No. 43

REPUBLIC OF INDONESIA
PERUSAHAAN UMUM LISTRIK NEGARA

FINAL REPORT OF FEASIBILITY STUDY ON THE KOTAPANJANG HYDRO ELECTRIC POWER DEVELOPMENT PROJECT

MAIN REPORT

MARCH 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF INDONESIA
PERUSAHAAN UMUM LISTRIK NEGARA

FINAL REPORT
OF
FEASIBILITY STUDY
ON
THE KOTAPANJANG HYDRO ELECTRIC POWER DEVELOPMENT PROJECT

MAIN REPORT

MARCH 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Republic of Indonesia, the Government of Japan decided to conduct a Feasibility Study on the Kotapanjang Hydroelectric Power Development Project and entrusted the Study to the Japan International Cooperation Agency (JICA). The JICA sent the study team headed by Mr. Yoshiaki Shimada several times to Indonesia during the period of January 1982 - March 1984.

The team exchanged views with the officials concerned of the Government of Indonesia and conducted a field survey in the Kampar Kanan river basin, Riau province. After the team returned to Japan, further studies were made and the present report has been prepared.

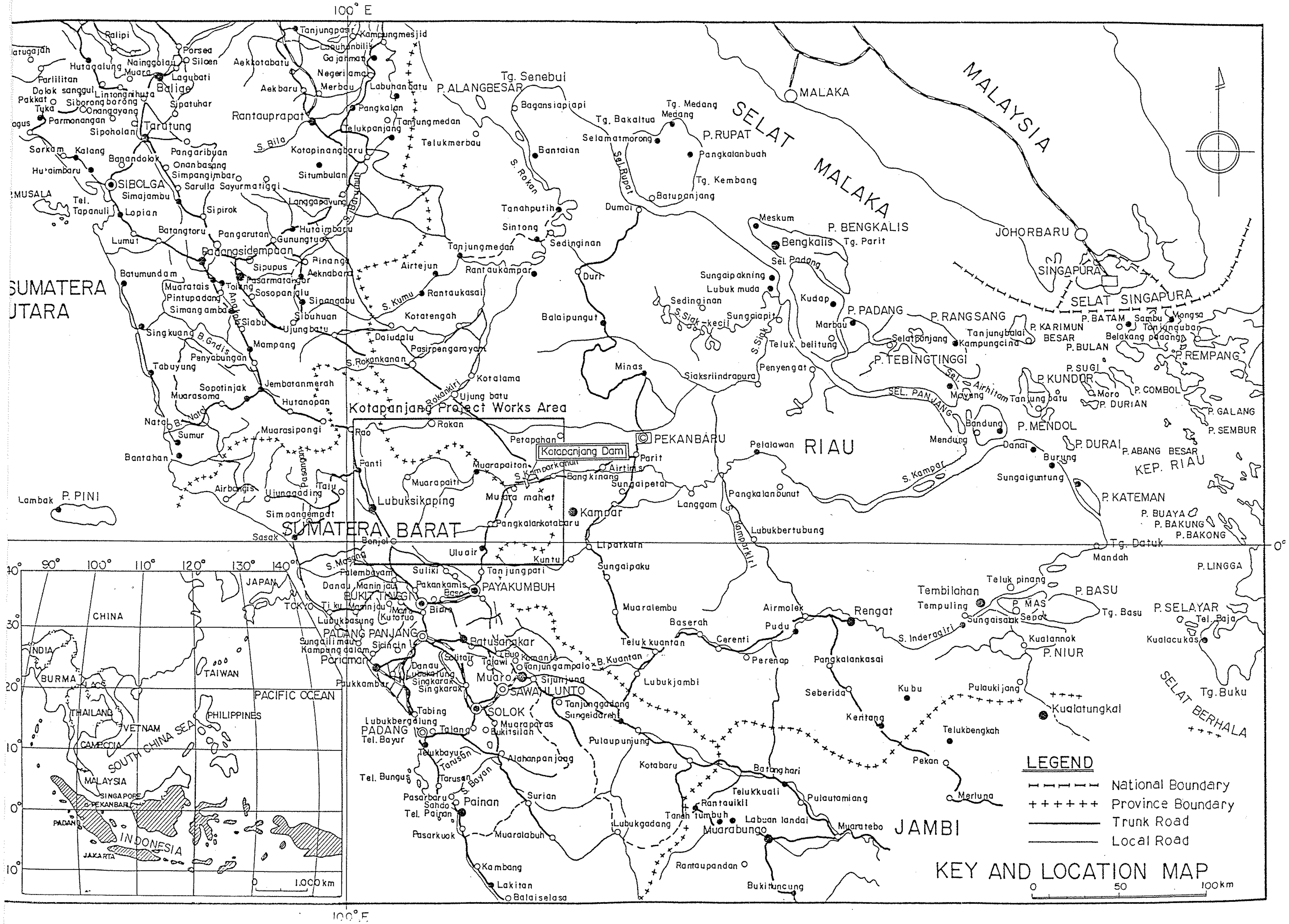
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

Tokyo, March, 1984

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency



KEY AND LOCATION MAP

General Map of the Project Area

Scale 1:500,000

Kotapanjang Site

Kotapanjang dam site

--- Looking from upstream ---

Kuok borrow site

--- Downstream about 11 km from the dam site ---

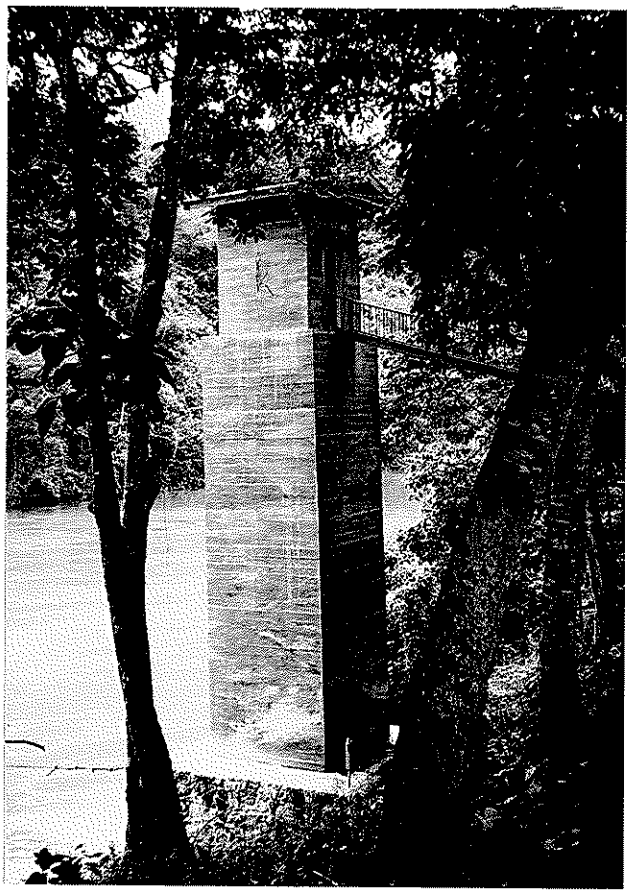
Muara Takus buddhist remains

--- Looking from the river side ---

Dumai Port

--- View at the public berth, extension work is under going ---

Established new flow gauging station
in Rantau Berangin



MAIN REPORT

CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY AND UNIT

Glossary

Badan Perencanaan Pembangunan Nasional (BAPPENAS)	National Planning and Development Board
Badan Perencanaan Pembangunan Daerah (BAPPEDA)	Provincial Planning and Development Board
Badan Koordinasi Penanaman Modal (BKPM)	Investment Coordination Committee
Badan Tenaga Atom Nasional (BATAN)	Indonesia Atomic Energy Agency
Biro Pusat Statistik	Central Bureau of Statistics
Bupati	Chief of Kabupaten (Regency)
Camat	Chief of Kecamatan (District)
Departemen Pekerjaan Umum (DPU)	Department of Public Works
Departemen Pertambangan dan Energi	Ministry of Mining and Energy
Desa	Village
Dinas Kehutanan	Forestry Service
Dinas Pendidikan dan Kebudayaan (PDK)	Education and Culture Service
Dinas Perikanan	Fisheries Service
Dinas Perindustrian	Industries Service
Dinas Perkebunan Rakyat	People's Tree Crops Service
Dinas Pertambangan	Mining Service
Dinas Pertanian Rakyat	People's Agricultural (food crops) Service
Dinas Transmigrasi	Transmigration Service
Direktorat Penyelidikan Masalah Air (DPMA)	Water Resource Research Institute
GSI	Geological Survey of Indonesia

JICA	Japan International Cooperation Agency
Kabupaten	Regency
Kantor Sensus dan Statistik	Statistics and Census Office
Kecamatan	District
Kepala Desa	Chief of village
Kepulauan Riau	The regency of Island Riau
Kotamadya	An incorporated city, the same level of government as a regency/kabupaten
Lembaga Meterologi dan Geofisika	Bureau of Meteorology and Geophysics (BMG)
Pekerjaan Umum (PU)	Ministry of Public Works
Perusahaan Terbatas Perkebunan (PTP)	Private Estate Enterprise
Perusahaan Umum Listrik Negara (PLN)	Head Office of State Electricity Public Corporation
P.T. Perkebunan (PTP)	Government Estate Company
Proyek-Proyek Pengembangan Sumber Air (P3SA)	Water Resources Development Project
Pusat Penyelidikan Masalah Kelistrikan (LMK)	Electric Power Research Center
Rencana Pembangunan Lima Tahun Ketiga (REPELITA)	Five Year Development Plan
Sumatera Barat	West Sumatra
Unit Pelaksana Proyek (UPP)	Project Execution Unit
Wilayah III	Province of West Sumatra, Province of Riau and the District of Kerinci, the Province of Jambi (Region III)

Unit

mm	millimeter
cm	centimeter
m	meter
km	kilometer
mm^2	square millimeter
cm^2	square centimeter
m^2	square meter
km^2	square kilometer
ha	hectare
m^3	cubic meter
kg	kilogram
t	ton
sec	second
min	minute
hr	hour
kg/cm^2	kilogram per square centimeter
m^3/sec	cubic meter per second
kW	kilowatt
kWh	kilowatt hour
kVA	kilovolt ampere
MW	megawatt
GWh	gigawat hour
o	degree
^oC	centigrade degree
%	percent
No. (Nos.)	Number(s)
1982/83	Fiscal year 1982

SUMMARY

1. Introduction

The feasibility study for the Kotapanjang Hydroelectric Power Development Project has been carried out as part of the technical cooperation program of the Government of Japan in accordance with the Scope of Work agreed upon by the Government of the Republic of Indonesia and the Government of Japan on the 6th October 1981. In implementing this study, the Government of Japan designated the Japan International Cooperation Agency (JICA) as the executing agency, and JICA dispatched a survey team to the project site. The results of the study have been summarized in this feasibility study report. Meanwhile, the Government of Indonesia appointed Perusahaan Umum Listrik Negara (PLN) as the executing agency, and PLN carried out the investigation by employing local contractors. The study was thoroughly carried out with close cooperation among both Governments, PLN and JICA.

This project is intended to meet the rapidly increasing electric power demand in Riau Province while promoting the provincial electrification rate. Moreover, completion of the Kotapanjang Dam will enable realization of flood control and increase the amount of water available for irrigation in the downstream area. Thus, the project stands as an important key for regional development of the province. Moreover, development of this domestic hydropower source will make it possible to reduce consumption of oil on a large scale.

The objectives of this study are to carry out the field investigation work at feasibility level to work out an optimum development plan to demonstrate the technical, economic and financial feasibility of the Kotapanjang project.

2. Regional Economy in Riau Province

Roughly half of the total production of oil in Indonesia is produced in Riau Province. In fact, the province accounts for 83.1% of the regional gross domestic production (RGDP) according to the index compiled in 1980, thus making the province unique in this respect.

Agricultural production constitutes the second major economic activity of the province, with its RGDP amounting to 29.2%. Despite this, however, the province must import rice. Although there are vast expanses of land which could be used for the paddy fields, development to realize this has been slow. Also, existing paddy fields are frequently subjected to seasonal flooding. Recently, to eliminate some of the problems, irrigation projects have been implemented, but there still remains much to be done.

Other agricultural changes which have occured in recent years are large scale government-financed plantation projects for rubber, coconut and palm oil.

Moreover, Riau Province is the site of a large transmigration scheme. By 1981, 27,500 households had been relocated in the province, with 61,000 more scheduled to be relocated soon according to REPELITA III. This transmigration program is expected to be actively promoted even after REPELITA IV.

The industrial sector is constiduted of small scale industries. Although large scale oil-related industries, including petroleum refineries and naphtha hydrocracking units, are located mainly in Dumai and Sungaipakning, it seems that these large scale industries are not closely related to the needs of the regional manufacturing industries.

3. Demand and Supply of Electric Power

The power demand forecast has been carried out for the entire Wilayah III in accordance with the Scope of Work. Prior to this forecast, it was envisaged that all electric power to be generated under this project would not be consumed solely in Riau Province, but a portion of the power would be supplied to West Sumatra by interconnecting the transmission lines to the power system in West Sumatra. However, based upon the power demand forecast in both Riau Province and West Sumatra Province, it is estimated that electric power generated at the Kotapanjang Hydro-Power Plant can only supply the needs for Riau Province when the Kotapanjang Project is scheduled to be completed in 1991. It is also clear that the supply and demand of electric power is more critical in Riau Province than in West Sumatra Province. As a result, the electric power demand and supply plan has been worked out in the consideration that electric power generated at the Kotapanjang Power Plant will be consumed for the time being in Riau Province, and that interconnection with the power system in West Sumatra Province be promoted to ensure stability of the power system in the province in the future.

The installed capacity of PLN power facilities in Riau Province as of 1981 was comparatively small of 18,724 kW. However, the electric power demand for the past eight years (from 1973 through 1981) grew at an annual average rate of 18% and the growth rate was as high as 34% particularly over the past two years.

The electric power forecast was carried out with the year 2000 as the target year. Meanwhile, power demand in Kepulauan Riau, a prefecture comprising many islands, was excluded from the demand forecast since it is difficult to interconnect the power system to that in the prefecture.

As a result of the demand forecast, the power demand and peak load in Riau Province is estimated to reach 1,260.2 GWh and 287.7 MW in the year 2000. This is equivalent to about 27.5 times and 23.4 times larger than the records of 45.8 GWh and 12.3 MW in 1981. In other words, the power demand and peak load in the nineteen year period are estimated to

grow at an annual average rate of 19% and 18%, respectively over the next years. Moreover, the electric power demand, in the ten year period from 1981 through 1991 until the Kotapanjang Hydro-Power Plant is completed, is estimated to grow at a very high annual average rate of 29%.

Until the Kotapanjang Hydro-Power Plant has been completed, the electric power demand will be covered by constructing diesel power plants. Thereafter, a reserve generating capacity can be created for peak power supply after completion of the Kotapanjang Hydro-Power Plant. Old diesel power plants will be scrapped, some comparatively new ones will be used as cold power plants (standby power plants) to reduce oil comsumption. These diesel power plants will serve as reserve power supply sources and will be operated later in response to power supply needs.

4. Site Conditions

(1) Topography

The topography around the dam site consists of a narrow valley. On the other hand, a vast quasi-tableland exists about 10 km upstream of the dam site. Thus, the dam site is an area having excellent topography whereby a medium size dam can create a large reservoir. However, the river gradient around the dam site is a gentle 1:1,090, so a head can only be obtained from the dam. The dam site is located about 85 km from Pekanbaru, the provincial capital and about 20 km from Bangkinang. The site is easily accessible from the national road running along the Kampar River.

(2) Geology

The dam site mainly consists of dacitic tuff. The left bank is a gentle slope of about 25^{o}. Class D rock is deeply distributed from the intermediate stage to the upper stage, and the appearance depth of Class CM rock becomes shallower from 24 - 4m toward the river bed. The appearance depth of CL class rock is 14 m at EL. 80m. The right bank has a steep slope of 40^{o}, and its

upper part comprises a precipice with height of about 50m where foundation bedrock is exposed. The appearance depth of Class CM rock is 4 - 9m, and that of Class CL is within 2m. Generally, the excavation line is rather deep on the left bank, while the line is shallow on the right bank. Although the bedrock on the left and right banks is evaluated to be sufficient as foundation bedrock, the foundation on the left bank requires special treatment.

Sufficient concrete aggregate is available from the four river deposits sites located upstream and downstream of the dam site. About 10 km upstream of the dam site is a quarry site (QR-1) where sufficient and good quality aggregate is available. Through further tests of the aggregate and from an economic comparative study, detailed methods for obtaining aggregate can be determined.

(3) Hydrology

The annual rainfall within the catchment area of the dam site is estimated to be 3,000 - 3,500 mm, making the area one of the most intensive in Indonesia.

The yearly average runoff at the dam site over the past eleven years was 173.52 m^3/sec, with an annual total inflow of 5,472 x 10^6 m^3. When these values are converted into monthly values, the maximum runoff is 225.59 m^3/sec in December, and the minimum runoff is 111.03 m^3/sec in August. The yearly average specific yield per 100 km^2 is 5.20 m^3/sec. Therefore, it is clear that river discharge is considerable. In this study, river discharge is planned so as to eliminate dead discharge from the reservoir under normal conditions.

The design flood discharge is estimated to be 9,000 m^3/sec based on a 200-years probability.

(4) Investigation and Countermeasures Regarding Compensation for Submerged Property

Major facilities expected to be submerged due to construction of the reservoir are estimated to include 2,664 houses, 3,864 ha of paddy fields, 162 public facilities, 25.3 km of national road and 27.2 km of provincial roads, etc.

Appropriate compensation should be provided for submerged households. Also, compensatory consideration should be made for sites of relocated households be chosen as close as possible to their former residences within transmigration and plantation projects. Nine (9) prospective transmigration sites were selected after discussion with Provincial Planning and Development Bord (BAPPEDA).

The relocated roads were selected along the routes as close as possible to the existing roads after comparative study taking into account regional development, economy and other factors for the future. However, since study of the relocated roads is also under way by Ministry of Public Works (PU), the routes for the relocated roads is left to a final decision by the Government of Indonesia.

(5) Environmental Study

There are Buddhist religious remains near Muara Takus at the terminal of the reservoir. These remains, which date back to the 11th and 12th centuries, are archaeologically and historically important cultural assets. Therefore, the high water level of the reservoir was determined to be 85m, which is lower than the lowest elevation of the remains, 86.25m. In this way, the remains can be preserved and be free from submergence. However, the water level of the reservoir will be raised temporarily to 86.39m due to the back water phenomena at the time of flood (200-years probability). An embankment with height of 2.5m and length of 1.5 km will be constructed facing the reservoir near the site of the remains. Moreover, the foundation of the remains will be reinforced as required in the future. For preservation of the remains, detailed work methods based upon the results of further study regarding topography, geology, etc. should be developed.

5. Power Generation and Transmission Line Plan

Regarding the development system of this site, a single stage development system and two stage development system were considered during the initial stage. The single stage development system will make it possible to realize a large scale reservoir, though a large amount of compensation will be required. In the case of the two stage development system, the two sites have to be of the regulating pondage type, and the scale of development has to be made smaller than the single stage system. As a result of comparative study regarding these two systems, the single stage development system proves to be the one most economically optimal.

With respect to the type of a dam to be built, comparative study of a concrete gravity dam and a fill dam was carried out. In the case of a fill dam, countermeasures against flooding and flood discharge facilities are required due to the scale of flooding at the site, therefore, a fill dam requires greater cost than a concrete dam. Topographically, the river width is small, thus negating any advantage of a fill dam type. On the other hand, selection of a concrete gravity dam is much more advantageous in view of topography, and construction materials. As a result, the concrete gravity dam was adopted.

As the water level rises, the capacity of the reservoir tends to increase rapidly, with the B-C also increasing. However, due to the Muara Takus Buddist ruins and Pangkalan Kotabaru (population: 8,572) at the terminal of the reservoir, the high water level of the reservoir is limited to 85 m in order to avoid flooding of the ruins and submergence of the town. As it is considered possible to obtain sufficient reservoir capacity even with this water level, the high water level has been determined to be 85m.

Regarding the scale of the power plant, comparative study was carried out by assuming seven (7) different turbine discharges. As the scale becomes larger, both B and B - C tend to increase. Even if the scale of development is made larger, the major part of construction cost, which consists of the dam and compensation costs, will remain unchanged, while the construction cost of the facilities from the intake through to the

tailrace will only increase to a certain extent. Therefore, the kW valve will increase.

Still, if the scale is made too large, it will be impossible to realize effective operation of the power plant. In consideration of the future power demand and supply plan in Riau Province, the optimum scale of development is determined to be 111 MW when the equivalent continuous time of peak load is 12 hours.

A main tansformer adjacent to the power station steps up voltage of the generated power. A 150 kV transmission line conveyeys the power to a switchyard, which is located on a hill of 177m (EL), 400m downstream from the power station.

The transmission line of 150 kV with 2 circuits will be constructed for a length of 70 km from the switchyard to a substation in Pekabaru.

6. Feasibility Design

The reservoir has been designed on the basis of high water level of 85.0m and active storage capacity of 1,040 x 10^6 m^3 on the assumption that the reservoir will be operated for the purpose of electric power. Based upon the design flood discharge of 9,000 m^3/sec (200-years probability), the spillway is designed to enable discharge at 85.0m of water level. The energy dissipator of the horizontal apron system which employs a hydraulic jump is provided with chute blocks and dentated sills in order to reduce the construction costs.

The powerhouse has been arranged immediately below the left bank of the dam. The total output of the power plant is determined to be 111 MW (37 MW x 3 units) with a turbine discharge of 348 m^3/sec and an effective head of 38.1m. Three penstocks, with total length of 77m, and one tailrace, with total length of 80m, will be constructed.

A space of 200m x 100m on the left bank of the dam will provided to construct the switchyard. A transmission line (150 kV, 2 circuits) extending to 70 km from the switchyard to the proposed substation will be constructed.

7. Construction Plan

The main construction work for the Kotapanjang Project is scheduled to be commenced in April 1987 and commissioned in March 1991.

In view of the fact that the topography at the dam site is a valley and that the river has a winding section in the immediately downstream of the site, river flow will be diverted by constructing one diversion tunnel (1,000 m^3/sec) on the left bank prior to construction of the dam.

An aggregate plant will be constructed on the left bank about 500m upstream of the dam site. Aggregate produced at this plant will be transported to the crest of the dam via belt conveyor. Then concrete will be mixed at batching plant (mixer: 1.5 m^3 x 3 sets) and placed by using cable crane (13.5 tons).

Heavy equipment will be unloaded at the Sungai Siak Port in Pekanbaru, and land-transported to the project site along the national road. There are 32 bridges from the port to the project site, of which 16 bridges will have to be reinforced.

8. Construction Cost

The total construction cost is estimated to be US$190,194 x 10^3, of which the foreign currency portion is US$110,997 x 10^3 and the local currency portion is US$ 79,197 x 10^3. However, no price escalation or interest to be incurred during the construction period is included in the total construction cost. The construction cost per kW and that per kWh are

estimated to be US$1,713 and US$0.38, respectively then energy cost is estimated to be Rp. 52/kWh. The cost is justifiable when compared with that of other projects in Indonesia, and sufficiently competitive judging from the electric tariffs of PLN. Meanwhile, the price escalation cost and the interest during the construction period are expected to be US$116,362 x 10^3 and US$64,225 x 10^3, respectively. Therefore, the total construction cost, including price escalation and interest, is estimated to be US$370,781 x 10^3.

9. Economic and Financial Analysis

The economic internal rate of return (EIRR) is estimated to be 17.71%. When the price is assumed to escalate at 10% and 20%, the EIRR according to sensibility analysis will become 16.10% and 14.73%, respectively. As a result, the economic feasibility of the project has been proven.

The financial internal rate of return (FIRR) is estimated to be 13.53% in case the interest during the construction period is not included, and 11.53% in case the interest is included. Thus, the project is viewed to be feasible in terms of FIRR as well.

Regarding the possibility of debt reimbursement, the cash balance will show a profit six (6) years after operation of the power plant. Thereafter, this project will bring about a net profit of about US$44 x 10^3 a year, and a total net profit of US$762,948 x 10^3 in 30 years. Thus, this project is also evaluated to be feasible in view of reimbursement of debt. In addition, mitigation of flood, increased supply of irrigation water, development of tourism, fish farming, etc., are also considered after completion of the reservoir, and are seen as associated benefits.

CONCLUSION AND RECOMMENDATIONS

1. Conclusion

(1) Summary of the Project

As a result of the feasibility study, the following optimal plan was adopted. The plan envisages that the Kotapanjang hydroelectric power plant will have a capacity of 111 MW (37 MW x 3) and that three generators will commence their operation simultaneously. The operation of the plant is planned in such a way that electricity is supplied as uniformly as possible throughout the year. The generated energy will have a peak in May of 45.6 GWh and low in October of 37.1 GWh, approximately 81% of the peak. As for its daily oepration, continuously equal load time is set as 12 hours to enable the plant to contribute to base load supply as much as possible.

The dam has a head 58m, embankment width of 267m of middle size, and the reservoir has a total capacity of 1,454 x 10^6 m^3 of large size. The location of the dam is endowed with an abundant rain fall and river run-off.

The results of the economic and financial analysis prove the projects's feasibility to ensure further high priority of the Project.

(2) Important and Urgency of the Project

The significance of the Kotapanjang Project lies in its contribution to upgrading the welfare of the people in Riau Province through electrification of the communities as well as meeting an increasing demand for energy.

The completion of the Project will remove the bottle-neck in electricity supply and meet new demand. The Project will complete the distribution network within Riau Province, thus enhancing drastically the electrification of the areas which have not been provided with electricity.

The Kotapanjang power plant will become the first hydroelectric power plant in Riau Province. The large reservoir will serve as a core impetus to the region's development, functioning not only for power generation but also for other purposes such as flood control in the lower basin, additional irrigation water supply, tourism, and aquaculture.

The development of hydropower generation will enable saving in petroleum consumption and in foreign exchange.

Based upon the above findings, it is essential to realize the Project at the earliest possible date for the benefit on the region and state.

The completion of the Project is estimated to be in March 1991 at the earliest. Therefore the next procedure, i.e. detailed engineering, must be commenced as soon as possible.

2. Recommendations

(1) Compensation for Submerged Areas

Proper consideration must be taken for the people in the submerged areas regarding the provision of land for resettlement. It is recommended that a neutral public agency be established to facilitate the transfer of people from the area. Route selection of the relocated roads must await the Indonesian Government's decision, which it is hoped will take place as soon as possible so that the implementation schedule will not be delayed.

(2) Study on Muratakus Remains

In the neiborhood of the Muratakus remains several valuable artifacts have been discovered, and it is expected that there will be more. Organized and prompt survey and excavation should be conducted during the seven years before the reservoir is filled.

Prope measures should be designed and implemented to preserve the remains based upon further thorough investigation.

(3) Stepped up Development of the Related Transmission Facilities

The Project includes the power transmission lines from Kotapanjang to Pekanbaru and the substation at Pekanbaru.

Other related transmission facilities within Riau Province must also be built by the completion of the Kotapanjang Project in March 1991.

GENERAL FEATURES OF THE PROJECT

Capacity of the power plant

Maximum out put	:	111,000 kW (37,000 kW x 3 units)
Firm peak out put	:	99,000 kW
Maximum discharge	:	348 m^3/sec
Effective head	:	38.1m
Annual generated energy	:	495 x 10^6 kWh

Reservoir

Reservoir capacity	:	1,454 x 10^6 m^3
Active storage capacity	:	1,040 x 10^6 m^3
Normal high water level	:	85.0m
Low water level	:	73.5m
Effective depth	:	11.5m
Surface area	:	124 km^2
Catchment area	:	3,337 km^2
Annual average inflow	:	173.52 m^3/sec

Dam

Type		:	Concrete gravity type
Height		:	58.0m
Freeboad		:	2.5m
Crest length		:	267.0m
Crest width		:	5.0m
Elevation of nonoverflow crest		:	87.5m
Elevation of overflow crest		:	67.5m
Overflow depth		:	17.5m
Overflow length		:	72.0m (12m x 5 gates = 60m, 3m x 4 pier = 12m)
Dam volume		:	313,000 m^3
Base width		:	55.1m
Surface slope	Upstream	:	1:0.15
	Downstream	:	1:0.80

Spillway

Type		:	Overflow, chute and dentated sill type
Design flood		:	9,000 m^3/sec (200-year flood)
Gate	Type	:	Roller gate
	H x W x units	:	18.0m x 12.0m x 5 units

Diversion work

Diversion tunnel	Unit	:	1 unit
	Length	:	425m
	Diameter	:	9.5m
	Capacity	:	1,000 m^3/sec

Intake

Type		:	Pressure type
Elevation of intake bed		:	67.5m
Gate	Type	:	Roller gate
	H x W x units	:	9m x 13m x 3 units
Screen	H x W x units	:	20m x 13m x 3 units

Penstock

Type	:	Buried type
Length	:	77.0m
Units	:	3 units
Diameter	:	5.00m - 4.18m
Thickness	:	15 mm - 13 mm
Mateiral	:	40 kg/mm^2 tensile strength class
Design pressure	:	6 kg/cm^2

Power house

Type	:	Ground type
Length	:	79.5m
Width	:	26.5m
Height	:	41.0m

Tailrace

Type	:	Open channel type
Length	:	80.0m
Gradient	:	1:32
Section	:	Trapezium
Width of inverst	:	43.0m

Turbine

Type	:	Vertical shaft Kaplan type
Installed capacity	:	37,000 kW x 3 units
Rated discharge	:	116 m^3/sec/units
Effective head	:	38.1m
Number of revolutions	:	167 r.p.m.

Generator

Type	:	3-phase AC generator
Capacity	:	44,000 kVA x 3 units
Voltage	:	11 kV
Frequency	:	50 Hz

Main transformer

Type	:	Outdoor 3-phase oil immersed Oil material air forced
Capacity	:	44,000 kVA x 3 units
Voltage	:	11/150 kV

Transmission line

Section	:	From power house to Pekanbaru substation
Length	:	70 km
Phase	:	3-phase system
Voltage	:	150 kV
Number of circuits	:	Double
Conductor	:	ACSR 330 mm^2
Support	:	Steel tower

Substation

Location	:	Pekanbaru
Type	:	3-phase oil natural transformer with forced air circulation
Capacity	:	25 MVA x 2 units*
Voltage	:	150/20 kV

Note: * Other substations will be constructed to supply power for the areas of dumai, Taluk Kuantan, Pasirpengarayan and Tembilahan.

CHAPTER 1 INTRODUCTION

1.1 Background of the Project

Located in the central part of Sumatra, Riau Province is the largest oil producing province in Indonesia where about 150 million barrels of crude oil, equivalent to about 50% of total crude oil production throughout the country, is produced a year. In a vast area of 94,562 km^2 where the big four rivers, namely, the Rokan River, Siak River, Kampar River and Indragiri River flow, Riau Province has a great potential for the development of agriculture.

In spite of such abundant natural resources, the economy of Riau Province has so far been relatively stagnant when compared with that of other provinces because of a delay in public investment.

However, in order to improve the living standard of the poeple and promote balanced regional development, the Government of Indonesia has so far implemented three 5-year development plans, and is about to execute the fourth 5-year development plan (REPELITA IV, 1984/85-1988/89)in the near future. In Riau Province, the effect of these 5-year programs has gradually been taking shape, and the regional development including replenishment of social capital and industrialization is expected to materialize at a rapid tempo in the near future along with the progress of the transmigration program, etc.

The power generating facilities of PLN in Riau Province were as small as 18,724 kW in 1981, and the electrification rate was as low as 6.4% because of insufficient power distribution facilities. Electric power is supplied by PLN mainly to the urban areas and surrounding areas, and power demand in other areas is covered independently by private diesel power plants.

However, although the annual average growth rate of power demand of PLN in Riau Province excluding Kepulauan Riau was 18% during the eight

year period from 1973 through 1981, the power demand had grown at an extraordinary high rate of 34% in two years from 1979 through 1981. Moreover, power demand is expected to grow at a rate as high as 29% a year from 1981 through 1991, and at an average rate of 19% a year from 1981 through 2000.

In order to meet such rapidly increasing power demands, PLN perceived the utilization of abundant hydro-power sources of the Kampar Kanan River, Rokan River and Indragiri River, and has been directing its effort for successively implementing the development of these hydro-power sources and the formation of a trunk power transmission system in Riau Province and throughout Sumatra. The development of these hydro-power sources will make it possible to greatly reduce domestic consumption of a large amount of oil, secure foreign currency reserve and ultimately contribute extensively to the national economy of Indonesia in the future.

The Kotapanjang Hydro-Power Project, located along the middle reaches of the Kampar Kanan River, has been selected as the first hydro-power source development project in Riau Province in consideration of the above factors. This project is highly economical in that a maximum output of 111 MW can be obtained by constructing a medium scale dam with a height of 58 m and a total reservoir capacity of $1,545 \times 10^6$ m^3, and the site is near and accessible from Pekanbaru, the capital of the province. In addition to the supply of electric power, creation of the reservoir will ensure mitigation of any flooding and increase supply of irrigation water in the downstream area. Consequently, this project is an important project constituting a key for the regional development of Riau Province.

In consideration of the necessity and urgency of this project, the Government of Indonesia requested the Government of Japan on the 15th June 1981 to carry out a feasibility study for this project. In response to this request, the Government of Japan appointed JICA as an execution agency of this study and dispatched a pre-liminary survey team to Indonesia. On the 6th October 1981, an agreement concerning the scope of work was concluded between both of the governments. Moreover, the Government of Indonesia appointed PLN of the Ministry of Mining and Energy as an agency in charge of executing the feasibility study.

1.2 Past Study for the Project

With respect to this project, the following investigations were carried out by Tokyo Electric Power Services Co., Ltd. (TEPSCO) in the past in response to the request of PLN.

(1) Reconnaissance Study

In September and November 1979, project finding was conducted regarding the entire basin of the Kampar River. At that time, a development plan of the Mahat River, a tributary of the Kampar River was considered by PLN. As a result of reconnaissance study, however, the Kotapanjang site was picked out. Then, a two-stage development plan for step-by-step development of the Kotapanjang site and Mahat site had been worked out, and summarized in the Reconnaissance Report in March 1980.

(2) Pre-feasibility Study

In August 1980, further detailed study was carried out with respect to the area along the Kampar River. Regarding the Kotapanjang site, a single stage large scale development plan was worked out and proposed for subsequent comparative study with the two stage development plan. This single stage development plan is roughly similar to the plan adopted in this feasibility study. The results of the study were summarized in the Pre-feasibility Report in October 1980.

1.3 Objectives and Scope of Study

The objectives of this study were to work out an optimum development plan for the Kotapanjang Hydro-Power Development Project being planned in the area along the Kampar Kanan River, a tributary of the Kampar River by executing feasibility grade study including field investigations in order to prove the technical, economic and financial feasibility of the project.

The scope of this study was as described in the Scope of Work, and this feasibility study was carried out in accordance with the following three stages:

(1) Preliminary investigation stage;
(2) Detailed field investigation stage; and
(3) Feasibility design stage.

1.4 Study Activities

Prior to the execution of the feasibility study, JICA entrusted the study to TEPSCO, and a survey team consisting of 14 members was organized as shown in Table 1.1 and dispatched to the project site. The study team was organized of civil engineers, hydrologic engineers, geologic and topographic engineers, electrical engineer and economist, and the study activities were extended by mobilizing the knowledge and experience of these engineers and experts in the respective fields. Meanwhile PLN entrusted the field investigation works to local contractors and dispatched its counterparts to the project site. Thereby, the feasibility study including field investigations was carried out in close cooperation with the JICA survey team, local contractors and PLN's counterparts. During the execution of this study, moreover, much related data and information was obtained from pertinent agencies of the Government of Indonesia. The field investigations and home office design was carried out according to the following schedule:

Preliminary investigation (reconnaissance)	:	24th Jan. 1982 - 21st Feb. 1982
Preliminary investigation (field investigation) and detailed field investigation	:	24th June 1982 - 5th Dec. 1982
Detailed field investigation	:	27th June 1983 - 11th Mar. 1984
Feasibility design	:	6th Dec. 1983 - 11th Mar. 1984

On the occasion of field investigation, reconnaissance was first carried out, and the existing data and information were collected under the

cooperation of the pertinent government agencies at the same time. In addition, the technical specifications for field investigation were prepared and submitted to PLN.

The main items of investigation work are as listed below:

(1) Survey
Topographic survey, cross sectioning, levelling, control point survey and aerial photogrammetry.

(2) Geological survey
Drilling, seismic prospecting, test adit investigation, permeability test, Lugeon test, grouting test, rock shearing test, test pits investigation and laboratory test of sampled materials.

(3) Meteorological and hydrological investigation
Installation of flow gauging station and rain gauge stations.

These investivation works were entrusted to the local contractors in Indonesia by PLN and carried out under the supervision of the JICA survey team. The local firms who took part in the works are as listed below:

(1)	Ground survey	:	P.T. HEXA KUERA
(2)	Aerial photogrammetry	:	P.T. MAGAPLANA
(3)	Geological survey	:	P.T. WIRATMAN P.T. ANDALAS G.H.
(4)	Installation of flow gauging station and rain gauge stations	:	P.T. HEXA KUERA

In parallel with the field investigations, survey and study were carried out with respect to the power demand and supply plan, power generation plan, transmission line and substation plans, transportation of equipment and materials, compensation for residences and properties, socio-economic and environmental study.

The field office and accomodation for the JICA survey team were provided by PLN Projects Construction Office (West Sumatra and Riau) in Bangkinang about 18 km donwstream of the dam site. The field investigation was carried out by using this facility as a base for study. Based upon the results of field investigation, an interim report was prepared by home office work in March 1983. Subsequently, the feasibility design was carried out, and this final report has been prepared. Meanwhile, this final report consists of two volumes, the Main Report and Appendix, containing the results of the entire feasibility study.

Table 1.1 Members of JICA Survey Team

	Assignments	Members' names
1.	Team Leader	Y. Shimada
2.	Assistant Team Leader (Civil Engineering)	S. Yamada
3.	Civil Engineering	T. Mimuro
4.	Hydrologic, meteorological and water quality survey	A. Kakita
5.	Hydrologic, meterological and water quality sruvey	Y. Yoshida
6.	Geological survey, drilling and seismic prospecting	T. Moritani
7.	Geological survey, drilling and seismic prospecting	K. Nakamata
8.	Drilling	S. Makino
9.	Rock shearing test	S. Namubu
10.	Aerial photogrammetry	J. Ishii
11.	Ground survey	Y. Koike
12.	Levelling	S. Shirahama
13.	Power demand and supply, transmission line and substation	T. Murata
14.	Economic survey	H. Takanashi

CHAPTER 2 REGIONAL ECONOMY IN RIAU PROVINCE

Riau is a unique province in Indonesia. Its economy is dominated by the oil industry, which produces almost one half of the total petroleum of the country. Recent oil production has declined, yet it still accounted for 83.1 percent of the Regional Gross Domestic Product (RGDP) of Riau in 1980. (Refer to Table 2.1 and 2.2)

Table 2.1 Regional Gross Domestic Product at 1975 Constant Prices Including Oil (Rupiah Billion)

	1975	1976	1977	1978	1979
RGDP	1,807	1,826	1,786	1,658	1,682
Annual Change (%)	-8.1	+1.1	-2.2	-7.2	+1.4
Oil	1,593	1,608	1,546	1,424	1,405
Mean Annual Compound Change of RGDP (%)	-3.1	-3.1	-3.1	-3.1	-3.1

Source: "Regional Income, 1973-1979", Statistical Office, Riau Province

Table 2.2 Regional Gross Domestic Product at 1975 Constant Prices Excluding Oil (Rupiah Billion)

	1975	1976	1977	1978	1979
RGDP	166.24	174.37	189.32	198.83	213.05
Annual Change (%)	+1.9	+4.9	+8.6	+5.0	+7.2
Mean Annual Compound Change of RGDP (%)	+5.5	+5.5	+5.5	+5.5	+5.5

Per Capita RGDP (excl. oil)	1980	106,822 (Rp) =	$170.4
Per Capita RGDP (incl. oil)	1980	763,382 (Rp) =	$1,217.5
Population	1980	2.17	(million)
RGDP (excl. oil)	1980	231,733	(million Rp)
RGDP (incl. oil)	1980	1,656,450	(million Rp)
(Per Capita GDP in Indonesia)	1980	$420	

The breakdown of the Regional Gross Domestic Product by sector is summarized in Table 2.3.

The economy, with oil excluded, is dependent on agricultural activities, which is the prime influence on growth in other sectors. It provides the overwhelming portion of employment opportunities, raw mate rials for industrial processing, goods for transportation by river and sea and the major source of income for rural households and urban households. It accounted for 29.2 percent of RGDP in 1980. Major crops are rice, maize, cassava, rubber and coconut.

Most food crops are produced by small land holders or subsistence cultivators satisfying their own households needs. Food crop surpluses which do occur are generally marketed in the production locality. Riau is a net rice importer which is mainly due to the fact that only a small portion of land is fully irrigated and rice crops are lost when the rivers flood before harvest so that yields are still below the national average.

Plantation is a recent growing subsector in agriculture. Large-scale plantation of rubber, coconut and oil palm cultivation is now under way with the strong financial support of the government.

During REPELITA III, 54,000 ha is under cultivation for rubber 47,000 ha for coconut, 2,700 ha for coffee plantation. For REPELITA IV, 38,000 ha is envisaged for rubber plantation and 26,000 ha for coconut plantation. For Riau these major cash-crops are markted for export and expected to generate more foreign currency earnings. Therefore, perennial cropping constitutes an important part of the key to future economic development in Riau province.

The industrial sector appears relatively small and consists of cottage-type industries. Large petroleum based industries such as refineries and hydrocracking units are concentrated at Dumai and Sungai Pakning and show little linkage with local manufacturing industries. Between 1974-1979, it is estimated that the industrial sector had increased

at 6.3 percent per annum. Major agro-based industries are crumb rubber, coconut oil, fish paste, wooden boards and saw mills.

In general, manufacturing industries are material oriented industries and the sector itself is at an infant stage. Therefore market oriented industries as well as agro-based industries are thought to have a large potential in the near future. Good examples are soft drinks, palm oil and coconut oil, wearing apparel, glass products and metal industries.

Island Riau (Kepulauan Riau) is also suited for export oriented industries. It contains bauxite on Bintan Island which is the only place being mined in Indonesia. Deposits of tin are found in Singkep, Karimun and Kundur which are expected to be exploited in the future. Batam Island is also a part of Kepulauan which is designated for free-trade zone for joint development with Singapore. Batam is already earmarked to receive active foreign investment and envisaged to become an industrial center for export.

A transportation system has not yet been developed in the Province. The main road network is the roads from Pekanbaru to Bangkinang to Pasir Pengarayan in the northwest, from Pekanbaru to Taluk Kuantan in the southwest, and to Rengat in the south. In addition, there is the main highway linking Pekanbaru with Dumai, the main harbor built by Caltex and two interprovincial highways linking Bangkinang with West Sumatra in the northwest and linking Teluk Kuantan with West Sumatra in the southwest. As of the end of 1979, the government achieved 387 km for asphalt-road construction, 813 km for gravel-road and 2,707 km for earth-road. During REPELITA III, new road construction of 900 km between Parit and Taluk Kuantan and 130 km between Pekanbaru and Dumai are underway, together with rehabilitation and upgrading of the existing roads and bridges.

However, the outstanding feature of transport in Riau is the importance of sea and river transport in the system. There are four large rivers, from north to south the Rokan, Siak, Kampar and Indragiri. All are navigable for long distances inland from the sea except the Kampar. The three navigable rivers are very significant to the province's economic

activities, being vital as a means of supplying goods to the many villages located along their banks and for shipping out rubber, timber and other agricultural products. Thus, development of an extensive transport network, both road and river, will exert a great impact on the level of economic activities, since one of the national objectives for Riau province is stipulated that transportation development is aimed at obtaining more appropriate growth among regions or areas, and especially the opening up of potential areas still isolated.

Table 2.3 Riau Regional Gross Domestic Product, 1973 - 1979

Value: Rp.Billions at 1975 Constant Prices (Excluding Oil Revenue)

	1973		1974			1975			1976			1977			1978			1979		
	Rp.B	% of Total	Rp.B	% Change	% of Total	Rp.B	% Change	% of Total	Rp.B	% Change	% of Total	Rp.B	% Change	% of Total	Rp.B	% Change	% of Total	Rp.B	% Change	% of Total
AGRICULTURE	48.94	32.6	50.69	+ 3.6	31.1	50.01	- 1.3	30.1	54.41	+ 8.8	31.2	59.11	+ 8.6	31.2	58.27	-1.4	29.3	60.44	+ 3.7	28.4
food crops	18.54	12.3	20.32	+ 9.6	12.5	22.41	+10.3	13.5	23.09	+ 3.0	13.3	26.96	+16.8	14.2	28.24	+ 4.8	14.2	24.84	-12.0	11.7
plantation crops	10.09	6.7	10.10	+ 0.1	6.2	11.28	+ 1.7	6.3	12.49	+10.7	7.1	12.12	- 3.0	6.4	11.55	- 4.7	5.8	11.96	+ 3.5	5.6
livestock	2.95	2.0	3.35	+13.6	2.1	3.50	+ 4.5	2.1	3.43	- 2.0	2.0	3.81	+11.1	2.0	3.51	- 7.9	1.8	4.59	+30.8	2.2
forestry	8.19	5.1	7.23	-11.7	4.4	3.86	-46.6	2.3	6.93	+79.5	4.0	7.16	+ 3.3	3.8	6.03	-15.4	3.0	9.27	+53.7	9.3
fishing	9.17	6.5	9.68	+ 5.6	5.9	8.95	- 7.5	5.4	8.48	- 5.3	4.9	9.05	+ 6.7	4.8	8.94	- 1.2	4.5	9.78	+ 9.4	4.6
MINING AND QUARRYING	11.10	7.4	13.86	+24.9	8.5	13.15	- 5.1	7.9	12.09	- 8.1	6.9	12.76	+ 5.5	6.7	12.47	- 2.3	6.3	14.23	+14.1	6.7
oil (wages and salaries)	6.72	4.5	8.82	+31.3	5.4	8.69	- 1.5	5.2	8.38	- 3.6	4.8	8.60	+ 2.6	4.5	9.06	+ 5.3	4.6	9.48	+ 4.6	4.5
bauxite	2.25	1.5	2.37	+ 5.3	1.5	1.82	-23.2	1.1	1.72	- 5.5	1.0	2.39	+39.0	1.3	1.85	-22.6	0.9	1.93	+ 4.3	0.9
tin	1.80	1.2	2.33	+29.4	1.4	2.30	- 1.3	1.4	1.63	-29.1	0.9	1.41	-13.5	0.8	1.06	-24.8	0.5	2.30	+117.0	1.1
quarrying	0.33	0.2	0.34	+ 3.0	0.2	0.34	0.0	0.2	0.36	+ 5.9	0.2	0.36	0.0	0.2	0.5	+38.9	0.3	0.52	+ 4.0	0.2
INDUSTRY	7.45	5.0	7.91	+ 6.2	4.9	8.82	+11.5	5.3	8.51	- 3.5	4.9	9.69	+13.9	5.1	10.14	+ 4.9	5.1	10.75	+15.8	5.0
WATER & ELECTRICITY	0.23	0.2	0.27	+17.4	0.2	0.25	- 7.4	0.2	0.35	+40.0	0.2	0.38	+ 8.6	0.2	0.48	+28.3	0.2	0.55	+14.6	0.3
CONSTRUCTION	3.85	2.6	3.94	+ 2.3	2.4	4.02	+ 2.0	0.4	4.15	+ 3.2	2.4	4.20	+ 1.2	2.2	4.32	+ 2.9	2.2	4.47	+ 3.5	2.1
COMMERCE, HOTEL AND RESTAURANT	38.61	25.7	43.39	+12.4	26.6	43.54	+ 0.3	26.2	46.16	+ 6.0	26.5	50.76	+10.0	26.8	53.61	+ 5.6	26.9	60.12	12.1	28.2
commerce	38.02	25.3	42.75	+12.4	26.2	42.86	+ 0.3	25.8	45.47	+ 6.1	26.1	50.06	+10.1	26.4	52.89	+ 5.7	26.6	59.35	+12.2	27.9
TRANSPORT AND COMMUNICATION	18.76	12.5	20.05	+ 6.9	12.3	21.54	+ 7.4	13.0	23.15	+ 7.5	13.0	25.32	+ 9.4	13.4	27.95	+10.4	14.1	29.40	+ 5.2	13.8
land	3.51	2.3	4.01	+14.2	2.5	4.31	+ 7.5	2.6	4.78	+10.9	2.7	5.67	+18.6	3.0	6.66	+17.5	3.4	7.88	+18.3	3.7
air	0.53	0.4	0.58	+ 9.4	0.4	0.71	+22.4	0.4	0.69	- 2.8	0.4	0.71	+ 2.9	0.4	0.73	+ 2.8	0.4	0.85	+16.4	0.4
sea/river	14.43	9.6	15.17	+5.1	9.1	16.17	+ 6.6	9.7	17.31	+ 7.1	9.9	18.50	+ 6.9	9.8	20.09	+ 8.6	10.1	20.05	- 0.2	9.4
communication	0.28	0.2	0.29	+ 3.6	0.2	0.35	+20.7	0.2	0.37	+ 5.7	0.2	0.43	+16.2	0.2	0.48	+11.6	0.2	0.62	+29.2	0.3
BANKING AND FINANCE	1.20	0.8	1.51	+25.8	0.9	1.35	-10.6	0.8	1.38	+ 2.2	0.8	1.22	-11.6	0.7	1.36	+11.5	0.7	1.84	+35.3	0.9
REAL ESTATE	14.30	9.5	14.68	+ 2.7	9.0	14.79	+ 0.7	8.9	15.38	+ 4.0	8.8	15.71	+ 2.1	8.3	15.99	+ 1.8	8.0	16.38	+ 2.4	7.7
GOVERMENT	4.43	3.0	5.35	+20.8	3.3	7.00	+30.8	4.2	6.84	- 2.3	3.9	7.86	+14.9	4.2	11.52	+46.6	5.8	11.74	+ 1.9	5.5
MISCELLANEOUS SERVICES	1.33	0.9	1.55	+16.5	1.0	1.77	+14.2	1.1	1.95	+10.2	1.1	2.31	+18.5	1.2	2.72	+17.8	1.4	3.13	+15.1	1.5
TOTAL RGDP	150.2	100.0	163.20	+ 8.6	100.0	166.24	+ 1.9	100.0	174.37	+ 4.9	100.0	189.32	+ 8.6	100.0	198.83	+5.0	100.0	213.05	+7.2	100.0

Source: Perkiraan Pendepatan Regional Propinsi Daerah Tingkat I Riau, 1973 - 79 and Kantor Sensus Statistik Riau.

CHAPTER 3 DEMAND AND SUPPLY OF ELECTRIC POWER

3.1 Power Conditions

3.1.1 General

The Riau Province is located in the central part of the Sumatra Island, and consists of two major cities Pekanbaru and Dumai, and five prefectures (Kabupaten) Kampar, Indragiri Hulu, Indragiri Hilir, Bengkalis and Kepulauan Riau in a total area of about 94,000 km^2. The Kabupaten Kepulauan Riau consists of 3,000 or more large and small islands.

As at the end of 1981, the population was estimated to be 2,230,000, and increasing at an annual rate of 3.11%, exceeding the average increase rate of 2.32% throughout the country. However, the population density is 23.7 persons per km^2 and far lower than the nationwide average density of 77 persons per km^2. Although the population density in the southern part of the province is lowest with a population increase rate of only 1.67%, the increase rate is nearing the average rate of the province along with the construction of trunk roads, development of agriculture, progress of the transmigration projects, etc. In Pekanbaru, the capital city of the province, the population is as great as 190,000 and increasing at a higher rate of 5.5% a year than the average rate. Furthermore, its population is expected to increase at a higher rate than ever in proportion to the progress of urbanization in the future.

According to the transmigration projects promoted by the Government of Indonesia, 27,500 households had been transmigrated to Riau Province as of 1981 under the two five-year Plans in the past. The settlement ratio was initially low, but the ratio has improved nearly to 90% in the last two to three years. At present 61,000 households equivalent to a little more than 10% of the total number of 500,000 households of transmigrants over Indonesia are scheduled to be transmigranted into the province under REPELITA III (1979/80 - 1983/84).

According to recent survey, the population in Riau Province is expected to reach 3,900,000 in 2001 and it is said to be possible to accomodate 8,000,000 people in 2020.

Regarding the sector-wide economic development, the potential productivity in the agricultural sector will not be realized due to insufficient irrigation facilities. However, production of cash crops is expected to increase at an extraordinary rate as a result of agricultural plantation projects (palm, coconut, rubber, etc.).

In the commercial sector, the activities are expected to be accelerated along with the construction of the Sumatra Highway, modernization of infrastructures related to ports and implementation of the free port plan on the Batam and Bintan Islands.

In the industrial sectors, the activities are mainly related to the agriculture and forestry industries, and the majority of this sector is shared by rubber factories, timber mills, plywood plants, coconut oil plants and fish meal plants. The average growth rate in the past five years from 1974 through 1979 was 5.8% and by far lower than the nationwide average rate of 12.6%. This resulted from the industrial structures of this province which are raw material-oriented and consist of agriculture-related industries. However, this sector is expected to grow at a substantially higher rate in the future as a result of the growth of consumer good production, progress of the agricultural industry by plantation, and implementation of the free trade port projects.

Riau Province is an oil producing province where 150 million barrels of crude oil are produced per annum. Although the production of oil has been cut down reflecting the reduction of the international oil price, "Hydro-cracker Project (total cost US$ 1,530 million) is carried out in Dumai in an effort to realize transfer from dependence on crude oil production to the production of oil products of higher added values. Moreover, the tin and bauxite resources are distributed in various area of the island, and exploration of these resources is expected to be carried out in the future.

In the electric power industrial sector, the Government of Indonesia has worked out a power generation plan for further reliance upon hyrdo-electric power sources and freedom from oil-firing thermal power source in accordance with the policy: "Secure oil for export." In other words, a plan for electric power supply has been worked out in coordination with the growth of electric power demand throughout Indonesia. According to this plan, the annual growth rate is estimated to be 14 to 18% (17% average).

3.1.2 Pattern of Power Supply

In Riau Province, electric power is presently supplied by diesel power plants mainly to the areas where diesel power plants are installed and partially to surrounding areas.

In West Sumatra, there is a 20 kV power distribution network called Batang Agam in Bukittinggi, and hydro-power plant and diesel power plants are interconnected to the network. However, electric power is supplied from diesel power plants in other areas.

On the other hand hotels, bulk, medium and small industrial plants and public facilities (radio broadcasting station and air-port) own their own diesel power generating facilities, and electric power is self-supplied.

3.1.3 Present Power Supply Facilities

In Riau Provice, generating facilities and distribution lines are installed in the respective cities and towns, and electric power is supplied individually to these cities and towns.

At the end of 1981, the total installed capacity of PLN's generating facilities in Riau Province was 18,724 kW and the peak load was 12,351 kW (Refer to Tables 3.1 and 3.5).

Other than those of PLN, 60 or more pure private generating facilities are being operated with a total installed capacity of 279,162 kVA (about 223 MW), including 187,500 kVA (about 150 MW) of Caltex Pacific Indonesia, 78,750 kVA (about 66.5 MW) of Pertamina and 12,912 kVA (about 10 MW) of other pure private generating facilities (Refer to Table 3.2).

In the cities and towns of the province, electric power is supplied to each customer by 6 kV distribution lines. In Pekanbaru, a 20 kV distribution line is under construction, and a 20 kV distribution line construction project is in the planning stage in Dumai and other towns.

In West Sumatra Province, on the other hand, the generating facilities and distribution lines are installed and operated individually in the respective cities and towns. In addition, there is a power supply system to which 20 kV distribution lines called Batang Agam, hydro-electric and diesel power generating facilities are interconnected, and electric power is supplied to the surrounding area of Bukittinggi.

At the end of 1981, the total installed capacity of power generating facilities of PLN in West Sumatra Province was 40,896 kW, with a peak load of 23,996 kW (Refer to Tables 3.3 and 3.6).

In addition to those of PLN, 50 or more pure private power generating facilities with a total installed capacity of 39,154 kVA (about 31 MW) are in operation (Refer to Table 3.4).

As in the case of Riau Province, electric power is supplied to each customer in each city and town in the province by 6 kV distribution lines, although power is supplied by 20 kV distribution lines in Batang Agam. Moreover, 20 kV distribution lines are under construction in the Padang City, the capital of the province, and 20 kV distribution lines are under planning stage also in other cities and towns.

3.1.4 Present Status of Power Demand and Supply

The historical record over the past nine years of power demand and supply in Riau Province is shown in Table 3.5. The consumer-wise historical record of power demand and supply is also shown in Table 3.7.

Based upon these tables, the factors as summarized below can be picked up:

(1) As for the power distribution system, diesel power generating is operated individually by the respective cities and villages. In spite of the fact that power is supplied only to the respective surrounding areas, power loss is as high as 20% or more. This loss is considered to be caused either because of inadequate distribution line voltage in contrast with the power distribution range, or because load larger than the distribution line capacity is applied. Therefore, it will be required to improve the capacity of the distribution lines under construction or in the planning stage according to the improvement program of distribution lines.

(2) Since the yearly load factor is as low as 40%, it will be required to construct a trunk transmission line for interconnection to the power generating facilities and to realize efficient operation of the power generating facilities.

(3) The power consumption and the peak load which had been growing at an annual average rate of about 18% and 20%, have been increasing at as a high rate as 27% and 25%, respectively, in these two to three years.

Based upon Table 3.2 and 3.7, the following factors can be considered:

(1) Although the ratio of the demand for residential use is gradually decreasing and that for industrial and commercial use is increas-

ing, the demand for residential use still occupies 53% of the total demand.

(2) The power generating facilities of consumers owning purely private generating facilities amount to 15 times those of PLN, and the annual power consumption is estimated to be 1,070 GWh, equivalent to more than 20 times the sold energy by PLN. This is considered to have resulted from the inadequate power supply system of PLN, whereby high quality electricity could not be stably supplied. Therefore, bulk customers, particularly industrial plants, are obliged to use their own power generating facilities to supply power by themselves under the present situations.

The historical record of power demand and supply over the past 9 years in West Sumatra Province is shown Table 3.6. According to this table, the power loss is as high as nearly 30%, and the yearly load factor is also considerably low similarly as in the case of Riau Province.

The annual power consumption and the peak load, which had been growing at a rate of about 16% and 18%, has been growing at a remarkably high rate of 22% and 24%, respectively in these three years.

In the entire Wilayah III area, the power consumption and peak load are increasing at an annual average growth rate of about 16% and 19%, respectively.

In view of the electrification rate as at the end of 1981, on the other hand, the number of electrified households is 28,604 in contrast with the total household number of 446,760, and the electrification rate is 6.4% in Riau Province. In the city areas of Pekanbaru and Dumai, the number of electrified households is 16,447 and composes 57% of the total number of electrified households (throughout the province). Meanwhile, the ratio of the

electrified households to the number of households in the urban area is 32%.

As at the end of 1981, the number of electrified households was 59,419 among the total households number of 695,800, and the electrification rate was 8.5% in West Sumatra Province. Moreover, the number of electrified households in the urban areas of Padang, Solok, Sawahlunto, Padang Panjang, Bukittinggi and Payakumbuh was 48,514 and occupied 82% of the total number of electrified households (throughout the province). Meanwhile, the electrification rate of the number of households in the urban area was 32%.

Regarding the load characteristics, the daily load curve in September 1982 in Riau Province (the daily load curves based upon the customers to whom power is supplied from PLN) is as shown in Fig. 3.1. According to these curves, the daily load factor is as high as 61.7%, and greatly different from the early load factor of about 40%.

The daily load curve (in June 1982) in West Sumatra Province is also as high as slightly less than 60% as shown in Fig. 3.2, and considerably different from the yearly load factor of about 35%, indicating that the load factor fluctuates similar to that of Riau Province.

3.1.5 Electricity Basic Tariff (Basic Electricity Tariff)

The amount of sold energy and revenue by sold energy in Riau Province are as follows (Refer to Fig. 3.7 and Fig. 3.8):

Year	Sold energy (MWh)	Revenue (10^3 Rp.)	Average power rate (Rp./kWh)
1975/76	18,530.2	481,229.3	25.97
1976/77	20,274.3	639,654.1	31.55
1977/78	23,158.4	725,089.5	31.31
1978/79	28,338.4	885,858.4	31.26
1979/80	35,267.8	1,148,790.5	32.57
1980/81	46,766.7	2,231,786.5	42.72
1981/82	57,182.3	2,892,580.4	50.58

Note: The values listed above include those of Kepulauan Riau, an isolated island.

For reference, the average power rate in 1975/76 and earlier is shown below:

1972/73	1973/74	1974/75
17.01 Rp./kWh	19.20 Rp./kWh	20.48 Rp./kWh

The electricity basic tariff revised in February 1982 and February 1983 are shown in Table 3.9.

As described above, the power rate is increasing at an annual average rate of 11.7%, and if the rate increases at the same rate, the rate is estimated to become 136.5 Rp./kW in 1990/91. However, an annual increase rate of 10% is adopted.

3.2 Power Demand Forecast

The power demand both in Riau Province and West Sumatra Province is forecast while taking into account the transmigration policy of the Government of Indonesia and new waiting customers under industrial plant construction projects, and assuming that the general customers owning pure private generating facilities will receive power their supply from PLN instead of the private facilities.

As a result, the power demand in both of the provinces in the year 2000 is forecast as follows:

Provinces / Items / Year	Riau		West Sumatra	
	Annual power consumption (GWh)	Peak load (MW)	Annual power consumption (GWh)	Peak load (MW)
1981	45.8	12.3	70.9	24.0
2000	1,260.2	287.7	2,319.4	529.5
Annual average growth rate (%)	19	18	20	18

The growth of power demand and the schedule for power source development projects in both of the provinces are shown in Tables 3.10 and 3.20 as well as Figs. 3.3 - 3.6. As these tables and figures indicate, the construction of Kotapanjang Hydro-Power Plant must be completed in 1990/91 in order to meet increasing power demand in Riau Province.

A few years after the Kotapanjang Hydro-Power Plant completion, this power plant will constitute a main power source, and old diesel power generating facilities will be scrapped, and comparatively new diesel power facilities will be operated as a backup power source, while some others will be reserved as a standby power source.

3.2.1 Method of Power Demand Forecast

Power demand forecast in both Riau Province and West Sumatra Province was carried out by classifying the modes of power consumption into the following four categories, that is, residential use, commercial use, public use and industrial use. Then, on the basis of the data and information obtained from BAPPEDA, Dinas Perindustrian, Dinas Perkebunan, Dinas Kehutanan and other pertinent authorities in addition to the past data including trends and plans pertaining to power demand and supply of PLN, the power demand was forecast by integrating and totallizing these data while taking into account the results of discussions with personnel in charge of pertinent authorities.

The basic conditions adopted for power demand forecast in Riau Province and West Sumatra Province are as follows.

Electrification rate of PLN (common to both of the province):

Year	Urban Area	Rural Area
1983/84	50%	7%
1988/89	60%	13%
1993/94	65%	20%
1998/99	70%	30%
2003/04	75%	40%

Annual power consumption per household of PLN target (common to both of the provinces):

Year	Urban Area	Rural Area
1983	1,500 kWh	700 kWh
1988	1,800 kWh	800 kWh
1993	2,000 kWh	950 kWh
1998	2,500 kWh	1,000 kWh
2003	3,000 kWh	1,200 kWh

Transmigration program of the Government of Indonesia (Riau Province):

Year	No. of households
1982/83	7,925
1983/84	22,500
1984/85 - 1988/89	70,000
1989/90 - 1993/94	80,000

Population as at the end of 1981:

Riau Province	2,233,700
West Sumatra Province	3,479,300

Annual average growth rate of population in the future:

Riau Province	4.1%
West Sumatra Province	2.5%

No. of family members per household in the future:

5 members

The power demand in Kepulauan Riau, the isolated island is excluded from that in Riau Province.

The power demand is classified into the categories of uses.

Classification into categories of uses

- o Residential use
- o Commercial use
- o Public use

} These categories are further classified in terms of urban area and rural area.

- o Industrial use — This category is further classified as follows:

(a) Customer A : Customers receiving power supply from PLN

(b) Customer B : Customers to whom power is self-supplied from pure private generating facilities

(c) Customer C : Waiting customers according to new projects

3.2.2 Power Demand Forecast

The results of the power demand forecast in Riau Province and West Sumatra Province are as described below:

Power demand forecast in Riau Province

The results of power demand forecast in Riau Province are shown in Table 3.10.

(1) Power demand for residential use

The electrification rate based upon the residential customers contracted with PLN at the end of 1981 is as follows:

Categories	No. of households	No. of residential customers	Electrification rate
Uraban area	51,400	16,447	32.0%
Rural area	307,800	7,686	2.5%
Sub-total	359,200	24,133	6.7%

Meanwhile, the estimated number of electrified households according to the basic conditions and annual power consumption per household are shown respectively in Tables 3.11 and 3.12.

Based upon the above data, the power demand for residential use is forecast as follows:

(Unit: Gwh)

Year	1981	1985	1990	1995	2000
Urban area	19.7	38.7	59.9	86.5	121.4
Rural area	5.8	24.1	62.9	137.7	237.8
Total	25.5	72.8	122.8	224.2	358.2

(2) Power demand for commercial use

Based upon the ratio of the commercial customers to the number of electrified households in the past nine years, the constitution factor is assumed to be 0.14 in the urban area and 0.08 in the rural area.

Meanwhile, the annual power consumption by commercial customers contracted with PLN based upon the past records is shown in Table 3.13. According to this table, the annual power consumption per commercial customer is 2,590 kWh in the urban area and 1,090 kWh in the rural area and the annual average growth rate is 7.5% and 7%, respectively.

The estimated number of commercial customers is shown in Table 3.14, and the demand for commercial use is forecast as follows:

(Unit: GWh)

Year	1981	1985	1990	1995	2000
Urban area	6.1	14.4	27.7	49.2	87
Rural area	1.6	3.6	11.9	32.6	71.4
Total	7.7	18.0	39.6	81.8	158.4

(3) Power demand for public use

The ratio of the number of public customers to the number of electrified households and the number of contracted commercial customers is 0.03 in the urban area and 0.01 - 0.05 in the rural area according to the data in the past nine years.

The annual power consumption by public customers contracted with PLN is shown in Table 3.15. According to this table, the annual power consumption per contracted customer is 9,940 kWh in the urban area and 2,990 kWh in the rural area, and the annual average growth rate is 7.8% and 3%, respectively. When the annual average power consumption is assumed to grow at the same rate, the number of contracted customers for public use is estimated as

shown in Table 3.16, and the demand for public use is forecast to grow as follows.

(Unit: GWh)

Year	1981	1985	1990	1995	2000
Urban area	5.8	13.7	26.6	48.1	85.9
Rural area	1.4	3.5	7.8	9.3	12.8
Total	7.2	17.2	34.4	57.4	98.7

(4) Power demand for industrial use

The power demand for industrial use is largely classified into the followng three categories:

(a) Customer A: Existing industrial customers contracted with PLN as follows:

Area	No. of customers	Capacity contracted with PLN (kVA)
Pekan Baru	14	2,250
Bagan Siapiapi	1	13.5
Total	15	2,263.5

The past record of industrial use power demand over the past nine years is shown in Table 3.17.

(b) Customer B: Customers who are self-supplying power from pure private generating facilities and are expected to become PLN's customers in the future.

50 customers; a total installed capacity of 86,725 kVA

The names of customers, installed capacity of pure private power generating facilities, etc. are shown in Table 3.18.

(c) Customer C: Waiting customers according to new projects. Major customers are collected from BKPM, PLN,

Dinas Perkebunan Rakyat and Dinas Kehutanan (Refer to Table 3.19).

On the basis of the above data, the power demand for industrial use is forecast as follows:

(Unit: GWh)

Year	1981	1985	1990	1995	2000
Power demand	5.4	80.3	127.4	532.5	644.9

Power demand forecast in West Sumatra Province

The results of the power demand forecast in West Sumatra, which was carried out according to the same method as that adopted in Riau Province, are shown in Table 3.20.

(1) Power demand for residential use

The electrification rate according to the residential customers contracted with PLN at the end of 1981 is as follows:

Area	No. of households	No. of residential customers	Electrification rate (%)
Urban area	149,200	48,514	32.5
Rural area	546,600	10,905	2.0
Total	695,800	59,419	8.5

Meanwhile, the estimated number of electrified households based upon the basic conditions and annual power consumption per household are shown respectively in Tables 3.21 and 3.22.

According to these data, the power demand for residential use is forecast as follows:

(Unit: GWh)

Year	1981	1985	1990	1995	2000
Urban area	35.3	99.8	173.8	303	516.6
Rural area	4.1	27.7	64.8	116.2	186.1
Total	39.4	127.5	238.6	419.2	702.7

(2) Power demand for commercial use

Based upon the ratio of the number of commercial customers to the number of electrified households over the past nine years, the constitution factor of power demand for commercial use is assumed to be 0.05 in the urban area and 0.04 in the rural area.

Meanwhile, the annual power consumption by commercial customers contracted with PLN based upon the past records is shown in Table 3.23. According to this table, the annual power consumption per contracted commercial customer is 4,000 kWh in the urban area and 1,000 kWh in the rural area, and the annual average growth rate is 7% and 3%, respectively.

The estimated number of contracted commercial customers is shown in Table 3.24, and the demand for commercial use is forecast as follows:

(Unit: GWh)

Year	1981	1985	1990	1995	2000
Urban area	10.8	24.9	53.2	104.2	206.9
Rural area	0.3	2.1	4.6	9.0	15.7
Total	11.1	27.0	57.8	113.2	222.6

(3) Power demand for public use

According to the data over the past nine years, the ratio of the number of public consumers to the number of electrified households + that of contracted commercial customers is assumed to be 0.04 in the urban area and 0.01 - 0.03 in the rural area. The annual power consumption of the contracted public customers is shown in Table 3.25. According to this table, the annual power consumption per contracted public customer is 8,000 kWh in urban areas and 3,900 kWh in rural areas, and the annual average growth rates are 0.8% and 5.8%, respectively. The estimated number of contracted public customers is shown in Table 3.26, and the power demand for public use is forecast as follows:

(Unit: GWh)

Year	1981	1985	1990	1995	2000
Urban area	14.2	32.9	52.2	75.8	112.2
Rural area	1.1	7.0	11.6	25.9	51.8
Total	15.3	39.9	63.8	101.7	164.0

(4) Power demand for industrial use

The power demand for industrial use can be classified into the following three categories:

(a) Customer A: Existing industrial customers contracted with PLN

Number of customers: 229

Capacity contracted with PLN: 5,934 kVA

The historical record of industrial use power demand over the past nine years is shown in Table 3.27.

(b) Customer B: Customers who are self-supplying power from pure private generating facilities and expected to become PLN's customers.

Number of customers: 22

Installed capacity : 35,034 kVA

The names of customers and installed capacity of the respective pure private power generating facilities are shown in Table 3. 28.

(c) Customer C: Waiting customers according to new projects. The demand of the major customers is shown in Table 3.29.

Power demand forecast in Wilayah III

The results of power demand forecast in Wilayah III are indicated in Table 3.30 and Figs. 3.7 and 3.8.

3.3 Power Facility Extension Plan of PLN

3.3.1 Generating Plants

In order to meet the rapid growth of power demand, PLN is planning to extend and construct diesel power plants. However, the JICA survey team has worked out the power facility extension plan shown in Tables 3.31 and 3.32 by referring to the plan of PLN.

3.3.2 Power Transmission System

PLN is planning to construct a trunk transmission line within Wilayah III in order to construct, extend and interconnect power plants. In order to meet the future power demand expected to increase by demand forecast, and ensure stable supply of high quality electric power and effective utilization of power generating facilities, it is required to forcefully promote the trunk transmission line project including that for interconnecting the power system in Riau Province and West Sumatra Province. A draft power transmission system program in Wilaya III is shown in Fig. 3.9.

3.3.3 Power Distribution Line

In coordination with or prior to execution of the trunk transmission line construction program, the power distribution line construction project is under planning stage as shown in Tables 3.33 and 3.34. Moreover, the voltage of distribution lines is scheduled to be unified into 20 kV and 380/220V in the future.