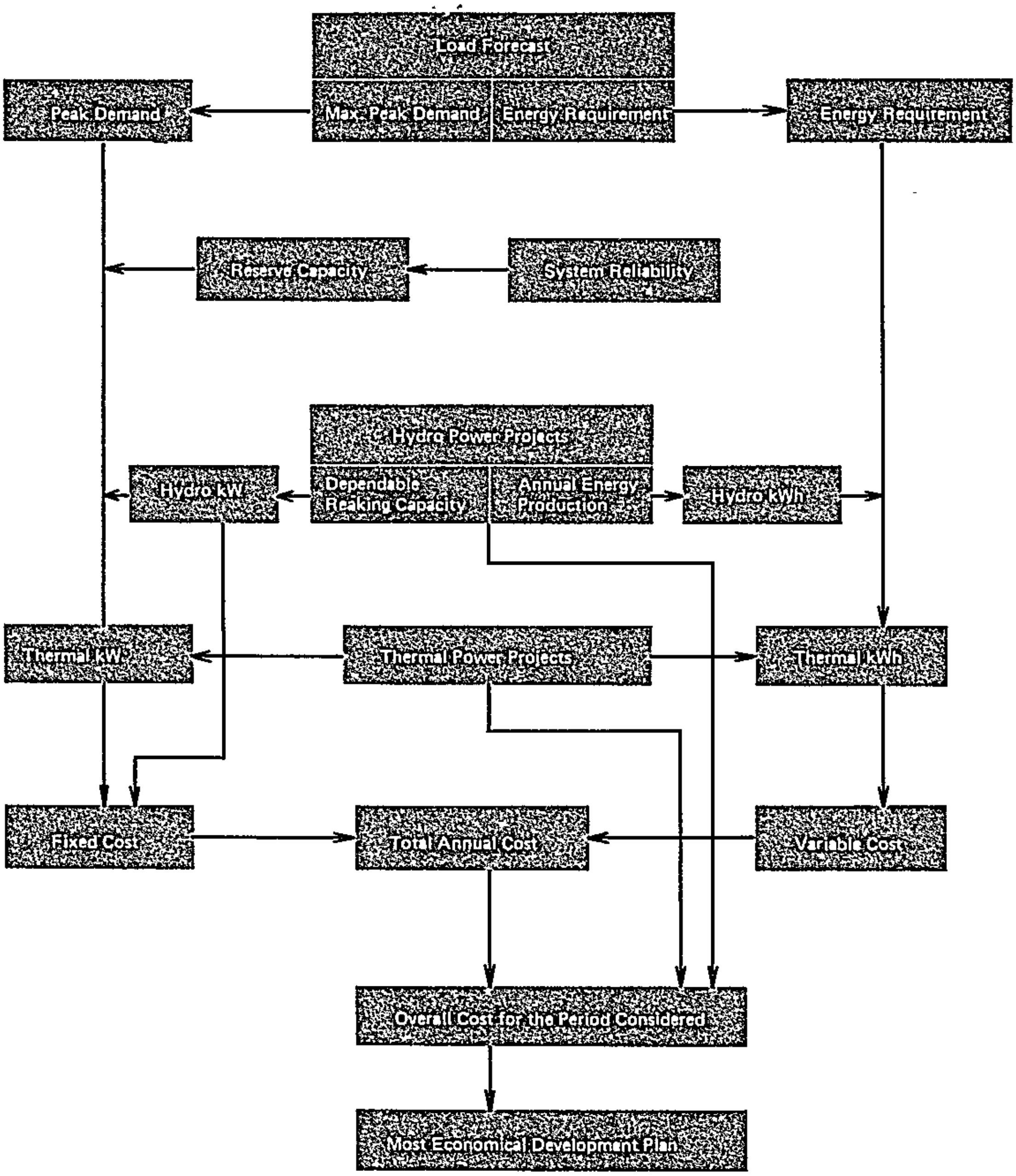


Fig. X-1 SCHEMATIC DIAGRAM OF POWER DEVELOPMENT PROGRAM

Table X-1. REQUIRED DEVELOPMENT CAPACITY

(MW)

	1970	1972	1974	1976	1978	1980	1982	1984	1985
Peak demand	69	92	121	164	213	280	350	440	495
Reserve capacity	7	9	12	16	21	28	35	44	50
Required capacity	76	101	133	180	234	208	385	484	545

only at the present stage but in the foreseeable future.

The power systems in East Java are still small, and their largest thermal unit capacity is 25 MW at Perak. From a small unit capacity as this, the merit of unit capacity can not be expected. Power is costly there. In order to economize the energy, two large capacity units would be required at the same time if the reserve capacity should be equivalent to the maximum capacity unit, with the result that, because of too costly advanced investment, large capacity units can not be installed; the power will remain expensive. A calculation shows that energy cost of a 75 MW capacity unit is 5 percent less than that of a 50 MW capacity unit, and it will be 9 percent when generated by a 125 MW capacity unit. (See tables X-8 and X-9). The problem that PLN should solve now is how to supply less expensive power in abundance. Therefore, economy should not be sacrificed by taking countermeasures against occurence of system outage which is very seldom. The power industry in East Java has not been developed to the stage where protective measures precede. Consequently, it is advisable that all efforts be made by PLN to install larger capacity thermal units in the system.

When a large capacity unit is to be introduced to a small system in which the reserve capacity is 10 percent only, it is necessary to prepare for outage of a large unit by analyzing the possible situations of the system to be incurred by the outage and establishing countermeasures in advance of the installation. If a generator with a capacity equivalent to 20 percent of the system capacity suddenly tripps during full operation, the system frequency will fluctuate exceeding the maximum allowable frequency fluctuation of 2 Hz for thermal power plants, which will result in outage of all the thermal power plants to cause the system to collapse. In East Java, a situation like this is inevitable for the time being. The problems are how often such an outage will occur and how fast the system can be recovered by what measures. No such case has been encountered in Indonesia. In Japan, past record reveals that the annual outage ratio of a 50 to 125 MW class thermal unit is 1.4 percent (outage ratio = outage hours / calendar hours x 100), and the frequency is 4 times a year. Naturally, such figures vary according to the age of a unit and the level of maintenance technic. Although data are not available, it is presumable that a fault entailing serious damages requiring emergency stoppage occurs in less than one out of four. In more than three cases, adequate measures are taken by limiting or cutting the load or by increasing the receipt of power from other sources before the unit in trouble is tripped, thereby saving the system from serious damages.

When the second unit of the same capacity is installed, the situation of system failure will be further improved. Besides, system failure with a frequency of once a year is conceivable from other reasons. If due countermeasures is established, outage of system can be restored in about 30 minutes.

The system can also be protected to some extent by system protective relays if the fault is not very serious. To protect a system, various measures should be taken as described in XI. Transmission and Distribution Development Program.

Regular maintenance of a large capacity thermal unit is possible even in a small system with a 10 percent reserve capacity. According to Plan T-C described hereinafter, the peak demand and the supply capability will be as follows in 1976 when the first 50 MW capacity thermal unit is put into operation.

Table X-2. PEAK DEMAND AND RESERVE CAPACITY

(MW)

		1976	1977	1978
Required capacity	(A = B + C)	180	202	234
Reserve capacity	(B = 10% x C)	16	18	21
Peak demand	(C)	164	184	213
Supply capability	*(D)*	*218*	*218*	268
Balance	(E = D – A)	38	16	34
Total reserve capacity	(F = B + E)	54	34	55

As can be seen from the table, the actual reserve capacity will exceed the 10 percent target, and cover the outage of a 50 MW capacity unit. In 1977, it will become short, covering the outage by only 16 MW in the year end supply capability. Therefore, if the power supply program is examined into detail, at the beginning of the year for instance, such shortage in power supply at the time of large unit outage due to maintenance would be reduced to such an extent that load restriction will not be needed.

3-2 Demand and Supply

Critical Condition

In East Java, the dry season is from May to August and the wet season from September to April. However, due to very small fluctuation in daylight hours and temperature, seasonal fluctuation in power demand is negligible. The load growth is almost linear throughout, with the maximum load of a year appearing in December. The power supply capability fluctuates seasonally in East Java where there are hydro power plants. Many of the existing hydro power plants in East Java have been operated by use of irrigation water. And, most of the hydro power projects proposed or under construction are multipurpose including irrigation. Therefore, discharge from the power plants generally increase for irrigation in dry season increasing their output at the same time. In wet season, however, water is stored in reservoirs for release in dry season resulting in a decrease in energy production. This is specifically the case of Sengguruh power plant of Kalikonto system and Ngebel power plant of Madiun system which stop power generation in wet season. The thermal power plants produce energy constantly regardless of the season. But, the energy production of the system as a whole decreases in wet season due to the hydraulic condition stated above. In December, the demand is largest of the year, while the available power is small, and it is the crucial month for power supply. Therefore, studies were made based on the December demands and December supply capability, since if December demands are all satisfied, the supply capability will not fall short.

Dependable Peaking Capability

In studying the demand and supply pattern, the load, or the power supply requirement, was assumed as 110 percent of the estimated power demand and 100 percent of the estimated energy demand (power is represented by kW and energy by kWh), while the power supply capability was considered as the dependable peaking capacity in power and the annual average energy production in energy.

A thermal power plant could generate power constantly at its rated capacity. But, this is not true with a hydro power plant, where energy production is subject to the natural runoff, to a certain degree if not totally. In power supply programing, valuable is the dependable output. Sengguruh and Ngebel power plants which do not produce energy in wet season are not reliable power sources, and therefore, they are not counted in the long-range program: When a power plant has a reservoir, its producible energy varies according to the water level in the reservoir. But, a dependable capacity is obtainable under the adverse condition of low water level, depending upon the operation rule of the reservoir. The dependable capacity of a power plant with a reservoir can not be determined before the reservoir operation rule is established.

The dependable capacity and annual energy production of the existing power plants and those under construction were estimated as shown in Table X-3.

System Requirement in Peak Supply Capability

A study was made on the proportion of a peak supply capability (comprising mainly hydro power) in the future. As stated in VII-3. Daily Load Curve, the daily load factor is 77 percent, 70 percent in annual load factor, and the peak duration time is about four hours in the present systems in East Java. These figures were presumed to remain almost the same for about 10 years to come, except that the midnight load would be lowered and the daytime load would rise in the daily load courve. Based on the load forecast of the Report, the peak demand, daily average load and peak portion (= peak demand — daily average load) at year ends of 1975, 1977 and 1980 were obtained as shown in Table X-4.

If the daily load curve remains similar in shape, it could be configurated as shown in Fig. X-2.

The most economical system operation in the future is thought to be attained by allocating the peak load primarily to hydro power plants. The peak portion will be 64 MW only in 1980.

Table X-3 DEPENDABLE PEAKING CAPACITY AND ANNUAL ENERGY PRODUCTION

	Installed capacity (MW)	Dependable peaking capacity (MW)	Annual energy production (million kWh)	Remarks
Existing				
Hydro	44.3	29.1	160	
Thermal	50	50	285	capacity factor 65 %
Diesel	18.3	13.1	43	
Under construction				
Seloredjo	4.5	3.5	55	includes downstream increment
Karangkates 1st stage	70	62	340	
Diesel	4.8	4.8	16	capacity factor 40 %
Proposed				
Karangkates 2nd stage	35	31	93	
Gas turbine	12.5	12	22	capacity factor 20 %
Thermal 50 MW unit	50	50	310	" 70 %
75 MW "	75	75	460	" 70 %
125 MW "	125	125	770	" 70 %

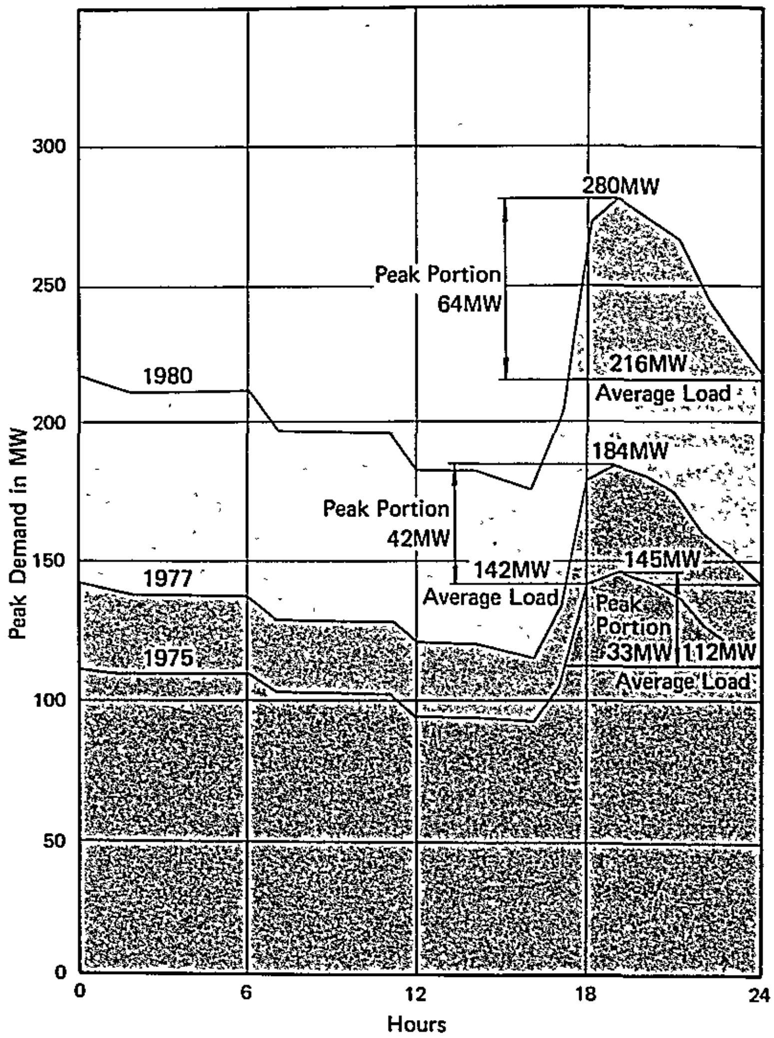


Fig. X-2 FORECASTED PEAK PORTION

Mendalan and Siman hydro power plants that have daily regulation ability can supply peak power of 25 MW for four hours a day. And, when Karangkates power plant, 62 MW in dependable capacity, and if a gas turbine unit, 12 MW in dependable capacity, are added in 1973 and 1972, the peak supply capability will amount to nearly 100 MW in 1973 which will be adequate till 1980. There will be adequate peaking capacity even if the gas turbine is not installed. A prospect for the years after 1980 is somewhat hard to make for it will involve changes in shape of the load curve. But, the trend appearing in Table X-4 gives ground to infer that the peak portion will reach a 100 MW level in or around 1984. Therefore, it was assumed that the need of peak supply capability, abundant till 1980, would not arise till the mid 1980's.

4. Evaluation of Hydro Power Projects

Following the estimate of power supply requirement which was based on the load forecast, individual hydro and thermal power projects were studied prior to formulation of the power development program. For this purpose, a criterion should be established to evaluate conceivable hydro power projects.

So far in the Republic, hydro power projects were evaluated in terms of an alternative thermal power plant. However, the evaluation of the alternative thermal power has not been standardized, and the resultant evaluations of hydro power projects are not comparable with each other. To take one project in the Republic, there are various evaluations, positive and negative, depending upon the person or organization that evaluated it. A criterion should be established so that hydro power projects can be compared with each other on the same basis of evaluation, no matter whoever evaluates whichever project. With the criterion standardized, the B/C method based on the standard thermal power plant is thought most appropriate, and is also applicable to comparison between alternative plans of one hydro power project in determing the scale of development.

Table X-4 PEAK DEMAND AND AVERAGE LOAD

		1975	1979	1980
Peak demand	(MW)	145	184	280
Average demand	(MW)	112	142	216
Peak portion	(MW)	33	42	64

4-1 Benefit-cost Method

The benefit-cost method is based on the hypothesis that if the hydro power project in question can not be materialized, an equivalent thermal power plant should be constructed in its stead to meet the demand. If several hydro power projects are proposed, these projects can be compared in relation to the standard thermal power plant. The thermal power unit considered as an standard should be of a type prospected to be typical among those commonly adopted in the system at the time when the hydro power plant in question would be operational. A thermal unit of too large capacity or too small capacity is not appropriate for the standard unit. In this respect, it is not necessary for the standard thermal power unit to have the same capacity as the proposed hydro power plant. In other words, the basis of evaluation lies in the unit cost of the standard thermal power unit at the time of its would-be operation. Fig. X-3 shows the procedure of benefit-cost method of evaluation schematically.

Evaluation of Hydro Power Project

The following equation is applicable to the evaluation of a hydro power project.

B = kW x B (kW) + kWh x B (kWh)

where,

B	:	benefit of hydro power-project
kW	:	effective maximum output of hydro
kWh	:	effective energy of hydro
B (kW)	:	unit benefit or per kW fixed cost of standard thermal
B (kWh)	:	unit benefit or per kWh variable cost of standard thermal

The equation identifies the benefit as a sum of kW and kWh benefits separately the value of peak supply capability peculiar to the hydro power plant. The effective maximum output in the equation equals to the saving of thermal capacity, and in the study it is taken as the dependable peaking capacity of hydro. The effective energy is equal to the saving of thermal energy, and it was considered to be the annual average energy production of hydro power plant. In principle, the power generated at a hydro power plant is evaluated at the high voltage bus bar of primary substation for comparison with that of thermal power plant; and includes the transmission line to the primary substation less transmission loss.

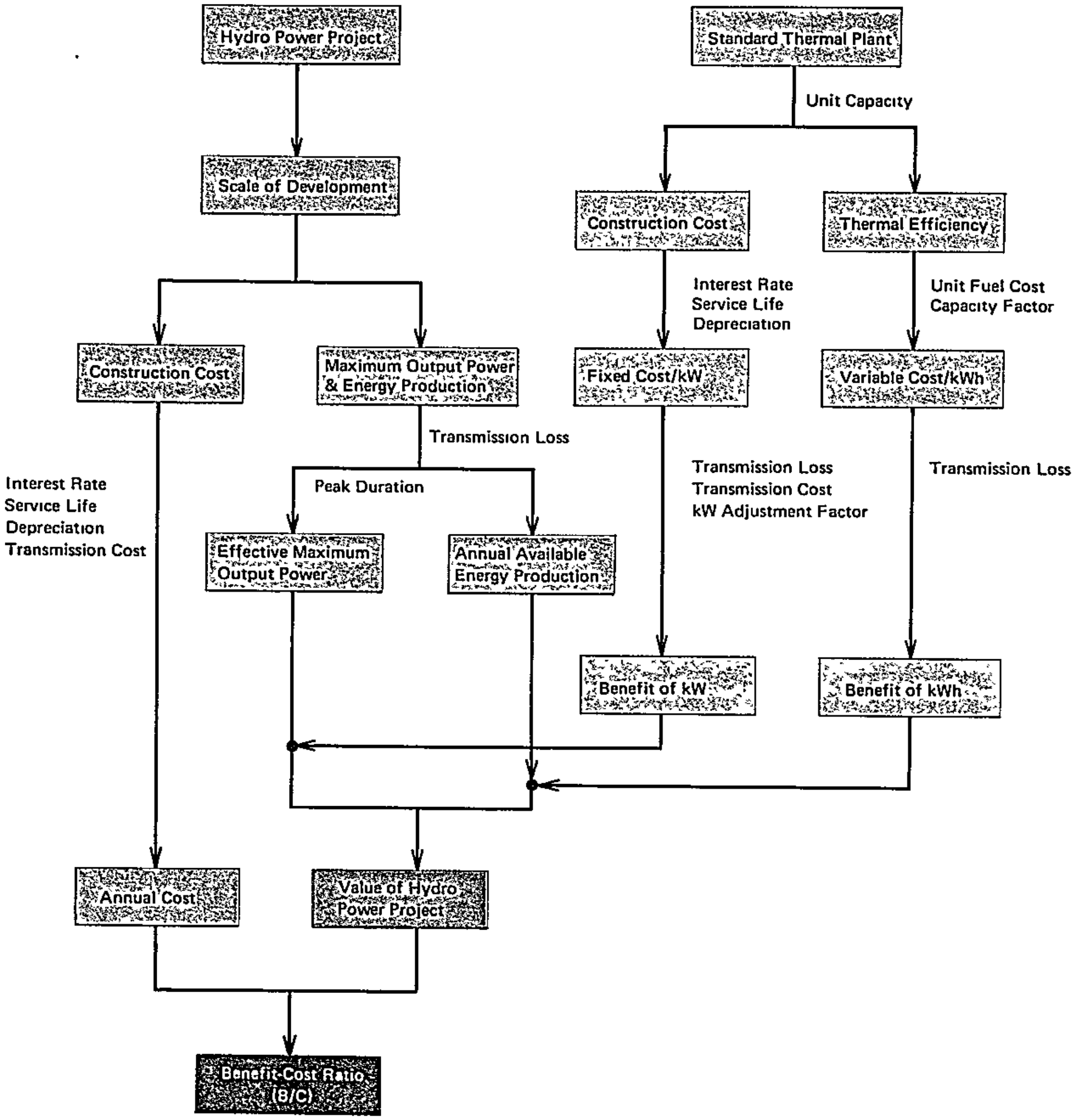


Fig. X-3 SCHEMATIC DIAGRAM OF HYDRO POWER PROJECT EVALUATION

Standard Thermal Power Plant

In the Report, a thermal power plant of two 50 MW capacity units was assumed to be the standard power plant to be compared with the proposed hydro power projects. This is because the present Report aims at the period of 1975 to 1985, and a power plant with two 50 MW capacity units was believed to be normal size during that period. As a matter of course, the unit size would be larger if the Report is focussed on the further future. The primary substation where dydro power is to be compared was assumed to be Waru II substation. Table X-5 gives the general features of the standard thermal power plant, together with the data on 75 MW and 125 MW capacity unit for comparison purposes. The unit construction cost of thermal power plant was estimated based on the prevailing international prices. According to data made available by ECAFE, the construction cost of Tandjung Priok and Tandjung Perak power plants was US$ 320 to 330 per kW which is extremely high. There seem to be involved problems peculiar to the Republic. However, all possible efforts should be exerted to make the cost reasonable. Economical energy is obtainable only when the construction cost is reasonable. The foreign currency requirement was assumed to be 80 percent of the total construction cost, and 20 percent in domestic currency.

Table X-5 BASIC FIGURES OF STANDARD THERMAL POWER PLANT

		Case 1		Case 2		Case 3	
Plant capacity	(MW)	100		150		250	
Unit capacity x No. of unit	(MW x No.)	50 x 2		75 x 2		125 x 2	
Capacity factor	(%)	70		70		70	
Annual energy production	(million kWh)	613		920		1,533	
Station service use	(%)	7		6.5		6	
Annual available energy	(million kWh)	570		860		1,440	
Thermal efficiency at sending end	(%)	33.5		34.5		35.3	
Annual fuel consumption	(thousand kL)	166		243		398	
Unit construction cost	(US$/kW)	180	(174)	165	(160)	155	(150)
Construction cost	(million US$)	18.0	(17.4)	24.8	(24.0)	38.8	(37.6)
Foreign currency	80%	14.4	(13.9)	19.8	(19.2)	31.0	(30.0)
Domestic "	20%	3.6	(3.5)	5.0	(4.8)	7.8	(7.6)
No. of persons for O & M		120		140		160	
Serviceable life		30		30		30	

Note: Construction cost at 6% interest rate.
Figures in parentheses are for 3% interest rate.

Annual Cost of Standard Thermal Power Plant

The annual cost of the standard thermal power plant was divided into the fixed cost and variable cost. The fixed cost does not vary with changes in operation or utilization of plant including capital cost, pay roll, a part of operation and maintenance cost, and a part of overhead cost; capital cost comprising about 70 percent and operation and maintenance cost 25 percent. The variable cost is associated with operation or utilization of plant. Fuel cost is the major single component comprising 97 percent of the variable cost, and the remaining is a part of maintenance and overhead costs. Taxes and duties were not considered. The annual cost was assumed to be in an equal amount over the productive life. The conditions upon which the annual cost was computed are shown in Table X-6.

The fuel cost assumed was to be US$0.015 (Rp 6.25) per litre which is the current purchase price at Tandjung Perak power plant. This price is almost the same as that of Japan where oil requirement is entirely dependent on import. In view of this fact, the price of fuel oil in Indonesia, an oil exporting country, is remarkably high. Directly proportional to the variable cost, the fuel cost needs to be lowered. The fuel oil consumption by thermal power plants will increase rapidly; as against the 1971 consumption, it will be about 3 times in 1980 and around 6 times in 1985. Therefore, quantitative discount should be considered.

Table X-6 CONDITIONS FOR ANNUAL COST CALCULATION OF THERMAL POWER PLANT

Interest rate	
Foreign currency	3% and 6%
Domestic currency	10%
Service life	30 years
Capital recovery factor	
At interest rate 3%	5.10%
〃 6%	7.27%
〃 10%	10.61%
Annual salary	600 $/person
Repair and maintenance cost	2% of construction cost
Foreign currency portion	80%
Domestic currency portion	20%
Miscellaneous cost	0.2% of construction cost
Administration cost	8% of total operation and maintenance cost
Fuel cost	15 mills/litre (6.25 Rp./litre)

Tables X-7 and X-8 show the annual cost in equal amount over the productive life of the standard thermal power plant obtained from the above conditions.

If the interest rate is 6 percent, the power and energy cost of the standard thermal power plant are as given in Table X-7.

The quotient of the fixed cost at sending end divided by the installed capacity is the unit power cost. Likewise, the quotient of the variable cost at the power plant divided by the energy production at the sending end is the energy cost. In order to obtain the costs at the high voltage bus bar of primary substation from the above costs, the construction cost and loss in transmission of a 150 kV double circuit line, connecting the thermal power plant to the primary substation (Waru II substation was assumed) were assumed as shown in Table X-9

Table X-7 ANNUAL COST CALCULATION OF THERMAL POWER PLANT

Interest rate: 6%
(thousand US$)

	50 MW x 2			75 MW x 2			125 MW x 2		
	Fixed	Variable	Total	Fixed	Variable	Total	Fixed	Variable	Total
Interest and depreciation	1,429	–	1,429	1,971	–	1,971	3,082	–	3,082
Foreign currency	1,047	–	1,047	1,440	–	1,440	2,254	–	2,254
Domestic "	382	–	382	531	–	531	828	–	828
Operation and maintenance	396	72	468	531	99	630	795	155	950
Wage and salary	72	–	72	84	–	84	96	–	96
Repair	288	72	360	397	99	496	621	155	776
Miscellaneous	36	–	36	50	–	50	78	–	78
Administration	32	6	38	42	8	50	64	12	76
Tax and duty	0	0	0	0	0	0	0	0	0
Fuel	–	2,490	2,490	–	3,645	3,645	–	5,970	5,970
Total cost	1,857	2,568	4,425	2,544	3,752	6,296	3,941	6,137	10,078
Unit cost at sending end									
Power cost ($/kW)	18.6	–	–	17.0	–	–	15.8	–	–
Energy " (mill/kWh)	–	4.51	7.76	–	4.36	7.32	–	4.26	6.99

Table X-8 ANNUAL COST CALCULATION OF THERMAL POWER PLANT

Interest rate: 3%
(thousand US$)

	50 MW x 2			75 MW x 2			125 MW x 2		
	Fixed	Variable	Total	Fixed	Variable	Total	Fixed	Variable	Total
Interest and depreciation	1,075	–	1,075	1,488	–	1,488	2,336	–	2,336
Foreign currency	714	–	714	979	–	979	1,530	–	1,530
Domestic "	361	–	361	509	–	509	806	–	806
Operation and maintenance	385	70	455	516	96	612	773	150	923
Wage and salary	72	–	72	84	–	84	96	–	96
Repair 278	278	70	348	384	96	480	602	150	752
Miscellaneous	35	–	35	48	–	48	75	–	75
Administration	31	6	37	41	8	49	62	12	74
Tax and duty	0	0	0	0	0	0	0	0	0
Fuel	–	2,490	2,490	–	3,645	3,645	–	5,970	5,970
Total cost	1,491	2,566	4,057	2,045	3,749	5,794	3,171	6,132	9,303
Unit cost at sending end									
Power cost ($/kW)	14.9	–	–	13.6	–	–	12.7	–	–
Energy " (mill/kWh)	–	4.50	7.12	–	4.36	6.74	–	4.26	6.46

Since all the annual cost of transmission line can be thought as fixed cost, the power cost and energy cost were obtained as follows:

$$\text{Power cost} = \frac{1857.+49}{100 \times 10^3 .(1-0.02)} \times 10^3 = \frac{1906}{98} = \text{US\$19.5/kW}$$

$$\text{Energy cost} = \frac{2568 \times 10^3}{570\,(1-0.02) \times 10^6} = \frac{2568}{559} \times 10^{-3} = 4.59 \text{ mills/kW}$$

Table X-9 ANNUAL COST OF 150kV TRANSMISSION LINE

Number of circuits:	2	
Distance:	25	km
Construction cost:	520	thousand dollars
Serviceable life:	50	years
Capital recovery factor:	6.34	%
Operation and maintenance cost:	3.0	%
Annual cost:	48.5	thousand dollars
Loss ratio		
kW and kWh:	2	%

Unit Benefit

Then, the unit benefit was obtained from the above costs at the high voltage bus bar of primary substation as follows:

Unit benefit of kW = Power cost x 1.2
Unit benefit of kWh = Energy cost

The constant of 1.2 in the above equation is called kW adjustment factor and derived from the following conception.

Outage of thermal power plant, including both scheduled outage and forced outage, is longer than that of hydro power plant. Therefore, additional capacity is required for a thermal power plant to secure the same reliability as a hydro power plant of the same capacity. Such addition can be regarded as a benefit of the hydro power plant. Therefore, in order to put the reliabilities of thermal power plant and hydro power plant on the same level, adjustment is needed on the power produced at the thermal power plant. The adjustment factor, variable with the component ratio of hydro and thermal, is usually within a range of 1.1 to 1.3 approximately.

If the interest rate is 6 percent,
Unit benefit of kW = 1.2 x 19.5 = US$ 23.4/kW
Unit benefit of kWh = 4.59 mills/kWh
and, if the interest rate is 3 percent,
Unit benefit of kW = 1.2 x 15.5 = US$ 18.7/kW
Unit benefit of kWh = 4.59 mills/kWh

These unit benefits were the basis or criterion to evaluate hydro power projects.

Factor Affecting Unit Benefits

The unit benefit value obtained in the above is subject to change corresponding to changes in essential factors of cost component of thermal power. The unit kW benefit varies almost in proportion to the change in construction cost. In addition, it will be influenced by interest rate, depreciation method, productive life and kW adjustment factor. If the construction cost changes by ±10 percent and the interest rate is reduced from 6 percent to 3 percent, the unit kW benefit will vary as shown in the following table.

Table X-10 SENSITIVITY CHART OF KW BENEFIT

(US dollars)

Interest rate	Construction cost		
	+ 10%	0	– 10%
3 %	20.8	18.7	16.5
6 %	25.8	23.4	20.7

The unit benefit of kWh is also variable in proportion to the fuel cost, and with the capacity factor of the thermal power plant. Usually, the capacity factor is assumed to be 70 percent in planning new addition of units of 50 MW or larger. However, if it is assumed at 80 percent, the kWh benefit will decline by 2.2 percent, and if it is 60 percent the kWh benefit will rise by 2.2 percent.

Annual Cost of Hydro Power Plant

C as used in the B/C method is annual cost of hydro power plant which is obtained by multiplying the construction cost by annual cost ratio and equalizing the product over the productive years. In case of a multipurpose project, the construction cost is the cost after allocation to the other purposes. Generally a hydro power plant is assumed to have a productive life of 50 years. The annual cost of hydro power plant is again variable by the construction cost, interest rate and depreciation method. Therefore, for comparison purpose, such conditions should be set uniform so as to be applicable to other hydro power plants.

Benefit-Cost Ratio

The benefit and the cost obtained in the manner described in the above paragraphs will give the value of B/C. B/C value of over 1.0 indicates that, in most cases, the hydro power project in question is economical and advantageous over a thermal power plant. When the B/C value is less than 1.0, the hydro power plant is judged to be economically inferior to a thermal power plant, and therefore, its implementation should be postponed till the time comes when the B/C value turns out to be over 1.0. However, due care should be exercised at this stage because both kW and kWh benefits of the standard thermal power plant are not absolute but variable in a somewhat large range. In addition, the construction cost of hydro power project is liable to increase during the course of construction, sometimes by 10 to 20 percent. Therefore, the cost estimate of the standard thermal power plant, as well as, hydro power projects should be based on realistic prices of equipment and materials. In consideration of the intangible merits of hydro power projects, a hydro power project giving a B/C ratio of over 0.95 is judged to be eligible as a project to be contemplated in the implementation program, and at least, its feasibility study should be conducted if it is in the prefeasibility stage.

4-2 Evaluation of Hydro Power Project

By application of the evaluation method described hereinabove, the respective hydro power projects in East Java were evaluated. The projects that have been studied on their feasibility or pre-feasibility are Karangkates 2nd stage and Wlingi project downstream of Karangkates. In the Report, studies were made of these two projects in formulating the implementation program. Other projects could, of course, be implemented preceding thermal power plants if they are proved to be economical in terms of the B/C value, since a high B/C value indicates the superiority of the hydro power project to a thermal power plant.

Karangkates 2nd Stage Project

Karangkates 1st stage will be completed in 1973. It will have an installed capacity of 70 MW with two 35 MW capacity units. The powerhouse is designed for three units to total 105 MW in ultimate installed capacity. For the third unit, Lahor dam, a 70 meters high rockfill dam, has been proposed on the Lahor river, a tributary of the Karangkates, to divert water of the tributary to Karangkates reservoir by a 600 meters long diversion tunnel. Excavation of the tunnel has already been performed in part. The construction cost of the 1st stage is to be allocated between flood control, irrigation and power generation. But, the second stage construction cost would be borne by power only. In respect of the third unit and Lahor dam, the following combinations are conceivable.

Table X-11 DEVELOPMENT OF KARANGKATES PROJECT

Case		Installed capacity (MW)	Dependable peaking capability (MW)	Annual energy production (million kWh)	Construction cost † (thousand US$)
	Karangkates 2 units:				
1.	without Lahor	70	62	340	55,000
2.	with Lahor	70	62	430	+ 11,900
	Karangkates 3 units:				
3.	without Lahor	105	93	340	+ 3,900
4.	with Lahor	105	93	433	+ 15,800

Source: Nippon Koei Co., Ltd

† excluding interest during construction and related transmission line.

The 1st stage development is Case 1. Conceivable at the present stage are cases 2 to 4 inclusive. As can be seen from the table, Case 3 which does not include the construction of Lahor dam would not serve to increase annual energy production. While in East Java, as stated in X. 3-2 System Requirement on Peaking Supply Capability, addition of a peaking capacity will not be necessary till about 1980 after Karangkates 1st stage is complete. Energy is wanted in the system rather than power. Therefore, Case 3 was eliminated for it would require advanced capital investment although the system reliability would be improved by ample reserve capacity. If peaking power is needed, Case 3 would be the most suited, providing less expensive peak energy.

Case 2 includes the construction of Lahor dam and the diversion tunnel. Energy production would be increased by 90 million kWh per annum with the same installed capacity. Additional transmission line would not be necessary. Case 4 consists of the installation of the third unit in addition to the construction of dam and diversion tunnel, and it would serve to increase both power and energy output. But, it would require an additional 150 kV circuit of 125 kilometers long transmission line to Waru II. Cases 2 and 4 were evaluated respectively at Waru II substation in relation to the standard thermal power unit with the result shown in Table X-12. In the evaluation, interest during the construction period of 4 years was included in the construction cost. The transmission line loss was assumed at 3 percent both

Table X-12 EVALUATION OF 2nd STAGE KARANGKATES PROJECT

		Case 2: Karangkates 2 units with Lahor		Case 4: Karangkates 3 units with Lahor	
		Interest rate		Interest rate	
		3%	6%	3%	6%
Benefit					
Increased power	MW	–	–	30	30
Unit benefit value	$/kW	18.7	23.4	18.7	23.4
Power benefit	thousand $	–	–	561	702
Increased energy	million kWh	87.5	87.5	90	90
Unit benefit value	mill/kWh	4.59	4.59	4.59	4.59
Energy benefit	thousand $	402	402	413	413
Total benefit	thousand $	402	402	974	1,115
Cost					
Construction cost of dam and power plant	thousand $	12,500	13,000	16,600	17,300
Annual cost factor	%	4.89	7.34	4.89	7.34
Annual cost	thousand $	611	954	812	1,270
Construction cost of transmission line	thousand $	–	–	720	740
Annual cost factor	%	6.89	9.34	6.89	9.34
Annual cost	thousand $	–	–	50	69
Total cost	thousand $	611	954	862	1,339
B/C		0.66	0.42	1.13	0.83

in kW and kWh. The installation of an additional transmission line circuit was estimated to cost US$ 700 thousand excluding interest during construction. According to the result shown in Table X-12, Case 2 can not be justified due to low B/C value which is attributable to non-increment in kW output. Case 4 is economically feasible provided that it can be financed at an interest rate of 3 percent. If the interest rate is 6 percent, the B/C value goes down to 0.83 which result in costly electricity. The critical rate of interest is thought to be somewhere around 4.0 percent. The B/C value in this range, as stated in the preceeding paragraph *Benefit-Cost Ratio,* makes the project eligible for consideration in contemplating the overall power development program.

However, there still remains a problem unsolved in connection with the effect to the downstream. The maximum discharge of the three units would be 160 cubic meters per second, which might have to be re-regulated for use in the downstream basin. However, no detailed studies have been made sofar. There seems to be no data, either, on the downstream effect to be brought about by the discharge of 107 cubic meters per second, the discharge of the two units under construction. If the re-regulation is required, the above project evaluation should be re-considered including the construction of the re-regulating dam. In the event that the re-regulating pond is required but not constructed for some time, the kW benefit of the third unit could not be expected until the pond is completed, and the accrual is kWh benefit only. Overcasting the economic soundness of Karangkates project, the re-regulating pond is an urgent problem to be studied.

According to *2nd Stage Explanatory Note of Karangkates Power Project* provided by the Brantas River Office of the Ministry of Public Works, if the construction of Lahor dam is executed in succession to the Karangkates

1st stage construction, a saving of US$ 2.5 million can be expected by utilizing the construction equipment now employed in the construction of Karangkates dam and powerhouse. Although there is a discrepancy between the total construction costs of the *Explanatory Note* and Table X-11, *if the saving of US$ 2.5 million is applicable to Table X-11, the B/C* value of Case 4 would be 0.95 approximately.

Wlingi Project The Wlingi project was proposed primarily for the purpose to control the movement of volcanic ash of Mt. Kelud located near the middle reaches of the Brantas river, in addition to irrigation and power generation. (According to recent information, however, it has been decided by the Government that the sediment control will be performed on the tributaries and not on the main stream, Brantas). Situated about 30 kilometers downstream of Karangkates dam, Wlingi reservoir would also function as an afterbay of Karangkates power plant. In respect of the sediment control, several proposals were submitted and studied by the Government as well as Nippon Koei Co., Ltd. But, a conclusion has not been reached. Therefore, data used in the Report have a nature of prefeasibility stage.

Table X-13 BASIC FIGURES OF WLINGI PROJECT

1.	Reservoir		
	Catchment area		2,900 km^2
	Storage capacity	Gross	24 million m^3
		Net	3,8 million m^3
	Draw down		1 m
2.	*D a m*		
	Type	sand-gravel fill with center imperious core	
	Height	47 m	
	Crest length	450 m	
	Embankment	one million m^3	
3.	Power plant		
	Rated head		22 m
	Max. discharge		200 m^3/sec
	Installed capacity		40 MW
	Dependable peaking capacity		16.5 MW
	Annual energy production		154 million kWh
4.	Construction period	5 years including preparatory works	
5.	Construction cost		20,900 thousand US$
	(excluding interest during construction and transmission line)		

Source: Nippon Koei Co., Ltd.

The small dependable capability is attributable to the discharge required for irrigation in dry season. Electricity is a by-product of Wlingi project. Nevertheless, the Government intends to justify the economic soundness of the project from the power benefit only without allocating the construction cost to the other purpose. As in the case of Karangkates *2nd stage, the B/C* value which represents an index of the feasibility of the power phase of the project, was obtained as shown in Table X-14. In estimating the construction cost of transmission line to Waru II substation, the line between Karangkates power plant and Waru II was assumed to be existing and therefore not considered, and the 150 kV single circuit transmission line between Karangkates power plant and Wlingi power plant which is 28 kilometers in distance was assumed to cost US$ 500 thousand. The transmission line loss between Wlingi power plant and Waru substation was assumed to be 3 percent. As can be seen from the table, the B/C value of the project is 0.89 even at an interest rate of 3 percent. A review of the project from the stand point of electricity only reveal that the economic feasibility can not be justified. Wlingi project was not considered in the power development program. Wlingi project is a multipurpose project by nature, and power generation is a subordinate function. It is an unreasonable demand to evaluate Wlingi project from the power phase only. The evaluation of the project should be made taking into account benefits expected from other fields for which the project has been formulated. The project, being at the stage of pre-feasibility, will have to be studied of its feasibility. In the feasibility study, the following points should be clarified.

i. whether or not the sediment control on the main stream is reasonable;
ii. whether or not Wlingi reservoir is too far downstream to re-regulate the discharge from Karangkates powerhouse; and
iii. whether or not the maximum discharge of 200 cubic meters per second is too large for a re-regulating power plant.

Table X-14 EVALUATION OF WLINGI PROJECT

Items	Unit	Interest rate 3%	Interest rate 6%
Benefit			
Dependable peaking capability	MW	16.0	16.0
Unit benefit value	$/kW	18.7	23.4
Power benefit	thousand $	299	374
Annual energy production	million kWh	149	149
Unit benefit value	mill/kWh	4.59	4.59
Energy benefit	thousand $	684	684
Total	thousand $	983	1,058
Cost			
Construction cost of dam and power plant	thousand $	21,900	22,900
Annual cost factor	%	4.89	7.34
Annual cost	thousand $	1,071	1,681
Construction cost of transmission line	thousand $	510	520
Annual cost factor	%	6.89	9.34
Annual cost	thousand $	35	49
Total	thousand $	1,106	1,730
B/C		0.89	0.61

5. Thermal Project

A thermal power project does not have peculiarities as a hydro project. The construction cost, annual energy production and electricity cost may be determined, in formulating a long range program, by the size and number of generating units. There are many cases in which the unit size is determined first and the plant site is sought afterwards. Naturally, land reclamation cost, foundation construction cost, construction cost of intake for cooling water, and fuel cost are variable with the location. But such variations are within a range of ±5 percent in total as against the construction cost. The followings were the basic policies adopted in formulating the thermal power projects.

i. The fuel will be exclusively heavy oil.
ii. No inland thermal power plant will be considered.
iii. Large capacity units will be adopted insofar as the system reliability permits.

(1) As mentioned in VI. Energy Resource for Electricity, the Republic has abundant oil deposits. Although the prevailing price of residual heavy oil is not low when compared with that in Japan, it will possibly be reduced in the future. The supply is stable in abundant quantity. Coal deposit is also available in the Republic, but as a fuel it is costly, and not stable in supply. In addition, the construction cost of coal burning thermal power plant is 20 percent higher than that of oil fueled plant. Equipped with both oil and coal burning facilities, Tandjung Perak and Tandjung Priok thermal power plants are not economical. The terhaml power plants to be constructed in the future were thought to burn residual heavy oil only.

(2) The present load center of East Java system is Surabaja. In the future, the industrial district presently within a boundary of Surabaja will expand westward connecting to Gresik and at the same time to the southeast to merge another industrial district in Pasuruan. The prospected industrial district being located along the coast, thermal plants should be located on the coast near to the load center or along a big river near its estuary in consideration of transportation of equipment and fuel oil and the availability of cooling water. It is said that there are a few thermal power plants proposed to be built near to the oil wells, including those in operation and of recent strikes in East Java. However, these power plants are not recommendable unless a low delivery price of residual heavy oil is confirmed; the delivery price should be far lower than US$ 0.015 (Rp.6.25) per litre which is the price at Perak and low enough to more than offset the demerits of an inland power plant. An inland thermal power plant is generally higher in construction cost than a plant on the coast by 5 to 10 percent. In many cases, a cooling tower is necessary at an inland power plant where water is not available sufficiently. The transmission line to load center is another cause to raise the cost. Inland transportation of equipment and materials is not only an inconvenience but reflects in the power cost. Furthermore, as an oil industry usually has its own transportation means of products from the oil well to a nearby port, it is thought advantageous to locate the thermal power plant near the port.

(3) The unit capacity is referred to in 3-2 Demand and Supply of this chapter in relation to the system reserve capacity. In preparing the implementation program, the unit capacity was determined in the following manner. As the unit capacity becomes large, the more scale merit will yield to lower the unit electricity cost as shown in tables X-7 and X-8. However, fault of a large unit may cause the system to collapse. Thus, the power economy and the system reliability conflict each other. In the Report, precedence was given to economy, during the foreseeable future period, by adopting unit capacity of a size of about 20 percent of the prospected system supply capability at the time when the unit starts operation.

The problem of unit size is experienced by most of the developing countries. There was a case in Thailand where a 200 MW capacity unit was installed in a system which was carrying a peak demand of about 800 MW only.

In East Java where a hydro power unit of 35 MW in installed capacity will start operation in 1974, a thermal unit to be installed thereafter should be larger than the 35 MW. Based on the 20 percent ceiling as against the current system supply capability, the unit size may be 50 MW in 1976, 75 MW in 1979 and 125 MW in 1984.

Proposed Sites for Thermal Power Plant

The conceivable sites for construction of thermal power plants are New Perak, Pasuruan and Gresik. These sites were considered from the standpoint of system composition and operation, but the actual sites were not surveyed at site.

The premises of Tandjung Perak thermal power plant, which is now operated with two 25 MW units, has a space for installation of two more units of the same capacity as the existing. Therefore, two units of a larger capacity were proposed to be installed in the space which, already re-adjusted, is ideal for the units scheduled to be completed by 1975. The operation of the existing two units is annoyed by corrosion of pipes to supply sea water for cooling. This, however, can be solved technically. An OTCA study team dispatched to the Republic in 1969 suggested countermeasures in this regards. (Report on National Power Study in Republic of Indonesia, OTCA, Japan 1969).

Next to this project, conceivable are Pasuruan and Gresik. However, there is ample time for investigations before a site is determined.

6. Power Development Program

Policy of Program Formulation

In the studies described previously, the power supply requirement and the eligible hydro and thermal power projects were determined. These eligible projects were arranged in several chronological orders of implementation satisfying the future power supply requirement. In the arrangement, however, emphasis was put on economical power supply rather than the complete satisfaction of power requirement. In pursuing economy, due consideration should be given to the trend of electricity cost in the future when the projects will have been implemented, in addition to the construction cost of the projects.

Demand and Supply till 1975

The estimated demand is shown in Table X-1 and the power supply requirement is 110 percent of the estimated demand including the reserve capacity. The increases in demand and supply hereinafter referred to are considered on a yearly basis neglecting the monthly increases. Table X-15 shows the power supply capability at the end of 1970.

The power development program of PLN until 1974 is as follows:

	Additions
1970, 1971 and 1972:	diesel units of 4.8 MW in total installed capacity
1973:	a 12.5 MW capacity gas turbine unit (to be relocated from Palembang) Seloredjo hydro power plant, 4.5 MW in installed capacity

Even with the above additions of generating facilities, the power supply capability will fall short by 82 million kWh in 1972 and 62 million kWh in 1973 (See Table X-25). As the estimates in the above were made regarding the systems in East Java as one, the situation in isolated system will be worse than what is indicated by the figures. Therefore, the relocation to East Java of the gas turbine should be materialized. To cope with the shortage in power supply capability in 1972 and 1973, Tandjung Perak power plant will have to be operated to produce more energy than the present schedule. The same is true with the gas turbine and diesel units to be installed in the future; they are scheduled to be operated at a capacity factor of 40 percent in the Report. Otherwise, PLN will have to tide over the years by means of power supply curtailment.

Table X-15 PRESENT SUPPLY CAPABILITY

	Energy production (million kWh)	Dependable peaking capability (MW)
Hydro	142	29
Thermal	255	50
Diesel	40	13
Total	467	92

Sengguruh power plant will be submerged in Karangkates reservoir resulting in an decrease of 18 million kWh in annual energy production. However, the system dependable capacity will not change, as Sengguruh power plant produces energy in dry season only and the output is not counted as dependable in Table X-15. Since Karangkates power plant will provide to the system an allowance in supply capability by producing about 340 million kWh annually from 1974, the older half of the existing diesel units are planned to be retired from service. With the operation of Karangkates power plant, the demand will be met by the supply till 1975. In 1975, however, the supply capability will fall short again by about 120 million kWh in energy and 12 MW in power. No plan is established by PLN for the years of 1976 and after. Therefore, the Report is essentially directed to put its objective in the years of 1976 and the following years.

Retirement Schedule of Diesel Power Plant

The existing diesel units are being used over their depreciation periods, and the maintenance is costly. Therefore, about one half of the capacity of existing diesel units is scheduled to be retired in 1974, which corresponds to 6 MW in dependable capacity. In 1976, the power generation is to be reduced. Further, in 1978 all the existing diesel units will be retired. Of the retired units, units of relatively better conditions will be used again at places not electrified. Expensive in fuel cost, the gas turbine unit was scheduled to be lowered in its capacity factor, as in the case of diesel units, to 20 percent in 1976 when a new addition of thermal unit will be put in the system, and after 1978 it will be a stand-by unit.

Construction Period of Hydro Power Project

The construction period of Karangkates 2nd stage is scheduled to be four years including the construction of Lahor dam. However, the implementation of the 2nd stage has not been approved by the Government as of October 1971. The conceivable earliest time for the construction to begin is the beginning of fiscal 1972. Consequently, the completion of the 2nd stage can not be expected before mid 1976. In formulating the power development program, power produced by the 2nd stage unit can be considered to be incorporated in the system only after 1976 at the earliest. The construction period of thermal power plant assumed to be three years. Therefore, the increment in demand in 1976 is likely to be met by a thermal power plant.

Conceivable Development Programs

Six power development plans were prepared for selection to be made later. The plans cover the 10 year period from 1975 to 1985, and are composed of thermal units of 50, 75 and 125 MW capacities and the Karangkates 2nd stage including Lahor project. Wlingi project is not considered as stated previously. Plans designated with "T" are composed of thermal units only, and plans with "H" include the Karangkates 2nd stage. Common to all plans, the thermal units to be installed after 1983 are to be 125 MW in capacity. As illustrated in tables X-24 and X-25, the supply capability was scheduled in all of the plans to increase to meet the estimated demand in each year in both power and energy. As peaking capacity, dependable peaking capacity was taken instead of the installed capacity. Installation schedule of all the alternative plans are shown in Table X-16 and in fig's. X-4 and X-5.

(1) Plan T - A.

	Additional unit
1976	50 MW
1978	50 MW
1979	50 MW
1981	50 MW
1982	50 MW
1983	50 MW
1984	125 MW
Total:	425 MW

After successive additions of six 50 MW capacity units, a 125 MW capacity unit will be installed in 1984. This plan was prepared for comparative purpose with Plan T - B.

(2) Plan T - B.

	Additional unit
1976	75 MW
1979	75 MW
1981	75 MW
1983	75 MW
1984	125 MW
Total:	425 MW

The 75 MW capacity unit in 1976 will lower the system reliability. However, this plan makes clear the merit of fewer number of units.

(3) Plan T - C.

	Additional unit
1976	50 MW
1978	50 MW
1979	50 MW
1981	50 MW
1982	75 MW
1984	75 MW
1985	125 MW
Total:	475 MW

This plan is an intermediate one between plans T-A and T-B. After the installation of four 50 MW capacity units, two 75 MW units will be installed, resulting in the largest total installed capacity of all the plans.

(4) Plan T - D.

	Additional unit
1976	50 MW
1978	50 MW
1979	75 MW
1981	75 MW
1983	75 MW
1985	125 MW
Total:	450 MW

This is also an intermediate plan between plan T-A and plan T-B, but with earlier realization of 75 MW capacity unit.

(5) Plan H - A.

	Additional unit
1976	50 MW thermal
1978	50 MW thermal
1979	31 MW hydro
1980	75 MW thermal
1982	75 MW thermal
1984	125 MW thermal
Total:	406 MW

As stated in *Construction Period of Hydro Power Plant,* Karangkates 2nd stage is most likely to start operation in 1977. Therefore, thermal units will have to be installed in 1976, and also in 1978 because even if Karangkates 2nd stage is operational in 1978, the energy production will not be sufficient and require an additional thermal unit in the same year. This is not economical. As a result, Karangkates 2nd stage is scheduled to be in service in 1979.

(6) Plan H - B.

	Additional unit
1976	31 MW hydro and 50 MW thermal
1978	50 MW thermal
1980	75 MW thermal
1982	75 MW thermal
1984	125 MW thermal
Total:	406 MW

In this plan, Karangkates 2nd stage was assumed to be complete in 1975 and start operation from 1976, though it is very difficult to be realized by that time. As Karangkates 2nd stage alone will not be sufficient, a 50 MW capacity thermal unit will also be installed.

Evaluation of Six Plans The six plans, that are thought almost indentical in their function in the system were evaluated in terms of the construction cost per kW and energy cost. Evaluation of benefits was not performed because they were thought to have the same benefits. Interest rate was assumed in two kinds, 3 percent and 6 percent. The evaluation was solely based on generating facilities, and transmission and distribution facilities were thought to be common to all the six plans, and therefore not included in the evaluation.

Table X-16 INSTALLATION SCHEDULE IN ALTERNATIVE PLANS

Year/Plan	T-A	T-B	T-C	T-D	H-A	H-B
1976	1T-50	1T-75	1T-50	1T-50	1T-50	Karangkates 1T-50
1977	–	–	2T-50	–	–	–
1978	2T-50	–	2T-50	2T-50	2T-50	2T-50
1979	3T-50	2T-75	3T-50	1T-75	Karangkates	–
1980	–	–	–	–	1T-75	1T-75
1981	4T-50	3T-75	4T-50	2T-75	–	–
1982	5T-50	–	1T-75	–	2T-75	2T-75
1983	6T-50	4T-75	–	3T-75	–	–
1984	1T-125	1T-125	2T-75	–	1T-125	1T-125
1985	–	–	1T-125	1T-125	–	–
Total installed capacity (MW)	425	425	475	450	406	406

Note: 2T-75 stands for No. 2 unit, thermal and 75 in unit capacity.

Construction Cost

The construction cost of Karangkates 2nd stage was estimated to be US$ 17.3 million at 6 percent interest and US$ 16.6 million at 3 percent interest. The annual disbursement was assumed to be made in the proportion of 20, 20, 35 and 25 in the four years, and the foreign currency requirement to be 50 percent. The construction costs of thermal power plants were estimated to be as follows:

Table X-17 UNIT CONSTRUCTION COST OF THERMAL POWER PLANT

(US$/kW)

	50 MW	75 MW	125 MW
Interest rate 3%	174	160	150
Interest rate 6%	180	165	155

Strictly speaking, the construction cost of No.1 unit of a thermal power plant is high, and it goes down as the number of units increases. In the Report, the cost was assumed to be these average. The annual disbursement was assumed to be made in the proportion of 20, 35 and 45 in the three years of construction period, and the foreign currency requirement to be 80 percent.

Energy Cost

The energy costs were calculated for the respective plans and for the period of 1975 to 1985 with the result shown in Table X-18. It would have been better if the energy cost of the existing power plants had been included in the calculation to show the energy cost of the system as a whole. However, since data on the existing power plant were not available, the energy cost of the existing hydro power plant including those to be completed before 1975 was excluded. In other words, included in the calculation were existing and proposed thermal power plants and hydro power plants to be completed after 1974. The reason why the existing thermal power plants were included in the calculation was that the utilization of Perak power plant would largely vary with the plans. The hydro power plants which do not require fuel will be utilized with the first priority in any plan contributing equally to the system, therefore, excluded from the calculation.

The energy cost was calculated in the manner described below. It is the policy in meeting power demand to first utilize hydro power plants which do not require fuel, and put thermal power plants into operation. Of the thermal power plants, the then largest unit should be operated first since the larger the unit, the power generated becomes economical. If the largest unit is not enough, the second largest, the third and so on should be operated in the order. Diesel units and gas turbine units will also be operated if the steam thermal units can not produce sufficient energy. The annual energy production of Perak thermal power plant was obtained with a plant factor of 65 percent and those of other thermal power plants were calculated with a plant factor of 70 percent. From the annual energy production of each thermal unit, the annual fuel consumption and the fuel cost of each unit were obtainable through the unit consumption rate. The unit consumption rate and the fuel cost were thought from available data to be as shown in Table X-18

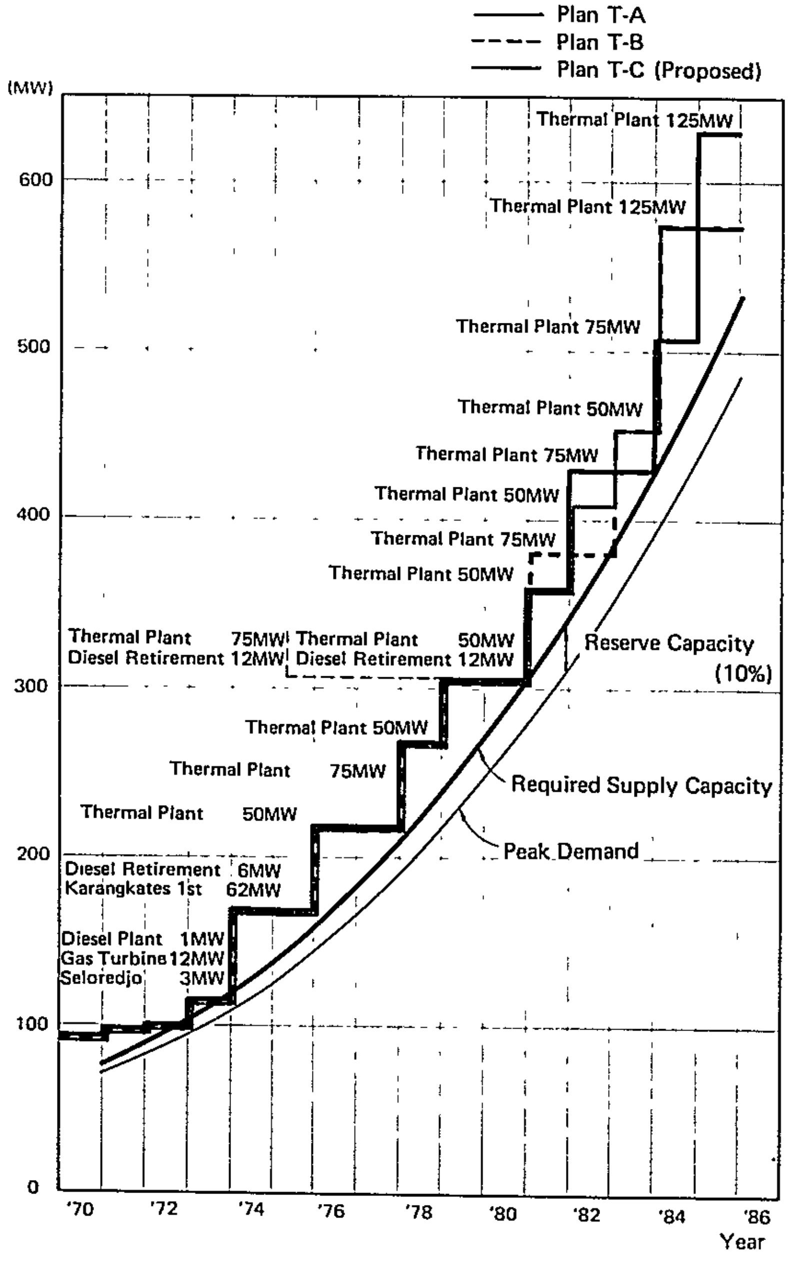


Fig. X-4 KW BALANCE

Table X-18 UNIT CONSUMPTION RATE AND COST OF FUEL

	Unit consumption rate (litre/kWh)	Fuel	Unit fuel cost (mill/litre)	(Rp./litre)
125 MW unit	0.26	Heavy oil	15	6.25
75	0.265	" "	15	6.25
50	0.27	" "	15	6.25
25	0.35	" "	15	6.25
Diesel	0.31	I.D.O.	22	9.2
Gas turbine	0.45	H.S.D.	31	12.8

Note: Unit consumption rate of 25 MW unit is based on the actual records of operation *of Perak Thermal power plant and gives a rather high value.*

Since all the thermal power plants were proposed on the coast, the fuel oil

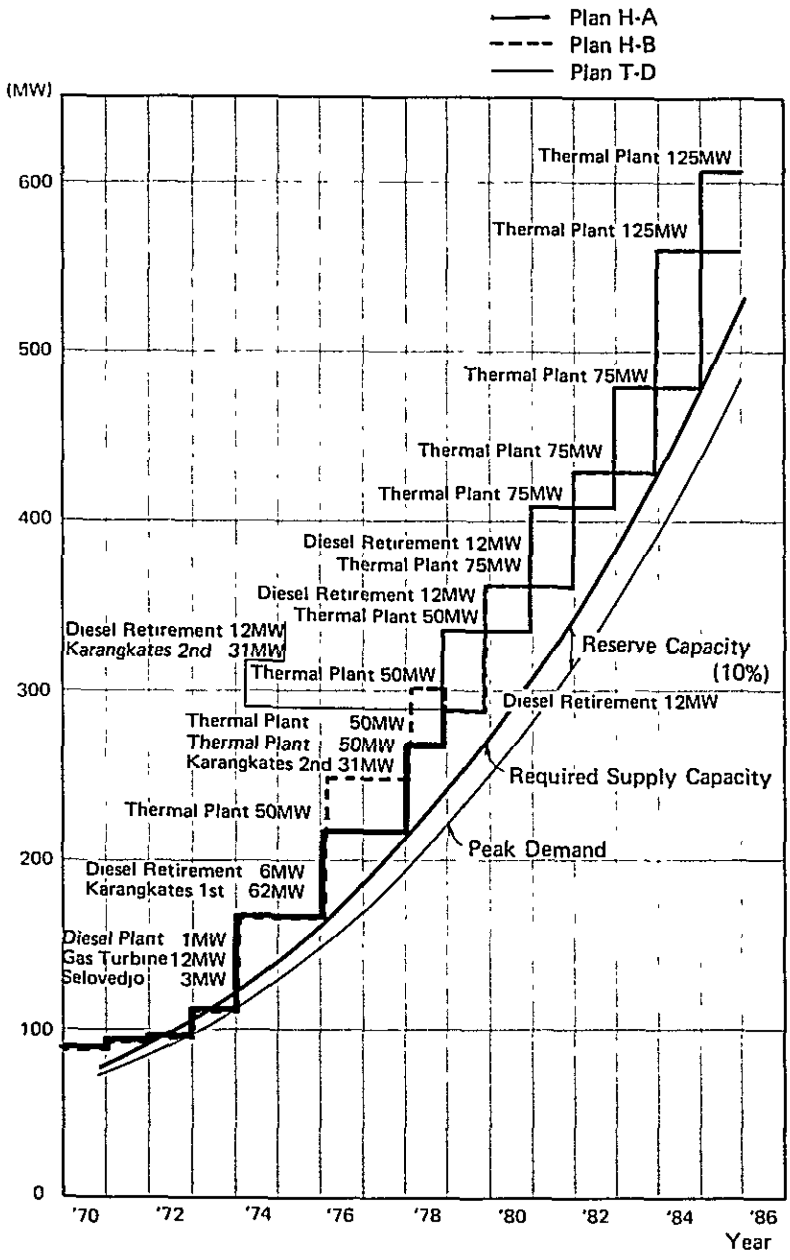


Fig. X-5 KW BALANCE

was considered obtainable at the price of US$ 0.015 (Rp.6.25) per litre, the purchase price at Perak. As a fuel of diesel engines, I.D.O. was assumed, and its price was estimated at US$ 0.022 (Rp.9.2) per litre including transportation cost of Rp.1.2 per litre since diesel units are scattered in the eastern part of the territory. The gas turbine was assumed to burn H.D.S., and its price to be US$ 0.031 (Rp.12.8) per litre. The fixed cost of generating facilities was obtained by multiplying the construction cost by the annual cost factor and then by equalizing the product over the serviceable life. The annual cost factor adopted is shown below.

Table X-19 ANNUAL COST FACTOR

	Hydro		Thermal	
Service life (year)	50		30	
Interest rate (%)	3	6	3	6
Capital recovery factor (%)	3.89	6.34	5.10	7.27
O & M and others (%)	1.0	1.0	2.7	2.7
Total annual cost (%)	4.89	7.34	7.8	9.97

The fixed cost of the existing Perak power plant obtained with an interest rate of 6 percent was assumed to be the same with an interest rate of 3 percent. The diesel units as of 1975 will have been all depreciated, for that the latest installation of diesel unit was in 1955 and the depreciation period is 20 years. Therefore, as for the diesel unit, considered was the operation and maintenance cost only which in consideration of the obsolescence of the diesel units, was assumed to be 4 percent annually of the estimated construction cost totalling US$ 80 thousand per annum. The diesel units, approximately 5 MW in total installed capacity, to be installed in the future were assumed to have a serviceable life of 20 years, and its annual cost to be US$ 100 thousand at 6 percent interest rate. The annual cost of all the diesel units, including the existing and the proposed, would be US$ 180 thousand and it would not change until 1978. The construction cost of gas turbine unit was estimated at US$ 2,240 thousand, and its annual cost to be US$ 280 thousand based on 6 percent interest rate and assuming the serviceable life to be 15 years and the operation and maintenance cost to be 2 percent annually of the construction cost.

Table X-20 gives the energy cost of Plan T-C until 1985 obtained in the manner described in the foregoing, and Fig. X-6 shows the trend of its change. The figure clearly shows that the energy cost per kWh will steadily reduce to 8 mills by the adoption of larger capacity units of 50 MW and 75 MW.

Comparison of Plans The plans are compared in tables X-21 and 22. The total installed capacity varies with the plans; the largest is seen in Plan T-C and the smallest in plans H-A and H-B, being respectively 475 MW and 406 MW. Consequently, Plan T-C requires the largest capital investment of US$ 80.2 million in total. While the smallest investment requirement is US$ 69.0 million of plan T-B which proposes the largest average unit capacity. If compared in terms of the unit construction cost, US$ 162 per kW of plan T-B is the lowest, and plans T-D, T-C and T-A are in the range of US$ 166 to US$ 172 per kW. Plans H-A and H-B are US$ 196 per kW.

In order to annalyze the effect of implementation timing, the present worth

Table X-20-1 ANNUAL COST CALCULATION OF SYSTEM (Plan T - C)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Total generation (million kWh)	890	1,007	1,130	1,300	1,495	1,720	1,920	2,150	2,410	2,700	3,020
Hydor	520	520	520	520	520	520	520	520	520	520	520
Existing	125	125	125	125	125	125	125	125	125	125	125
Seloredjo	55	55	·55	55	55	55	55	55	55	55	55
Karangkates 1st	340	340	340	340	340	340	340	340	340	340	340
〃 2nd	–	–	–	–	–	–	–	–	–	–	–
Thermal	370	487	610	780	975	1,200	1,400	1,630	1,890	2,180	2,500
125 MW unit	–	–	–	–	–	–	–	–	–	–	770
75 〃	–	–	–	–	–	–	–	460	460	920	920
50 〃	–	310	310	620	930	930	1,240	1,170	1,240	1,240	810
25 〃	285	178	285	160	45	270	160	–	190	20	–
Diesel	41	–	15	–	–	–	–	–	–	–	–
Gas turbine	44	–	–	–	–	–	–	–	–	–	–
Fuel consumption (thousand kilo liters)											
Residual	100	147	183	224	266	344	390	438	523	584	663
125 MW unit	–	–	–	–	–	–	–	–	–	–	200
75 〃	–	–	–	–	–	–	–	122	122	244	244
50 〃	–	83	83	166	249	249	332	316	332	332	219
25 〃	100	64	100	58	17	95	58	–	69	8	–
Diesel (I.D.O.)	13	–	5	–	–	–	–	–	–	–	–
Gas turbine (H.S.D.)	20	–	–	–	–	–	–	–	–	–	–

Table X-20-2 ANNUAL COST CALCULATION OF SYSTEM (Plan T - C)

Interest Rate: 3%
(thousand US$)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Total
Fuel cost	2,395	2,200	2,850	3,360	4,000	5,510	5,850	6,470	7,850	8,670	9,950	
Residual	1,500	2,200	2,740	3,360	4,000	5,150	5,850	6,470	7,850	8,760	9,950	
I.D.O.	275	–	110	–	–	–	–	–	–	–	–	
H.S.D.	620	–	–	–	–	–	–	–	–	–	–	
Cost of power plant	2,060	2,740	2,740	3,420	3,920	3,920	4,600	5,540	5,540	6,480	7,950	
Hydro Karangkates 2nd	–	–	–	–	–	–	–	–	–	–	–	
Thermal	2,060	2,740	2,740	3,420	3,920	3,920	4,600	5,540	5,540	6,480	7,950	
125 MW unit	–	–	–	–	–	–	–	–	–	–	1,470	
75 "	–	–	–	–	–	–	–	940	940	1,880	1,880	
50 "	–	680	680	1,360	2,040	2,040	2,720	2,720	2,720	2,720	2,720	
25 "	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	
Diesel	180	180	180	180	0	–	–	–	–	–	–	
Gas turbine	280	280	280	280	280	280	280	280	280	280	280	
Total annual cost	4,455	4,940	5,590	6,780	7,920	9,070	10,450	12,010	13,390	15,240	17,900	107,745
Present worth factor	0.971	0.943	0.915	0.889	0.863	0.838	0.813	0.789	0.766	0.744	0.722	
Present worth in 1975 beginning	4,326	4,658	5,115	6,027	6,835	7,601	8,496	9,476	10,257	11,339	12,924	87,054
Thermal generation (million kWh)	370	487	610	780	975	1,200	1,400	1,630	1,890	2,180	2,500	
Generating cost (mill/kWh)	12.06	10.14	9.16	8.69	8.12	7.56	7.46	7.37	7.08	6.99	7.16	

Table X-20-3 ANNUAL COST CALCULATION OF SYSTEM (Plan T - C)

Interest Rate: 6%
(thousand US$)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	Total
Fuel cost	2,395	2,200	2,850	3,360	4,000	5,150	5,850	6,470	7,850	8,760	9,950	
Residual	1,500	2,200	2,740	3,360	4,000	5,150	5,850	6,470	7,850	8,760	9,950	
I.D.O.	275	–	110	–	–	–	–	–	–	–	–	
H.S.D.	620	–	–	–	–	–	–	–	–	–	–	
Cost of power plant	2,060	2,960	2,960	3,860	4,580	4,580	5,480	6,720	6,720	7,960	9,900	
Hydro Karangkates 2nd												
Thermal	2,060	2,960	2,960	3,860	4,580	4,580	5,480	6,720	6,720	7,960	9,900	
125 MW unit	–	–	–	–	–	–	–	–	–	–	1,940	
75 "	–	–	–	–	–	–	–	1,240	1,240	2,480	2,480	
50 "	–	900	900	1,800	2,700	2,700	3,600	3,600	3,600	3,600	3,600	
25 "	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	
Diesel	180	180	180	180	0	–	–	–	–	–	–	
Gas turbine	280	280	280	280	280	280	280	280	280	280	280	
Total annual cost	4,455	5,160	5,810	7,220	8,580	9,730	11,330	13,190	14,570	16,720	19,850	116,615
Present worth factor	0.943	0.890	0.84	0.792	0.747	0.705	0.665	0.627	0.592	0.558	0.527	
Present worth in 1975 beginning	4,201	4,592	4,880	5,718	6,409	6,860	7,534	8,270	8,625	9,330	10,461	76,880
Thermal generation (million kWh)	370	487	610	780	975	1,200	1,400	1,630	1,890	2,180	2,500	
Generating cost (mill/kWh)	12.04	10.60	9.52	9.26	8.80	8.11	8.09	8.09	7.71	7.67	7.94	

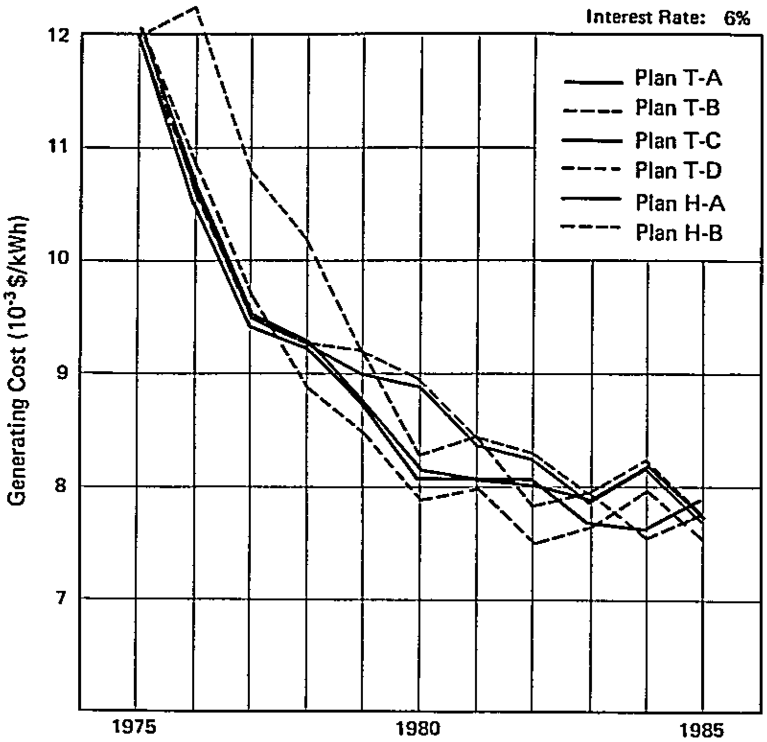


Fig. X-6 TREND OF GENERATING COST

as of 1972 was obtained in terms of construction cost per kW. As shown in tables X-21 and 22, US$ 102 per kW of plan T-B is the lowest closely followed by plans T-C and T-D, both US$ 104 per kW. Plans H-A and H-B which include hydro power project are respectively US$ 128 and US$ 134 per kW. When viewed from the energy cost, the order changes according to the year. Generally, Plan T-B ranks at the top with the least expensive energy cost and is followed by in the order of plans T-D, T-C, T-A, H-A and H-B. However, plan T-C follows immediately after plan T-D with negligible difference. Tables X-21 and 22 also give the ultimate energy costs of the respective plans; the ultimate energy costs to be attained when the system capacity in each plan is utilized to the fullest after 1985. Therefore, the ultimate energy costs of plans T-B, T-C and T-D will be lowered far below the costs in 1985. The order of plans in total expenditures during the 10 year period and in present worth as of 1975 are the same as that in the energy cost. However, the difference between plans T-C and T-D is nil in total expenditures as well as in the present worth. The above is the trend observed in the case of 6 percent interest rate. At an interest rate of 3 percent, this trend does not change.

From the economical point of view, the plans can be placed in the order of T-B, T-D, T-C, T-A, H-A and H-B. However, Plan T-B, including installation of a 75 MW capacity unit in 1976, is thought to be a little too advanced from the technical stand point. Following Plan T-B, there are plans T-D and T-C, and difference between the two is almost nil. As a conclusion of the Report, plan T-C is recommended because plan T-C would be better from the stand point of system reliability. Plans H-A and H-B which include the development of hydro power projects are costly as compared with the other plans that are based on the development of thermal power plants only. Therefore, plans H-A and H-B are not selected. This is attributable to the study's premise that peaking capacity will not be nece-

Table X-21 COMPARISON OF ALTERNATIVE PLANS

Interest Rate: 6%

Plan	Total output (MW)	Construction cost				Generating cost (mill/kWh)					Annual expenditure (thousand $)	
		(thousand $)	Cost/kW ($)	Present worth in 1972 (thousand $)	Present worth in 1972 Cost/kW ($)	1977	1980	1983	1985	Final	Total	Present worth in 1975
T - A	425	73,400	173	46,225	109	9.52	8.11	7.89	7.67	7.47	117,335	77,439
T - B	425	69,000	162	43,499	102	9.74	7.91	7.64	7.47	7.31	114,470	75,555
T - C	475	80,200	169	49,130	103	9.52	8.11	7.71	7.94	7.35	116,615	76,880
T - D	450	74,600	166	46,748	104	9.52	8.25	8.01	7.78	7.34	117,205	76,884
H - A	406	79,500	196	52,024	128	9.52	8.90	7.90	7.64	7.64	119,215	79,382
H - B	406	79,500	195	54,407	134	10.80	8.90	7.90	7.64	7.64	121,760	80,749

Note: T = Thermal Plan
H = Hydro Plan

Table X-22 COMPARISON OF ALTERNATIVE PLANS

Interest Rate: 3%

Plan	Total output (MW)	Construction cost				Generating cost (mill/kWh)					Annual expenditure (thousand $)	
		(thousand $)	Cost/kW ($)	Present worth in 1972 (thousand $)	Present worth in 1972 Cost/kW ($)	1977	1980	1983	1985	Final	Total	Present worth in 1975
T - A	425	71,000	167	55,964	132	9.16	7.56	7.20	6.96	6.80	108,255	87,448
T - B	425	66,800	157	52,632	124	9.25	7.41	7.01	6.80	6.67	106,030	85,705
T - C	475	77,600	163	60,255	127	9.16	7.56	7.08	7.16	6.69	107,745	87,054
T - D	450	72,200	160	56,707	126	9.16	7.63	7.30	7.05	6.69	108,275	87,529
H - A	406	76,800	189	61,723	152	8.35	7.90	7.11	6.85	6.85	107,658	87,009
H - B	406	76,800	189	63,020	155	9.68	7.90	7.11	6.85	6.85	109,080	88,283

Note: T = Thermal Plan
H = Hydro Plan

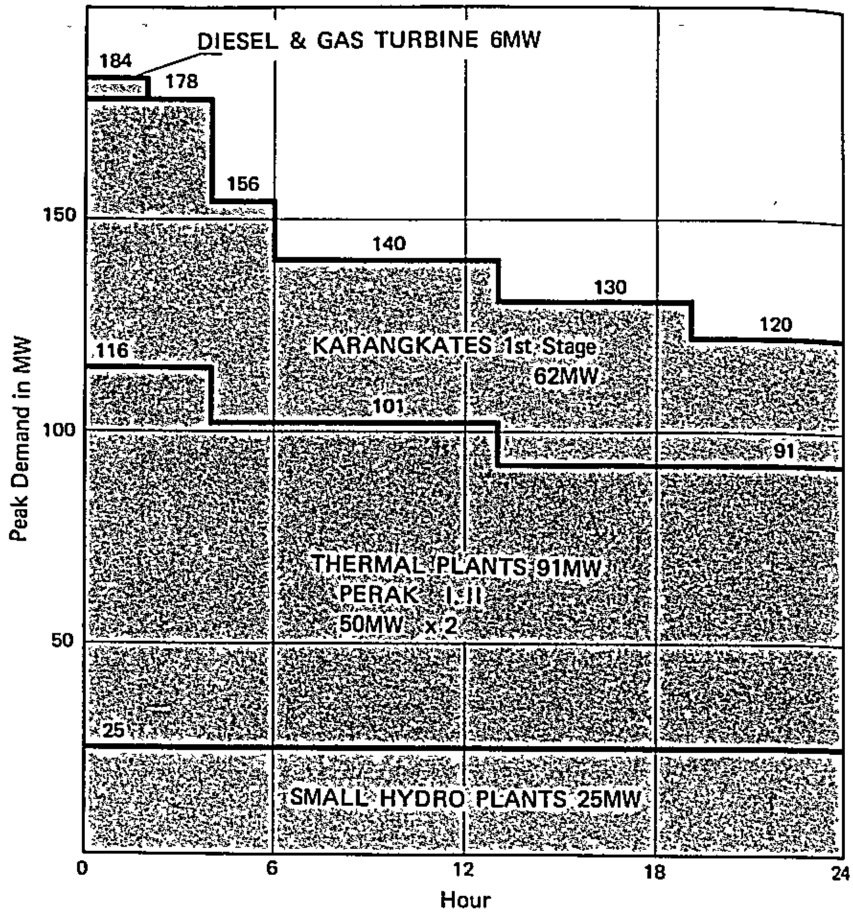


Fig. X-7 KW BALANCE
– 1977 –

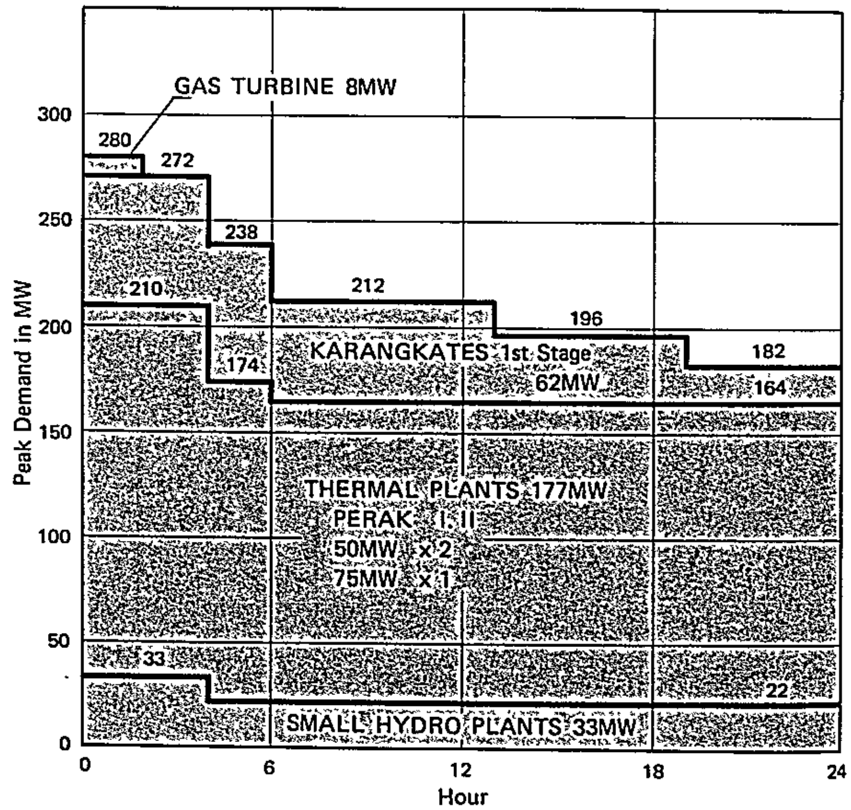


Fig. X-8 KW BALANCE
– 1980 –

Table X-23 KW BALANCE (Plan T - C)

(MW)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Required capacity	76	85	101	112	133	160	180	202	234	268	308	341	385	435	484	545
Peak demand	69	77	92	102	121	145	164	184	213	244	280	310	350	395	440	495
Reserve (10%)	7	8	9	10	12	15	16	18	21	24	28	31	35	40	44	50
Supply capability	92	95	96	112	168	168	218	218	268	306	306	356	431	431	506	631
Existing plant																
Hydro	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thermal	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diesel	13	–	–	–	7	–	–	–	–	0	–	–	–	–	–	–
Proposed plant																
Diesel		3	4	5	–	–	–	–	–	0	–	–	–	–	–	–
Gas turbine				12	–	–	–	–	–	–	–	–	–	–	–	–
Seloredjo				3	–	–	–	–	–	–	–	–	–	–	–	–
Karangkates 1st					62	–	–	–	–	–	–	–	–	–	–	–
Thermal 50 MW No.1							50	–	–	–	–	–	–	–	–	–
No.2									50	–	–	–	–	–	–	–
No.3										50	–	–	–	–	–	–
No.4												50	–	–	–	–
Thermal 75 MW No.1													75	–	–	–
No.2															75	–
Thermal 125 MW No.1																125
KW balance	16	10	–5	0	35	8	38	16	34	38	–2	11	46	–4	22	86

Note: – shows the continuation of the former figure.

Table X-24 ENERGY BALANCE (Plan T - C)

(million kWh)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1885
Energy demand	421	474	562	626	744	890	1,007	1,130	1,300	1,495	1,720	1,920	2,150	2,410	2,700	3,020
Supply capability	467	477	480	564	889	889	1,167	1,167	1,477	1,734	1,734	2,044	2,504	2.504	2,964	3,734
Existing plant																
Hydro	142	–	–	124	–	–	–	–	–	–	–	–	–	–	–	–
Thermal	285	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diesel	40	–	–	–	25	–	15	–	–	0	–	–	–	–	–	–
Proposed plant																
Diesel		10	13	16	–	–	–	–	–	0	–	–	–	–	–	–
Gas turbine				44	–	–	22	–	–	0	–	–	–	–	–	–
Seloredjo				55	–	–	–	–	–	–	–	–	–	–	–	–
Karangkates 1st					340	–	–	–	–	–	–	–	–	–	–	–
Thermal 50 MW No.1							310	–	–	–	–	–	–	–	–	–
No.2									310	–	–	–	–	–	–	–
No.3										310	–	–	–	–	–	–
No.4												310	–	–	–	–
Thermal 75 MW No.1													460	–	–	–
No.2															460	–
Thermal 125 MW No.1																770
Energy balance	46	3	–82	–62	145	–1	160	37	177	239	14	124	354	94	160	714

Note: – shows the continuation of the former figure.

ssary until around 1980 at the earliest. Consequently, hydro power and thermal power were evaluated on the same basis. If peaking capacity is required, power development without utilizing hydro power resources will be favorable. The study revealed that the need for peaking capacity following Karangkates 1st stage would come into being in the 1980's. The power development program should be reviewed and checked with the actual growth of demand. Chances may be given to the hydro power development projects in such a review.

The demand and supply in the case that the power development is implemented according to Plan T-C are shown respectively in figures X-7 and X-8 for the years of 1977 and 1980 and in tables X-23 and X-24. Also shown in Table X-26 is the investment schedule of Plan T-C with the breakdown of the total requirement of 80 million dollars.

Immediate Step to be Taken

In the foregoing studies, the next generating facility to be installed by 1975 following the completion of Karangkates 1st stage is determined to be a 50 MW capacity thermal unit. In consideration of the three years construction period, the installation of the unit should be in the premises of Tandjung Perak power plant where no land reclamation and preparation are necessary. In order to complete the thermal unit in the said period, the Government and PLN are required to start immediately on the financing of the project, as well as, investigations and preparation of definite designs including specifications.

Table X-25 *FEATURES OF NEW PERAK THERMAL POWER PLANT*

Location	In the compound of Tandjung Perak Thermal power plant
Installed capacity	50 MW x 2
Date of operation	
No. 1 unit	1975
No. 2 unit	1977
Construction cost	
2 units	18 million $

There will be two years interval between the scheduled completion dates of the first unit and the second unit. However, in view of the present fast rising international market prices of equipment and machinery it would be one way to purchase the equipment economically to purchase the second unit at the time of the first unit procurement with a delayed delivery time. The above construction cost includes the generating facilities only.

Table X-26 INVESTMENT SCHEDULE (Plan T - C)

Power Plant			1972	1973	1974	1975	1976
Thermal 50 MW	No.1	Total	–	1,800	3,200	4,000	–
		Foreign currency	–	1,440	2,560	3,200	–
		Domestic "	–	360	640	800	–
	No.2	Total	–	–	–	1,800	3,200
		Foreign currency	–	–	–	1,440	2,560
		Domestic "	–	–	–	360	640
	No.3	Total	–	–	–	–	1,800
		Foreign currency	–	–	–	–	1,440
		Domestic "	–	–	–	–	360
	No.4	Total	–	–	–	–	–
		Foreign currency	–	–	–	–	–
		Domestic "	–	–	–	–	–
Thermal 75 MW	No.1	Total	–	–	–	–	–
		Foreign currency	–	–	–	–	–
		Domestic "	–	–	–	–	–
	No.2	Total	–	–	–	–	–
		Foreign currency	–	–	–	–	–
		Domestic "	–	–	–	–	–
Thermal 125 MW	No.1	Total	–	–	–	–	–
		Foreign currency	–	–	–	–	–
		Domestic "	–	–	–	–	–
Total			–	1,800	3,200	5,800	5,000
Foreign currency			–	1,440	2,560	4,640	4,000
Domestic			–	360	640	1,160	1,000
Present worth factor			–	0.890	0.840	0.792	0.747
Present worth in 1972			–	1,602	2,688	4,594	3,735

Interest rate: 6%
(thousand US$)

1977	1978	1979	1980	1981	1982	1983	1984	Total	Year of completion
–	–	–	–	–	–	–	–	9,000	1975
–	–	–	–	–	–	–	–	7,200	
–	–	–	–	–	–	–	–	1,800	
4,000	–	–	–	–	–	–	–	9,000	1977
3,200	–	–	–	–	–	–	–	7,200	
800	–	–	–	–	–	–	–	1,800	
3,200	4,000	–	–	–	–	–	–	9,000	1978
2,560	3,200	–	–	–	–	–	–	7,200	
640	800	–	–	–	–	–	–	1,800	
–	1,800	3,200	4,000	–	–	–	–	9,000	1980
–	1,440	2,560	3,200	–	–	–	–	7,200	
–	360	640	800	–	–	–	–	1,800	
–	–	2,500	4,400	5,500	–	–	–	12,400	1981
–	–	2,000	3,520	4,400	–	–	–	9,920	
–	–	500	880	1,100	–	–	–	2,480	
–	–	–	–	2,500	4,400	5,500	–	12,400	1983
–	–	–	–	2,000	3,520	4,400	–	9,920	
–	–	–	–	500	880	1,100	–	2,480	
–	–	–	–	–	3,900	6,800	8,700	19,400	1984
–	–	–	–	–	3,120	5,440	6,960	15,520	
–	–	–	–	–	780	1,360	1,740	3,880	
7,200	5,800	5,700	8,400	8,000	8,300	12,300	8,700	80,200	
5,760	4,640	4,560	6,720	6,400	6,640	9,840	6,960	64,160	
1,440	1,160	1,140	1,680	1,600	1,660	2,460	1,740	16,040	
0.705	0.665	0.627	0.592	0.558	0.527	0.497	0.469		
5,076	3,857	3,574	4,973	4,464	4,374	6,113	4,080	49,130	

XI

TRANSMISSION AND DISTRIBUTION DEVELOPMENT PROGRAM

The development program of transmission and distribution system was formulated based on the estimated future demand and in line with the power development program established in Chapter X. Today, the rehabilitation and expansion of the transmission and distribution system is being executed in compliance with a schedule prepared for a period of up until 1974. Accordingly, the present program covers a period of 1975 to 1985. Detailed studies on power flow, voltage control and system stability are given in the appendix to this Report.

1. Basic Considerations

The power demand in East Java is thought to increase remarkably resulting from the extensive electrification and the large potential demand in the industrial sector. The proposed transmission lines may be divided into three groups according to their roles. One is to be connected from the new power plants; the second is to supply power to load centers where industrial load will be the principal load; and the third is to be extended into rural areas to promote electrification.

Reliability

The transmission lines to convey power from power plants and those to supply power to load centers are important in the system and require high reliability. On the other hand, the transmission lines to be extended for electrification of rural areas supplying low-cost and stable energy may be low in reliability at the initial stage when compared with the others, as long as less expensive energy can be supplied to the area. Therefore, 70 kV single circuit transmission line was considered for this purpose. In the 1980's, however, the extension of the 70 kV line was scheduled in a manner to constitute local loops in order to raise the reliability regionally, as well as to promote the electrification.

The followings are the basic factors in planning the transmission and distribution facilities.

i. The facilities should satisfy the reliabilities described later.
ii. In view of the existing facilities and the size of the system, the voltages of transmission facilities were determined to be 150 kV and 70 kV and the distribution facilities to be 20 kV and 220/380 V.
iii. From the size of the system, the unit transformer capacities were rated at 35 MVA for 150 kV and 3 MVA, 6 MVA and 10 MVA for 70 kV. Three to four units was the objective in determining the number of transformers at a substation.
vi. Due to the short lengths of the transmission lines, twice the surge impedance loading was the target value in determining the transmission line capacities. They are,

150 kV	per single circuit	112 MVA
70 kV	" " "	24 MVA
30 kV	" " "	4.4 MVA
25 kV	" " "	3.1 MVA.

2. Voltage Levels

150 kV

The highest voltage in the Republic, 150 kV has been adopted for the 146 kilometers long transmission line from Tjawang substation to Tjigereleng substation via Djatiluhur to supply power produced at Djatiluhur power plant, completed in 1964, to Djakarta and Bandung, as well as, for the 110 kilometers long transmission line between Karangkates power plant and Waru II substation which, now under construction, is scheduled to be completed in 1973.

The ordinance (Declear No. 39/K/1970) in 1970 provided for the standard ization of voltages. The 150 kV is, according to the ordinance, a special voltage for a special case, and a voltage higher than 70 kV is stipulated as 110 kV or 220 kV. However, adoption of the two voltages that are close to the prevailing voltage of 150 kV was avoided for the reasons described below. In the Report, the 150 kV was adopted for the future high voltage transmission lines.

i. The 150 kV transmission lines, 256 kilometers in total length, are already in operation or under construction in Java.
ii. Close to the existing 70 kV in voltage, the 110 kV is too low in relation to the size of the system.
iii. If 220 kV is adopted, transformers will be necessary between the 220 kV and the existing 150 kV lines with the result that the merit expected from transmission lines connecting the large cities will be curtailed.
iv. The 150 kV transmission now under construction between Karangkates power plant and Waru II substation should be effectively utilized in supplying power to Surabaja, Pasuruan and Malang, the largest load centers in East Java.
v. The adoption of 220 kV would require a large initial investment in relation to the size of demand and for connection with the 150 kV line.
vi. The East Java system will be interconnected with the Central system presumably in 1985. The 150 kV will be sufficient for the interconnection.
vii. As stated in XIII. Overall Studies on All Java System, the trans-island transmission line will have to be 330 to 380 kV, and both 150 and 220 voltages are disqualified for the purpose.

The 150 kV transmission lines will be used as major power source lines of the system, and after about 1980 when the 70 kV lines become short in capacity, it will serve to interconnect regional systems in East Java. When a 125 MW thermal unit is put into operation in 1985, the East Java system will be interconnected with the Central Java system at 150 kV in order to improve the reliability of East Java system as a whole.

70 kV At present, the 70 kV lines comprise the principal systems in East Java. In the future when the systems are expanded, they will be used as subtransmission lines serving to accelerate the electrification of rural areas. The 70 kV lines to be constructed until 1985 will extend over a total distance of about 900 kilometers-circuit, requiring a large portion of the total capital investment of the implementation program as a whole.

30 kV and 25 kV These voltages are being used on subtransmission lines of a part of Kalikonto system and Madiun system. The 30 kV lines total to a length of 205.7 kilometers, and the 25 kV lines 57.0 kilometers. After 1975, however, transmission lines of these voltages will not be constructed since these voltages will be too low as a system voltage where demand is expected to grow large. In addition, the subtransmission line voltage should also be standardized as soon as possible. The existing subtransmission lines of 30 kV and 25 kV, however, will have to be utilized effectively during their serviceable lives.

The distribution voltages are 6 kV and 127/220 V in East Java except a part of Surabaja. In order to promote the electrification in East Java, the future distribution voltages were assumed to be 20 kV and 220/380 V which are the highest values among those set forth in the 1970 ordinance. Connected to the existing facilities, some of the proposed distribution facilities will not be able to be operated at 20 kV immediately after installation. Such facilities, too, were assumed to be designed for the 20 kV distribution so that the voltage could be raised easily in the future. In order to hike the prevailing voltage, detailed investigations are necessary. Further, the hike of voltage should be executed step-by-step in line with a comprehensive development plan.

Distribution Voltage

3. Level of Reliability

The level of reliability will directly reflect in the construction cost of transmission and distribution facilities. It is one of the objectives of the electric utility to supply stable energy with a high reliability. However, the reliability level should be determined duly taking into account the utilization factor of the facilities in relation to the socio-economic requirement, such as, promotion of electrification, nursing of industry, etc. in order to have the transmission and distribution facilities effective.

Prevention of Power Failure

The degree of damages by power failure to consumers vary with the nature and location of demand. Power failure in a large city could possibly cause social unrest, and to a factory it might bring severe damages. If power failure occurs in a city like Surabaja, Pasuruan, Malang or Madiun in which is large and dense population with relatively advanced industries, damages would be large especially to the textile, cement and chemical industries of the cities. Therefore, the transmission and distribution facilities in these areas were assumed to be designed in such a way that failure of a single circuit would not be followed by power supply failure. In areas other than the above, such power supply failure of temporary nature was considered inevitable in the incipient stage. But, these areas were assumed to decrease by 1980.

Reliability of Power Source Line

The feeders of the present power plants in the East Java system are composed of two routes or two circuits. For the future planning, two or more circuits were considered in order to prevent tripping of power plants of large capacities which would be caused by a temporary failure of transmission line.

Protection of System

The 150 kV transmission lines will be all protected by power line carrier relay systems from grounding fault and short circuit fault in order to maintain the system stability. In consideration of the future system of high complexity, all the 150 kV substations will have double bus bars to facilitate system operation.

Transmission Line Overloding

The transmission line will be designed in a manner to restrict a temporary overload within allowable current capacity of the conductor; the temporary overloading to be caused by disconnection of a line section on account of maintenance or fault. If the overloading occurs, the load will be dispersed by system operation as soon as possible.

Transformer Overloding

Overloading of a transformer will cut its life short. The transformers at principal substations should be designed in a manner to restrict within a short period an overload of less than 150 percent of the rated capacity; the overload to be caused by outage of another transformer of the substation. The transformers to be installed in rural areas were assumed to satisfy the above conditions later. It will be around 1980 or 1985 that a majority of the transformers will become satisfactory to the conditions.

4. **Transmission Facilities Expansion Program**
According to the power development program established in the Report covering the period up to 1985, future generating capacity additions will be all thermal units after 1973 when Karangkates hydro power plant is completed. They will be New Perak power plant with two 50 MW units, Grati power plant with two 50 MW units and one 125 MW unit and Gresik power plant with two 75 MW units, totaling 475 MW in installed capacity.

Till 1974 The system rehabilitation and expansion program has already been decided of its outline as indicated in table XI-1 and XI-2. Its features are the interconnection between Kalikonto and Madiun systems, the second circuit installation of Kalikonto 70 kV system and the construction of a 150 kV transmission line between Karangkates hydro power plant and Waru II substation.

Table XI-1 TRANSMISSION LINE EXPANSION PROGRAM
(Scheduled until 1974)

Transmission Line	Rated voltage (kV)	Length (Km)	No. of Circuit	Date in service
Karangkates - Waru II	150	110	1/2	1973
Bangil - Probolinggo	70	55	2	1973
Sukolilo Branch	70	2	2	1973
Waru II - Bangil	70	32.2	1/2→ 2	1973
Bangil - Blimbing	70	40.5	1/2→ 2	1973
Letjes - Lumadjang	30	32	1	1973
Tulungagung - Trenggalek	30	32	1	1973
Delopo - Ponorogo	25	14	1	1973
Modjokerto - New Madiun	70	110	1/2	1974
Blimbing - Polehan	70	13.0	1/2→ 2	1974
Sengkaling branch	70	1.5	2	1974
Kertosono branch	70	1	1	1974
New Mediun - Mranggen	25	5	2	1974
Mranggen - Ngawi	25	23	1	1974
Mranggen - Magetan	25	16	1	1974

From 1975 to 1979 Transmission lines will be constructed at 150 kV along with the completion of New Perak power plant and Grati power plant. At the same time, the 70 kV single circuit transmission lines will be expanded for electrification of East Java, although the reliability will be somewhat low.

From 1980 to 1985 To connect Gresik power plant to be completed in this period, a 150 kV transmission line will be constructed from Waru II substation. At the same time, the 150 kV grid system will spread out to regions where demand will have increased rapidly. The 70 kV single circuit lines will be further expanded to form local loops for the electrification and reliability improvement purposes. Also, a 150 kV transmission line will be constructed, in parallel with the construction of a 125 MW thermal unit, to connect to a system in Central Java.

Table XI-2 TRANSFORMER EXPANSION PROGRAM
(Scheduled until 1974)

Name of substation	Transformer Rated voltage (kV)	Transformer New capacity (Total cap.) (MVA)	Date in service
Waru II	150/70	39 x 2 (78)	1973
Sukolilo	70/20	10 x 1 (10)	1973
Probolinggo	70/30/6	10 x 1 (12)	1973
Kediri	30/6	3 x 2 (9)	1973
Trenggalek	30/6	3 x 1 (3)	1973
Modjokerto	70/30/6	10 x 1 (13)	1973
Ngawi	25/6	0.8 x 2 (1.6)	1973
Ponorogo	25/6	3 x 1 (3)	1973
Lumadjang	30/6	3 x 1 (3)	1973
Sawahan	70/20	10 x 1 (32)	1974
Perak	70/20	10 x 1 (20)	1974
Sengkaling	70/6	3 x 1 (3)	1974
Bangil	70/20/6	10 x 1 (26)	1974
Kertosono	70/6	3 x 1 (3)	1974
Magetan	25/6	3 x 1 (3)	1974
New Mediun	70/25	10 x 1 (10)	1974

Thus, by 1985, a transmission network free from supply failure which would be caused by single transmission line fault will be established with the provisions of more than two routes in major regions. At this stage, the system left isolated will be one in Patjitan region. Regions remote from the transmission network will also be electrified by 20 kV distribution lines. Spread out throughout East Java at this stage, the power network will contribute to the more rapid electrification of East Java. The transmission and distribution facilities to be constructed by 1985 are enumerated in table XI-3 and XI-4 and Fig. XI-1. Fig XI-2 gives a power system diagram in 1985.

Peak Load Estimate

The future peak demand and energy demand were estimated in VIII. and IX. The regional peak loads were obtained from the energy demand of the respective regions based on a uniform annual load factor of 70 percent with the results shown in Table XI-5. The peak loads of substations were estimated based on the number of waiting customers, the estimated population growth and the capacities of privately owned generating facilities taking into account the peak loads of the existing substations in 1970. The power flows prospected for the years of 1976, 1978, 1980 and 1985 are shown in the appendix to this Report.

New Power Plant and Bulk Transmission Plan

The system planning is subject to the locations of proposed power plants and their timing of implementation. In the Report, the thermal power plants were assumed to be constructed at Perak, Grati and Gresik. The 150 kV transmission lines to connect the future thermal power plants were planned in a manner to effectively utilize the 150 kV transmission line between Karangkates power plant and Waru II substation. As a result, a grid system centering Waru II substation was proposed to be established covering the load centers of Gresik, Surabaja and Pasuruan in order to secure sufficient capacity to meet the growing demand of these regions. The transmission lines to supply energy to Modjokerto, Madiun, Malang and

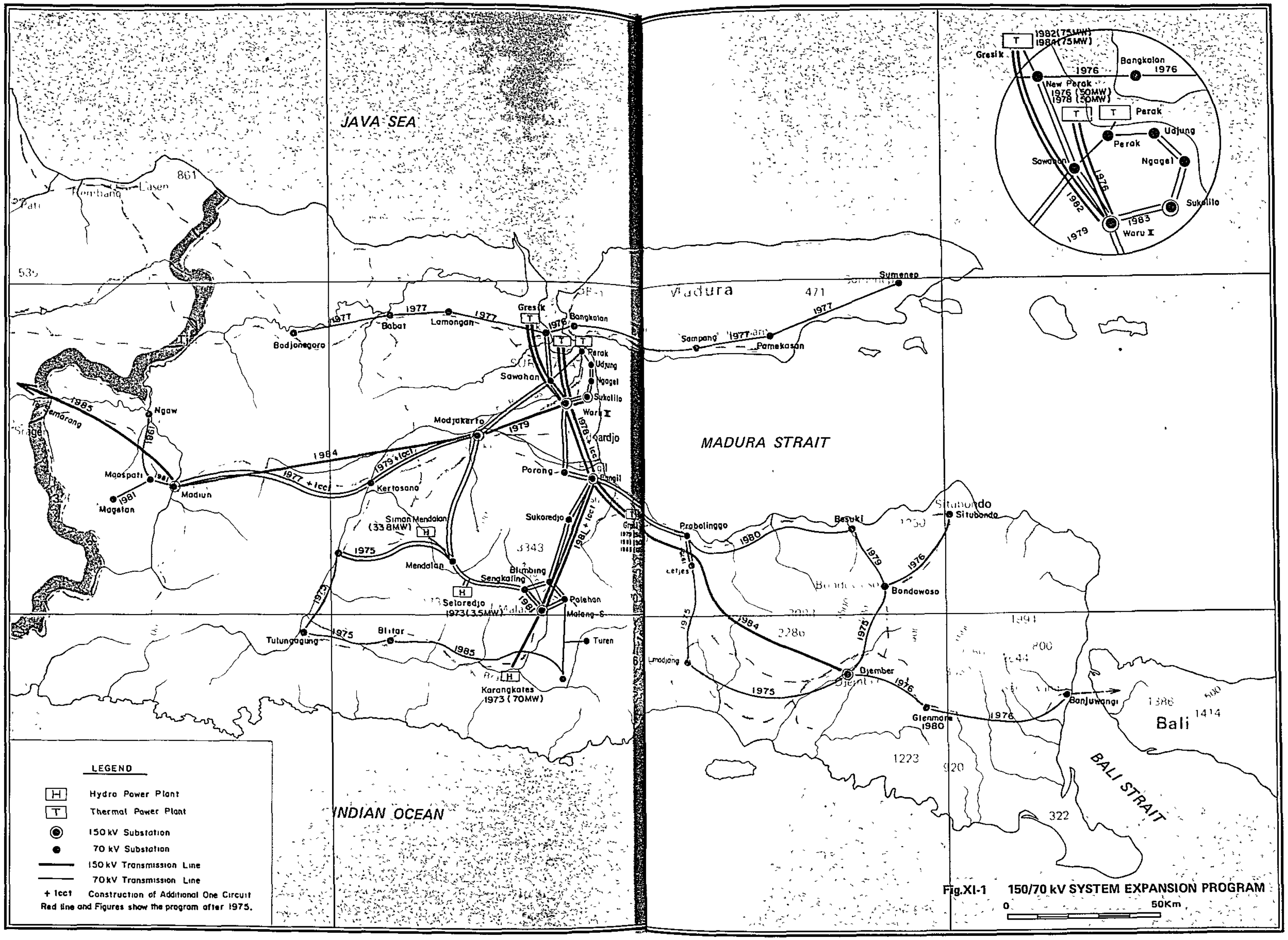


Fig.XI-1 150/70 kV SYSTEM EXPANSION PROGRAM

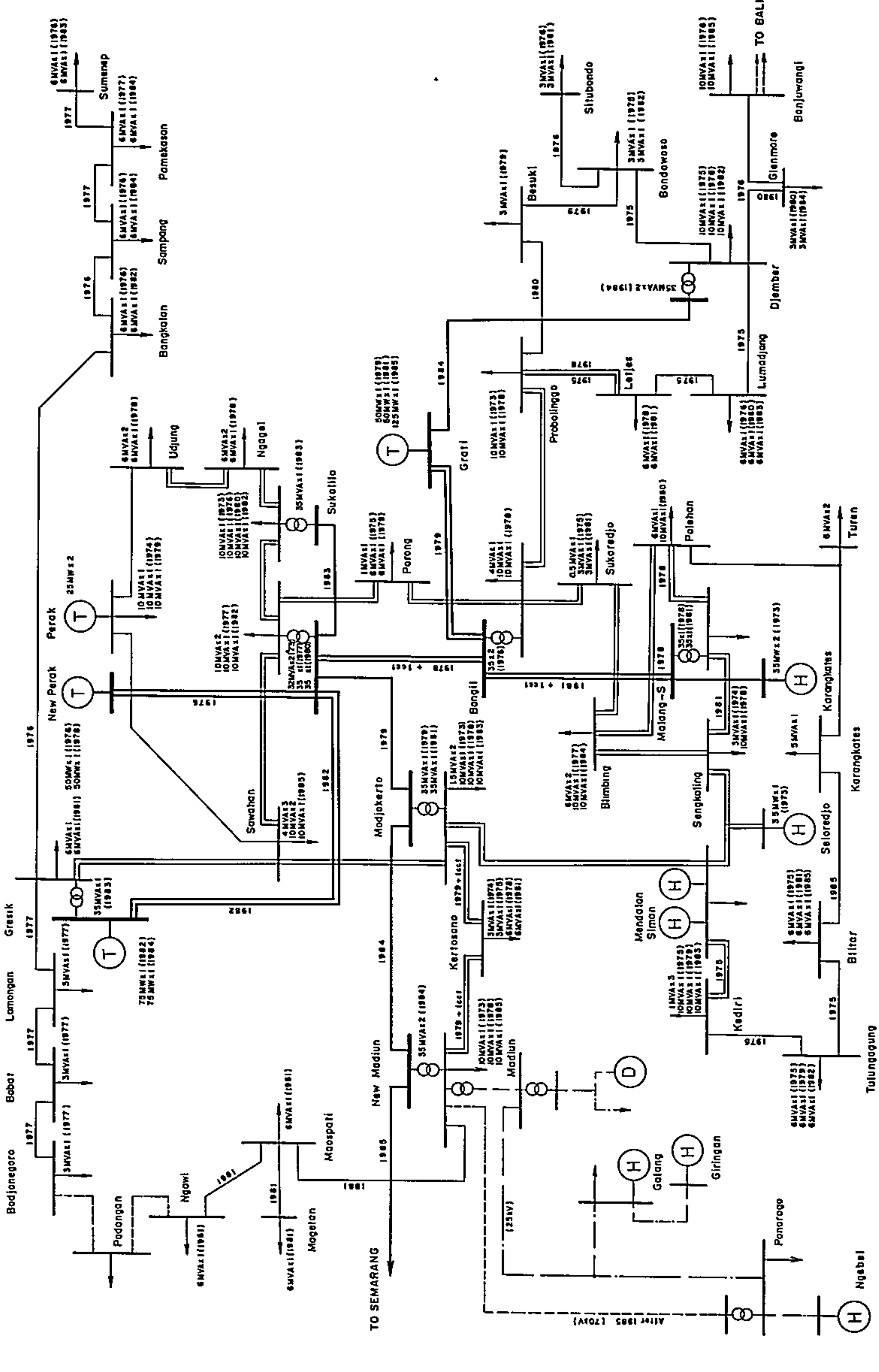


Fig. XI-2 POWER SYSTEM DIAGRAM

Table XI-3 TRANSMISSION LINE EXPANSION PROGRAM (1975 - 1985)

Transmission line	Rated voltage (kV)	Length (Km)	No. of circuit	Terminal end Rated voltage (kV)	Terminal end No. of circuit	Date in service
Probolinggo - Letjes	70	11	½	70	1	1975
Letjes - Lumadjang	70	32	1			1975
Lumadjang - Djember	70	60	1	70	1	1975
Djember - Bondowoso	70	35	1	70	2	1975
Mendalan - Kediri	70	28	2	70	2	1975
Kediri - Tulungagung	70	28	1	70	2	1975
Tulungagung - Blitar	70	29	1	70	2	1975
Bangil branch	150	0.5 x 2	½	150	2	1976
New Perak - Waru II	150	20	2	150	2	1976
Bondowoso - Situbondo	70	32	1	70	2	1976
Djember - Banjuwangi	70	77	½	70	2	1976
Gresik - Bangkalan	70	3 †	1			1976
Gresik - Bangkalan	70	19	1	70	2	1976
Bangkalan - Sampang	70	50	1	70	2	1976
Lumadjang branch	70	0.5 x 2	1	70	2	1976
Gresik - Lamongan	70	35	1	70	2	1977
Lamongan - Babat	70	30	1	70	2	1977
Babat - Bodjonegoro	70	26	1	70	2	1977
Sampang - Pamekasan	70	20	1	70	2	1977
Pamekasan - Sumenep	70	55	1	70	2	1977
Bangil - Waru II	150	33	½→2	150	2	1978
Malang Selatan branch	150	0.5 x 2	½	150	2	1978
Probolinggo - Letjes	70	11	½→2	70	3	1978
Letjes branch	70	0.5	1	70	1	1978
Malang Selatan - Polehan	70	10	2	70	4	1978
Grati - Bangil	150	30	2	150	2	1979
Waru II - Modjokerto	150	30	½	150	2	1979
Bondowoso - Besuki	70	33	1	70	2	1979
New Madiun - Modjokerto	70	110	½→2	70	4	1979
Besuki - Probolinggo	70	60	1	70	2	1980
Glenmore branch	70	0.5 x 2	1	70	2	1980
Malang Selatan - Bangil	150	50	½→2	150	2	1981
Malang Selatan - Sengkaling	70	10	2	70	4	1981
Maospati - Ngawi	70	23	1	70	2	1981
Maospati - Magetan	70	15	1	70	2	1981
New Madiun - Maospati	70	13	1	70	2	1981
Waru II - Gresik P.P.	150	25	2	150	2	1982
Gresik P.S. - Gresik	70	5	2	70	4	1982
Waru II - Sukolilo	150	13	½	150	2	1983
Grati - Djember	150	110	½	150	2	1984
Modjokerto - New Madiun	150	110	½	150	2	1984
New Madiun - Semarang	150	155	½	150	1	1985
Blitar - Karangkates	70	35	1	70	2	1985

Note: † Marine cable.

Table XI-4 TRANSFORMER EXPANSION PROGRAM (1975-1985)

Name of substation	Transformer Rated voltage (kV)	New capacity (MVA)	(Total Cap.) (MVA)	Date in service
Porong	70/20	6 x 1	(7)	1975
Sukoredjo	70/20	3 x 1	(3.5)	1975
Kertosono	70/20	3 x 1	(6)	1975
Kediri	70/20	10 x 1	(10) †	1975
Tulungagung	70/20	6 x 1	(6) †	1975
Blitar	70/20	6 x 1	(6) †	1975
Djember	70/20	10 x 1	(10)	1975
Bondowoso	70/20	3 x 1	(3)	1975
Bangil	150/70	35 x 2	(70) 197	1976
Sukolilo	70/20	10 x 1	(20)	1976
Lumadjang	70/20	6 x 1	(6)	1976
Banjuwangi	70/20	10 x 1	(10)	1976
Situbondo	70/20	3 x 1	(3)	1976
Bangkalan	70/20	6 x 1	(6)	1976
Sampang	70/20	6 x 1	(6)	1976
Waru II	150/70	35 x 1	(113)	1977
Waru II	70/20	10 x 1	(30)	1977
Lamongan	70/20	3 x 1	(3)	1977
Babat	70/20	3 x 1	(3)	1977
Bodjonegoro	70/20	3 x 1	(3)	1977
Pamekasan	70/20	6 x 1	(6)	1977
Sumenep	70/20	6 x 1	(6)	1977
Blimbing	70/20	10 x 1	(22)	1977
Malang Selatan	150/70	35 x 1	(35)	1978
Ngagel	70/20	6 x 1	(18)	1978
Udjung	70/20	6 x 1	(18)	1978
Sengkaling	70/20	10 x 1	(13)	1978
Bangil	70/20	10 x 1	(36)	1978
Probolinggo	70/20	10 x 1	(20) †	1978
Letjes	70/20	6 x 1	(6) †	1978
Kertosono	70/20	6 x 1	(12)	1978
Modjokerto	70/20	10 x 1	(23)	1978
Madiun	70/20	10 x 1	(20)	1978
Djember	70/20	10 x 1	(20)	1978
Modjokerto	150/70	35 x 1	(35)	1979
Perak	70/20	10 x 1	(30)	1979
Porong	70/20	6 x 1	(13)	1979
Kediri	70/20	10 x 1	(20)	1979
Tulungagung	70/20	6 x 1	(12)	1979
Besuki	70/20	3 x 1	(3)	1979
Waru II	150/70	35 x 1	(148)	1980
Sukolilo	70/20	10 x 1	(30)	1980
Polehan	70/20	10 x 1	(16)	1980
Lumadjang	70/20	6 x 1	(12)	1980
Glenmore	70/20	3 x 1	(3)	1980
Modjokerto	150/70	35 x 1	(70)	1981
Malang Selatan	150/70	35 x 1	(70)	1981

(Continued)

Name of substation	Transformer Rated voltage (kV)	New capacity (MVA)	(Total Cap.)	Date in service
Gresik	70/20	6 x 1	(12)	1981
Sukoredjo	70/20	3 x 1	(6.5)	1981
Letjes	70/20	6 x 1	(12)	1981
Kertosono	70/20	6 x 1	(18)	1981
Blitar	70/20	6 x 1	(12)	1981
Ngawi	70/20	6 x 1	(6)	1981
Maospati	70/20	6 x 1	(6)	1981
Magetan	70/20	6 x 1	(6)	1981
Situbondo	70/20	3 x 1	(6)	1981
Waru II	70/20	10 x 1	(40)	1982
Tulungagung	70/20	6 x 1	(18)	1982
Djember	70/20	10 x 1	(30)	1982
Bondowoso	70/20	3 x 1	(6)	1982
Bangkalan	70/20	6 x 1	(12)	1982
Gresik P.P.	150/70	35 x 1	(35)	1983
Sukolilo	150/70	35 x 1	(35)	1983
Kediri	70/20	10 x 1	(30)	1983
Modjokerto	70/20	10 x 1	(33)	1983
Lumadjang	70/20	6 x 1	(18)	1983
Sampang	70/20	6 x 1	(12)	1983
Sumenep	70/20	6 x 1	(12)	1983
Blimbing	70/20	10 x 1	(32)	1983
Madiun	150/70	35 x 2	(70)	1984
Djember	150/70	35 x 2	(70)	1984
Glenmore	70/20	3 x 1	(6)	1984
Pamekasan	70/20	6 x 1	(12)	1984
Sawahan	70/20	10 x 1	(42)	1985
Blitar	70/20	6 x 1	(18)	1985
Madiun	70/20	10 x 1	(30)	1985
Banjuwangi	70/20	10 x 1	(20)	1985

Note: † Total capacity not included 30 kV transformer.

Djember where large demands are projected will be extended from this grid system after 1979. In 1985, a 150 kV transmission line will be extended from New Madiun substation to Semarang in order to enhance the system reliability, as well as, to save the reserve capacity of the system.

Surabaja and Modjokerto

There are eight substations in these regions, and the transmission line linking these substations will constitute a loop system. In addition, Sukolilo substation is scheduled to be constructed in East Surabaja branch by 1974. *To supply energy to the 70 kV system, 150 kV transformers will be installed* at Modjokerto substation in 1979 and Sukolilo substation in 1983 in addition to Waru II substation. Gresik thermal power plant will also have 150 kV / 70 kV transformers for power supply in Gresik region. The construction schedule is that the 150 kV transmission lines between New Perak and Waru II and between Gresik and Waru II are to be completed respectively in 1976 and 1982. Further, Waru II - Modjokerto line (150 kV) and Waru II - Sukolilo line (150 kV) are scheduled to be constructed during the period of 1979 to 1983 as a countermeasure against overload of the 70 kV transmission lines.

Pasuruan and Malang In Pasuruan at present, power is supplied from Bangil substation to Probolinggo, Letjes and Lumadjang by 30 kV transmission lines. And, the construction of a 70 kV transmission line is scheduled between Bangil and Probolinggo. In parallel with the Grati thermal power plant construction, a 150 kV transmission line will be constructed between the power plant and Bangil substation by 1979. Prior to the completion of this line, to cope with the capacity shortage of Waru II - Bangil line (70 kV), Karangkates - Waru II line (150 kV) will be connected to Bangil substation in 1976, and it will be made double circuit in 1978.

For power supply to Malang, Sengkaling substation will be constructed by 1974. Malang Selatan substation will be constructed to the south of Malang in 1978, and it will be connected to Karangkates - Waru II transmission line (150 kV). The second circuit will be installed for the section between Bangil and Malang Selatan in 1981 to raise the reliability.

A 70 kV transmission line will be constructed from Probolinggo to Djember via Letjes and Lumadjang to supply energy to eastern region around Djember. However, Letjes and Lumadjang substations will not be connected to this 70 kV line until the 30 kV line, to be constructed prior to the 70 kV line, becomes short in capacity. Connections to the 70 kV line will be made in 1976 and 1978 respectively from Lumadjang substation and Letjes substation. In 1978, the section between Probolinggo and Letjes will have the second circuit installed.

Kediri The region is being supplied power by a 30 kV transmission line. To cope with the growth in demand of the region, a 70 kV transmission line will be constructed by 1975 from Mendalan hydro power plant to Blitar via Kediri and Tulungagung. In addition, another 70 kV line will be installed between Karangkates substation and Blitar substation by 1985 for higher reliability and larger supply capability. A 70 kV transmission line is also conceivable between Kertosono and Kediri to supply power to Kediri. This, however, would not be effective as stated in the appendix to the Report.

Madiun To supplement the shortage of Madiun system capacity, a 70 kV transmission line will be constructed from Modjokerto of Kalikonto system to Madiun via Kertosono by 1974. As a result, the Madiun system will be integrated in the Kalikonto system. The Modjokerto - Madiun line will be strengthened by installing the second circuit in 1979 to cope with the increase of demand in Madiun region. Further, a 150 kV transmission line is scheduled from Modjokerto to New Madiun substation in 1984. The increase of demand in the regions of Maospati, Ngawi and Magetan is thought to necessitate the construction of 70 kV transmission line by 1981. However, Ponorogo region will rely on the present 25 kV transmission line for some time.

Djember and Eastern Region Power supply in this region is being carried out by diesel units. The population is large. Privately owned generating units are also large in number. The future demand of this region is expected to grow at a rapid pace. Within the years of 1975 and 1976 the major cities of Djember, Bondowoso, Situbondo and Banjuwangi will be interconnected by 70 kV transmission lines. In 1980, Besuki will be connected to Bondowoso by another 70 kV line. A transmission line to be completed in 1980 interconnecting Probolinggo and Besuki will serve to supply energy to Eastern region and help raise the supply reliability to the major cities. Further, a 150 kV transmission line will be constructed between Grati power plant and Djember in 1984.

Other Region

A 70 kV transmission line has been proposed to supply power to Madura from Gresik power plant. The Report followed this project, and about 3 kilometers long marine cable was considered for across-the-channel interconnection. The interconnecting point on the side of Java is conceivable at Gresik, Tandjungsawa north of Gresik, and north Surabaja. Therefore, investigations on these sites are necessary to be done at an early stage. The 70 kV transmission line to supply energy to Bodjonegoro from Gresik is thought to have a surplus capacity in relation to the estimated demand. However, in view of the population in Bodjonegoro, 2.7 million approximately which is a great potential itself for the future expansion, the capacity of 70 kV is believed to be reasonable.

Table XI-5 ESTIMATED PEAK LOAD OF INTERCONNECTED SYSTEM (1975 - 1985) *(MW)*

Branch	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Surabaja	65.64	70.27	74.73	85.16	96.83	111.21	121.0	135.0	150.0	165.0	180.0
Pasuruan	16.00	19.02	21.63	24.85	28.43	32.44	36.5	41.5	47.0	54.0	60.0
Malang	18.89	20.88	23.11	25.86	28.79	32.02	35.5	39.0	43.0	48.0	53.0
Kediri	12.05	14.63	17.69	21.03	24.89	29.29	34.0	39.0	44.0	50.0	58.0
Madiun	10.60	12.53	14.63	16.93	19.34	22.12	25.0	29.0	33.0	37.0	42.5
Modjokerto	4.47	5.35	6.29	7.35	8.37	9.55	11.0	12.0	14.0	16.0	17.8
Djember	8.20	10.27	12.53	14.94	17.72	20.64	23.5	27.0	31.0	35.0	40.0
Banjuwangi	–	4.07	4.59	5.12	5.61	6.09	7.0	7.9	8.8	9.8	11.1
Situbondo	–	1.91	2.11	2.25	2.38	2.45	2.85	3.3	3.8	4.3	5.0
Bodjonegoro	–	–	0.44	0.93	1.38	1.88	2.2	2.5	2.9	3.4	4.0
Pamekasan	–	5.24	6.65	8.27	10.12	12.29	14.5	16.5	19.0	22.0	25.0
Total	135.85	164.1	184.4	212.7	243.8	280.0	313.6	351.3	393.3	440.3	493.1

5. Distribution Facilities Expansion Program

The present electrification ratio is about 20 percent in Surabaja region, and 4 to 5 percent on the average for East Java. In order to boost the ratio from the present level to the average of 13 percent in East Java, a large amount of fixed capital investment will be required for the expansion of distribution network.

Distribution Facilities

The distribution facilities should be expanded to meet the increasing demand of the existing customers, as well as, to raise the electrification ratio. The expansion program should be formulated taking into account the local conditions of the respective towns and villages. However, in the Report which aims at the long-range development program, the distribution facilities were studied from the macroscopic point of view. As in the case of Chapter IX. Load Forecast by Analytical Method, the power consumption was divided into three sectors of residential, commercial and industrial.

As shown in Table XI-6, the number of residential customers was approximately 196,900 in 1970, and is estimated to be 632,500 and 1,026,800 respectively in 1980 and 1985. The ratio of the annual average load to the total contract capacity, or the load factor multiplied by the demand factor, was 38 percent as of 1970, which was considerably large when compared

Table XI - 6 REQUIRED DISTRIBUTION TRANSFORMERS

	1970	1971	1972	1973	1974	1975
For residential customer						
Energy consumption (million kWh)	247.3	277.6	309.0	344.7	416.5	483.8
Coefficient†	0.38	0.375	0.369	0.364	0.359	0.353
Number of customer (thousand)	196.9	217.0	240.8	265.3	316.5	363.5
Average contract VA per customer	377.4	389.4	397.0	407.5	418.3	430.5
Contract MVA	74.3	84.5	95.6	108.1	132.4	156.5
Required distribution transformer (MVA)	94.2	100.6	106.1	112.4	127.1	137.7
For commercial customer						
Energy consumption (million kWh)	19.6	21.6	24.0	26.6	32.0	36.2
Coefficient†	0.167	0.169	0.171	0.173	0.175	0.177
Number of customer (thousand)	8.89	9.77	10.89	11.65	14.61	16.80
Average contract VA customer	1,506.2	1,493.3	1,471.0	1,505.5	1,426.4	1,389.3
Contract MVA	13.4	14.6	16.0	17.5	20.8	23.3
Required distribution transformer (MVA)	10.7	11.5	12.5	13.5	15.8	17.5
For industrial customer						
Energy consumption (million kWh)	54.4	68.1	103.3	116.2	135.4	184.6
Coefficient†	0.13	0.135	0.14	0.145	0.15	0.155
Contract MVA	47.9	57.6	84.2	91.5	103.0	136.0
Required distribution transformer (MVA)	15.8	18.4	26.9	28.4	30.9	40.8
Total						
Energy consumption (million kWh)	321.3	367.3	436.3	487.1	583.9	704.6
Contract MVA	135.6	156.7	195.8	217.1	256.2	315.8
Required distribution transformer (MVA)	120.7	130.5	145.5	154.3	173.8	196.0
Annual transformer requirement (MVA)	9.8	15.0	8.8	19.5	22.2	17.1

† coefficient = annual load factor X demand factor

Table XI-7 INCREASE OF TRANSMISSION AND DISTRIBUTION FACILITY (1975 - 1985)

Year	Transmission line (Km)			Transfromer (MVA)			Distribution
	150 kV	70 kV	Total	150 kV	70 kV	Total	(No. of unit)
1975	–	251	251	–	47	47	222
1976	41	182	223	70	41	111	171
1977	–	166	166	35	41	76	133
1978	34	21.5	55.5	35	84	119	211
1979	90	143	233	35	35	70	183
1980	–	61	61	35	29	64	221
1981	50	71	121	70	48	118	347
1982	50	10	60	–	35	35	393
1983	13	–	13	70	48	118	448
1984	220	–	220	140	9	149	505
1985	155	35	190	–	36	36	568
Total	653	940.5	1,593.5	490	453	943	3,402

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
562.1	641.2	729.5	823.3	933.3	1,041.3	1,165.1	1,303.3	1,452.9	1,623.8
0.348	0.343	0.337	0.332	0.327	0.321	0.316	0.311	0.305	0.30
412.2	464.0	517.9	573.9	632.5	696.9	767.8	846.0	932.1	1,026.8
447.4	459.7	477.1	493.3	515.1	531.4	548.2	565.5	583.4	601.8
184.4	213.3	247.1	283.1	325.8	370.3	420.9	478.4	543.8	617.9
151.2	162.1	173.0	181.2	189.0	214.8	244.1	277.5	315.4	358.4
41.3	46.6	52.0	58.1	64.3	70.6	77.6	85.4	93.8	103.8
0.179	0.181	0.183	0.185	0.187	0.189	0.191	0.193	0.195	0.197
19.16	21.63	24.19	26.89	29.58	32.55	35.86	39.51	43.53	47.95
1,373.1	1,357.3	1,341.0	1,332.0	1,327.0	1,310.4	1,294.0	1,277.9	1,261.9	1,246.0
26.3	29.4	32.4	35.9	39.3	42.7	46.4	50.5	54.9	59.8
19.5	21.5	23.3	25.5	27.9	30.3	32.9	35.9	39.0	42.5
203.8	221.2	272.2	335.6	414.5	465.1	523.3	590.3	667.3	752.4
0.16	0.165	0.17	0.175	0.18	0.185	0.19	0.195	0.20	0.205
146.1	153.0	182.8	218.9	262.9	287.0	314.4	345.6	380.9	419.0
42.4	42.8	51.2	59.1	71.0	77.5	84.9	93.3	102.8	113.1
808.2	909.0	1,053.7	1,217.0	1,412.1	1,577.0	1,766.0	1,979.0	2,214.0	2,480.0
356.8	395.7	462.3	537.9	628.0	700.0	781.7	874.5	979.6	1,096.0
213.1	226.4	247.5	265.8	287.9	322.6	361.9	406.7	457.2	514.0
13.3	21.1	18.3	22.1	34.7	39.3	44.8	50.5	56.8	–

with those of developed countries. However, as the electrification in rural areas is to be strongly pushed forward, an essential change can not be expected in the future. Therefore, the present 38 percent was assumed to decrease to 30 percent by 1985. From the ratio of annual average load, the total residential contract capacity was obtained to be 325.8 MVA and 617.9 MVA respectively in 1980 and 1985, which are 4.4 times and 8.3 times respectively of the present capacity.

The ratio of the annual average load to the contract capacity was also computed in the commercial sector and industrial sector to be respectively 18.0 percent and 13.7 percent in 1970. These values, relatively low at present, were assumed to increase to a degree close to the level of developed countries in 1985. The values thus assumed were the basis to estimate the future contract capacity. Further, 50 percent of the industrial customers were assumed to receive electricity at 70 kV or at 20 kV, and therefore, not considered in calculating the capacity of distribution transformer. The remaining 50 percent of the industrial customers was considered to be supplied power through distribution transformers to be used in common with the residential and commercial customers in order to increase the

the utilization factor of distribution transformers by taking advantage of the diversity of loads of the respective customers.

The capacities of distribution transformers were calculated based on the demand factors and diversity factors estimated as follows:

	Demand factor	*Diversity factor*
Residential	0.66	1.13
Commercial	0.80	1.13
Industrail	0.72	1.35

The result is shown in Table XI-6 for the respective years. According to the table, an annual average addition of 18.6 MVA in total transformer capacity will be required in the period from 1974 to 1979, and 45.2 MVA during the years of 1980 to 1984.

6. Construction Cost

The construction costs of transmission and distribution facilities were computed from the unit costs made available by PLN Exploitasi IX and other data. The total length of transmission lines was obtained based on the transmission line routes determined on topographical maps, and multiplied by 1.1 for cost estimation to cover an increase due to unknown factors. The supporting structures of 150 kV and 70 kV transmission lines

Table XI-8 TRANSMISSION AND DISTRIBUTION UNIT COST

(US dollars)

I t e m			Foreign currency	Local currency	Total
Transmission line					
150 kV	330 mm^2	double circuit per km	16,000	4,500	20,500
150 kV	330 mm^2	1st circuit of double circuit per km	11,700	3,800	15,500
150 kV	330 mm^2	2nd circuit of double circuit per km	4,700	1,500	6,200
150 kV	330 mm^2	single circuit per km	9,600	3,300	12,900
70 kV	120 mm^2	double circuit per km	10,000	3,000	13,000
70 kV	120 mm^2	1st circuit of double circuit per km	8,300	2,700	11,000
70 kV	120 mm^2	2nd circuit of double circuit per km	2,100	600	2,700
70 kV	120 mm^2	single circuit per km	6,600	2,300	8,900
70 kV	3/0	double circuit per km	8,800	3,000	11,800
70 kV	3/0	1st circuit of double circuit per km	7,700	2,700	10,400
70 kV	3/0	2nd circuit of double circuit per km	1,500	600	2,100
Line terminal					
150 kV	line terminal		100,000	20,000	120,000
70 kV	line terminal		41,100	6,000	47,100
20 kV	line terminal		15,000	2,000	17,000
Transformer					
150 kV/70 kV	35,000 kVA		233,000	22,000	255,000
70 kV/H.V.	3,000 kVA		63,000	6,000	69,000
70 kV/H.V.	6,000 kVA		77,000	6,000	83,000
70 kV/H.V.	10,000 kVA		92,000	7,000	99,000
Distribution					
20 kV	distribution unit		16,050	2,850	18,900

were assumed to be all steel towers, and the conductors to be 330 sq.mm. ACSR and 120 sq.mm. ACSR respectively. Double conductors to reduce the line impedance were not considered for that the distances between substations are not very long and that the installation work requires a higher technic. The steel towers of domestic production are available, but not considered for use because they are too expensive. All the materials were assumed to be purchased from foreign sources.

The locations of substations were determined based on information made available by PLN Exploitasi IX after reconnoitering about one half of the number. However, further investigations are necessary to finalize the plan. All the substation equipments were assumed to be purchased from foreign sources.

The distribution lines were assumed to be all overhead. The average distribution unit was assumed based on the present practice to consist of a distribution transformer (100 kVA x 1 unit), high voltage distribution lines of 800 meters in total length and low voltage lines of 1,400 meters in total length. The foreign currency requirement was assumed to be 85 percent of the unit construction cost.

The transmission and distribution facilities to be installed during the period of 1975 to 1985 are shown in Table XI-7 and Fig. XI-6. The total length of proposed transmission lines is 1,593 kilometers-circuit; 653 kilometers-circuit at 150 kV and 940 kilometers-circuit at 70 kV. Six 150 kV substations were proposed. The number of proposed 70 kV substations is 18 until 1979, which will be increased to 21 by 1985. The distribution units will be increased by 920 in number in the years of 1975 to 1979, and by 2,482 from 1980 to 1985.

The unit prices used in calculating the construction costs of transmission and distribution facilities are ennumerated in Table XI-8. The construction costs of respective transmission lines are shown in Table XI-9, and the total construction cost of the transmission and distribution facilities is given in Table XI-10. The cost of appurtenant equipment of substation, such as voltage regulating equipment and static condensers, was estimated at 5 percent of the substation construction cost.

Table XI-9 TRANSMISSION LINE COST

(thousand US dollars)

	Transmission line cost			Terminal end cost			Total cost			Fiscal
	Foreign	Domestic	Total	Foreign	Domestic	Total	Foreign	Domestic	Total	year
150 kV										
Bangil branch	11.7	3.8	15.5	200.0	40.0	240.0	211.7	43.8	255.5	1975
New Perak - Waru II	319.4	90.4	409.8	200.0	40.0	240.0	519.4	130.4	649.8	1975
Bangil - Waru II	155.2	50.8	206.0	200.0	40.0	240.0	355.2	90.8	446.0	1977
Malang Selatan branch	11.7	3.8	15.5	200.0	40.0	240.0	211.7	43.8	255.5	1977
Grati - Bangil	479.1	135.5	614.6	200.0	40.0	240.0	679.1	175.5	854.6	1978
Waru II - Modjokerto	349.8	115.0	464.8	200.0	40.0	240.0	549.8	155.0	704.8	1978
Malang Selatan - Bangil	235.2	77.0	312.2	200.0	40.0	240.0	435.2	117.0	552.2	1980
Waru II - Gresik P.P.	399.2	113.0	512.2	200.0	40.0	240.0	599.2	153.0	752.2	1981
Waru II - Sukolilo	151.6	49.6	201.2	200.0	40.0	240.0	351.6	89.6	441.2	1982
Grati - Djember	1,282.7	421.6	1,704.3	200.0	40.0	240.0	1,482.7	461.6	1,944.3	1983
Modjokerto - New Madiun	1,282.7	421.6	1,704.3	200.0	40.0	240.0	1,482.7	461.6	1,944.3	1983
New Madiun - Semarang	1,807.5	594.1	2,401.6	100.0	20.0	120.0	1,907.5	461.1	2,521.6	1984
70 kV										
Probolinggo - Letjes	91.0	30.0	121.0	41.6	6.0	47.1	132.0	36.0	168.0	1974
Letjes - Lumadjang	211.0	72.6	383.6	–	–	–	211.0	72.6	283.6	1974
Lumadjang - Djember	395.2	136.6	531.8	41.1	6.0	47.1	436.0	124.6	578.9	1974
Djember - Bondowoso	230.5	79.7	310.2	82.2	12.0	94.2	312.7	91.7	404.4	1974
Mendalan - Kediri	279.8	84.4	364.2	82.2	12.0	94.2	362.0	96.4	458.4	1974
Kediri - Tulungagung	184.4	63.8	248.2	82.2	12.0	94.2	266.6	75.8	342.4	1974
Tulungagung - Blitar	191.0	66.1	257.1	82.2	12.0	94.2	273.2	78.1	351.3	1974
Bondowoso - Situbondo	210.8	72.8	283.6	82.2	12.0	94.2	293.0	84.8	377.8	1975
Djember - Banjuwangi	637.4	209.6	847.0	82.2	12.0	94.2	719.6	221.6	941.2	1975
Gresik - Bangkalan †	310.0	100.0	410.0	–	–	–	310.0	100.0	410.0	1975
Gresik - Bangkalan	125.2	43.2	168.4	82.2	12.0	94.2	207.4	55.2	262.6	1975
Bangkalan - Sampang	329.3	113.9	443.2	82.2	12.0	94.2	411.5	125.9	537.4	1975
Lumadjang Branch	6.6	2.3	8.9	82.2	12.0	94.2	88.8	14.3	103.1	1975

(Continued)

	Transmission line cost			Terminal end cost			Total cost			Fiscal year
	Foreign	Domestic	Total	Foreign	Domestic	Total	Foreign	Domestic	Total	
Gresik - Lamongan	230.5	79.7	310.2	82.2	12.0	94.2	312.7	91.7	404.4	1976
Lamongan - Babat	197.6	68.3	265.9	82.2	12.0	94.2	279.8	80.3	360.1	1976
Babat - Bodjonegoro	171.2	59.3	230.5	82.2	12.0	94.2	253.4	71.3	324.7	1976
Sampang - Pamekasan	131.7	45.6	177.3	82.2	12.0	94.2	213.9	57.6	271.5	1976
Pamekasan - Sumenep	362.3	125.2	487.5	82.2	12.0	94.2	444.5	137.2	581.5	1976
Probolinggo - Letjes	22.9	6.2	29.1	123.3	18.0	141.3	146.2	24.2	170.4	1977
Letjes Branch	3.3	1.1	4.4	41.1	6.0	47.1	44.4	7.1	51.5	1977
Malang Selatan - Polehan	100.0	30.0	130.0	164.4	24.0	188.4	264.4	54.0	318.4	1977
Bondowoso - Besuki	217.3	75.2	292.5	82.2	12.0	94.2	299.5	87.2	386.7	1978
New Madiun - Modjokerto	229.5	61.7	291.2	164.4	24.0	188.4	393.9	85.7	479.6	1978
Besuki - Probolinggo	395.2	136.6	531.8	82.2	12.0	94.2	477.4	148.6	626.0	1979
Clenmore Branch	6.6	4.4	11.0	82.2	12.0	94.2	88.8	16.4	105.2	1979
Malang Selatan - Sengkaling	100.0	30.0	130.0	164.4	24.0	188.4	264.4	54.0	318.4	1980
Maospati - Ngawi	151.5	52.4	203.9	82.2	12.0	94.2	233.7	64.4	298.1	1980
Maospati - Magetan	98.8	34.2	133.0	82.2	12.0	94.2	181.0	46.2	227.2	1980
New Madiun - Maospati	85.6	29.6	115.2	82.2	12.0	94.2	167.8	41.6	209.4	1980
Gresik P.P. - Gresik	50.0	15.0	65.0	164.4	24.0	188.4	214.4	39.0	253.4	1981
Blitar - Karangkates	230.5	79.7	310.2	82.2	12.0	94.2	312.7	91.7	404.4	1984

† Marine cable.

Table XI - 10 INVESTMENT SCHEDULE

	1973	1974	1975	1976	1977
Transmission Line					
150 kV Total		136	769	105	830
Foreign Currency		110	621	85	666
Domestic Currency		26	148	20	164
70 kV Total	409	2,594	2,508	1,732	589
Foreign Currency	315	1,999	1,936	1,347	491
Domestic Currency	94	595	572	385	98
Transmission Line Total	409	2,730	3,277	1,837	1,419
Foreign Currency	315	2,109	2,557	1,432	1,157
Domestic Currency	94	621	720	405	262
Substation					
150 kV Total		77	471	255	255
Foreign Currency		70	431	233	233
Domestic Currency		7	40	22	22
70 kV Total	98	634	524	624	852
Foreign Currency	91	585	485	577	791
Domestic Currency	7	49	39	47	61
Miscellaneous Total	5	36	50	44	55
Foreign Currency	4	33	46	41	51
Domestic Currency	1	3	4	3	4
Substation Total	103	747	1,045	923	1,162
Foreign Currency	95	688	962	851	1,075
Domestic Currency	8	59	83	72	87
Distribution Total	553	3,762	4,052	3,345	3,909
Foreign Currency	470	3,194	3,441	2,841	3,320
Domestic Currency	83	568	611	504	589
Grand Total	1,065	7,239	8,374	6,105	6,490
Foreign Currency	880	5,991	6,960	5,124	5,552
Domestic Currency	185	1,248	1,414	981	938

(thousand US dollars)

1978	1979	1980	1981	1982	1983	1984	Total
1,326	83	582	706	959	3,684	2,143	11,323
1,045	65	460	562	744	2,807	1,621	8,786
281	18	122	144	215	877	522	2,537
846	779	933	215		61	344	11,010
674	608	752	182		47	266	8,617
172	171	181	33		14	78	2,393
2,172	862	1,515	921	959	3,745	2,487	22,333
1,719	673	1,212	744	744	2,854	1,887	17,403
453	189	303	177	215	891	600	4,930
255	294	433	77	586	867		3,570
233	268	396	70	536	792		3,262
22	26	37	7	50	75		308
421	405	676	450	487	186	323	5,680
390	375	625	417	452	172	300	5,260
31	30	51	33	35	14	23	420
34	35	55	26	54	53	16	463
31	32	51	24	49	48	15	425
3	3	4	2	5	5	1	38
710	734	1,164	553	1,127	1,106	339	9,713
654	675	1,072	511	1,037	1,012	315	8,947
56	59	92	42	90	94	24	766
3,566	4,534	6,689	7,584	8,629	9,723	9,125	65,471
3,028	3,850	5,680	6,440	7,328	8,256	7,749	
538	684	1,009	1,144	1,301	1,467	1,376	9,874
6,448	6,130	9,368	9,058	10,715	14,574	11,951	55,597
5,401	5,198	7,964	7,695	9,109	12,122	9,951	81,947
1,047	932	1,404	1,363	1,606	2,452	2,000	15,570

XII

INVESTMENT PROGRAM

1. Scope of Financing Program

The financing program covers the power development and associated transmission and distribution systems development that are described and formulated in Chapter X and Chapter XI respectively. The distribution system development program is formulated with a target to electrify 20 percent of the total households in East Java by 1990. However, it does not include the rehabilitation and expansion program of distribution facilities presently undertaken by PLN to be completed by the end of 1974. The disbursements under the financing program will be made in the twelve years of 1973 to 1984.

2. Conditions to Estimate Capital Requirement

Source of Supply of Equipment and Materials

All the electrical and mechanical equipmnet and materials of thermal power plants, substations, transmission lines and distribution facilities were assumed to be imported from abroad, although a few of them, such as, steel tower members and distribution transformers, are being produced in the Republic. However, the Republic's products are poor in quality, and the production capacity is limited. The imports, of course, may be substituted by the domestic products when they become competitive with foreign products both in quality and price.

Costs of Equipment and Materials

The costs of equipment and materials are the estimated probable prices on the international market in 1971. The unit costs of transmission and distribution facilities are described in Chapter XI. The cost of thermal power generating unit at 6 percent interest rate was assumed as follows:

Foreign Currency Requirement

The foreign currency portion covers the cost of procurement of equipment and materials, as well as, ocean freight and insurance, and domestic currency portion for unloading, wharfage, inland transportation and installation works. But, import duties and other taxes were not considered. In the construction cost of thermal power plants, 80 percent was considered to be foreign currency, and 20 percent to be domestic currency.

Interest during Construction

Interest during construction was calculated at two different rates of 3 percent and 6 percent, and included in the cost of equipment and materials. The construction periods were assumed to be 3 years for the thermal power plants and 2 years for transmission lines, substations and distribution lines. The annual disbursement was assumed to be made in the proportion of 20:35:45 in the 3 years, and 15:85 in the two years.

Exchange Rate

The capital requirement is indicated in U.S. dollars through the prevailing exchange rate of RP 415 to one U.S. dollar.

3. Capital Requirement

Tables XII-1 and XII-2 give the annual capital requirement obtained based on the above conditions. The total capital investment for the years of 1973 to 1984 is US$ 180 million of which US$ 80 million is for power generating facilities, US$ 23 million for transmission lines, US$ 10 million for substations and US$ 67 million for distribution facilities. The annual capital requirement will be US$ 15 million on the average over the 12 years. A large capital requirement is expected for the expansion of distribution networks, aiming at a high electrification ratio. Of the total US$ 180 million, US$ 65 million will be invested in the first six years averaging US$ 11 million annually, and US$ 115 million in the latter half of the twelve years averaging US$ 19 million annually, which is approximately

Table XII-1 INVESTMENT PROGRAMME

Interest rate: 6%

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Total
Generation													
Total	1,800	3,200	5,800	5,000	7,200	5,800	5,700	8,400	8,000	8,300	12,300	8,700	80,200
Foreign currency	1,440	2,560	4,640	4,000	5,760	4,640	4,560	6,720	6,400	6,640	9,840	6,960	64,160
Domestic currency	360	640	1,160	1,000	1,440	1,160	1,140	1,680	1,600	1,660	2,460	1,740	16,040
Transmission													
Total	420	2,780	3,350	1,870	1,450	2,210	880	1,550	940	980	3,830	2,540	22,800
Foreign currency	320	2,150	2,610	1,460	1,180	1,750	680	1,240	750	760	2,920	1,930	17,750
Domestic currency	100	630	740	410	270	460	200	310	190	220	910	610	5,050
Substation													
Total	100	770	1,070	940	1,180	720	750	1,190	560	1,150	1,120	350	9,900
Foreign currency	95	700	980	870	1,090	670	690	1,095	520	1,055	1,025	320	9,110
Domestic currency	5	70	90	70	90	50	60	93	40	95	95	30	790
Distribution													
Total	560	3,840	4,130	3,410	3,990	3,640	4,620	6,820	7,730	8,800	9,930	9,310	66,780
Foreign currency	480	3,250	3,510	2,900	3,370	3,090	3,930	5,790	6,570	7,480	8,440	7,910	56,720
Domestic currency	80	590	620	510	620	550	690	1,030	1,160	1,320	1,490	1,400	10,060
Total	2,880	10,590	14,350	11,220	13,820	12,370	11,950	17,960	17,230	19,230	27,180	20,900	179,680
Foreign currency	2,335	8,660	11,740	9,230	11,400	10,150	9,860	14,845	14,240	15,935	22,225	17,120	147,740
Domestic currency	545	1,930	2,610	1,990	2,420	2,220	2,090	3,115	2,990	3,295	4,955	3,780	31,940

Table XII-2 INVESTMENT PROGRAMME

Interest rate: 3%

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Total
Generation													
Total	1,800	3,100	5,600	4,900	6,900	5,600	5,500	8,000	7,800	8,000	12,000	8,400	77,600
Foreign currency	1,440	2,480	4,480	3,920	5,520	4,480	4,400	6,400	6,240	6,400	9,600	6,720	62,080
Domestic currency	360	620	1,120	980	1,380	1,120	1,100	1,600	1,560	1,600	2,400	1,680	15,520
Transmission													
Total	410	2,730	3,280	1,830	1,420	2,170	860	1,520	920	960	3,750	2,490	22,340
Foreign currency	315	2,110	2,560	1,430	1,160	1,715	670	1,215	740	745	2,860	1,890	17,410
Domestic currency	95	620	720	400	260	455	190	305	180	215	890	600	4,930
Substation													
Total	100	750	1,050	920	1,160	710	740	1,160	550	1,130	1,100	340	9,710
Foreign currency	95	690	965	850	1,075	655	680	1,070	510	1,040	1,010	315	8,950
Domestic currency	5	60	85	70	85	55	60	90	40	90	90	25	760
Distribution													
Total	550	3,760	4,050	3,340	3,910	3,570	4,530	6,690	7,580	8,630	9,730	9,130	65,470
Foreign currency	470	3,190	3,440	2,840	3,320	3,030	3,850	5,680	6,440	7,330	8,260	7,750	55,600
Domestic currency	80	570	610	500	590	540	680	1,010	1,140	1,300	1,470	1,380	9,870
Total	2,860	10,340	13,980	10,990	13,390	12,050	11,630	17,370	16,850	18,720	26,580	20,360	175,120
Foreign currency	2,320	8,470	11,445	9,040	11,075	9,880	9,600	14,365	13,930	15,515	21,730	16,675	144,040
Domestic currency	540	1,870	2,535	1,950	2,315	2,170	2,030	3,005	2,920	3,205	4,850	3,685	31,080

1 to 2 in proportion.

The foreign currency requirement is 82 percent of the total capital investment requirement. If the interest rate is 3 percent, the capital investment requirement calculated at 6 percent interest will be reduced by US$ 5 million approximately which is about 3 percent. The detailed investment schedules are attached to X. Power Development Program and XI. Transmission and Distribution System Development Program.

4. Magnitude of Capital Requirement

As stated in V. Future Growth of Economy, the capital investment in the electric power sector of the Republic is estimated to be US$ 330 million in 1969 to 1973, and US$ 430 million in 1974 to 1978. In the following five years of 1979 to 1984, at least US$ 430 million of capital investment, which equals the investment of 1974 to 1978, can be projected. This means that the capital investment during the ten years of 1974 to 1983 will be US$ 900 million approximately. Assuming that one fourth of the investment is to be appropriated to East Java, US$ 225 million could be used for the development of power industry of the province (Even if it is one fifth, the amount will be US$ 180 million) in the ten years of 1974 to 1983. The US$ 180 million of capital investment requirement for the power industry in East Java estimated in the Report is for the twelve years of 1973 to 1984 is deemed reasonable, and from the stand point of magnitude of fund requirement, it is believed reasonable in the light of the anticipated economic growth and expansion of the country.

5. Economic Soundness

Revenue and expenditure projection for the period of 1975 to 1985 was prepared on a tentative basis based on the implementation program of the Report.

Annual Cost The equalized annual cost over the serviceable life was computed based on the following conditions and assumptions.

i. The annual cost of facilities under the program includes interest payment, depreciation cost, operation and maintenance cost, overhead cost and fuel cost. The existing facilities as of the end of 1974 were not included due to lack of data.
ii. Interest rate : 3 percent and 6 percent.
iii. Serviceable life:

Thermal power plant	30 years
Transmission line	50 years
Substation	25 years
Distribution facilities	25 years

iv. Annual cost ratio (percent):

At 3 percent interest rate

	Interest and depreciation	Operation, maintenance and overhead	Total
Thermal power plant	5.10	2.7	7.8
Transmission line	3.89	3.0	6.89
Substation	5.74	2.5	8.24
Distribution focilities	5.74	5.0	10.74

TABLE XII-3 ANNUAL COST OF SYSTEM

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	 2005	Total
Interest rate : 3%												
Generation												
Fixed cost	680	680	1,360	2,040	2,040	2,720	3,660	3,660	4,600	6,070	6,070	
Fuel cost	1,245	1,245	2,490	3,735	3,735	4,980	6,570	6,810	8,640	9,950	9,950	
Total	1,925	1,925	3,850	5,775	5,775	7,700	10,230	10,470	13,240	16,020	16,020	
Transmission	408	549	651	793	866	964	1,034	1,100	1,330	1,540	1,540	
Substation	144	221	314	378	439	529	582	668	759	801	801	
Distribution	832	1,202	1,613	2,002	2,473	3,157	3,957	4,867	5,894	7,031	7,031	
Total	3,309	3,897	6,428	8,948	9,553	12,350	15,803	17,105	21,223	25,392	25,392	
Present worth factory	0.971	0.943	0.915	0.889	0.863	0.838	0.813	0.789	0.766	0.744	0.744 x 14.88	
Present worth in 1976	3,213	3,675	5,882	7,955	8,244	10,349	12,848	13,496	16,257	18,892	281,851	382,661
Interest rate : 6%												
Generation												
Fixed cost	900	900	1,800	2,700	2,700	3,600	4,840	4,840	6,080	8,020	8,020	
Fuel cost	1,245	1,245	2,490	3,735	3,735	4,980	6,570	6,810	8,640	9,950	9,950	
Total	2,145	2,145	4,290	6,435	6,435	8,580	11,410	11,650	14,720	17,970	17,970	
Transmission	565	760	901	1,097	1,198	1,333	1,429	1,520	1,838	2,129	2,129	
Substation	184	283	401	482	559	675	743	853	965	1,022	1,022	
Distribution	1,014	1,465	1,965	2,438	3,011	3,843	4,817	5,925	7,176	8,561	8,561	
Total	3,908	4,653	7,557	10,452	11,203	14,431	18,399	19,948	24,699	29,682	29,682	
Present worth factor	0.943	0.890	0.840	0.792	0.747	0.705	0.665	0.627	0.592	0.558	0.558 x 11.47	
Present worth in 1976	3,685	4,141	6,348	8,278	8,369	10,174	12,235	12,507	14,622	16,563	189,965	286,887

TABLE XII-4 ANTICIPATED REVENUE UNDER CURRENT POWER RATE

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	2005	Total
Energy requirement at consumer end. (million kWh)													
Total	704.7	803.6	905.7	1,049.1	1,210.0	1,403.1	1,571.0	1,760.0	1,971.0	2,208.0	2,473.0	2,473.0	
Residential	483.8	557.4	638.0	724.8	816.3	924.3	1,016.7	1,118.4	1,230.2	1,353.2	1,488.5	1,488.5	
Industrial	184.7	204.9	221.2	272.3	335.7	414.5	488.3	566.6	659.8	767.3	890.0	890.0	
Commercial	36.2	41.3	46.6	52.0	58.1	64.3	69.4	75.0	81.0	87.5	94.5	94.5	
Revenue (thousand US$)													
Total	11,375	12,937	14,530	16,852	19,495	22,642	25,443	28,471	31,924	35,812	40,163	40,163	
Residential	6,289	7,246	8,294	9,422	10,612	12,016	13,217	14,539	15,993	17,592	19,351	19,351	
Industrial	3,421	3,791	4,092	5,038	6,210	7,668	9,034	10,482	12,206	14,195	16,465	16,465	
Commercial	1,665	1,900	2,144	2,392	2,673	2,958	3,192	3,450	3,725	4,025	4,347	4,347	
Increased revenue † (thousand US$)		1,562	3,155	5,477	8,120	11,267	14,068	17,096	20,549	24,437	28,788	28,788	
Present worth factor													
at interest rate: 3%		0.971	0.943	0.915	0.889	0.863	0.838	0.813	0.789	0.766	0.744	0.744 x 14.88	
at interest rate: 6%		0.943	0.890	0.840	0.792	0.747	0.705	0.665	0.627	0.592	0.558	0.558 x 11.47	
Present worth in 1976													
at interest rate: 3%		1,517	2,975	5,011	7,219	9,723	11,789	13,899	16,213	18,719	21,418	319,547	428,030
at interest rate: 6%		1,473	2,808	4,601	6,431	8,416	9,918	11,369	12,884	14,467	16,064	184,243	272,674

Note: Unit power rate. Residential = 20 mills/kWh, Industrial = 18.5 mills/kWh, Commercial = 37 mills/kWh; † Based on 1975

TABLE XII-5 ANTICIPATED REVENUE UNDER PROPOSED POWER RATE

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	 2005	Total
Energy requirement at consumer end. (million kWh)													
Total	704.7	803.6	905.7	1,049.1	1,210.0	1,403.1	1,571.0	1,760.0	1,971.0	2,208.0	2,473.0	. . 2,473.0	
Residential	483.8	557.4	638.0	724.8	816.3	924.3	1,016.7	1,118.4	1,230.2	1,353.2	1,488.5	1,488.5	
Industrial	184.7	204.9	221.2	272.3	335.7	414.5	488.3	566.6	659.8	767.3	890.0	890.5	
Commercial	36.2	41.3	46.6	52.0	58.1	64.3	69.4	75.0	81.0	87.5	94.5	94.5	
Revenue (thousand US$)													
Total	14,432	16,467	18,576	21,458	24,686	28,533	31,936	35,625	39,807	44,497	49,732	49,732	
Residential	9,676	11,148	12,760	14,496	16,326	18,486	20,334	22,368	24,604	27,064	29,770	29,770	
Industrial	3,417	3,791	4,092	5,038	6,210	7,668	9,034	10,482	12,206	14,195	16,465	16,465	
Commercial	1,339	1,528	1,724	1,924	2,150	2,379	2,568	2,775	2,997	3,238	3,497	3,497	
Increased revenue † (thousand US$)		2,035	4,144	7,026	10,254	14,101	17,504	21,193	25,193	30,065	35,300	35,300	
Present worth factor													
at interest rate: 3%		0.971	0.943	0.915	0.889	0.863	0.838	0.813	0.789	0.766	0.744	0.744 x 14.88	
at interest rate: 6%		0.943	0.890	0.840	0.792	0.747	0.705	0.665	0.627	0.592	0.558	0.558 x 11.47	
Present worth in 1976													
at interest rate: 3%		1,976	3,908	6,429	9,116	12,169	14,668	17,230	19,877	23,030	26,263	391,830	526,496
at interest rate: 6%		1,919	3,688	5,902	8,121	10,533	12,340	14,093	15,796	17,778	19,697	225,920	335,787

Note: Unit power rate: Residential = 13 mill/kWh, Industrial = 18.5 mill/kWh, Commercial = 46 mills/kWh; † Based on 1975

At 6 percent interest rate

	Interest and depreciation	Operation, maintenance and overhead	Total
Thermal power plant	7.27	2.7	9.98
Transmission line	6.34	3.0	9.34
Substation	7.82	2.5	10.32
Distribution facilities	7.82	5.0	12.82

v. Fuel cost:

Residual heavy oil US$ 0.015 (Rp 6.25) per litre

The result is shown in Table XII - 3.

Estimated Revenues The revenues are solely from sales of electricity. Revenues to be derived from the operation of facilities to be built under the implementation program were assumed simply to be the increment over the 1974 power sales. The power rate was assumed in two ways; one was the actual unit sales price obtained from the total amount billed in 1970 and the other the proposed power rate schedule which, recommended in the Report of an OTCA team to the Republic in 1969, is higher than the present rate schedule by about 25 percent. These two rates are shown in the following table.

	Actual sales price		Proposed rate	
	mills/kWh	Rp/kWh	mills/kWh	Rp/kWh
Residential (S-1,S-2,R-1,R-2,U-1,U-2 and U-3)	13	5.41	20	8.24
Commercial (K-1,K-2 and K-3)	46	19.10	37	15.30
Industrial (P and Ch)	18.5	7.69	18.5	7.74
Average	16.5	6.88	10.8	8.64

Based on the estimated power sales and the unit price, the revenues were calculated as shown in Tables XII - 4 and XII - 5.

Balance The estimated revenues and expenses are as in the following.

TABLE XII-6 ANTICIPATED REVENUES AND EXPENSES (1976 - 2005)

(thousand USdollars)

	Revenues (1)	Expenses (2)	Net Revenues (3)	(3)/(1) (%)
Under current sales price				
At 3% interest	428,000 (21,800)	382,700 (19,500)	45,300 (2,300)	10.6
At 6% interest	272,700 (19,800)	216,900 (20,900)	–14,200 (–1,100)	–5.2
Under proposed power rate				
At 3% interest	526,500 (26,900)	382,700 (19,500)	143,800 (7,400)	27.3
At 6% interest	335,800 (24,400)	286,900 (20,900)	48,900 (3,500)	14.5

Figures in parentheses are annual revenues and expenses that are assumed to be constant over the years of 1976 to 2005.

According to the tentative calculation shown above, the revenues at the current rates of service will be sufficient to cover the expenses during the thirty years from 1976 if capital is borrowed at the interest rate of 3 percent. If the interest rate is 6 percent, the cost will exceed revenues showing deficit. If the power rate schedule is raised by about 25 percent, as recommended by an OTCA mission in 1969, net revenues will be 14.5 percent of the revenues at the interest rate of 6 percent, and the net revenues will amount to US$7.4 million annually if the interest rate is 3 percent.

Internal rate of return

The internal rate of return of the implementation program was obtained with use of the equation given below.

$$I = \sum_{t=1}^{30} \frac{(R_t - C_t)}{(1 + i)^t}$$

Where, I = Capital investment (including interest during construction)

R_t = Power sales revenues in t years at 1976

C_t = Expenses in t years (operation and maintenance cost plus fuel cost)

i = Internal rate of return

The internal rate of return thus obtained is rather low because the revenues considered are increment only which is to accrue after 1976 and the write off period is taken to be as long as 30 years. The result is as follows:

with present power rate schedule	6.7 percent
with proposed power rate schedule	11.1 percent

With the result given above, it may be said that the interest rate of funds for the implementation of the development program should be 5 percent or less if the present power rate schedule remains the same, and 9 percent or less if the power rate schedule is to be revised.

XIII

OVERALL STUDIES ON ALL JAVA SYSTEM

1. Scope

Java can be divided into three districts, East, Central and West; and the long-range development program is being studied independently for the three districts. The power industry in the Republic is believed to grow in pace with the economic development in which the industry will play an important role. Capital investment required by the industry will be a huge amount. Therefore, the development program should be established from the nation wide economic point of view. A basic concept should also be established to formulate the long-range development program. Unification of standards for electric installations should be adopted. When it is confined to the island of Java, interconnection of system throughout the island should be contemplated. The higher the load growth will bring about the earlier interconnection. The Report, however, presents the general prospected features of the interconnected Java system. The details were not studied because information and data on Central and West Java systems were not obtainable, in addition to that, at the request of P L N, the scope of works in the Report is confined to East Java only.

2. Basic Considerations of Trans-island Interconnection

The power demand in Java was estimated taking into account the trend of growth of demand in East Java as follows:

Table XIII-1 PEAK DEMAND ESTIMATE (1985 - 1995)

	1970	1985	1990	1995
West Java	170	770	1,320	2,200
Central Java	40	230	390	660
East Java	68.7	500	860	1,450
Total	278.7	1,500	2,570	4,310

The power demand in 1985 will become 5.4 times of the present, and reach a level of about 15 times of the present in 1995, necessitating, during the course, step-by-step interconnection of the present independent systems.

Interconnecting Method

The interconnection in Java is expected to be made in the following order.

- i. A small isolated system in an Exploitasi will grow large and seek economic energy from a neighboring system within or outside the Exploitasi. Thus, small systems will be interconnected.
- ii. Systems will be interconnected between Exploitasi in order to take advantage of higher system reliability, merits of large capacity unit thermal power plants, and common use of reserve capacities between the systems.
- iii. An interconnection throughout the island will be required in order to take further advantage of higher system reliability, diversities in system peak demand, merits of large unit capacity thermal power plants, and common use of reserve capacities among the systems.

The interconnections described in i. and ii. above will take place at an early stage. In the Report, interconnection with Central Java is proposed to improve reliability of system stability of East Java and to take advantage of the economies of scale of unit capacity.

Economies of Scale of Unit Capacity Large unit capacity generating facilities are advantageous in unit construction cost and efficiency. However, an extremely large unit in relation to the size of system, when stopped due to fault, will cause to largely lower the system frequency impeding normal function of industry and to induce tripping of other thermal power plants of the system, which will result in the entire system failure. Therefore, the size of generating unit is required to be less than 10 to 16 percent of the system capacity in general, in order to secure the reliability of power system. The maximum unit capacities considered to be allowable from the standpoint of system reliability are shown in Table XIII-2 for the systems of East Java, Central Java and West Java, as well as, for the interconnected all Java system.

The benefits of large unit capacity was calculated on an approximate basis with the result as follows.

Thermal Plant Construction Cost, 1985 - 1995

(million US dollars)

	Required Capacity (MVA)	Construction Cost Before inter-connection	Construction Cost After inter-connection	Difference
1985–1990	1,025	161.6	143.0	18.6
1990–1995	1,575	234.4	212.0	22.4
Total	2,600	396.0	355.0	41.0

According to the calculation, a saving of capital investment due to economies of scale of unit capacity will be US$ 18.6 million in the five years from 1985, and US$ 22.4 million in the same period from 1990, and continue to increase thereafter at an increasing rate.

Saving of Reserve Capacity In order to cope with forced and scheduled outages of generators, every system should have a reserve capacity equivalent to 7 to 15 percent of the system capacity. When a system is interconnected with another system of a similar or larger size, the total reserve capacity of the two systems may be reduced by using the reserve in common between the two systems. Such saving is obtainable from the number of thermal units and their sizes. Generally, as a system grows large with an increasing number of generating units, the reserve capacity can be reduced in ratio to the system capacity. Assuming the total reserve capacity can be decreased from 10 percent to 7 percent by the interconnection of the three systems, the reserve capacity saving will be 48 MW if the interconnection is made in 1985, and it will be 85 MW and 143 MW if the interconnection is made in 1990 and 1995 respectively.

Interconnection	Reserve Capacity Saving Capacity (MW)	Reserve Capacity Saving Construction cost (million US$)
1985	48	7.0
1990	85	13.2
1995	145	22.5

Interconnecting Facilities The capacity of interconnecting facilities is computed on an approximate basis to be 200 to 300 MW from an assumed maximum unit capacity in

Java which will cause maximum disturbances at the time of failure and from the three system capacities in the 1990's. Although the distance between Djakarta and Surabaja is about 600 kilometers, the transmission line capacity may be equivalent to the surge impedance loading as the Central Java system will be connected to the line on the way (See Fig. XIII-1). The surge impedance loading is 326 MW at a transmission line voltage of 330 kV, and 433 MW at 380 kV. Therefore, the transmission line voltage should be 330 kV or higher. This means that a lower voltage than 330 kV, 220 kV for instance, cannot be applied for the line. The construction cost of the transmission line is estimated to be approximately US$ 50,000 per kilometer and US$ 62,000 per kilometer respectively for 330 kV and 380 kV transmission lines. Assuming the construction cost of appurtenant facilities is 5 percent of the construction cost of the transmission line, the total construction cost of the interconnection facilities will be US$ 31.5 million and US$ 39.0 million respectively for the 330 kV and 380 kV transmission lines.

3. Summary

Economic Effect by Interconnection

The economic effect to be brought about by the construction of trans-island interconnection line was computed in approximate figures, and the results are shown in Table XIII-3. The economies of scale of unit capacity will amount to US$ 41.0 million in ten years after completion of the interconnection, and the savings in reserve will be US$ 7.0 million in 1985

Table XIII-2 NUMBER OF REQUIRED THERMAL GENERATING UNIT (1985 - 1995)
(For calculation of economies of scale of unit capacity)

(MW)

	1985		1990		1995
West Java					
Total Installed Capacity	850		1,450		2,420
Total System Capacity	770		1,320		2,200
Total Thermal Capacity	640		1,100		1,800
Generating Unit Capacity		150		250	
No. of New Unit		3		3	
Central Java					
Total Installed Capacity	250		430		725
Total System Capacity	230		390		660
Total Thermal Capacity	200		390		650
Generating Unit Capacity		50		75	
No. of New Unit		4		3	
East Java					
Total Installed Capacity	550		950		1,000
Total System Capacity	500		860		1,450
Total Thermal Capacity	500		850		1,450
Generating Unit Capacity		100		150	
No. of New Unit		4		4	
Total Java (all Java interconnected)					
Total Installed Capacity	1,610		2,830		4,745
Total System Capacity	1,500		2,570		4,310
Total Thermal Capacity	1,340		2,340		3,900
Generating Unit Capacity		250		400	
No. of New Unit		4		4	

and US$ 22.5 million in 1995 and those values will increase year by year. These economics shown in the figures are in part duplicated, and mere addition of the two is not appropriate in evaluating the economic effect as a whole. On the other hand, the interconnecting facilities, presumably 200 to 300 MW in capacity and 330 or 380 kV in voltage, will require a capital investment of about US$ 31.5 to 39 million. Therefore, the benefit resulting from the trans-island interconnection line will become even with the construction cost of the interconnection facilities in the 1990's. The interconnection should be materialized within the 1990's for the economical operation of power facilities in Java as a whole. Needless to say, the interconnection should be advanced if the load grows at an higher rate than expected. These are all rough estimates, and the detailed analysis should be performed at an early stage. Although the timing of the trans-island interconnection line will be in or about the 1990's, its outline should be determined as soon as practicable in order to realize the economical interconnection of minor systems, of not only East Java but whole Java, that will be implemented in the near future.

Table XIII-3 ECONOMIC EFFECT OF INTERCONNECTION THROUGHOUT ALL JAVA (1985 - 1995)

(million US dollars)

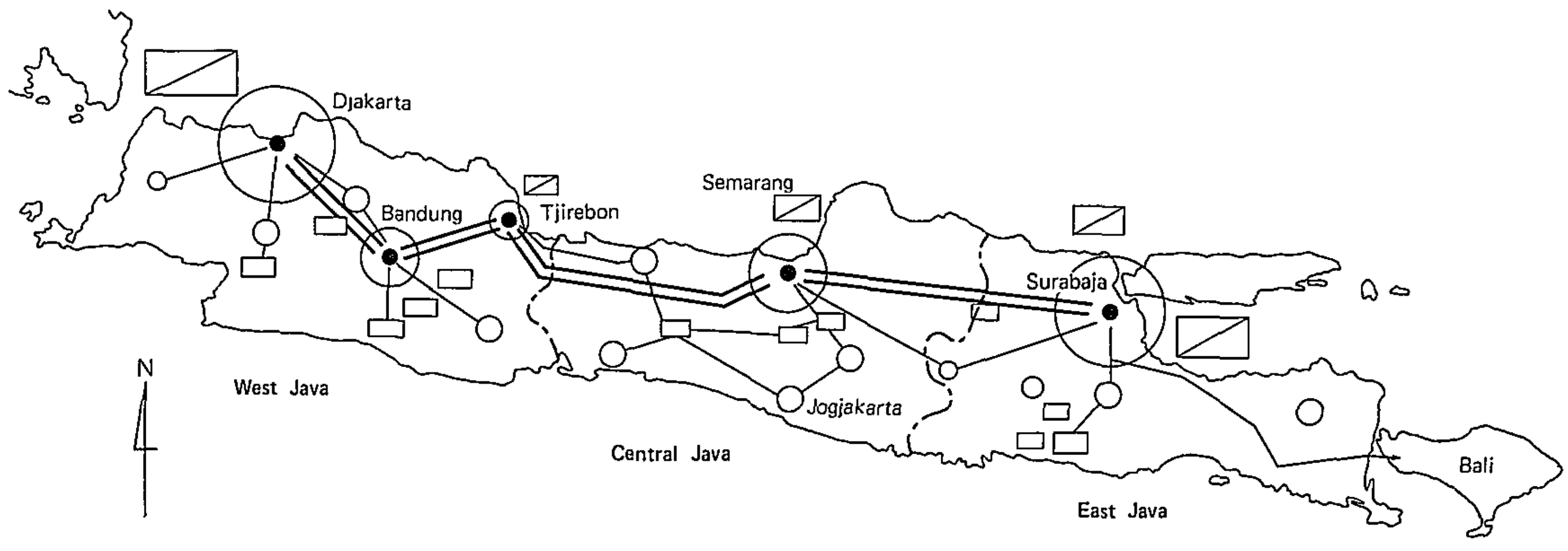
	1985		1990		1995	Total
Economies of scale of unit capacity		18.6		22.4		41.0
Saving reserve	7.0		13.2		22.5	–
Cost of interconnecting facility						
330 kV double circuit						31.5
380 kV double circuit						39.0

(1) The demand was estimated as shown in Table XIII-1.
(2) Installed capacity was estimated as 110 percent of the demand.
(3) Thermal power was assumed to comprise 75 percent of the total installed capacity in West Java and 90 percent in Central and East Java.
(4) Due to lack of data, reserve capacity was determined empirically.
(5) The figures are all approximate.

Transmission Line Voltage

The voltage of interconnecting transmission line across the island should be 330 kV or 380 kV. 220 kV as transmission line voltage is too feeble to traverse the island, and has no outstanding difference from the 150 kV line in their performances.

The highest voltage of the existing transmission lines in Java is 150 kV; one 150 kV system is in operation in West Java, and another under construction in East Java. There is no need to adopt a 220 kV system because the voltage is not sufficiently high, as in the case of a 150 kV system, to be adopted in the trans-island interconnection and because the interconnection between East Java and Central Java systems is feasible with the voltage of 150 kV. An economical comparison study of the East Java system for a 150 kV and 220 kV transmission lines is only to satisfy curiosity. Therefore, economic study was not performed on the 220 kV transmission line.



Legend

- Load
- Hydro Power Plant
- Steam Power Plant
- EHV Transmission Line
- Transmission Line

Peak Demand (MW)

	1970	1985	1990	1995
West Java	170.0	770	1,320	2,200
Central Java	40.0	230	390	660
East Java	68.7	500	860	1,450
(Total)	(278.7)	(1,500)	(2,570)	(4,310)

Fig. XIII-1 POWER SYSTEM INTERCONNECTION IN WHOLE JAVA —1990's—

APPENDIX

I. SYSTEM ANALYSES

Analyses were made on the system proposed in the Report in respect to the power flow, short circuit capacity and transient stability of the system. With the results, it has been confirmed that the system would be in a good condition with high reliability. The analyses were carried out by use of digital computors. The impedance map of the system is given in Fig. A-1, and all the results calculated are shown in Fig. A-2 to Fig. A-16.

(1) Power Flow

It is considered that power flow should be based on how the reactive power produced or supplied by a system is balanced with the reactive power consumed in the system. Selection of transformer tap settings should be made in a manner to maintain suitable operating voltage of the system.

(a) As some of the existing 70 kV transformers of Kalikonto system are provided with 70 kV fixed tap only, and the 150 kV transformers at Waru II substation under construction have on-load tap changers with a tap width of 157.0 kV to 132.0 kV, the system voltage at the load centers of East Java system should comply with these tap voltages. Therefore, the system voltage was selected within a range of 105 percent of the rated voltage, and at remote regions, such as, New Madiun, Djember and Madura, the system voltage was assumed to be more than 95 percent of the rated voltage.

(b) The transformer taps of the proposed thermal plants will be provided with four fixed taps of 102.5, 105.0, 107.5 and 110.0 percent of the rated voltage of 150 kV, while substation transformers will have on-load tap changers of a tap width of ±10 percent. As a results of analyses of power flow in the system, it was found that the range of voltage control is small, but the provision of the above tap width will be convenient for system operation, especially at the time of emmergency.

(c) Reactive power consumed in the system is supplied mainly by power plants, but at remote regions of the system it must be supplied by static condensers provided at major load centers. The capacities of static condensers calculated based on the above system voltage conditions are shown in the following table.

Number of Static Condensers Determined by Power Flow Calculation

(MVA)

	1976	1978	1980	1985
Waru II	10	10	20	–
New Madiun	10	20	10	–
Djember	–	–	10	10

These static condensers will be used for system voltage control of these regions, and the voltage will again be controled by on-load tap changer of each substation transformer. The static condensers to be provided at New Madiun substation and Djember substation will not be used under normal system condition after 150 kV transmission lines are constructed and new transformers are installed. The region wide voltage control of this region will be made by on-load tap changers instead of the static condensers, which, however, will be kept installed for emmergency purpose.

(d) It is desirable to simplify procedure of system operation, and parallel operation of 150 kV and 70 kV systems will not be performed in order to minimize and to localize system failure which will tend to spread out when the system is looped. The performance of voltage regulation and system losses will not be very much different even when the loop is dissolved.

(e) In the Report, it is considered to supply power to Kediri region by constructing a transmission line from Mendalan power plant to Kediri substation. There is an alternative plan to construct a transmission line from Kertosono substation to Kediri. As a result of analyses of the power flow, it was found that if power to Kediri is supplied from Mendalan by way of Modjokerto and Kertosono instead of from Mendalan straight to Kediri, the system losses will increase. Further, it would be necessary to install the secondary circuit on Modjokerto-Kertosono line in as early as 1976, and to provide the following installations for voltage control of Kediri system.

i. a static condenser at Kediri substation, or
ii. a 150 kV transmission line from Waru II to Modjokerto substation and a 150 kV/70 kV transformer at Modjokerto substation by 1976

Therefore, investigations on the terminal end of transmission line at Mendalan power plant and the route of transmission line from Mendalan directly to Kediri are necessary to be performed at an early stage in order to make economic comparison study.

(2) Short Circuit Capacity

The calculation of short circuit capacity were performed by digital computor as generation reactance X_d'. It was found that, in the 150 kV system, a short circuit capacity of bus bar was 1,000 to 2,000 MVA, and in the 70 kV system around Surabaja region and at other 70 kV substations they were respectively 1,200 MVA and 600 MVA or less. Therefore, circuit breakers to be provided must have a capacity of 3,500 MVA in the 150 kV system, and some 70 kV circuit breakers in the 70 kV system of Surabaja region must be replaced by larger capacity units. The circuit breakers thus removed will be able to be used at other substations.

(f) Power demand in Ponorogo region is estimated to be small in the Report. However, if unexpectedly large growth in demand is encountered in the future, a 70 kV transmission line should be constructed between Madiun and Ponorogo. If such is the case, and if reliability is needed on this line, another 70 kV transmission line from Tulungagung to Ponorogo via Trenggalek is desirable, for it will serve to supply reliable power not only to Ponorogo but to Trenggalek.

(3) Transient Stability

The system in the Report is confirmed by transient stability studies to be stable and to have a sufficiently high reliability. As a fault, a single circuit 3-line grounding fault was assumed, and high speed reclosure system (open-reclose-open) was assumed to be installed. Analyses were made on all the 150 kV transmission lines which would transmit power from the proposed thermal power plants to grid system of the Surabaja region. Results are shown in Fig. 12 to Fig. 16.

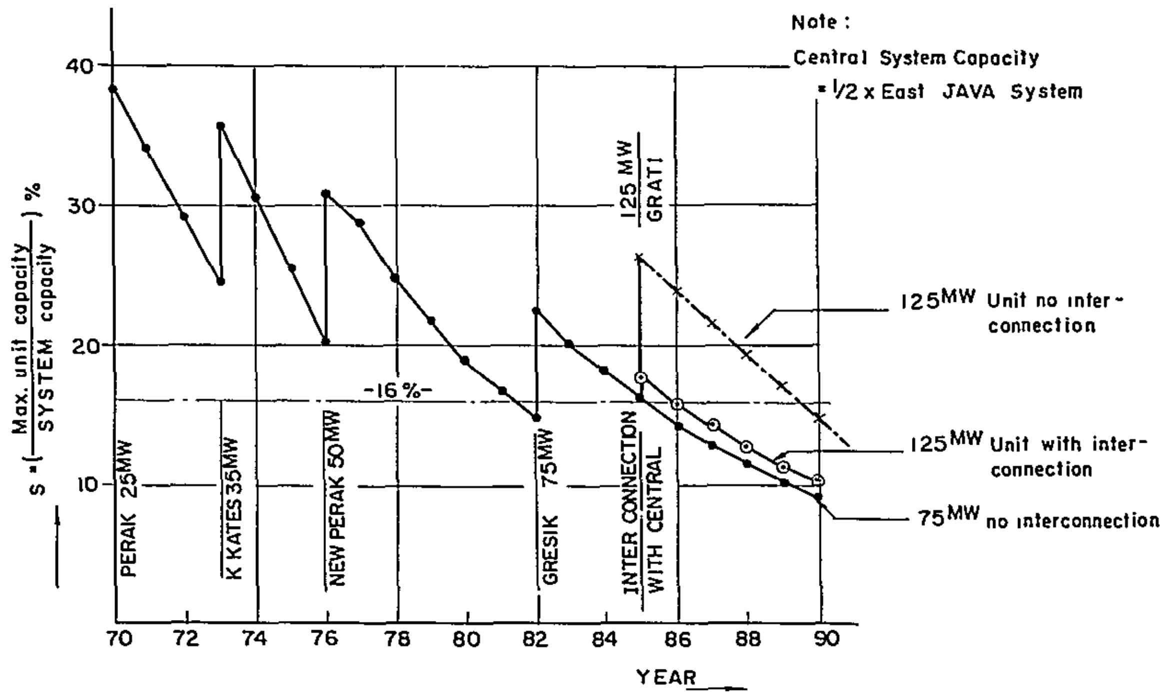
II. ECONOMIC EFFECT BY INTERCONNECTION BETWEEN EAST AND CENTRAL JAVA SYSTEMS

The maximum unit capacity of the present East Java system is 25 MW of thermal generating unit at Perak power plant. If the following equation is applied to the system, S is 38 percent in 1970.

$$S = \frac{\text{Max. generating unit capacity}}{\text{System capacity}} \times 100\ (\%)$$

In 1973, it will be 36 percent with a 35 MW unit to be installed at Karangkates power plant. As the maximum unit capacity becomes large, the percentage will decrease as shown in the following figure, and the reliability of system against the tripping of a generating unit will become higher.

The larger the generating unit, energy will be more economical. Therefore, in the Report, a 125 MW thermal unit is proposed to be installed in 1985 in order to take advantage of the economies of scale of unit capacity.



MAX. UNIT CAPACITY/SYSTEM CAPACITY-YEAR

However, S will become larger in this year, which means that the system will have somewhat low reliability. The benefit of interconnection between East and Central Java systems may be evaluated in terms of the economies of scale of unit capacity. Therefore, for comparison purpose, two cases were assumed; one is adopting 125 MW units with the two systems interconnected, and the other is 75 MW units without the interconnection. The results are shown in Fig. 17. As can be seen from the figure, a saving of construction cost of the generating plant will amount to about US$ 3 million (present worth in 1982) within five years after 1985. On the other hand, cost of interconnecting facilities will be about US$ 2.0 million. Therefore, the benefit of interconnection will be US$ 1.0 million in East Java system only, and it is considered that the benefit in Central Java system will be larger.

Therefore, installation of 125 MW thermal units and interconnection to Central Java system should be performed in 1985 from the economical standpoint. To interconnect between East and Central Java systems will bring about not only economies of scale of unit capacity but many other effects described in the Report.

III. MARINE CABLE INTERCONNECTION TO MADURA

To supply power to Madura island, marine cable was proposed for across-the-channel interconnection.

(1) Marine Cable

The marine cable was assumed to be 70 kV 3-core 100 sq. mm oil filled submarine cable to connect from the proposed 70 kV overhead transmission line. The cross section of this cable is shown in Fig. 18.

(2) Marine Cable Route

Many interconnecting routes were considered as indicated in Fig. 19. The distances of these routes are 2 to 3 kilometers long, but the construction cost varies greatly with the route condition and method of installation. Therefore, investigations of these routes are necessary to be performed by specialists at an early stage.

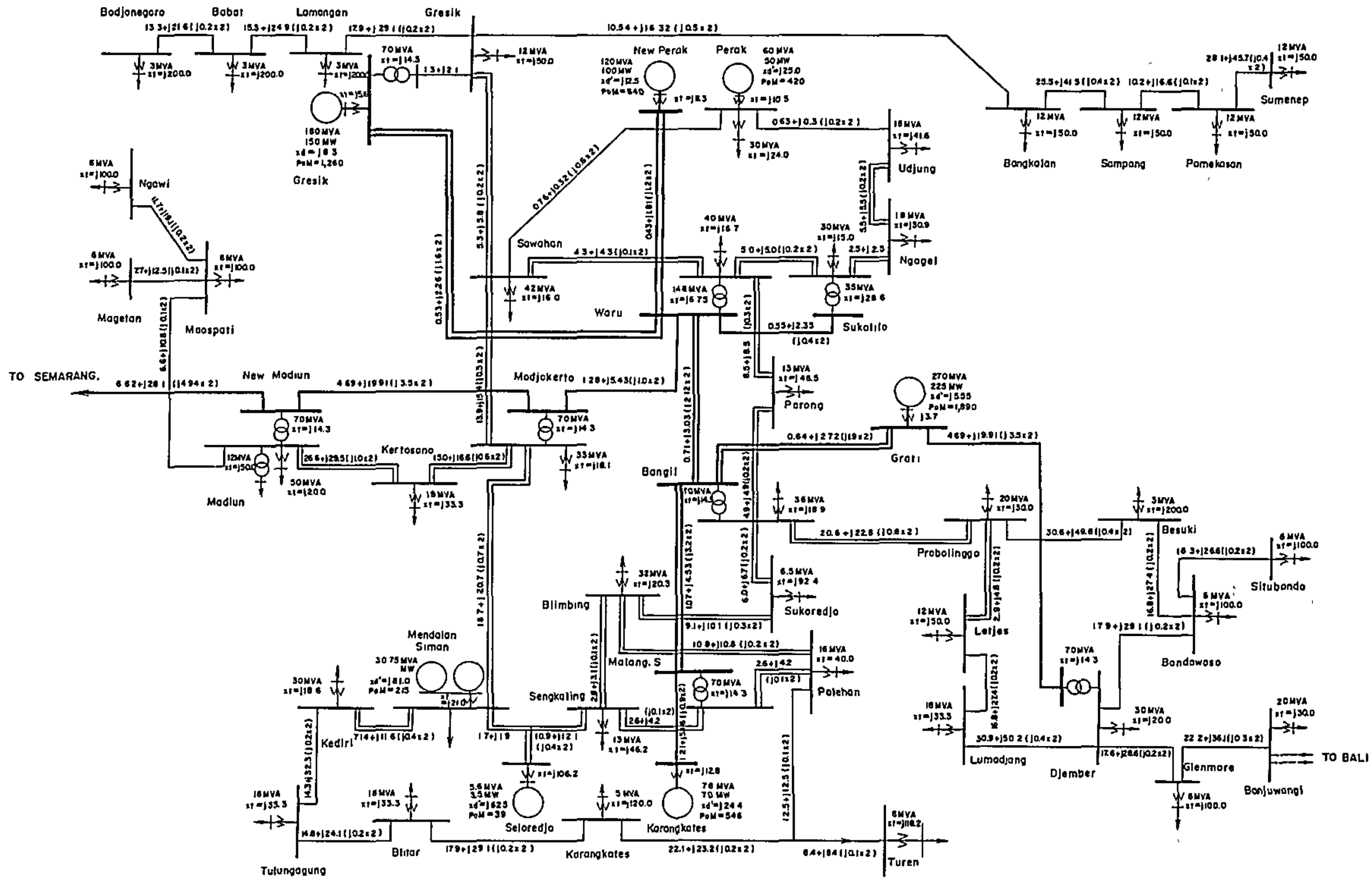


Fig. A-1 IMPEDANCE MAP AT 1985 (150 kV, 70 kV 100 MVA BASE)

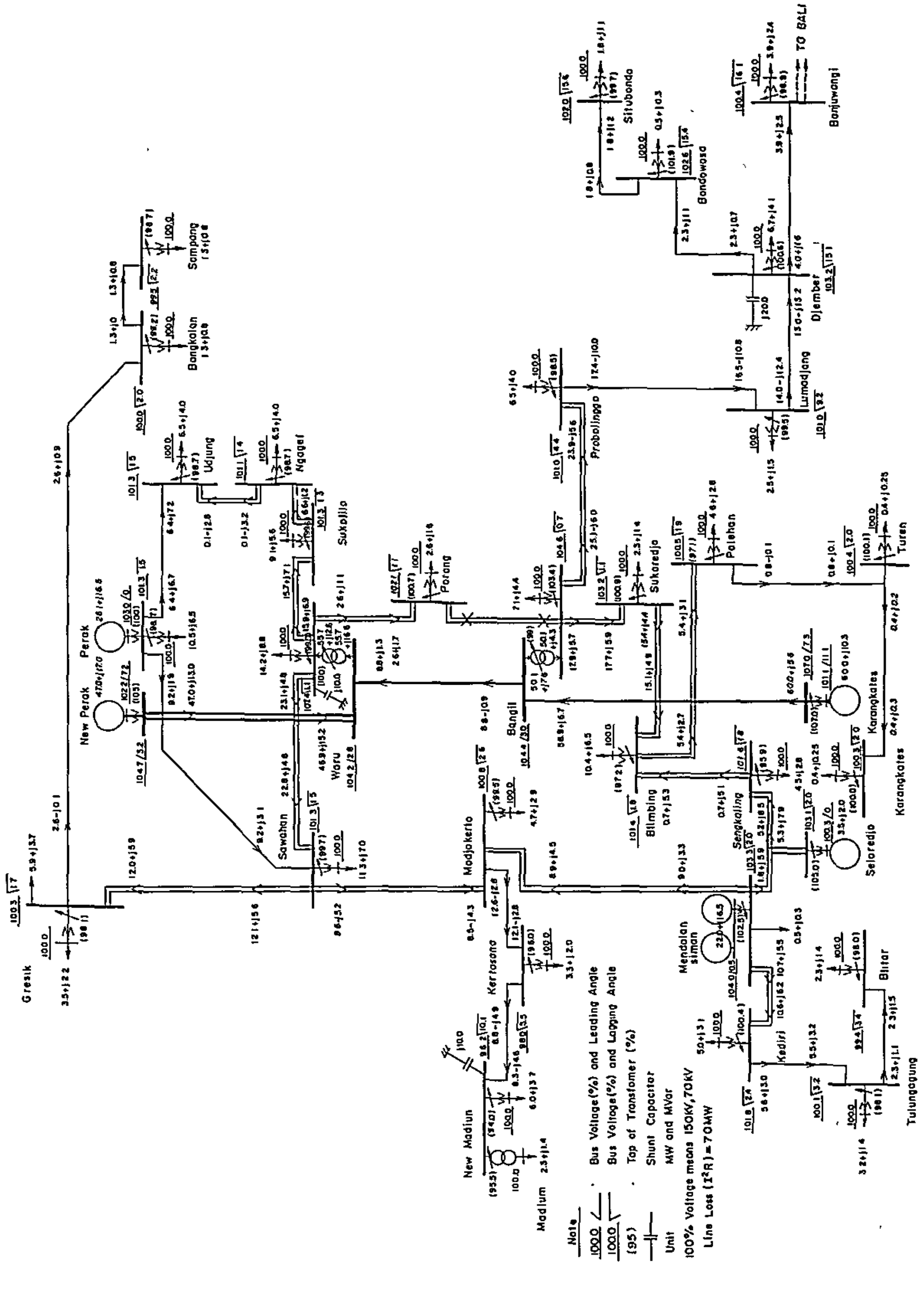


Fig. A-2. POWER FLOW AT PEAK TIME IN 1976

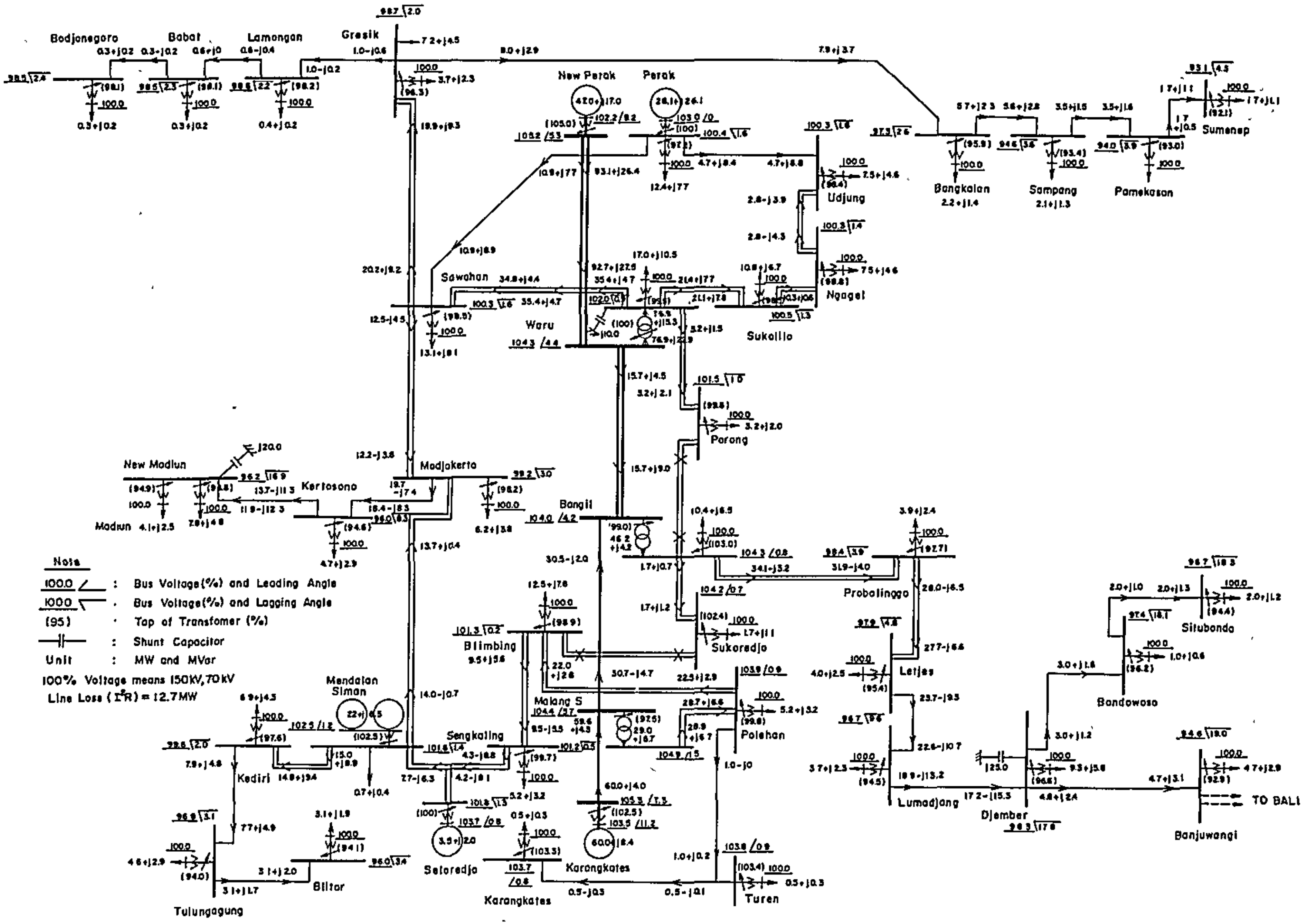


Fig. A-3 POWER FLOW AT PEAK TIME IN 1978

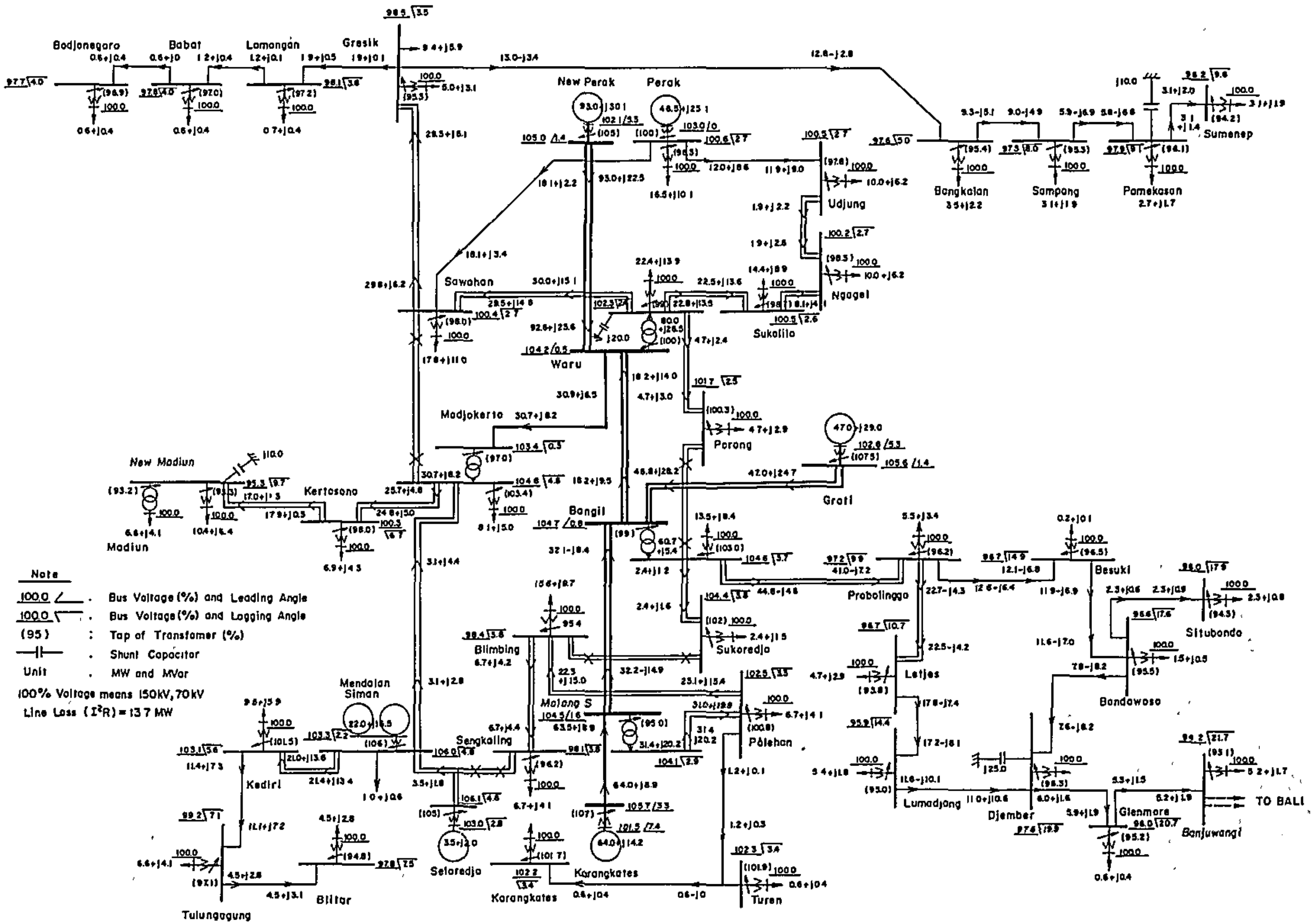


Fig. A-4 POWER FLOW AT PEAK TIME IN 1980

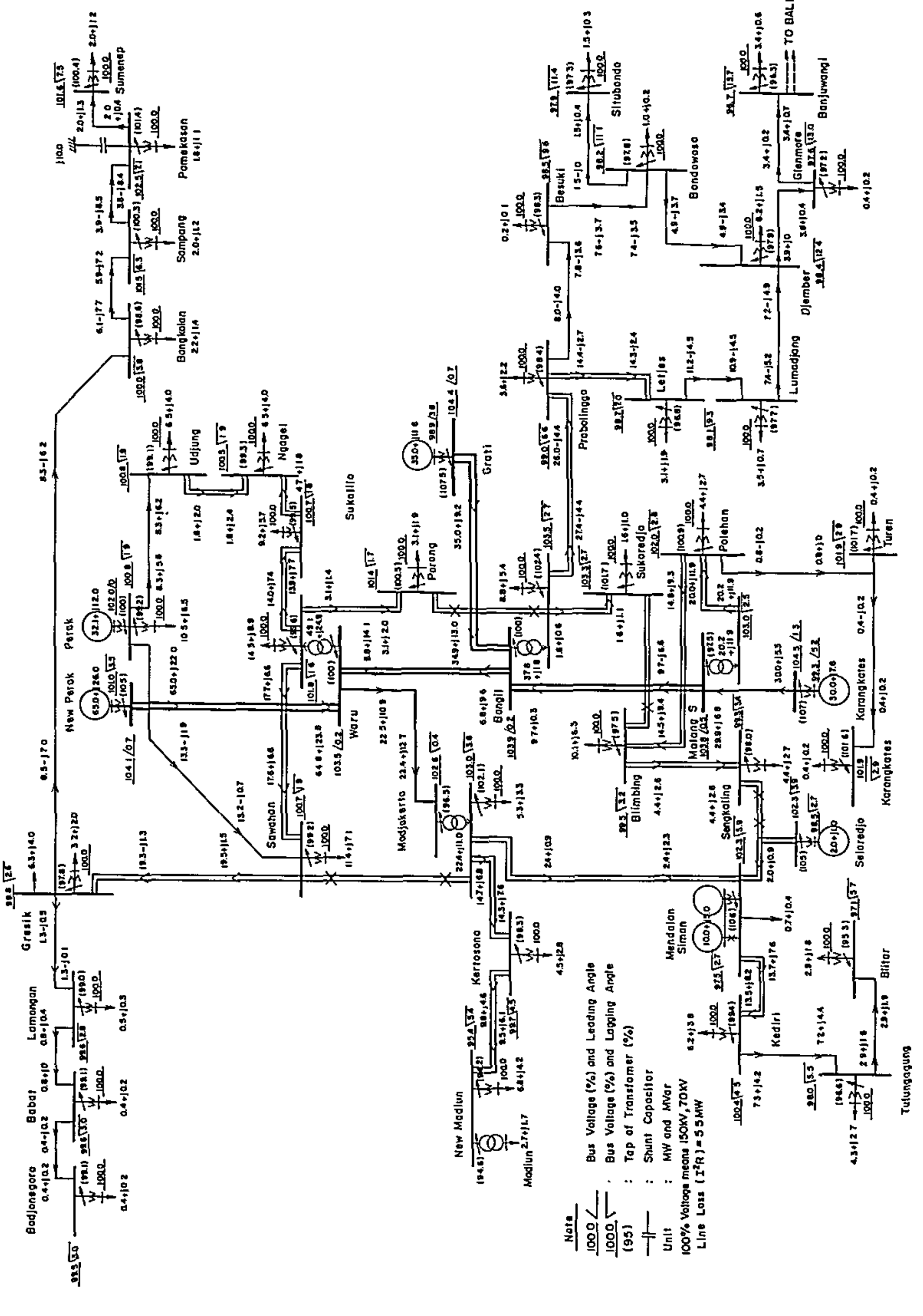


Fig. A-5 POWER FLOW AT OFF PEAK TIME IN 1980

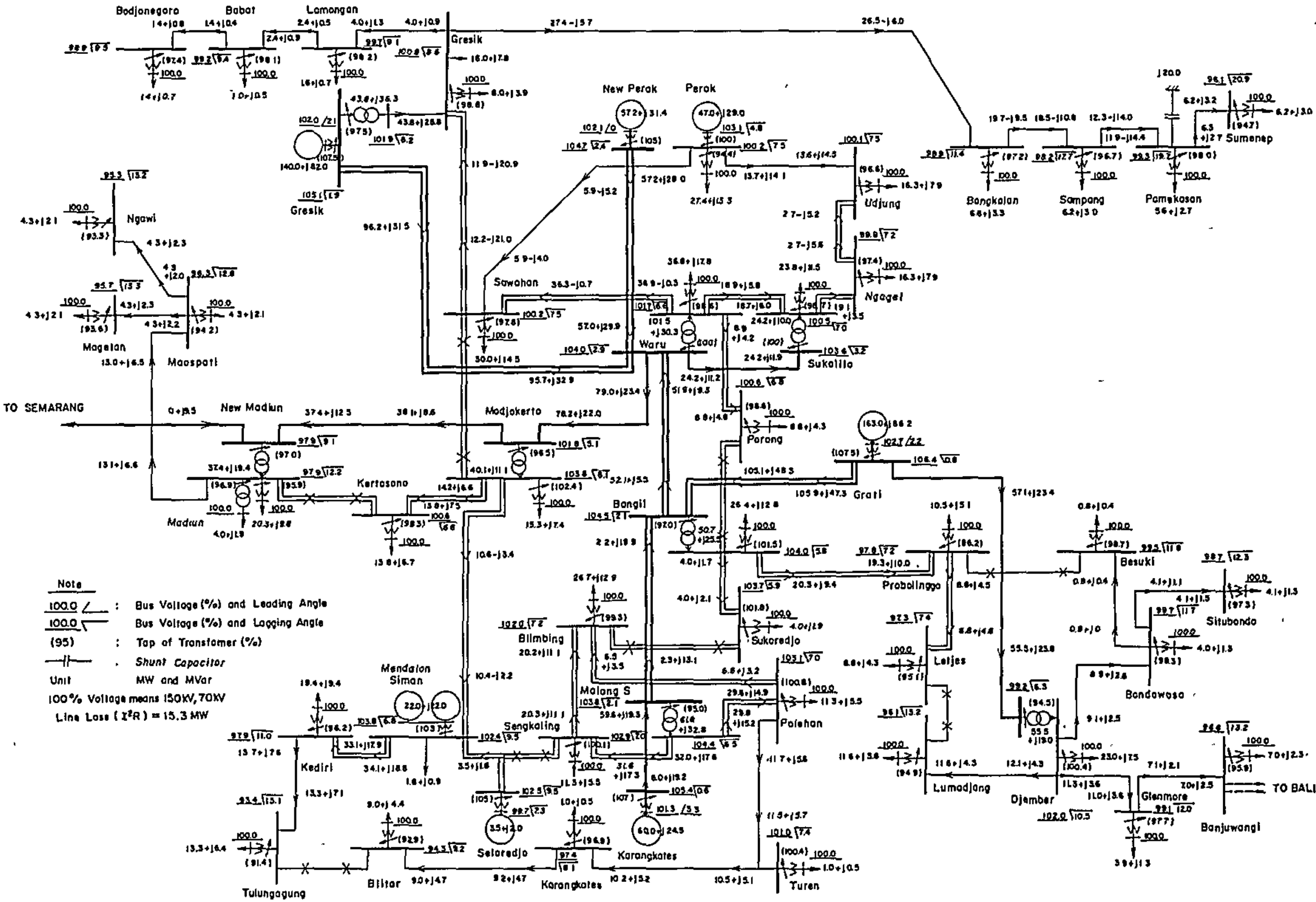


Fig. A-6 POWER FLOW AT PEAK TIME IN 1985

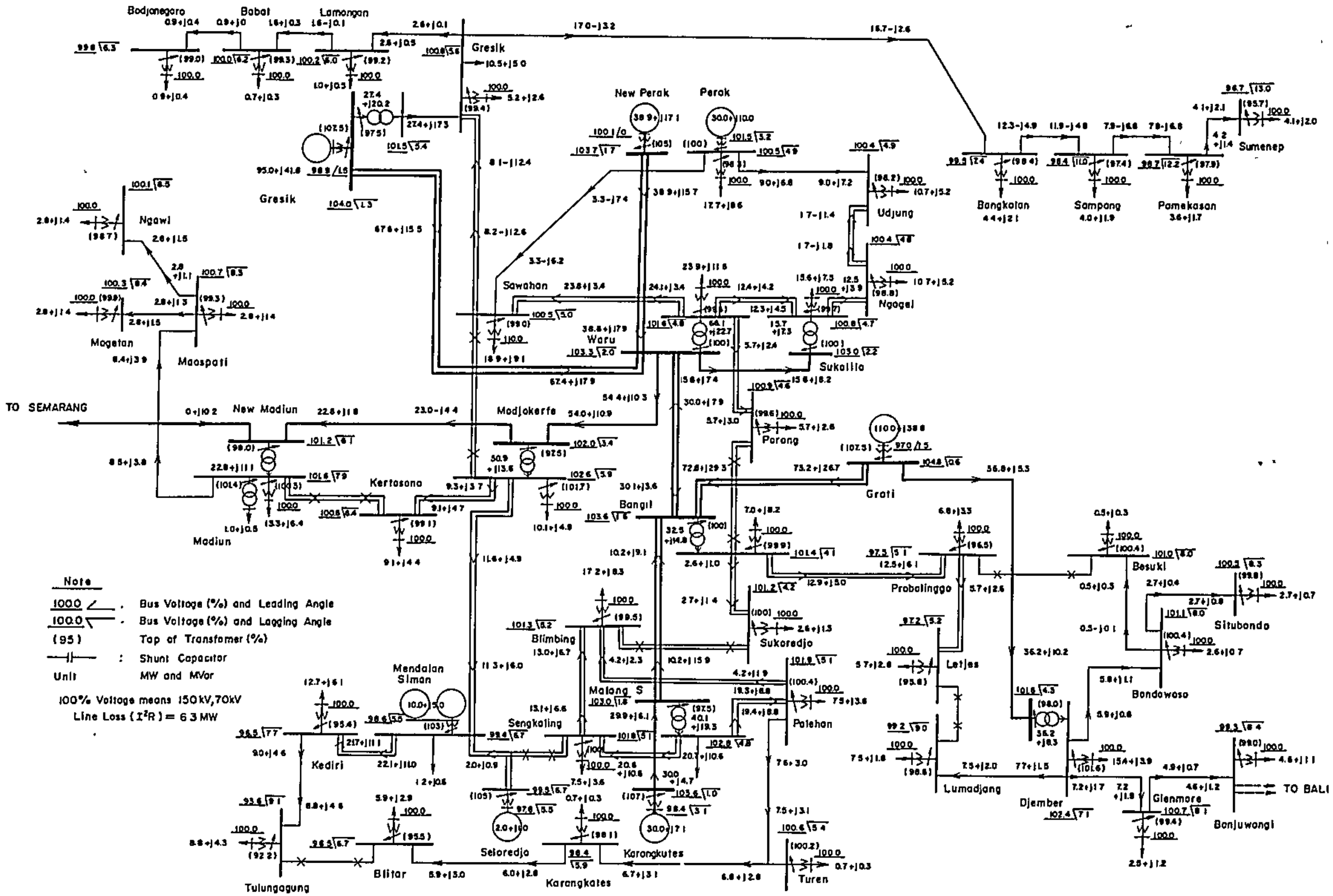


Fig. A-7 POWER FLOW AT OFF PEAK TIME IN 1985

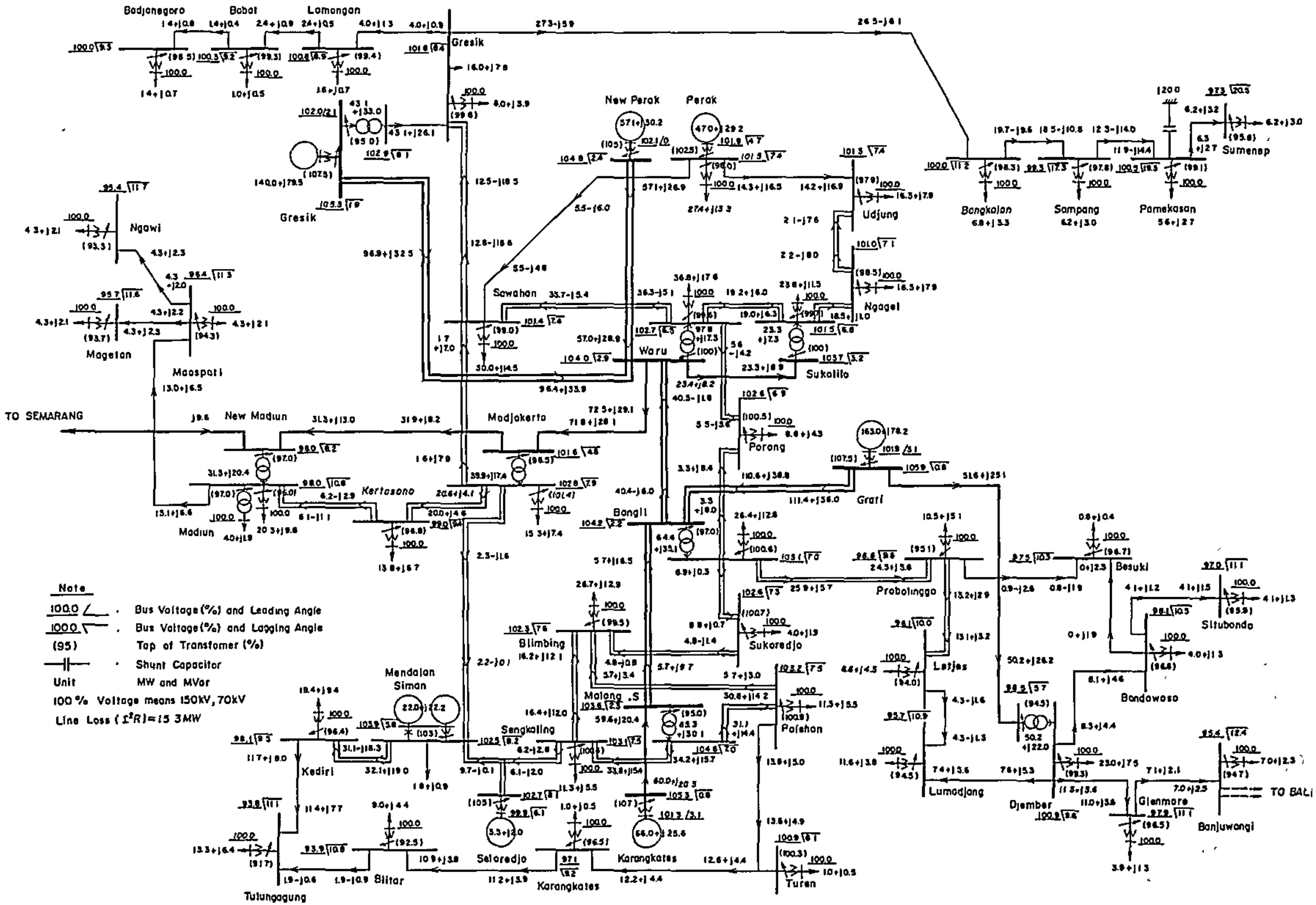


Fig. A-8 POWER FLOW AT PEAK TIME IN 1985 (ALL LOOP)

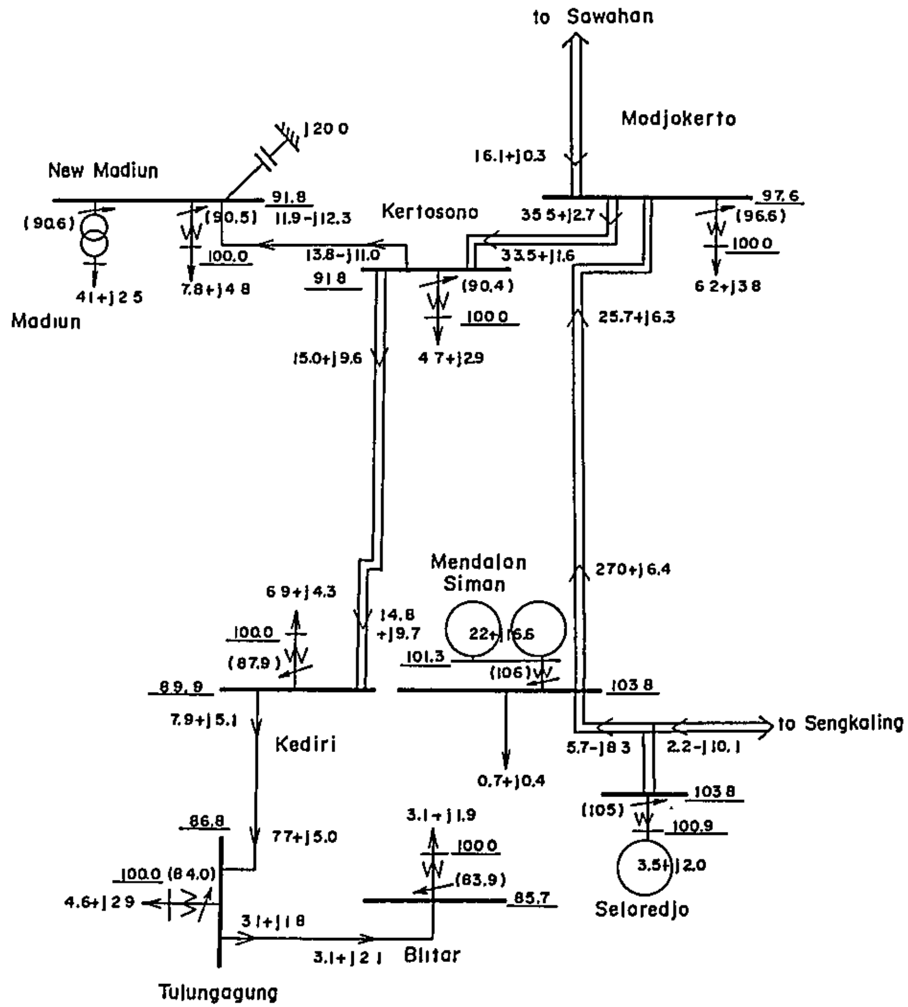


Fig. A-9 ALTERNATIVE PLAN (KERTSONO – KEDIRI) POWER FLOW WITHOUT STATIC CONDENSER AT PEAK TIME IN 1978

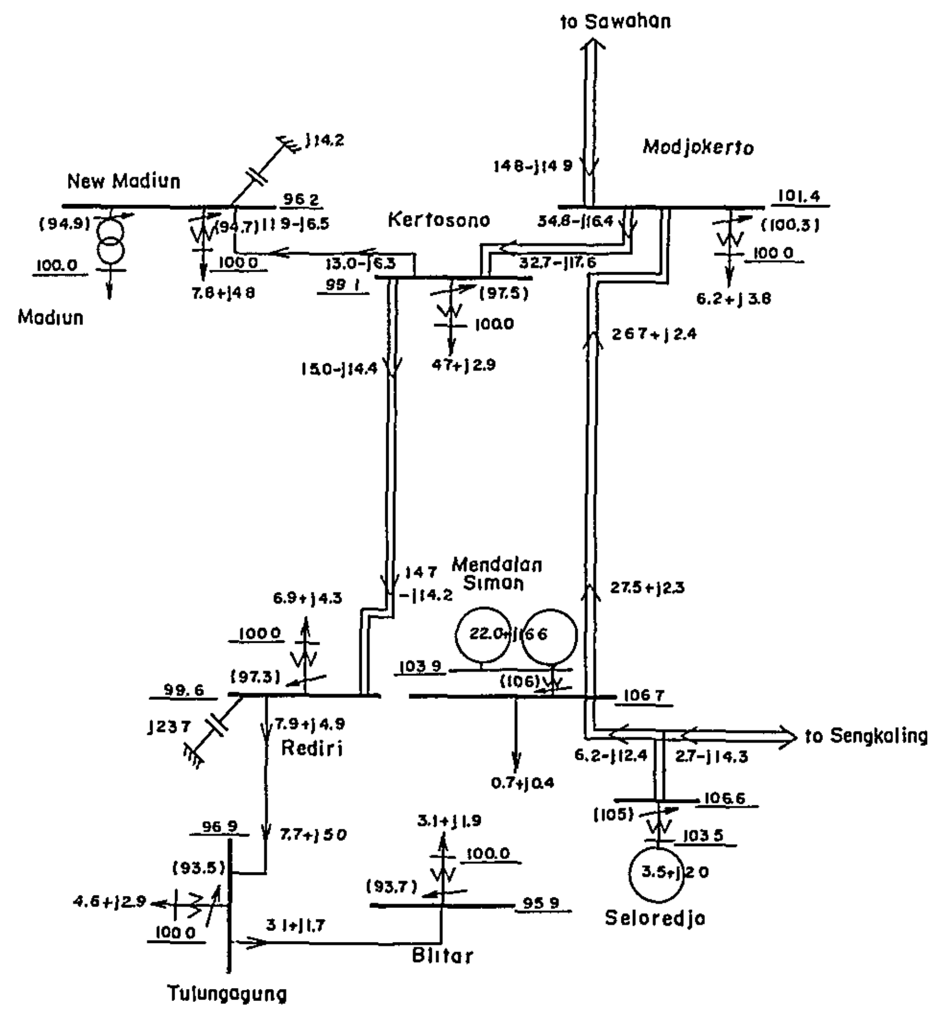


Fig. A-10 ALTERNATIVE PLAN (KERTSONO – KEDIRI) POWER FLOW WITH STATIC CONDENSER AT PEAK TIME IN 1978

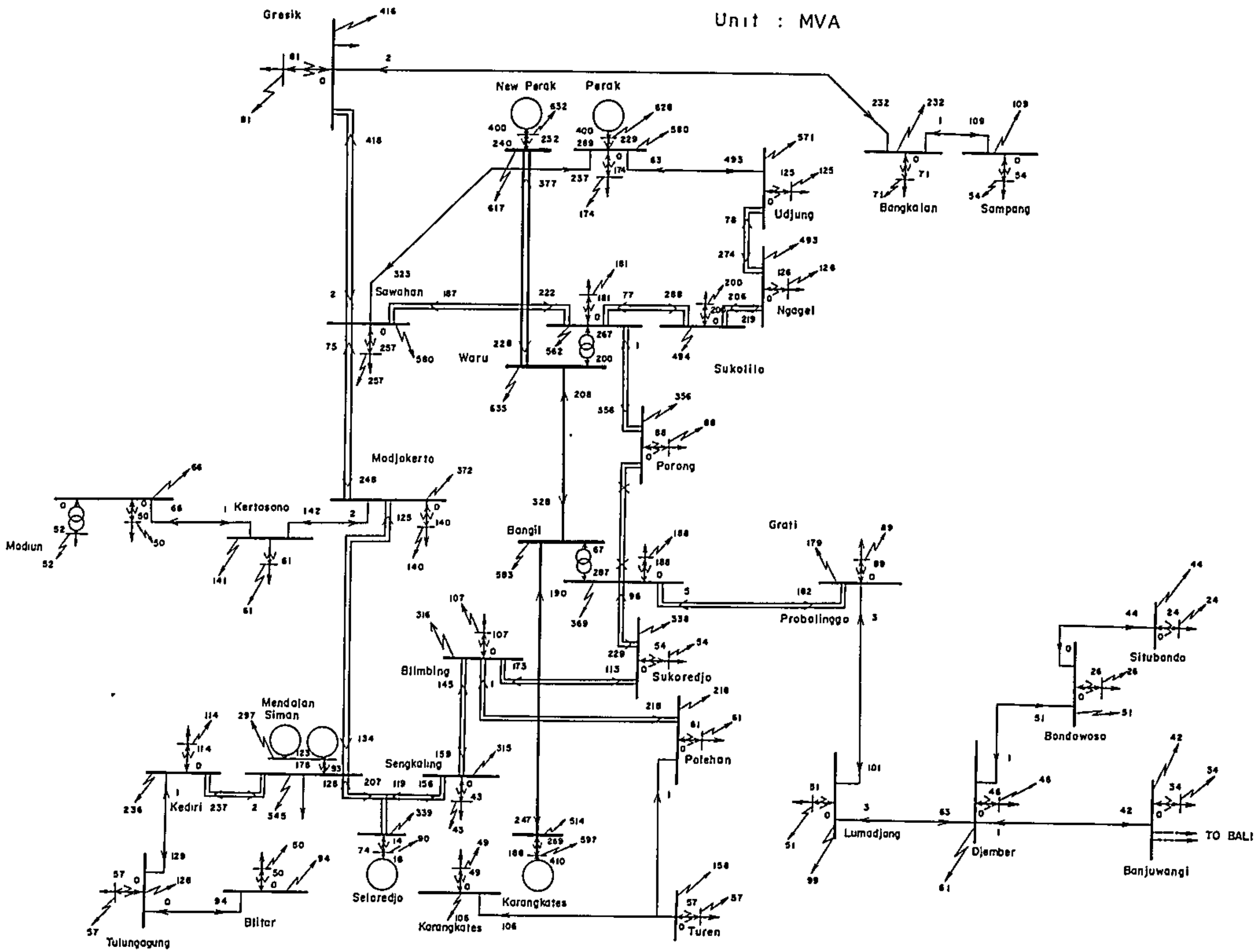


Fig. A-11 SHORT CIRCUIT CAPACITY AT 1976

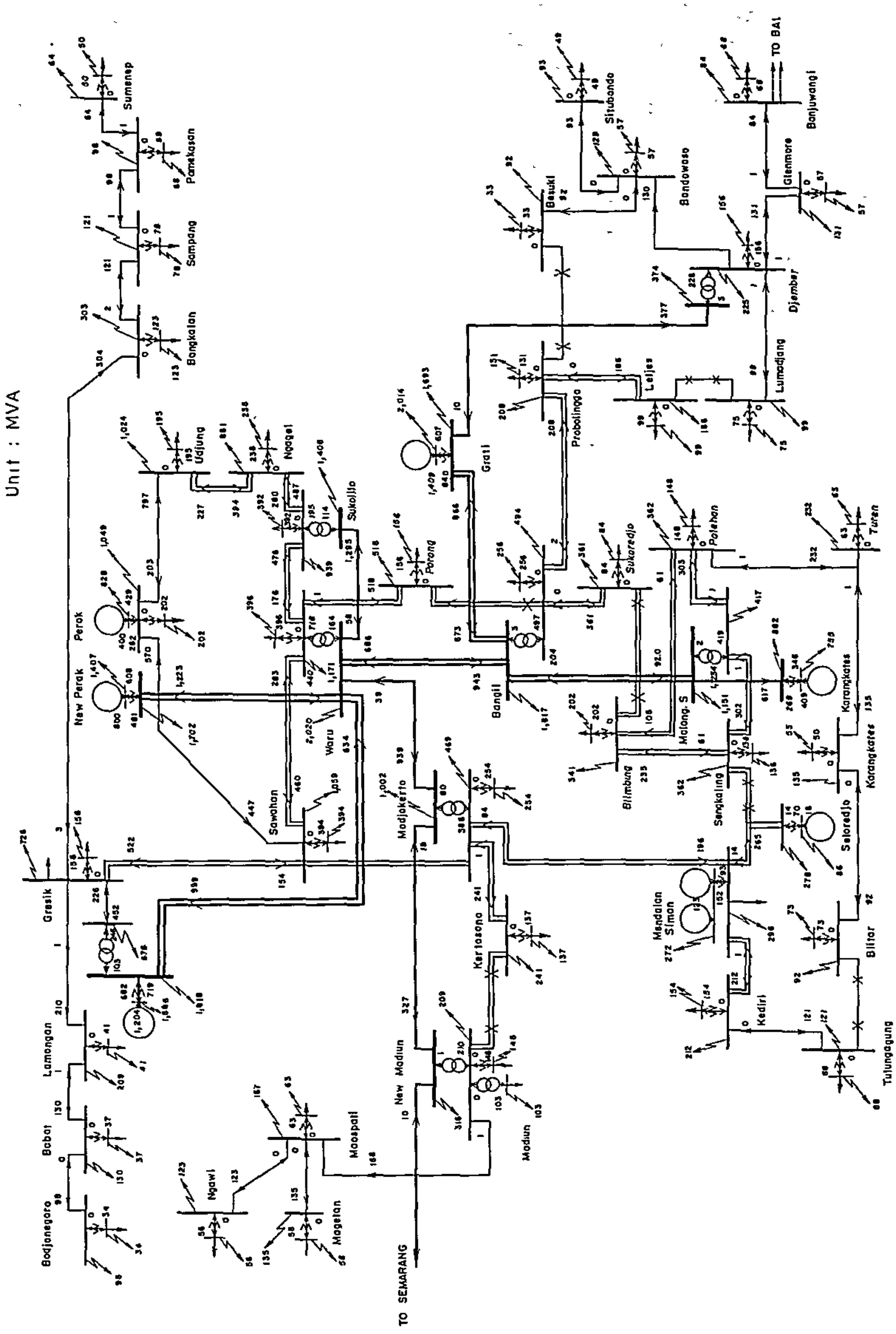


Fig. A-12 SHORT CIRCUIT CAPACITY AT 1985

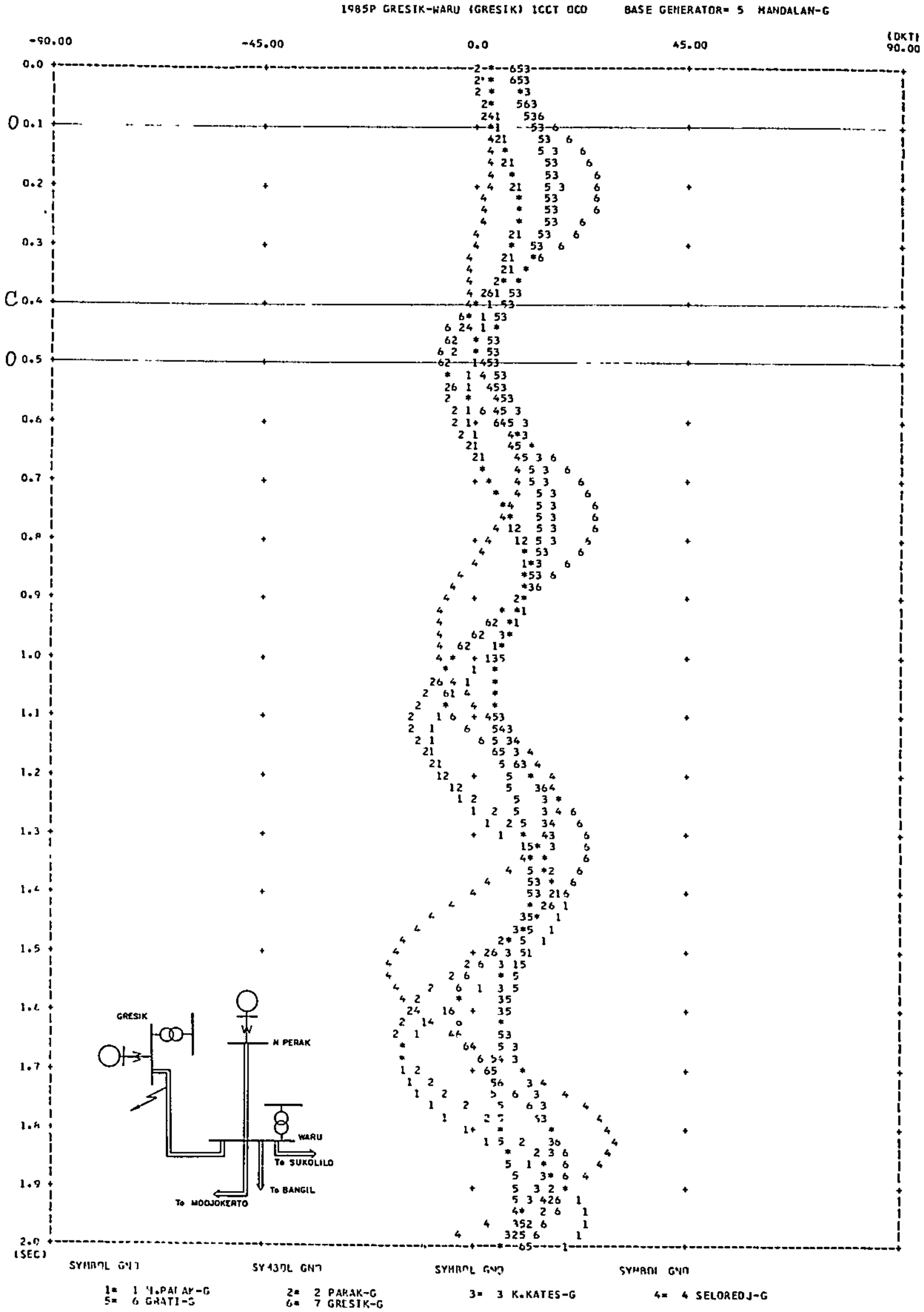


Fig. A-13 GRESIK-WARU 1cct 3LG O-C-O TRANSIENT STABILITY AT PEAK TIME IN 1985

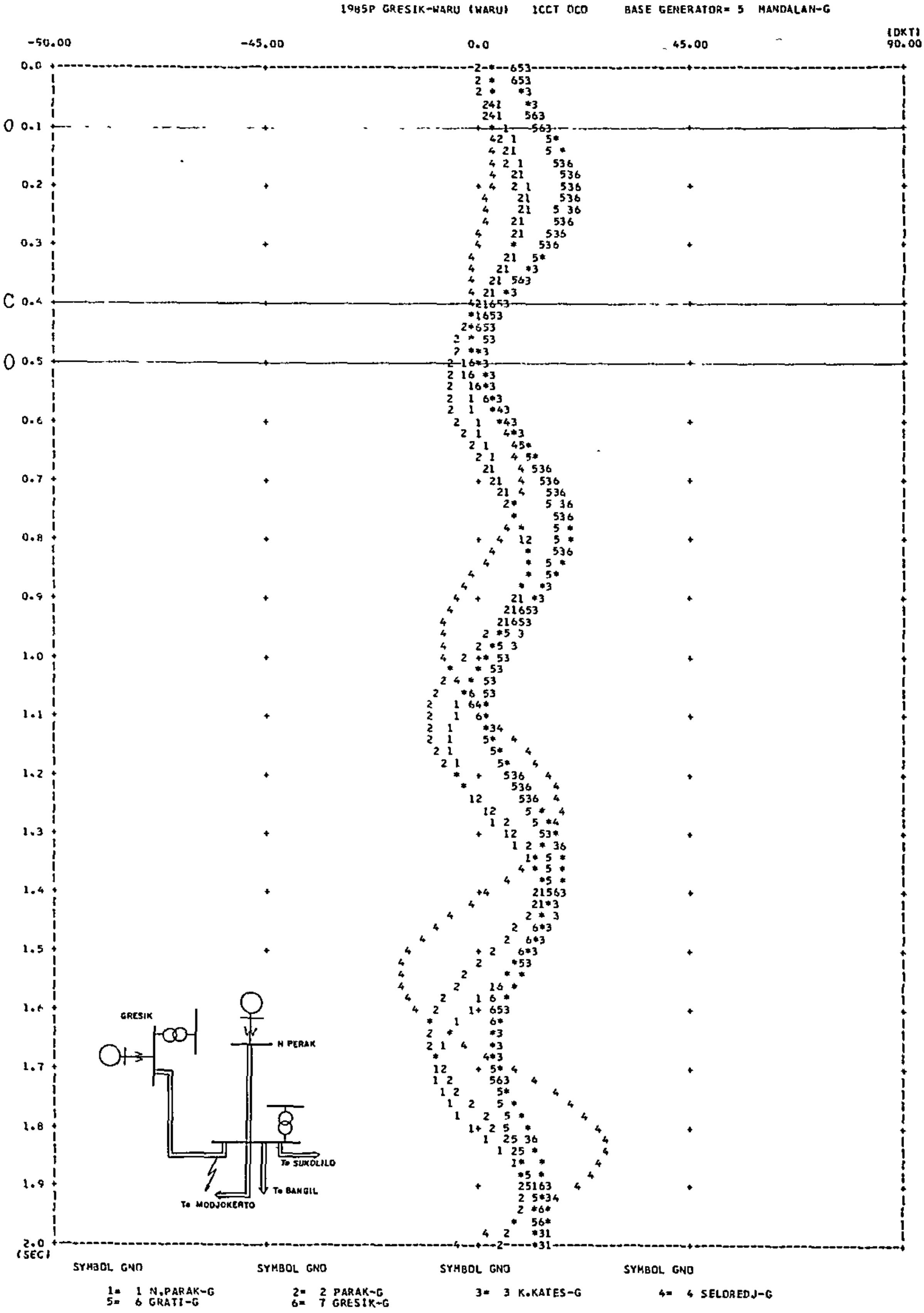


Fig. A-14 TRANSIENT STABILITY AT PEAK TIME IN 1985 WARU-GRESIK 1cct 3LG O-C-O

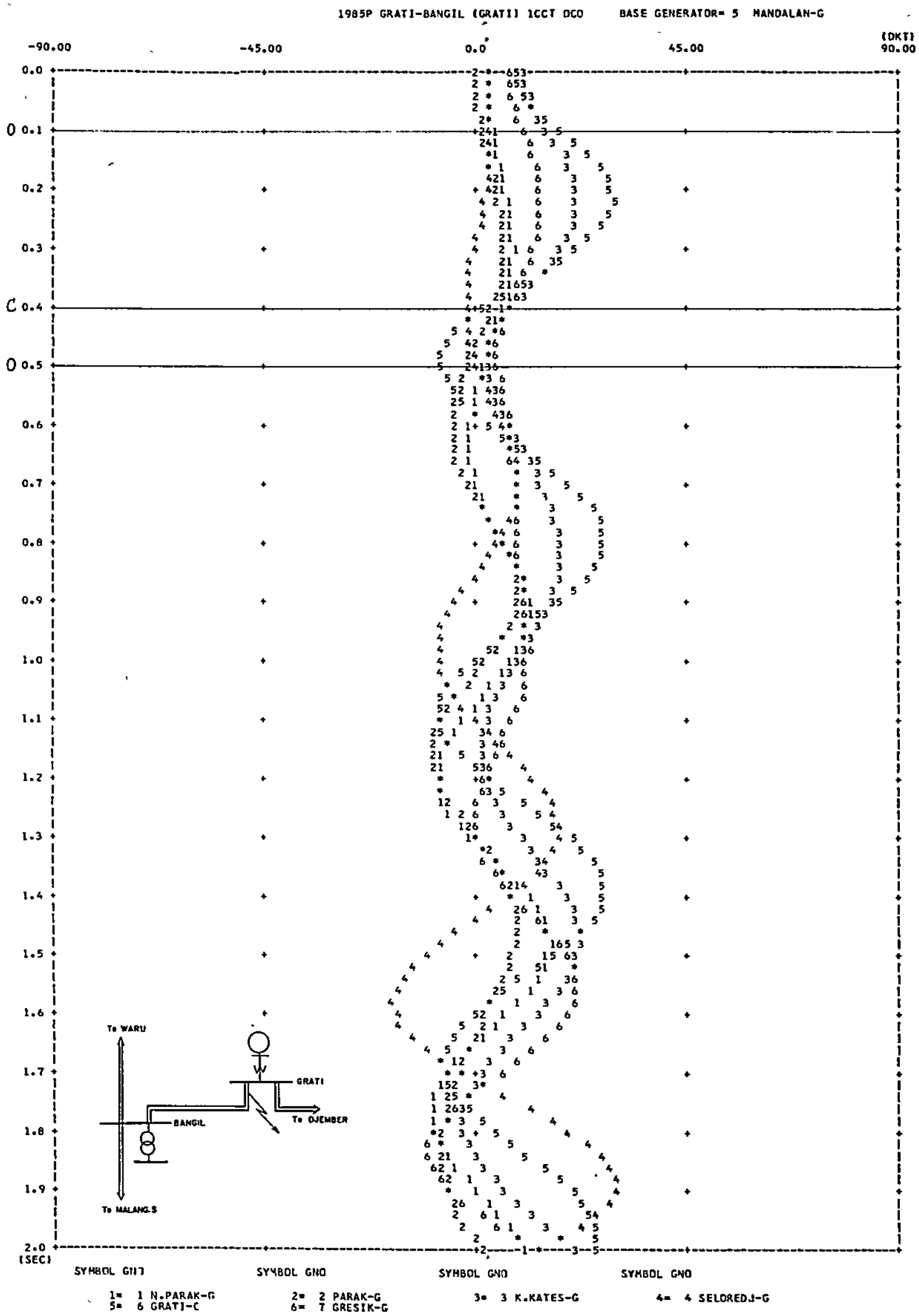


Fig. A-15 TRANSIENT STABILITY AT PEAK TIME IN 1985 GRATI-BANGIL 1cct 3LG O-C-O

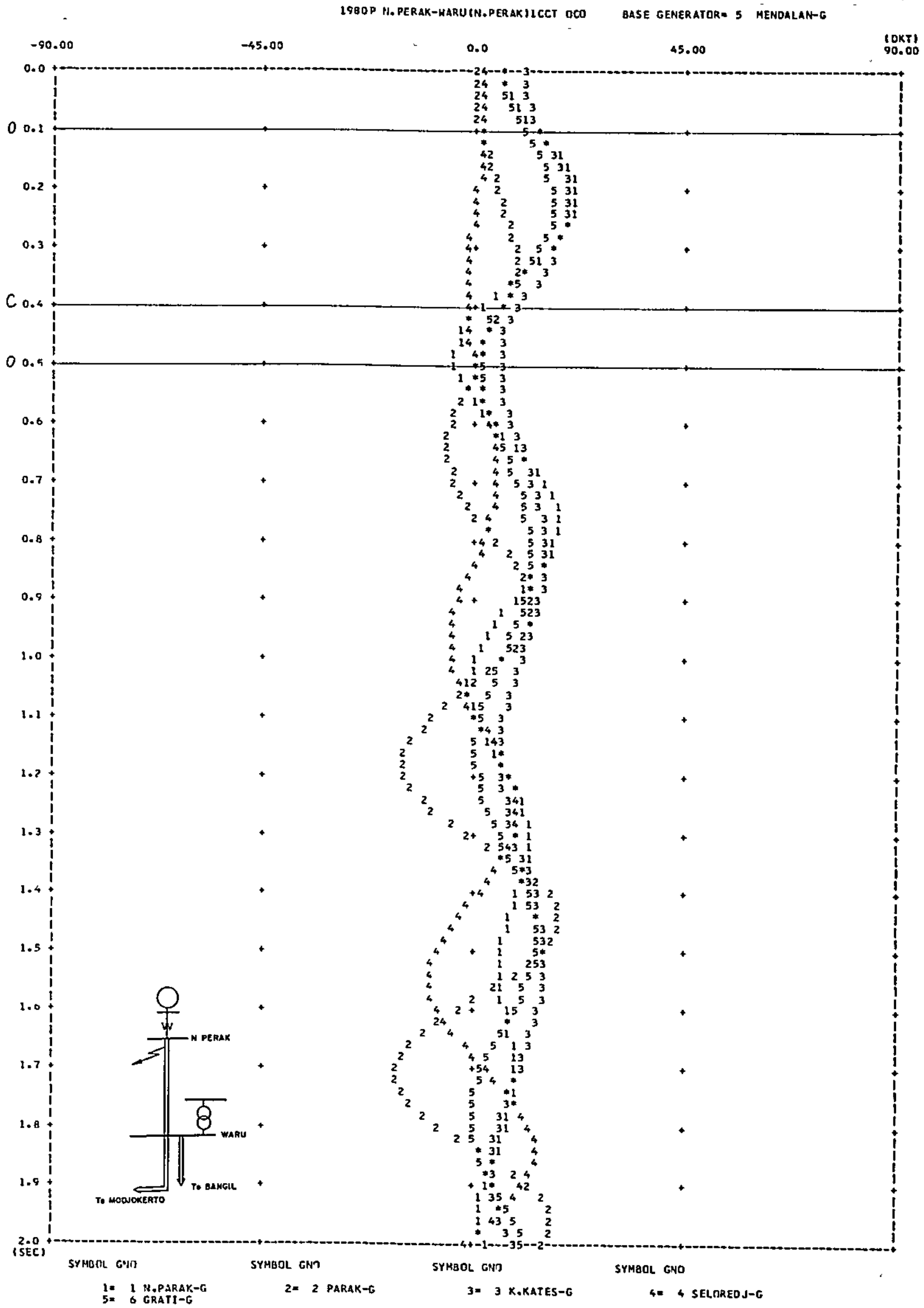
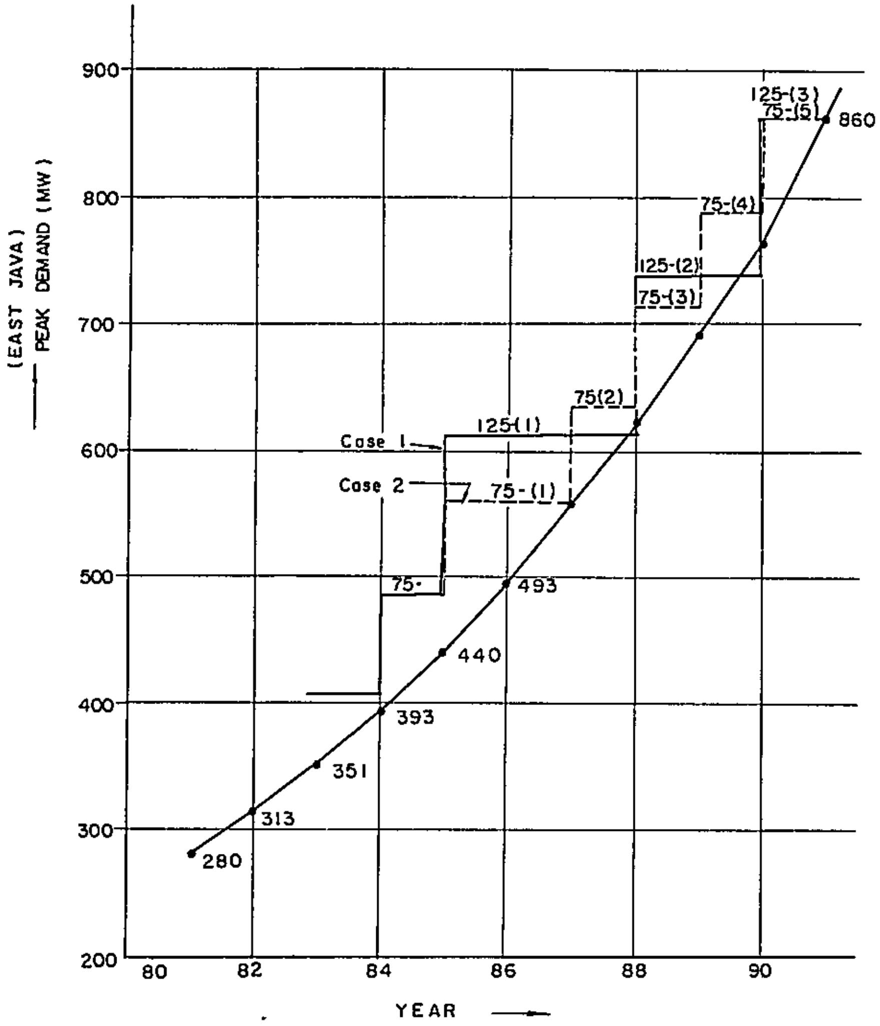


Fig. A-16 TRANSIENT STABILITY AT PEAK TIME IN 1980 NEW PERAK-WARU 1cct 3LG O-C-O

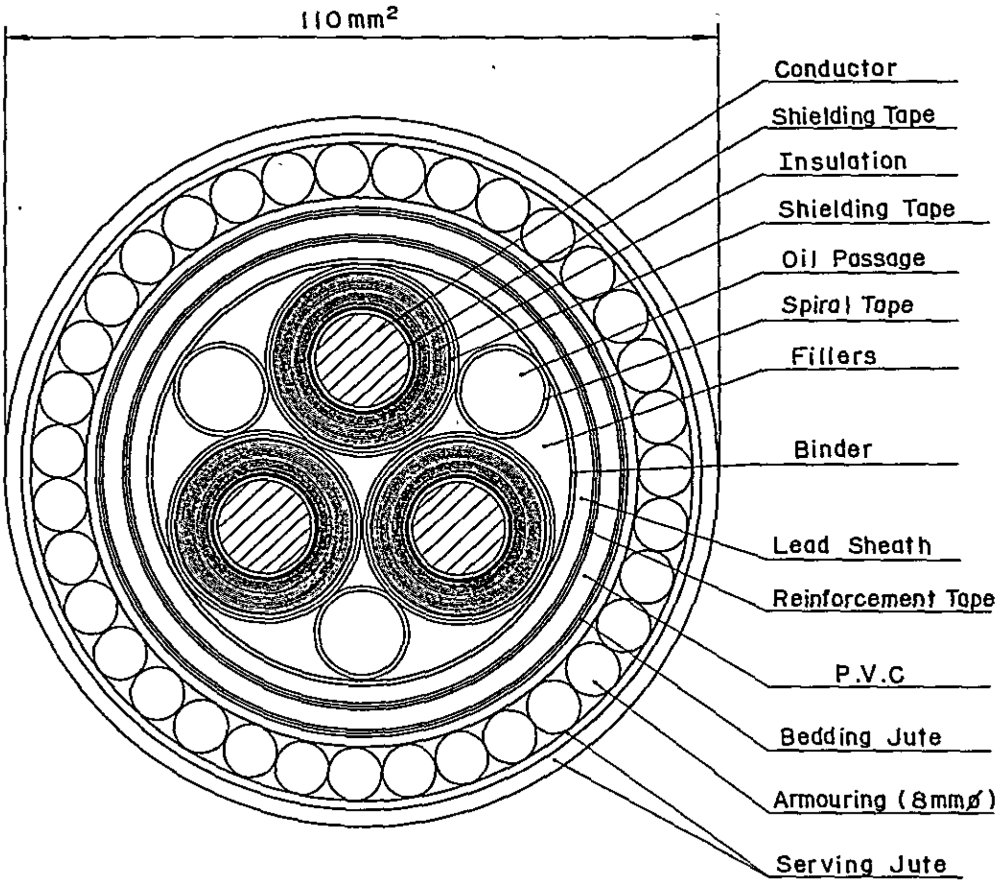


THERMAL P.P. CONSTRACTION COST AND
INTERCONNECTION FACILITY COST
(1985-1990) (Unit 10^3 US $, Interest cost 6 %)

YEAR		82	83	84	85	86	87	88	89	90	Total
Present worth FACTOR		0 945	0 89	0 84	0 79	0.75	0.705	0,665	0 627	0.592	
CASE 1	MW 125-(1)	3.900	6.800	8.700							19.400
	125-(2)				3.900	6800	8 700				19.400
	125-(3)						3.900	6.800	8.700		15.400
Total		3.900	6.800	8.700	3.900	6.800	12 600	6.800	8.700		58.200
Present worth (1982)		3 660	6.050	7.300	3.170	5.120	8.900	4.520	5.450		43.270
CASE 2	MW 75-(1)	2.500	4.400	5.500							12.400
	75-(2)			2.500	4400	5.500					12.400
	75-(3)				2 500	4 400	5.500				12.400
	75-(4)					2.500	4.400	5.500			12.400
	75-(5)						2.500	4.400	5.500		12.400
Total		2.500	4 400	8.000	6.900	12.400	12400	9.900	5.500		62.000
Present worth (1982)		2.360	3.910	6.710	5.450	9 270	8.750	6.900	3.450		46.800
Line			288	2.120							2.500
Present worth			256	1.794							2.050

* Benefit of Scale Merit in East JAVA system only 3 530 $\times 10^3$ US $
Inter-Connection cost 2.050 $\times 10^3$ "

Fig. A-17 THERMAL POWER PLANT COST & TRANSMISSION FACILITY COST (EAST JAVA – CENTRAL JAVA)



Approximate Outside Diameter	110 mm
Approximate Weight	32 kg/m

Fig. A-18 70 kV 3–CORE 100 mm² OF CABLE

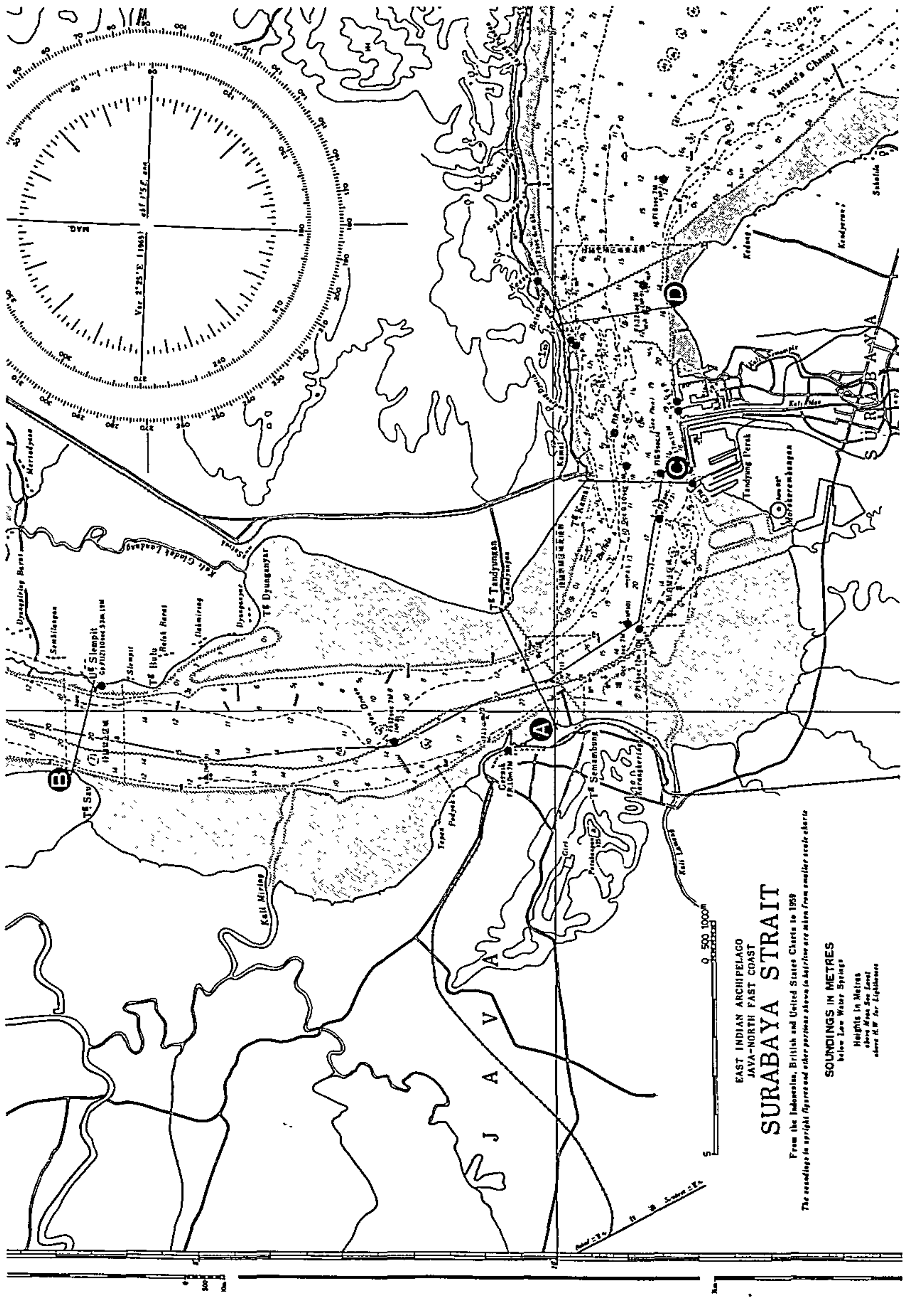


Fig. A-19 SURABAJA STRAIT