REPUBLIC OF INDONESIA
PERUSAHAAN UMUM LISTRIK NEGARA

FINAL REPORT
OF
FEASIBILITY STUDY
ON
ELECTRIC POWER SYSTEM DEVELOPMENT PROJECT
IN CENTRAL SUMATRA

July 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

It is with great pleasure that I present this Feasibility Study Report on the Electric Power System Development Program in Central Sumatra to the Government of the Republic of Indonesia.

This report embodies the result of a series of field surveys which were carried out in the Central Sumatra area, from June 5 to July 5, and from August 28 to September 13, 1985 by an 8-man survey team sent to Indonesia by the Japan Internatiotal Cooperation Agency following the request of the Government of Indonesia to the Government of Japan.

The survey team, headed by Mr.Hajime Nakamura, held a series of discussions on the Program with the officials concerned of the Government of Indonesia.

After the team returned to Japan,further studies were made and the present report has been completed.

I hope that this report will be useful as a basic reference for development of the program.

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.

June, 1986

Keisuke Arita

KEISUKE ARITA

President

Japan International Cooperation Agency

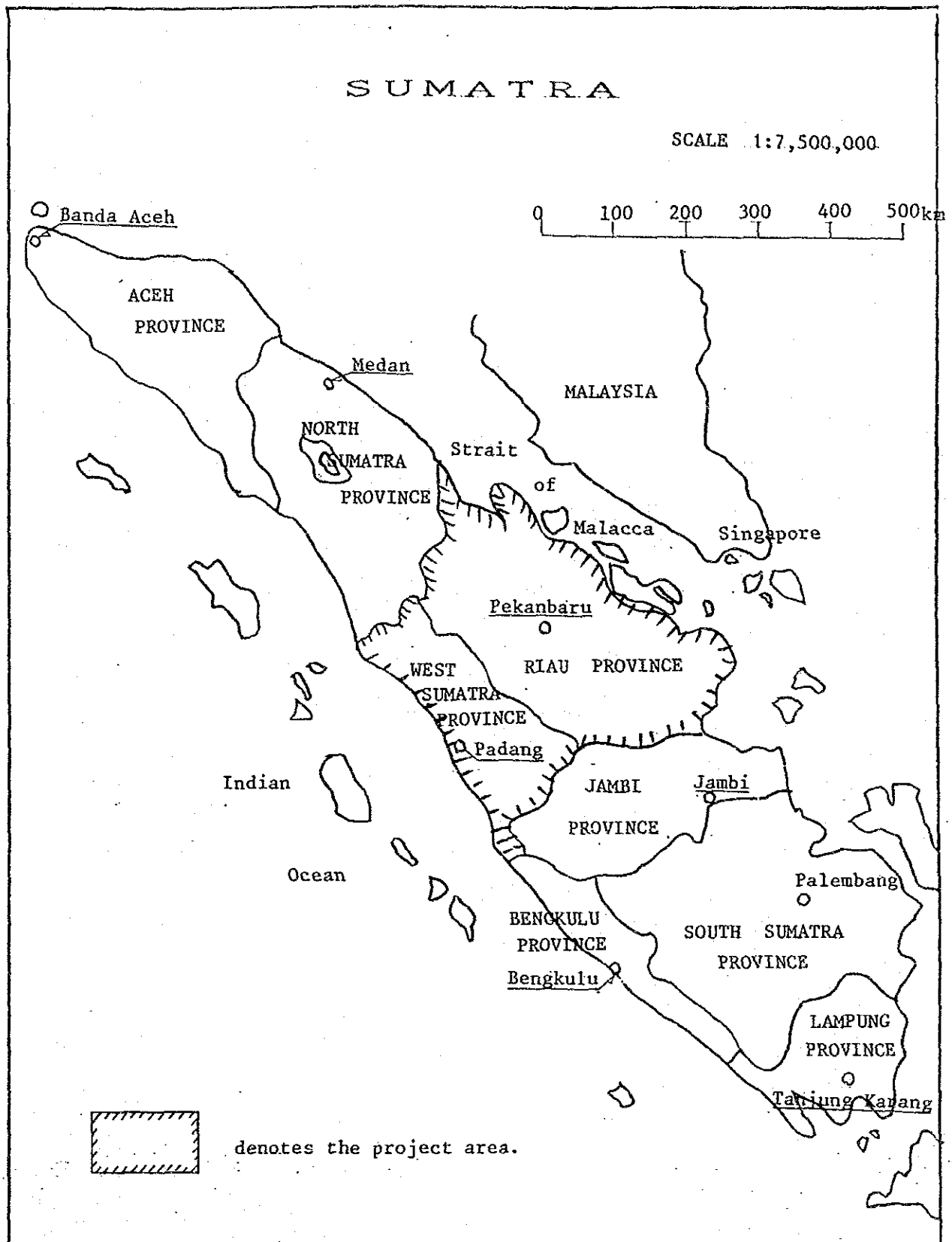


Fig. I Key and Location Map

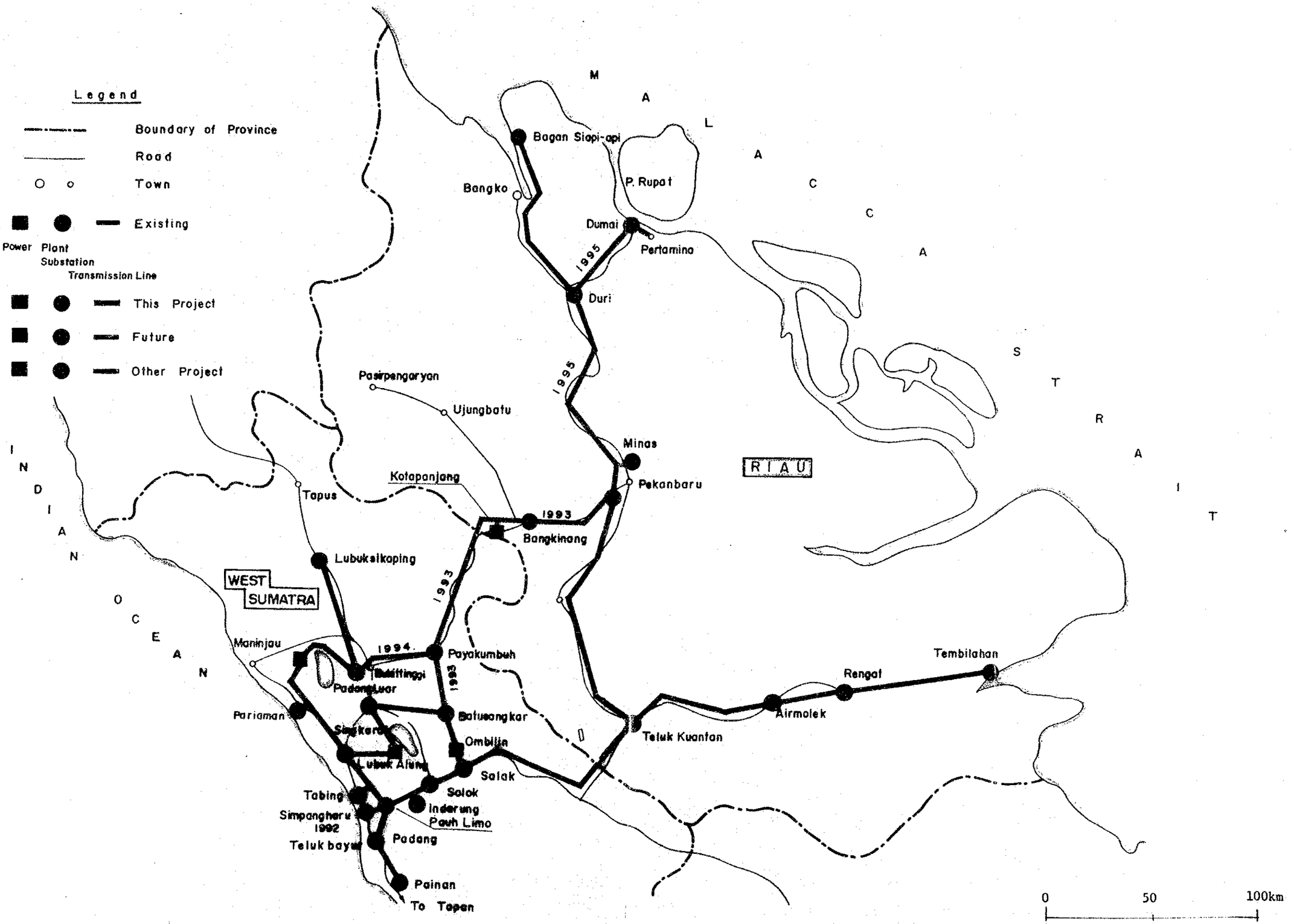
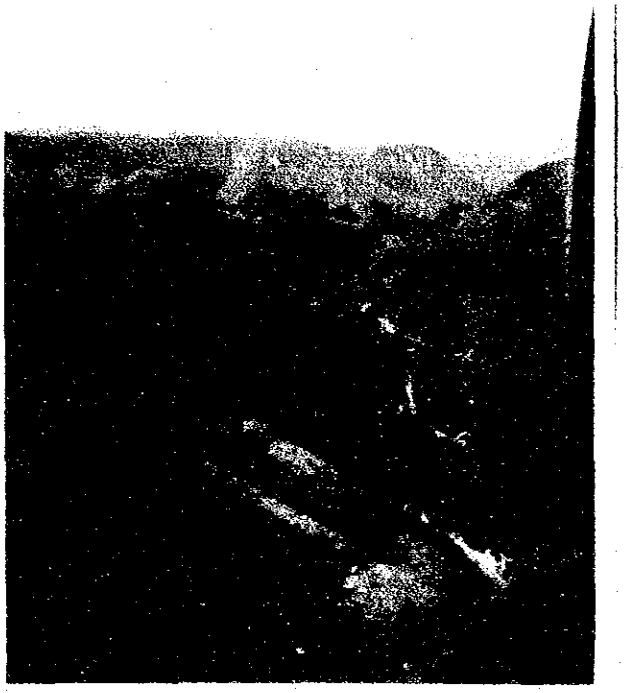


Fig. I Central Sumatra Transmission Line Development Program



Mountain Pass, North of Payakumbuh

A Perspective towards Mountain Pass, Payakumbuh

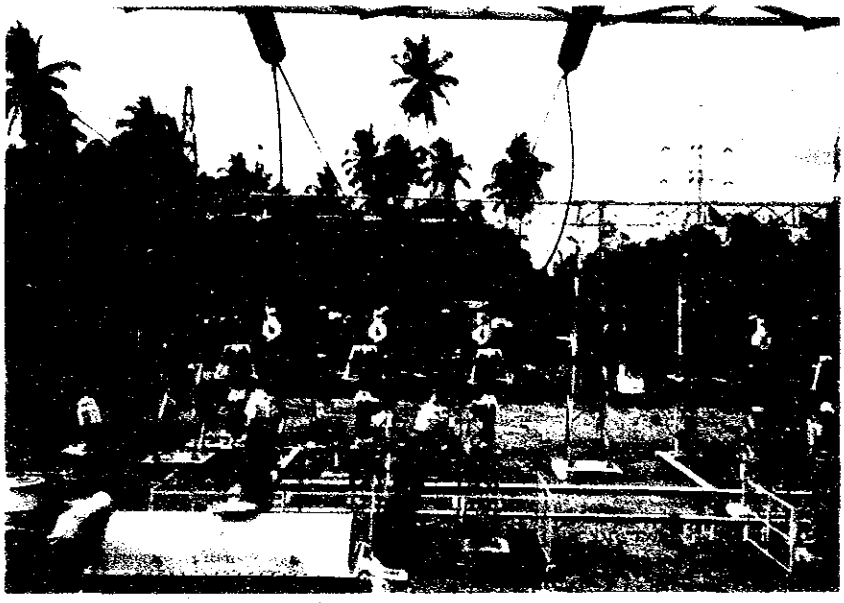
Transmission Line Route (2)

Old River Site between Kotapanjang and Pekanbaru

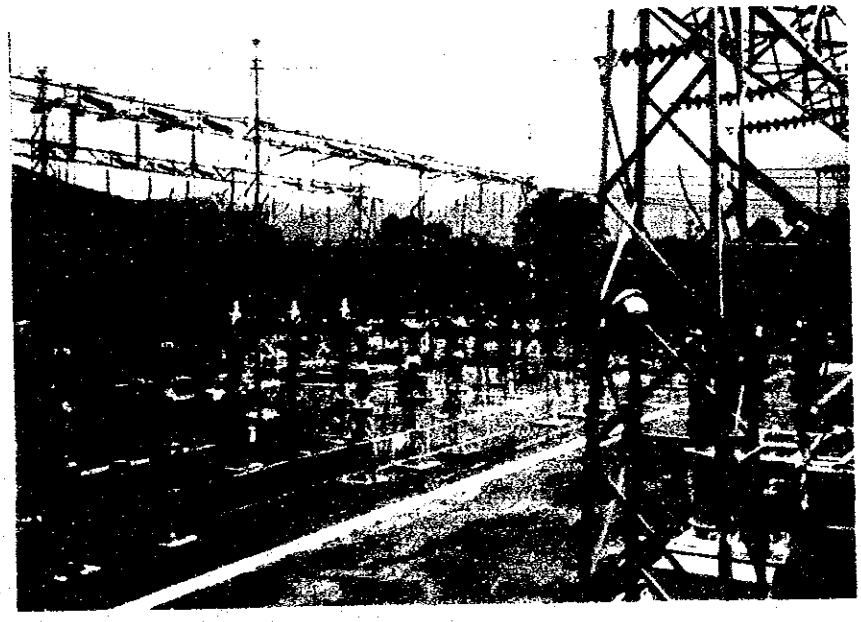
Section between Duri and Dumai

Substation

Lubuk Alung Substation 150 kV/20 kV, 10 MVA x 2

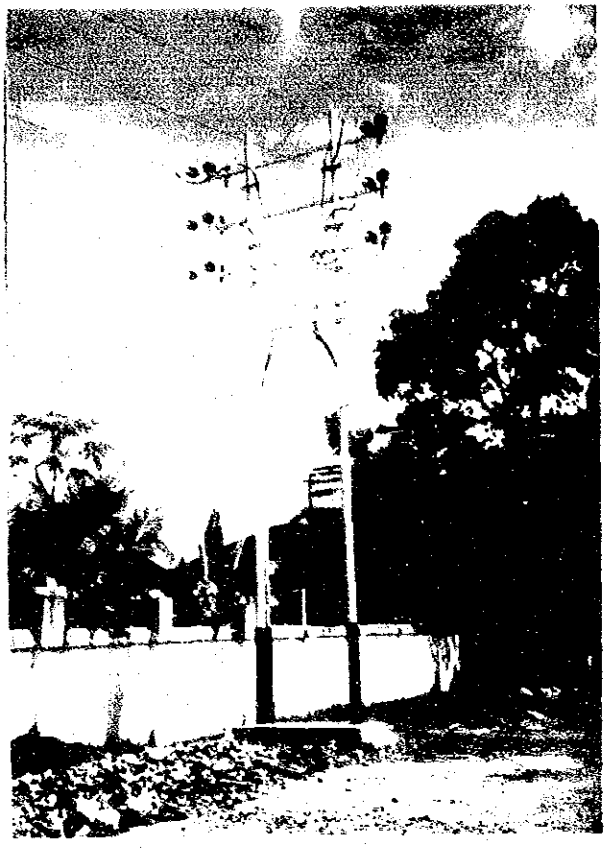


Pauh Limo Substation
150/20 kV, 30 MVA x 2

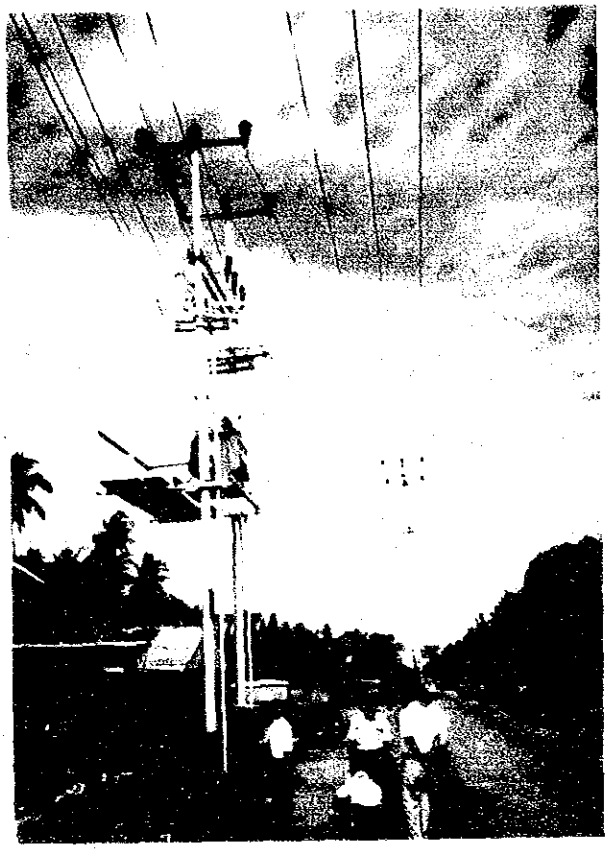


Distribution Line (In Padang)

Branch point between 20 kV overhead line and underground cable

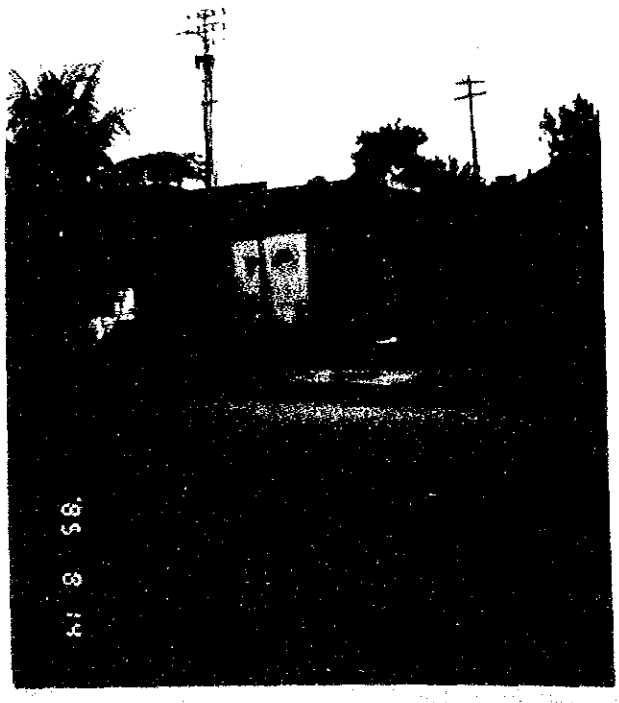


20 kV Pole Transformer



Cubicle for 20 kV Distribution Line

Kiosk for 20 kV Distribution Line



CONTENTS

Glossary

Badan Perencanaan Pembangunan	National Planning and Development Board
Badan Perencanaan Pembangunan Daerah (BAPPEDA)	Provincial Planning and Development Board
Badan Koordinasi Penanaman Model (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 (UPO)	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	milimeter
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
kW	kilowatt
kWh	kilowatt hour
KVA	kilovolt ampere
MW	megawatt
Gwh	gigawatt hour
°	degree
°C	centigrade degree
%	percent
No. (Nos.)	Number(s)
1982/83	Fiscal year 1982

SUMMARY

SUMMARY

1. Background of the Project

With a total area of 50,000 km^2, West Sumatra Province has the population of 3,600,000 and a population density nearly the same as the national average. The Barisan Mountain Range, with peaks of 3,000 meters high, runs longitudinally across the central part of the province in a northwest-southeast direction, making the Province largely mountainous.

Industrywise, there is the large Ombilin Coal Mine, the Padang Cement Plant, agricultural and forestry industries and a few light industries. Centering around the Padang Cement Plant, the demand for electric power is undergoing favorable growth. For ten years, from 1975 through 1984, the power demand indicated an average annual growth rate of a high 24%. Although the growth rate tended to turn sluggish in recent years due to the worldwide economic recession, the power demand is still expected to grow at an annual rate of 10%.

Subsequent to commissioning of the Maninjau Hydro-Power Plant (68 MW) in 1983, construction of the Ombilin Coal Fired Steam Power Plant (100 MW each in the first and second stages) and the Singkarak Hydro-Power Plant (100 MW each in the first and second stages) have been promoted to attain effective utilization of the Province's natural water resources.

On the other hand, Riau Province, 95,000 km^2 in total area, has a small population of 2,400,000. As such, the population density is about one-third that of the national average. Based upon transmigration projects implemented by the Government of Indonesia, however, the growth rate of population indicates 3.5%, which is higher than the national average rate. The coastal area in the northeastern part of the Province faces the Strait of Malacca, and is only 50 km

distant from the Malaysian Peninsula. Most of the Province comprises flat land including swampy zones. The southwestern part borders West Sumatra Province, and is over 500 km in length, with a great many people coming and going to and from these Provinces.

Industrywise, the oil industry in Riau Province is by far the largest in Indonesia, producing some 150 million barrels of crude oil, or roughly 50% of the nation's total annual oil output. Although the configuration ratio of GRDP in other industrial sectors is similar to that in West Sumatra, the Province lags behind West Sumatra in irrigation and other infrastructure facilities. However, as the recent transmigration policy of the Government has achieved steady progress, the industries associated with plantation projects are undergoing steady growth and modernization of road networks is being realized.

The annual average growth rate of power demand in the past ten years has marked a 17% increase. As for the pattern of power supply, diesel power plants are installed nearby the center of each demand area, and power is supplied dispersedly to individual local areas through distribution lines. Since there is no power system in the Province and electric power tends to be in short supply, the number of waiting consumers has exceeded 100, or 25 MW in terms of demand, within the Pekanbaru business area of PLN.

Under these circumstances, the people in the Province desire and need a stable supply of electric power, which can only be realized through development of power sources and modernization of the power system. As for expansion of power source, the development of the Kotapanjang Hydro-Power Site (111 MW) has been proposed.

On the basis of the current situations in West Sumatra Province and Riau Province presented above, the features of both provinces are summarized in the following table.

Comparison of the Regional Characteristics in West Sumatra and Riau Provinces

Province / Items	West Sumatra	Riau
Area	50,000 km^2	95,000 km^2
Population	3.6 million (1983)	2.4 million (1983)
Population density	72/km^2	25/km^2
Geographical features	Most of this Province comprises mountainous areas, with plains accounting for only one-fourth the total area.	Most of Province comprises plains: there are also many swampy zones.
Rainfall	3,000 - 4,000 mm/year (Suitable as hydro-power source sites)	3,000 - 4,000 mm/year
Coastal area	The Province faces the Indian Ocean. Padang Port is used for shipment of cement and coal.	This Province faces the Strait of Malacca. Dumai Port, a key port for international trade, mainly handles shipments of oil.
Farmland	With little potential farmland, production of paddy rice has been transferred to other provinces.	Vast potential farmland is available and production of paddy rice has been transferred here from other provinces.
Reserves of potential natural resources	Coal, limestone, marble etc.	The Province is rich in oil reserves, and has highly potential natural gas reserves.
Plantation	There are only a few potential plantation areas.	Wide areas suitable for plantation are available.
Industry	The Padang Cement Plant represents the large scale industry.	The Province has great possibilities for the development of industries related to oil, timber and agricultural products.
Transportation (Traffic)	This Province is convenient for traffic and transportation due to the large number of main roads.	With main roads now being extended, this Province is convenient for transportation.
Power demand	112 GWh/year (1984) + 87 GWh of Padang Cement	66 GWh/year (1984)
GDP of the Provinces *	Rp. 997 x 10^9 (1982)	Rp. 699 x 10^9 (1982), excluding oil production.

* At current price

Our assumptions for the future directions of the two Provinces are as follows. West Sumatra Province has been quite developed, historically and culturally, since early days. Most of farmland in the Province is cultivated, and production of paddy rice has been transferred to other provinces. In the industrial sector, production of coal, cement and other products related to natural resources is expected to grow steadely.

On the other hand, Riau Province is the leading oil producing and refining Province in Indonesia. What's more, due to the Government's transmigration policy in recent years, coconut oil and rubber plantation projects have been smoothly implemented in many areas. In addition, flat lands, which extend over a wide area, are highly suitable for modernization of road networks and siting of industrial plants. In the littoral area of 1,500 km facing the Strait of Malacca, it is possible to construct several modern ports in addition to expansion of Dumai Port.

The Barisan Mountain Range serves as the border between West Sumatra Province and Riau Province, and is blessed with abundant rainfall, an important factor which makes possible the conversion of the large water resource into electrical energy. As importantly, large high quality coal reserves are available. These two vast energy resources can be effectively utilized for improving the level of living and for promoting industrial development in both Provinces, which are closely related in terms of culture and administration.

Judging that the Central Sumatra Power System Development Project, now being planned by PLN, is truly justifiable, implementation of this feasibility study is of the highest significance.

2. Power Demand Forecast

Based on the data collected from PLN and other pertinent government agencies, power demand forecast up to the year 2005* was principally carried out based on a microscopic method. Final conclusion was obtained subsequent to checking the results of demand forecast based on a macroscopic method.

Namely, efforts were directed to clarify population growth rate, transition of household power consumption, number of waiting consumers and trend of industrial power plants in individual districts as well as industrial development projects with respect to 26 typical areas selected throughout Central Sumatra, excluding isolated islands in West Sumatra Province and Riau Province. On the basis of these figures the demand forecast necessary for compiling a power system development plan was carried out.

In executing demand forecast, efforts were also directed to clarify the present and future trends of Padang Cement, a particularly large consumer in West Sumatra, as well as those of PERTAMINA and CALTEX which operate large scale industrial power plants.

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* For working out the power system development plan by 1995, it is also required to take into account the demand forecast ten years beyond the year indicated.

Padang Cement has already been interconnected with the power system of PLN, and power demand of Padang Cement is expected to increase rapidly in the future in line with growth of its cement production.

CALTEX has its own independent 60 Hz 115 kV power system, and electric power for exploration and production of oil is supplied to a wide area, extending from Pekanbaru to Dumai in Riau Province. Therefore, it was judged that there is no possibility of power supply to CALTEX from PLN in the near future.

However, the focus of attention lies in the trends of PERTAMINA. The survey team met with executive officers of the company to confirm company intentions. As a result, it was confirmed that PERTAMINA could possibly become a customer of PLN in the future due to the deterioration of its existing captive power plants, provided that PLN would be in a position to establish a power system capable of ensuring a stable power supply by that time. Therefore, the demand forecast was carried out for two cases, namely, in case PERTAMINA becomes a customer of PLN and in case PERTAMINA continues to operate its captive power plants without receiving any power from PLN.

Moreover, since it is desirable to indicate the demand forecast values with some margins, the three standard levels, namely, basic, high and low levels of regional electrification rates, were established with respect to city, town and village areas, and yearly demand forecast was carried out. At the same time, efforts were directed to make it possible to clarify the yearly demand forecast in the cities, towns and villages which will be interconnected with the Central Sumatra Power System.

The total demand forecast values obtained by adding the demand from residential, commercial, industrial and public consumers are as shown in Tables 3.3-1, 2, 3 and 4.

According to these tables, the annual power demand, including that of PERTAMINA in 1995, is 1,193 GWh (annual average growth rate for ten years from 1985 through 1995: 14.4%), and the maximum power in the 150 kV system is 232 MW. In case the demand of PERTAMINA is excluded, the annual power demand and maximum power in 1995 are respectively, 1,097 GWh (annual average growth rate for ten years: 13.5%) and 202 MW.

3. Power System Planning

Based on the demand forecast mentioned above, study on the system plan in Central Sumatra was carried out by taking into account the power source development plan worked out by PLN and the system expansion plan now under study by PLN.

In extending this study, technical and economic comparative studies were carried out with respect to various alternative plans pertaining to transmission voltage, route of transmission line, etc., on the basis of the following basic policy. As a result, an optimum system plan by 1995 has been worked out.

a) A stable and efficient interconnected power system should be established for all of Central Sumatra through formation of the power system extending to West Sumatra and Riau Provinces.

b) In view of simplification of the number of voltage classes, coordination with the existing systems, scale of demand and other factors, the standard voltage classes in the primary circuit and secondary circuit should be 150 kV and 20 kV, respectively.

c) In consideration of regional service requirements, system trouble effects, restriction of short circuit capacity and ease of system operation, a target service reliability

should be established, and the power system configuration should be such as to make it possible to successively improve reliability in accordance with target system reliability.

3.1 Power Source Development Plan

The study for the Central Sumatra Power System Development Plan discussed herein should have been carried out based upon the official power source development plan of PLN in accordance with the "Scope of Work" dated Feb. 7, 1985 exchanged between PLN of the Republic of Indonesia and JICA of Japan. However, since the PLN development plan has not been fixed as of April 1986, the study team proceeded the preliminary study on the power system development plan.

Under the power source development plan of PLN which has been fixed as of April 1986, only the Ombilin Steam Power Plant (50 MW x 2) is scheduled to be commissioned in 1991, with no other power source development plan determined as yet.

Furthermore, in 1995, a new power source, equivalent to approximately 100 MW, will become necessary. The power source which might possibly cover this shortage will be either the Singkarak Hydro-Power Plant, which utilizing the head of water from Lake Singkarak toward the Indian Ocean, or the dam type Kotapanjang Hydro-Power Plant, which is proposed for siting upstream of Bangkinang along the Kampar Kanan River.

According to the results of our economic comparison in the preliminary study, it is considered advantageous to develop the Singkarak Hydro-Power Plant beforehand. However, construction of a power plant is not always determined according to economic priority.

Consequently, both of the plans envisaging construction of the Singkarak Power Plant and/or the Kotapanjang Power Plant were examined in our power system planning study.

Results show that there was basically no difference between either of the plans regarding priority of execution and period of power system extension.

3.2 Comparison of Various Alternative Trunk System Configuration Plans

While bearing in mind the expansion of the scale of power system by the year 2000 or 2005, comparative study of various alternative plans was carried out on the basis of the basic 150 kV plan so as to realize feasible and effective expansion of existing equipment.

Meanwhile, the values indicated in "High Case" demand forecast were applied for power system development.

As a result, it was evaluated to be advantageous to construct, first of all, a 150 kV 2 circuit transmission line between Ombilin, Payakumbuh and Pekanbaru to serve as a trunk power system.

(1) Comparison with alternative 150 kV plan

As an alternative 150 kV plan, a route through Kuantan was studied. However, this plan was concluded to be disadvantageous due to the long distance of the transmission line and the large initial investment required.

(2) Comparison with alternative 275 kV system introduction plan

According to PLN long term plan, there is a plan to introduce a 275 kV transmission line from South Sumatra to Ombilin. Taking into account this long term plan of PLN, it would be possible to study a power system plan for this project on the basis of a 275 kV transmission system. However, adoption of a 275 kV system is economically undesirable because of the high construction cost in the case of either route through Payakubuh or Kuantan.

(3) Study of other systems

From an economic point of view, it was evaluated to be appropriate to start construction of the transmission systems between the following respective routes in or after 1996:

Ombilin - Rengat - Tembilahan;
Duri - Pagan Siapi-api;
Pauh Limo - Pinan; and
Padan Luar - Lubuk Sikaping

Therefore, these routes were excluded from the scope of study under this project.

Meanwhile, it was evaluated to be appropriate to branch the transmission line to Bagan Siapi-api from Duri Substation as a starting point judging from the routing conditions of the line.

(4) Based upon the results of the above-mentioned comparative study, the power system in 1993 and 1995 is outlined as shown in Figs. 4.1-1, -2 and -3.

The power flow diagrams prepared based on the results of detailed system analysis conducted on this system are as shown in Figs. 4.3-1, -2 and -3.

Although phase modifiers should be arranged at several locations so as to maintain the voltage at an appropriate level, there will be no problem at all regarding power flow, short circuit capacity, static and transient stability.

As a result of study in view of power flow and economics, the size of the conductors for each transmission line was selected as follows:

Between Kotapanjang branch point and Pekanbaru (60 km)	410 mm^2	2 circuits
Between Ombilin - Payakumbuh - Kotapanjang branch point (141 km) and trunk line between Pekanbaru - Payakumbuh (173 km)	330 mm^2	2 circuits
Loop system between Padang Luar - Payakumbuh (31 km)	240 mm^2	1 circuit
Other branch lines	240 mm^2	2 circuits

Moreover, construction of six substations and grading-up of one existing substation having a total output of 250 MVA were planned as associated substations (Refer to Table 4.2-5).

4. Transmission Facilities

Together with study of the above-mentioned system plan, field investigation was also carried out along all proposed transmission line routes including alternative ones.

In addition, aerial investigation by helicopter was carried out along the proposed transmission line routes in Riau Province and proposed interconnected trunk transmission line routes in West Sumatra and Riau Provinces.

As a result, it was evaluated as being possible to construct interconnected transmission lines required to pass over steep mountainous areas, and it was confirmed that there would be no serious problem regarding the routes of other transmission lines.

Based upon the results of the above investigation, transmission line routes were established in 1/50,000 maps obtained in Indonesia, and basic design was carried out at the same time.

Meanwhile, the following items were taken into account in the selection and design of transmission line routes:

(1) Among the transmission lines extending to West Sumatra and Riau Provinces, the route from Payakumbuh in West Sumatra to an area 20 km toward Pekanbaru (a section of about 9 km) will cross over the steep Barisan Mountain Range. Therefore, the route was selected along roads, and special attention was paid for determining the locations, foundations and construction methods of transmission towers.

(2) There is a swampy area of former rivers from Bangkinang through Pekanbaru in Riau Province. Therefore, the route was selected so as to avoid this area wherever practicable, and should it be unavoidable to select the route in this area, pile foundations will be applied.

(3) The 115 kV transmission line, various oil pipelines and other facilities of CALTEX, extending from Minas to Dumai in Riau Province, were taken into account in selecting the transmission line route.

Although permission for crossing of the transmission line in the CALTEX area was obtained from the local head office at this time, sufficient discussions with CALTEX will be required prior to concretely determining the transmission line route. One of transmission towers (suspension type) is shown in Annex 5-8.

5. Substation Facilities

Along with selection of transmission line routes, field investigation of proposed substation sites was carried out and optimum substation sites were selected by comprehensively taking into account the transmission line routes, surrounding environment, earthquakes, the present and future trends of distribution lines, etc.

Moreover, study was carried out with respect to the following design requirements applicable to the scale of each substation:

(1) In selecting substation sites, the situations of urban development and coordination with transmission line routes were evaluated.

As a result, it is judged that there will be no particular problem in view of civil works at the sites. However, detailed investigation will be necessary in case site areas are newly acquired.

(2) Overall study was carried out with respect to extension of existing substations and boosting of voltage (Pauh Limo and Simpangharu) around Padang.

(3) For design of substations, study was carried out on the connection system, capacity of transformer banks, protection system and so forth. Also, the standard connection system and equipment layout were determined by taking into account the scale, importance and possibility of future extension of individual substations so as to apply an optimum system for each individual substation. (A typical connection diagram and layout are as shown in Annex 6-3 and -4).

(4) A load shedding system was adopted by taking into account countermeasures against a large-scale blackout in case of major power failure in the power system.

6. Distribution Facilities

Regarding distribution facilities, study was carried out chiefly on the countermeasures against trouble and improvement measures for equipment design based upon the present equipment conditions and occurrence of trouble.

Distribution systems in Central Sumatra have been expanded along with the progress of electrification by mainly installing diesel power plants in individual cities, towns and villages. Interconnection of distribution lines has been promoted in Padang, Bukittinggi and other cities, while reinforcement of

distribution systems has also been underway simultaneously with the expansion of the 150 kV trunk system from the Maninjau Hydro-Power Plant. Under this project, study was particularly carried out on the practical patterns of distribution line trouble, as well as standard design, system configurations, etc., of distribution systems. As a result, the following countermeasures were proposed:

(1) Countermeasures against tripping of the medium voltage system due to contact with trees

. Sufficient space should be provided between conductors and trees.
. Insulated conductors or overhead cables should be used.

(2) Countermeasures against disconnection of secondary fuses of transformers

. The horizontal distance of low voltage distribution line conductors shall be extended from 300 mm to 500 mm, or the line should be of vertical arrangement.

(3) Countermeasures against disconnection of consumer end fuses

. Use of breaker switches

Meanwhile, the number of power supply failures occurring in one year, namely, 1984, in Wilayah III are as follows:

. Duration of power supply failure: 77 min./consumer
. Number of power supply failures : 49 times/consumer

. These troubles occurred mainly due to the following causes:

. Trip of intermediate voltage system (20 kV and 6 kV) due to contact with trees (17.9 min./consumer, 19.0 times/consumer)

. Disconnection of transformer secondary fuses (10.0 min./consumer, 3.2 times/consumer)

. Disconnection of fuses in consumer buildings (6.4 min./consumer, 2.5 times/consumer)

. Shutdown of power plant (4.5 min./consumer, 5.8 times/consumer)

7. Load Dispatching System

At present, load dispatching in the power system in the West Sumatra Province is carried out by collecting information through telephone communication at the existing 150 kV Pauh Limo Substation in Padang. To ensure efficient and reliable operation of the entire power system at the time of formation of an interconnected power system in both West Sumatra and Riau Provinces, it is of utmost importance to establish a load dispatching system equipped with updated functions.

The power systems on Sumatra Island/s are divided into the northern, central and southern parts, and each power system has been expanded successively mainly in Medan, Padang and Palembang. Among these cities, a modern load dispatching facility has already been installed and operated in Medan, while construction of a similar scale load dispatching facility is being promoted in Palembang.

As a result of study on the load dispatching system under this project, a load dispatching facility having similar functions of the above two has been proposed so as to ensure smooth and accurate power system operation.

The load dispatching facility was proposed to be located in the capital city of Padang, where Wilayah III is located and it is

easy to exchange informations between the concerned government agencies.

8. Communication System and Equipment

The communication systems considered applicable in view of the power system in Central Sumatra include a microwave communication system and an optical communication system which incorporate optical fiber cable in overhead shielding wires of transmission lines as well as a power line carrier (PLC) system which is widely adopted in the power systems of PLN.

As a result of study on these systems and in view of the information processing capacity and construction cost, it was determined to adopt the PLC system under this project in consideration of the required information processing capacity and construction cost. Therefore, optical communication system will be adopted should transmission of information be difficult by the PLC system.

Namely, the optical communication system will be adopted from Payakumbuh and Ombilin to the Padang Load Dispatching Center, while the PLC system will be adopted in other areas.

9. Construction Schedule and Cost

9.1 Construction Plan

This project will be implemented in the following two stages:

a. Stage I : Site survey, detailed design, preparation of tender documents, etc.

b. Stage II : Execution of bidding, evaluation of tender documents, assistance in contract, and supervision of construction works, etc.

To ensure smooth progress of these works and complete the project on schedule, an overseas consultant will execute engineering services in cooperation with an Indonesian consultant.

(1) The site survey will be carried out by the Indonesian Consultant under instruction and supervision of the overseas consultant. On the basis of the results of this survey, the overseas consultant will execute detailed design and prepare tender documents, etc.

(2) The construction works of transmission line/s, substation/s, etc. based upon this plan will be executed by dividing into the following six blocks.

Block 1:	Ombilin - Payakumbuh - Pekanbaru	(The respectively associated transmission lines, substations and communication equipment)
Block 2:	Padang Luar - Payakumbuh	
Block 3:	Pekanbaru - Dumai	
Block 4:	Reinforcement of power system in Padang	
Block 5:	Dumai - PERTAMINA	

Block 6: Load dispatching facility: (Padang Load Dispatching Center including associated substation and communication equipment)

(3) Procurement of equipment and materials and construction of transmission lines and substations will be carried out under the supervision of an overseas consultant.

i) Transmission lines

a) The towers, conductors, groundwires, insulator devices, etc. for transmission lines will be procured on the basis of international tender.

b) Special tools for erection of towers, conductor stringing and other works will be procured on the basis of international tender.

c) All construction and erection works will be carried out by Indonesian constructions.

ii) Substations

a) Procurement and installation of substation equipment and other accessory equipment and materials will be carried out on the basis of international tender.

b) Civil and architectural/structural works will be carried out by Indonesian constructors.

9.2 Construction Schedule

As for construction of the transmission lines and substations according to the power system development plan in Section 4, the line

from the Ombilin Steam Power Plant and the Padang Luar Substation in West Sumatra through to the Pekanbaru Substation in Riau Province will be constructed in the first stage, and the line from Pekanbaru Substation through to the Dumai Substation will be constructed in the second stage. A schedule is as shown in Table 10.2-1.

9.3 Construction Cost

The construction cost was estimated based upon the above plan and schedule. This estimation was based upon the price level in Jan. 1986 and an exchange rate of Rp.1,100 and ¥200 to one US dollar. The unit cost was calculated with reference to that of similar projects and international price level.

10. Economic and Financial Analysis

The Objective of this financial and economic analysis is to evaluate whether implementation of this project by 1995 is justifiable and feasible from economic and financial point of view. Concretely, it was first confirmed if the construction of transmission lines would be the lowest cost method for supply of electric power compared with other realistic alternative plans (Least-Cost Solution).

For the transmission line routes confirmed to be the lowest cost method, the economic internal rate of return (EIIR) was calculated considering the revenue from power charge as the willingness to pay by consumers, namely the benefit from the project. As for financial analysis, the financial internal rate of return (FIRR) was calculated based upon the market price, and repayability of this project loan was studied.

Power demand forecast values were studied in case PERTAMINA is and is not assumed to become a customer of PLN, while fluctuation in oil prices, etc., were also analyzed.

As a result, the following transmission lines were evaluated to be economically feasible:

(1)	Transmission line between Padang - Payakumbuh - Pekanbaru	Commissioning in 1993
(2)	Transmission line between Pekanbaru - Dumai	Commissioning in 1995

CONCLUSION

1. Power Demand Forecast

1.1 In Case the Power Demand of PERTAMINA is Included

(Unit: GWh, MW, %)

Province \ Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Annual average growth rate, % '85-'90	'90-'95	'85-'95
West Sumatra Province	231.1	275.4	330.5	378.0	429.0	476.9	519.8	566.3	618.0	674.6	736.5	15.6	9.1	12.3
Riau Province	78.6	91.6	105.3	120.1	135.8	152.9	173.4	197.1	286.3	331.5	456.4	14.2	24.4	19.2
Total of Wilayah III	309.7	367.0	435.8	498.1	564.8	629.8	693.2	763.4	904.3	1006.1	1192.9	15.3	13.6	14.4
Maximum System Demand	54	63	72	79	88	96	103	111	164	178	232	12.2	19.3	15.7

1.2 In Case the Power Demand of PERTAMINA is not Included

(Unit: GWh, MW, %)

Province \ Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Annual average growth rate, % '85-'90	'90-'95	'85-'95
West Sumatra Province	231.1	275.4	330.5	378.0	429.0	476.9	519.8	566.3	618.0	674.6	736.5	15.6	9.1	12.3
Riau Province	78.6	91.6	105.3	120.1	135.8	152.9	173.4	197.1	286.3	331.5	360.4	14.2	18.7	16.4
Total of Wilayah III	309.7	367.0	435.8	498.1	564.8	629.8	693.2	763.4	904.3	1006.1	1096.9	15.3	11.7	13.5
Maximum System Demand	54	63	72	79	88	96	103	111	164	178	202	12.2	16.0	14.1

Notes 1. The demand in the respective isolated islands in both provinces was excluded.
2. The demand of Padang Cement is included in the demand of West Sumatra Province.
3. The maximum system demand refers to a maximum value of total demand incorporated into the Central Sumatra Power System.
4. The maximum system demand in 1985 is based on estimation.

2. Power System Plan

The transmission voltage of the Central Sumatra Power System should be 150 kV, and the power system configuration will be as presented below.

2.1 System Plan

Main power facilities		Distance or Number of Substations	No. of circuits or Capacity	Commission-ing
Transmission line from Ombilin Steam Power Plant to Pekanbaru through Payakumbuh		201 km	2 cct	Oct. 1993
Substation:	Payakumbuh	1	2x20 MVA	Oct. 1993
	Bangkinang	1	10 MVA	Oct. 1993
	Pekanbaru	1	2x50 MVA*	Oct. 1993
Transmission line from Padang Luar to Payakumbuh (The system in West Sumatra shall be of a loop type)		31 km	1 cct	Oct. 1994
Substation:	Batusangkar	1	10 MVA	Oct. 1994
Transmission line from Pekanbaru to Dumai		173 km	2 cct	Apr. 1995
Substation:	Duri	1	10 MVA	Apr. 1995
	Dumai	1	20 MVA	Apr. 1995

* Attention to Table 6.3-4

2.2 Countermeasures for Reinforcing the Padang Power System

Power facilities	Distance or Number of Substations	No. of circuits or Capacity	Commission-ing
Transmission line from existing Pauh Limo Substation to Simpangharu Substation	7 km	2 cct	Oct. 1992
Grading-up of existing Simpangharu Substation (20 kV) to 150 kV	1	30 MVA 30 MVA	Oct. 1992 Oct. 1995

2.3 Countermeasures for Power Supply to Customer by High Voltage Transmission Line

Power facilities	Distance	No. of circuits	Commission-ing
*Transmission line from Dumai to PERTAMINA plants	10 km	2 cct	Oct. 1995

*This transmission line is not required should PERTAMINA not be included in the power demand.

3. Construction Schedule

3.1 Transmission Line

Section of transmission line	Distance (km)	Substation	Voltage (kV)	No. of cct.	Size of conductor (mm^2)	Commission-ing period
Ombilin - Payakumbuh	58		150	2	ACSR 330	Oct. 1993
Payakumbuh - Branch point at Kotapanjang	83		150	2	ACSR 330	Oct. 1993
Branch point at Kotapanjang - Pekanbaru	60	T-branching at Bangkinang	150	2	ACSR 410	Oct. 1993
Padang Luar - Payakumbuh	31		150	1	ACSR 240	Oct. 1994
Pekanbaru - Dumai	173	T-branching at Duri	150	2	ACSR 330	Apr. 1995
*Dumai - PERTAMINA	10		150	2	ACSR 240	Oct. 1995
Pauh Limo - Simpangharu	7		150	2	ACSR 240	Oct. 1995

*The transmission line between Dumai and PERTAMINA will not be required should PERTAMINA not be included in the power demand.

3.2 Substation

Substations or power plants	Transformers Voltage (kV)	Capacity, MVA x No. of tr. banks	Construction (C) or extension (E)	Commission-ing period	Remarks
Payakumbuh	150/20	20 x 2	C	Oct. 1993	
Bangkinang	150/20	10 x 1	C	Oct. 1993	
Pekanbaru	150/20	50 x 2	C	Oct. 1993	Attetion to Table 6.3-4
Batusangkar	150/20	10 x 1	C	Apr. 1994	
Duri	150/20	10 x 1 + (1)	C	Apr. 1995	
Dumai	150/20	20 x 1	C	Apr. 1995	
Ombilin	150	outgoing x 2	E	Oct. 1993	For transmission line between Ombilin and Payakumbuh
Padang Luar	150	outgoing x 1	E	Oct. 1994	For transmission line between Padang Luar and Payakumbuh
Pauh Limo	150/20	outgoing x 2	E	Oct. 1992	Reinforcement of power system in Padang
Simpangharu	150/20	30 x 2	E	Oct. 1992	Reinforcement of power system in Padang
	Modification of existing equipment			Oct. 1995	

3.3 Load Dispatching Facility

Load dispatching office	Equipment and instruments	Commissioning
Padang	Modern equipment and instruments, including CPU and CRT units, should be installed.	Oct. 1995

3.4 Communication Equipment

Sections	Communication system	Commissioning
Padang Load Dispatching Office - Payakumbuh Substation - Ombilin Substation	Optical fiber telecommunication system	
Other sections	PLC telecommunication system	

4. Construction Schedule (Project Implementation Schedule)

(1) Period of engineering services: 1988 - 1995

Stage I : Execution of field investigations and detailed design, and preparation of tender documents

Stage II: Evaluation of tender documents, negotiation for contracts and construction supervision

(2) Construction work : 1989 - 1995

Block 1 Ombilin - Payakumbuh - Pekanbaru (1989 - Sept. 1993)
(including transmission lines, substations and associated telecommunication facilities)

Block 2 Padang Luar - Payakumbuh (1991 - Sept. 1994)
(including transmission lines, substations and associated telecommunication facilities)

Block 3 Pekanbaru - Dumai (1992 - March 1995)
(including transmission lines, substations and associated telecommunication facilities)

Block 4 Reinforcement (Modernization) of power system in Padang (1990 - Sept. 1995)
(including transmission lines, substations and associated telecommunication facilities)

Block 5* Power supply to PERTAMINA (1994 - Sept. 1995)
(including transmission lines, substations and associated telecommunication facilities)

Block 6 Load dispatching facilities (1992 - Sept. 1995)
(including transmission lines, substations and
associated telecommunication facilities)

* Excluding power receiving substation for PERTAMINA

5. Required Investment (Capital)

(Unit: 10^6 Yen)

Items	Foreign currency portion	Local currency portion	Total
1. Direct cost	10,508	3,920	14,428
Block 1	(4,233)	(1,689)	(5,922)
Block 2	(654)	(290)	(944)
Block 3	(2,740)	(1,197)	(3,937)
Block 4	(705)	(296)	(1,001)
Block 5	(270)	(103)	(373)
Block 6	(1,906)	(345)	(2,251)
2. Engineering fees and Governmental administration cost	998	372	1,370
3. Compensation	0	562	562
4. Physical contingency	725	383	1,108
Total	12,231	5,237	17,468
5. Price contingency	3,013	5,323	8,336
6. Interest during construction	2,158	2,982	5,140
Grand total	17,402	13,542	30,944

Note: In case of no power supply to PERTAMINA

Total	11,918	5,101	17,019
Grand total	16,962	13,172	30,134

(Converted to dollars by 1US$ = ¥200 for reference)

(Unit: 10^3 US$)

Items	Foreign currency Portion	Local currency Portion	Total
1. Direct cost	52,540	19,600	72,140
Block 1	(21,165)	(8,445)	(29,610)
Block 2	(3,270)	(1,450)	(4,720)
Block 3	(13,700)	(5,985)	(19,685)
Block 4	(3,525)	(1,480)	(5,005)
Block 5	(1,350)	(515)	(1,865)
Block 6	(9,530)	(1,725)	(11,255)
2. Engineering fees and Governmental administration cost	4,990	1,860	6,850
3. Compensation	0	2,810	2,810
4. Physical contingency	3,625	1,915	5,540
Total	61,155	26,185	87,340
5. Price contingency	15,065	26,615	41,680
6. Interest during construction	10,790	14,910	25,700
Grand total	87,010	67,710	154,720

Note: In case of no power supply to PERTAMINA

Total	59,590	25,505	85,095
Grand total	84,810	65,860	150,670

2. Basic assumption for estimation of required investment

(1) Foreign exchange rate is 1 US$ = 1,100 Rp, 1 US$ = J.¥200.

(2) Engineering fees (including government administration cost) is 9.5% of direct construction cost.

(3) Physical contingency consist of the total cost of 5% of direct construction cost +20% of engineering fees and compensation.

(4) Price Escalation
The price escalation was estimated at 3% per year for foreign currency portion and 10% per year for local currency portion.

(5) Interest rate during construction period
The interest rate during the construction period was estimated to be four (4) percent per year for foreign currency portion, sixteen (16) percent per year for half the total local currency portion, and zero (0) percent per year for the rest of the local currency portion consisting of interest-free government funds and PLN's own funds.

6. Economic and Financial Analysis

The construction project for the transmission line/s from the area around Padang to Dumai (the line up to Pekanbaru and the line up to Dumai are scheduled to be commissioned in Oct. 1993 and Oct. 1995 respectively) and the substation construction project are concluded to be feasible from economic and financial aspects for the following reasons:

(1) As a result of comparison with other alternative plans, this project is the least cost solution for power supply to the respective proposed areas.

(2) The economic internal rate of return (EIRR) is as high as 22.0% in case it is possible to expect the power demand of PERTAMINA, and as high as 16.4% even in case the power demand of PERTAMINA is not expected. Also, even when the EIRR is calculated by separating the transmission lines between the area around Padang and Pekanbaru and between Pekanbaru and Dumai, and even when the demand of PERTAMINA is excluded, the EIRR of the line between Pekanbaru and Dumai is still higher than 10%.

(3) The financial internal rate of return (FIRR) of the entire project is a high 19.9% when the demand of PERTAMINA is included, and the FIRR, when the demand of PERTAMINA is excluded, is still as high as 14.6%.

(4) The results of analysis based upon the above values also indicate that the sensibility will not vary to any large extent even if conditions worsen.

(5) There are no particular problems regarding repayment of loans associated with this construction project even if it is impossible to expect power demand of PERTAMINA.

(6) The results of the above-mentioned economic and financial analysis are based on conservative prerequisite conditions whereby the levels of power rate were converted into the present levels based on actual price levels.

The transmission line to Pekanbaru commissioned in 1993 has an enormously economical advantage as stated above, and moreover, from the technical viewpoint, this transmission line should be constructed as early as possible, because the power source in Pekanbaru can hardly meet the power demand in around 1992-93, even though all the planned diesel power units (6 MW x 6) are commissioned on schedule.
(Refer to Annex 11-2)

Considering the general procedure, however, commissioning of this transmission line has been determined as 1993, as earliest date.

SECTION 1

INTRODUCTION

SECTION 1 INTRODUCTION

In the cities of Central Sumatra (West Sumatra and Riau Provinces), electric power was supplied through medium or low voltage distribution lines from independent diesel power plants installed in the respective cities several years ago. Then, in 1983, with completion of the Maninjau Hydro-Power Plant (68 MW), which uses water from Lake Maninjau in West Sumatra, supply of electric power to Padang through approximately 100 km 150 kV transmission line was started, marking formation of a power system in West Sumatra. At present, however, electric power is still supplied to the demand area under a "one power plant through one route" system, meaning that a power system configuration has not been established yet.

To meet the growth of power demand in both of the provinces in future, PLN intends to implement the construction projects of the Ombilin Coal-Fired Steam Power Plant and the Singkarak Hydro-Power Plant in West Sumatra, and the Kotapanjang Hydro-Power Plant in Riau Province.

To promote development of these large scale power sources now under planning and to realize integrated economical operation of the power system so that it can respond to the growth of power demand in the future, it is of utmost importance to devise a suitable and efficient power system development plan.

1.1 Objectives and Scope of the Study

The objectives of this study are to work out the Central Sumatra Power System Construction Plan by 1995. The scope of study is as presented below:

1) Demand forecast
2) Investigation of existing power facilities and review of proposed power facility plans
3) Site survey for preparation of a power system construction plan
4) Establishment of procedures for computerized demand forecast and system planning, and transfer of technical knowledge to PLN engineers
5) Preparation of a power system construction plan
6) Preparation of estimation of the volume of work and the construction cost related to the above plan
7) Technical and economic evaluations of the above plan
8) Preparation of the construction schedule related to the above plan

1.2 Study Activities

In implementing the feasibility study, JICA organized a study team, consisting of the eight members shown in Table 1, and dispatched to Indonesia. The study team, comprising engineering experts in the fields of power demand forecast, system planning, design of transmission line and substation, study of distribution line, and economic study, undertook the activities in close cooperation with their PLN counterparts in Indonesia.

The schedules of investigations in Indonesia and study at the home office are as follows:

First site survey:	5th June 1985 - 5th July 1985
Second site survey:	28th Aug. 1985 - 13th Sept. 1985 (Until 6th Oct. 1985, for two T/L group members)
Home office analysis:	6th July 1985 - 31st May 1986

Prior to site survey, the survey team discussed and exchanged information on all basic matters at the PLN Head Office to enable efficient execution of subsequent surveys and investigations.

Meanwhile, the study/survey team was divided into three groups; a system planning, substation and distribution group, a transmission line group, and a demand forecast and economic study group. Survey was promoted while simultaneously holding full member meetings with PLN officials.

This resulted in the collection of a large volume of data and information, thanks to the kind cooperation extended by PLN and other authorities.

The major items of site survey activities are as listed below.

(1) Demand forecast and economic study

This group visited various government agencies including local offices of PLN, and collected a large amount of data and information required for demand forecast and economic evaluation. In addition, the group visited CALTEX and PERTAMINA in Riau Province to confirm the trend of power demand, while fully realizing their need to receive power from PLN in the future.

(2) System planning

This group carried out investigation on the present and future trends of the power system and problematical points, as well as undertaking study on the power supply methods to major individual demand areas and investigation of regional environments.

(3) Transmission line

This group carried out field investigation along all proposed transmission line routes and conducted aerial survey by helicopter over parts of the proposed routes. Moreover, detailed reconnaissance was carried out, particularly in the steep mountainous areas, where transmission lines for interconnection between West Sumatra and Riau Province are proposed to be constructed.

At the home office, the study team carried out analysis and study of data and information based on the results of site investigations/survey, and prepared this report in June 1986.

Table 1. Members of JICA Team

	Assignments	Members
1.	Team Leader	Hajime Nakamura
2.	System Planning (Sub Leader)	Ken Matsushima
3.	Design of Substation (Sub Leader)	Kunio Ohkawara
4.	Design of Transmission Line	Kunio Ohshima
5.	Study of Distribution Facilities	Toshiyuki Hasegawa
6.	Design of Foundation and Structure	Hiroyuki Kimura
7.	Demand Forecast	Takahisa Murata
8.	Economic and Financial Analysis	Teruyuki Tanabe
	Official (JICA)	Haruo Suzuki

SECTION 2

BACKGROUND OF THE PROJECT

SECTION 2 BACKGROUND OF THE PROJECT

The Government of the Republic of Indonesia is implementing transmigration to underpopulated Sumatra Island, Kalimantan Island and other areas so as to eliminate over-population on Java Island. At the same time, the Government is promoting large scale development projects, including production of agricultural products and modernization of infrastructures in the transmigration areas, in order to attain balanced development of the country.

Various projects promoted in Central Sumatra (West Sumatra and Riau Province) include expansion of coconut plantations, construction of associated coconut oil refining plants and other industrial plants, promotion of agriculture through irrigation, modernization of roads and infrastructure facilities, and various other projects. In addition, expansion of coal production at the Ombilin Coal Mine, extension of the Padang Cement Plant, as well as other projects are being promoted. Due to the progress of these projects, the electric power demand is undergoing steady growth.

The Province of West Sumatra has a total area of 50,000 km^2 and a population of 3,600,000, each representing slightly over 2% of these categories in Indonesia. Geographically, the southwestern part faces the Indian Ocean, while the northern part, northeastern part and southern part border North Sumatra Province, Riau Province and Jambi Province, respectively. The Barisan Mountain Range, of 3,000 m peaks, runs from northwest to southeast across the central part of the Province, occupying nearly three-fourths the Province's total area.

The major industries in West Sumatra consist of the Ombilin Coal Mine, Padang Cement, light industries in Bukittinggi, marble mining near Payakumbuh, etc., and include the agricultural and forestry industries. Recently in Padang, an industrial complex and other projects are being promoted, with the electric power demand also

undergoing steady growth. In view of electric power resources, the province boasts abundant supplies, from the Ombilin Coal Mine, where 550,000 tons of coal is produced annually, to the hydro-power sources utilizing water from Lake Maninjau and Lake Singkarak.

To meet the increase of power demand, the Maninjau Hydro-Power Plant (68 MW) was constructed in 1983, and power supply to Padang, the capital city, through a 150 kV transmission line, was started. Subsequently, toward the end of 1985, the 150 kV system was extended to Salak in the eastern part of the Province.

The electric power demand indicated an annual average growth rate of 18% for ten years from 1974 through 1983, and a very high annual average growth rate of 23% for the six years from 1978 through 1983. Although the growth of power demand is expected to slow down due to recent worldwise economic factors, the demand is still expected to grow at an annual rate of some 10% in the future. Therefore, it is essential to realize efficient and stable power supply to improve the welfare of the region's people by electrification and industrialization, now being implemented by the Government of Indonesia.

For these purposes, attention has been directed to the development of large scale, stable power sources, rather than expanding existing independent diesel power or gas turbine power plants. As a result, the Ombilin Coal-Fired Steam Power Plant and the Singkarak Hydro-Power Plant construction projects are planned so as to effectively utilize natural resources in the Province.

On the other hand, Riau Province has a larger total area, 95,000 km^2, a smaller population, 2,400,000, and a lower population density than West Sumatra province. However, due to influx of population following promotion of transmigration by the Government of Indonesia, the population in the Province has increased at the higher annual average rate of 3.5% than the national average in recent years. Although the transmigration policy of the Government has undergone

some changes, this trend of population increase is still considered to continue.

Geographically, the northeastern part of the Province faces the Strait of Malacca where large ocean-going vessels frequently navigate along the international trade route. The coast here extends some 1,500 km, and is only 50 km distant from the Malaysian Peninsula. The majority of the land in the Province comprises flat land and swamp zones, with the northern part, southwestern part and southern part bordering North Sumatra, West Sumatra and Jambi Provinces, respectively. Although the Barisan Mountain Range runs between West Sumatra Province, the border of the Province extends to as much as 500 km. What's more, the movement of people has been considerably greater than that of other provinces ever since olden times.

In Riau Province, the oil sector occupies an overwhelmingly large position as compared to other industries. In fact, it is the largest Indonesian oil producing province, boasting some 150 million barrels of crude oil annually. This is equivalent to about 50% of the total oil production of Indonesia on a yearly basis. In the other industrial sectors, the GRDP configuration ratio of agricultural, service and other industries is very similar to that in the Province of West Sumatra. However, actual production in Riau Province lags considerably behind and a considerable gap is seen in irrigation and other facilities. As a result of the transmigration policy of the Government, plantation projects and associated industries are undergoing steady growth. Modernization of road networks is also being steadily promoted.

Against this background, the growth rate of electrical energy consumption reached 17% on an annual average over the past ten years. However, electric power is noticeably dispersed and supplied only to limited demand centers through individual distribution lines from diesel power plants installed in these respective demand areas in accordance with the present pattern of

power supply. As there is no organized power system and the power supply capacity is insufficient in the Province, the number of waiting consumers in the service area of PLN has reached as many as 100, or the equivalent of about 25 MW.

Under these circumstances, the people in the Province desire a stable and sufficient power supply. This can only be realized by expansion of power sources and construction of power systems. Thus, development of the Kotapanjang hydro-power source is expected to be realized.

On the basis of the backgrounds of West Sumatra and Riau Provinces as outlined above, the characteristics of both provinces are summarized and presented in the following table.

Comparison of the Regional Characteristics in West Sumatra and Riau Provinces

Province / Items	West Sumatra	Riau
Area	50,000 km^2	95,000 km^2
Population	3.6 million (1983)	2.4 million (1983)
Population density	72/km^2	25/km^2
Geographical features	Most of this Province comprises mountainous areas, with plains accounting for only one-fourth the total area.	Most of Province comprises plains: there are also many swampy zones.
Rainfall	3,000 - 4,000 mm/year (Suitable as hydro-power source sites)	3,000 - 4,000 mm/year
Coastal area	The Province faces the Indian Ocean. Padang Port is used for shipment of cement and coal.	This Province faces the Strait of Malacca. Dumai Port, a key port for international trade, mainly handles shipments of oil.
Farmland	With little potential farmland, production of paddy rice has been transferred to other provinces.	Vast potential farmland is available and production of paddy rice has been transferred here from other provinces.
Reserves of potential natural resources	Coal, limestone, marble etc.	The Province is rich in oil reserves, and has highly potential natural gas reserves.
Plantation	There are only a few potential plantation areas.	Wide areas suitable for plantation are available.
Industry	The Padang Cement Plant represents the large scale industry.	The Province has great possibilities for the development of industries related to oil, timber and agricultural products.
Transportation (Traffic)	This Province is convenient for traffic and transportation due to the large number of main roads.	With main roads now being extended, this Province is convenient for transportation.
Power demand	112 GWh/year (1984) + 87 GWh of Padang Cement	66 GWh/year (1984)
GDP of the Provinces *	Rp. 997 x 10^9 (1982)	Rp. 699 x 10^9 (1982), excluding oil production.

* At current price

Presented herein below is our assumption for the future directions of the two Provinces based on the above-mentioned characteristics. West Sumatra Province has achieved considerable development historically and culturally since early days. Most farmland in the Province has been cultivated, and production of paddy rice has been transferred to other provinces. In the industrial sector, production of coal, cement and other products related to natural resources is expected to grow.

On the other hand, Riau Province leads Indonesia in the production and refining of oil. Moreover, due to the transmigration policy of the Government in recent years, coconut oil and rubber plantation projects have been undertaken over wide areas. In addition, the Province's abundant flat land area is highly suitable for modernization of road networks and siting of industrial plants. In the sea side area, some 1,500 km facing the Strait of Malacca, it is possible to construct several new ports, in addition to expansion of Dumai Port.

The Barisan Mountain Range, bordering the Provinces of West Sumatra and Riau, is blessed with abundant rainfall, which can be utilized for generating electrical energy. At the same time, the wealth of high quality coal reserves represents another vast energy resource which can be put to use to upgrade the people's level of living and for promoting industrial development in both Provinces, which are closely related in terms of culture and administration.

Judging that the Central Sumatra Power System Development Project now being planned by PLN is truly justifiable, implementation of this feasibility study is of the highest significance.

2.1 Economy

Economy of Indonesia achieved a very high annual growth rate, in light of international average, of 7.6 percent during 1970s in terms of real GDP owing to favourable international price and demand for its oil export. However, lower oil price and worldwide recession for the past several years forced the Government of Indonesia to adopt adjustment policies for less dependence on oil by, for instance, promoting development of non-oil sectors, devaluating Rupiah, strengthening the basis for tax revenues, passing the burden of development expenditures more on to private sector and public enterprises, and so forth.

These adjustment policies seem to be taking effect. GDP growth, which was declined to 2.2 percent in 1982, is estimated to be recovered to 6.5 percent in 1984 while reducing the inflation rate (Indonesia Consumer Price Index) to less than 3 percent for the fiscal year of 1984. Furthermore, the deficit in current account of international balance of payment was declined from 8.5 percent of GNP in 1982 to 2.4 percent in 1984.

The targeted growth rate of Indonesian economy during REPELITA IV is, despite the recent recovery, modestly set at 5 percent for real GDP and 3 percent for real per capita GDP while the target of West Sumatra and Riau, i.e., the area where the proposed project will be implemented, is slightly higher than the nation-wide rate as shown below.

Table 2.1-1 Major Economic Indicators

	Indonesia	West Sumatra	Riau 1/
Per capita GDP in 1982 (Rp.000)	387	302	342
Actual growth rate 1975-82 (%/year)			
GDP	7.1	8.4	6.1
Population	2.2	2.1	3.2
Per capita GDP	4.8	6.1	2.8
Target growth rate 1984-89 (%/year)			
GDP	5.0	6.0	6.5
Population	2.0	2.2	3.3
Per capita GDP	3.0	3.7	3.1

Note: 1/ Oil Sector is excluded.

Source: BAPPENAS, BAPPEDA-West Sumatra, BAPPEDA-Riau, BKPM-Riau

West Sumatra's land area of 50,000 km^2 and population of 3.6 million both occupy slightly above 2 percent of entire Indonesia. Although population density of about 72 persons per km is close to the nation's average, this province may be considered as densely populated area in light of agricultural land since topography is mountainous and, accordingly, only 14 percent of total land area is arable.

66 percent of 1.3 million labor force is employed by agricultural sector (including forestry and fishery), 26 percent by service (including transportation, public utilities, and public administration), and only 5 percent by industry. In production-wise, almost 50 percent of GRDP comes from the service, 32 percent from the agriculture, and 11 percent from the industry. Per capita GRDP of approximately Rp.300,000 in 1982 was about four-fifths of the national average; however, its growth rate between 1975 and 1982 was higher

than the nation-wide rate by more than 1 percent, given the higher GRDP growth rate and almost the same population growth rate compared with the national rate.

Although West Sumatra is presently exporting rice to other regions, the arable land has already been almost exhausted. Therefore, development of food crop production will be oriented to intensification by further expansion of irrigation facilities, use of improved seeds, application of more fertilisers, etc. As for estate crops, oil-palm plantation is expected to grow together with its processing industry. Furthermore, good potential for marine fishing and shrimp culturing is reported.

Despite the existence of large cement plants near Padang, West Sumatra's industrial base consists largely of small-scale enterprises. Among 2,500 industrial firms located in this province, about 96 percent are small-scale employing 3-4 persons on the average. Yet, this sector enjoyed a comfortable growth rate of 11 percent between 1975 and 82 supported mainly by expansion of the cement plants and development of food and beverage industry. During REPELITA IV, major thrust will be directed to agro-processing industries such as palm-oil refining, peanut-oil extraction, cassava processing, sugar mill, and rice mill. Growth of cement industry, on the other hand, will depend upon the growth of domestic market and climate for exports since Indonesia has already achieved self-sufficiency in cement market.

In the mining sector, an emphasis will be placed on development of coal mining in Ombilin/Sawahlunto area, where current production is about 550,000 tons per year against estimated reserve of 157 million tons. In addition, development of 400 billion tons deposit of limestone, and 500 million m^3 of marble near Payakumbuh are expected to play an important role for development of this province.

As opposed to West Sumatra, Riau is sparsely populated area with population density of 25 persons per km^2, given land area of 95,000 km^2 and population of 2.4 million. However, the population growth rate has been recording more than 3 percent, which is much higher than the nation's average, mainly due to net inflow of trans-migrants.

Economy of Riau is dominated by oil sector consisting of PERTAMINA and CALTEX, which produces about 40-50 percent of Indonesia's total crude oil. Although recent production has not been on upward trend, it still accounts for more than 80 percent of Riau's GRDP. Unfortunately, the oil sector is isolated and close linkage with other economic activities of the province is not in place. Despite its huge production, the oil sector as a whole absorbs only 4 percent of the total labor force, while the agriculture employs 60 percent, 28 percent by the service, and 5 percent by the industry.

If the oil sector is excluded, the macro economic statistics of Riau looks very similar to that of West Sumatra especially when sectoral GRDP share of agriculture and service sector, as well as their breakdowns to sub-sectors, are compared, although Riau's per capita GRDP is slightly higher than West Sumatra and its growth rate is lower. In reality, however, Riau appears to be less advanced in terms of production technologies and facilities. Irrigation facilities, for instance, are more developed in West Sumatra and, as a result, production per unit of planted area of major crops such as paddy and maize in Riau is about two-thirds of that of West Sumatra. Furthermore, the sectoral GRDP share of industry in Riau, i.e., 7 percent, falls short of that of West Sumatra and the nation's average by 4 percent and 6 percent, respectively.

Table 2.1-2 Sectorwise GRDP and Employment

Sectors	Sectorwise GRDP 1982 (%)			Growth rate of GRDP 1975 - '82 (%)			Sectorwise employment (%)		
	W. Sumatra	Riau	Indonesia	W. Sumatra	Riau	Indonesia	W. Sumatra	Riau	Indonesia
Agriculture	32.1	30.0	26.3	4.7	3.8	3.9	66.3	59.8	58.3
Edible product	18.4	17.1	16.7	3.9	4.9	4.4	-	-	-
Non-edible product	5.6	4.1	2.1	4.3	3.5	5.7	-	-	-
Gardening product	0.0	0.1	1.7	-10.4	-5.3	6.5	-	-	-
Stock-raising	3.4	2.0	2.4	6.9	6.0	1.9	-	-	-
Forestry	0.8	1.5	1.7	-0.7	10.6	-4.8	-	-	-
Fishery	3.9	4.3	1.8	9.4	-4.8	5.1	-	-	-
Mining	1.0	6.3*	19.6	17.9	-8.0	1.9	0.2	3.9	0.7
Oil	-	-	-	-	-8.1	-	-	-	-
Others	1.0	6.3	-	17.9	3.6	-	-	-	-
Industry	11.0	6.8	12.9	10.9	13.8	12.2	4.7	5.0	9.6
Construction	6.5	2.6	5.9	16.9	3.7	11.0	2.2	3.3	2.8
Service industry	49.6	54.3	35.4	9.9	6.9	9.6	26.4	28.1	28.6
Transport/Communication	7.2	11.7	4.7	7.6	6.1	13.1	-	-	-
Electricity/Waterworks	0.4	0.6	0.6	18.6	21.7	14.5	-	-	-
Commerce/Hotel	27.1	26.5	14.9	11.7	5.8	7.6	-	-	-
Financing	1.7	1.6	2.7	22.9	19.9	14.2	-	-	-
Real estate	3.1	6.2	2.9	2.1	0.7	9.6	-	-	-
Administration	8.4	6.3	7.4	9.2	18.6	10.2	-	-	-
Others	1.7	1.4	2.2	4.7	11.6	2.3	-	-	-
Total	100.0	100.0	100.0				100.0	100.0	100.0

Note: *Excluding oil sector.

Sources: Pendapatan Regional, BAPPEDA/Kantor Statistik (West Sumatra)
Investment Proposals, BKPM (West Sumatra)
Perkircan Pendapatan Regional, BAPPEDA/Kantor Statistik (Riau)
Rencana Penbangunan Lima Tahun Keempat. Propinsi Daerah Tingkat I Riau, World Bank Economic Report in Indonesia (1985)

2.2 Present Situations of Power Demand and Supply

2.2.1 Transition of Power Demand

According to the transition of power demand in both West Sumatra and Riau Provinces for the past ten years from 1975, the power demand indicated an annual average growth rate of 22% on an average in both Provinces, that is, 24% in West Sumatra Province and 17% in Riau Province (Refer to Table 2.2-1). Moreover, a very high annual average growth rate of 26% was recorded particularly during the four year period from 1978 through 1981. This very high growth rate of power demand is considered to have resulted from promotion of electrification in general households as part of the third five year development plan (REPELITA III) (Refer to Table 2.2-2).

However, the number of cities where the electrification rate exceeds 20% are Padang and Bukittinggi in the Province of West Sumatra and Pekanbaru in Riau Province. The rate still remains at about 10% in all other areas in Central Sumatra (Refer to Table 2.2-3).

Meanwhile, the categorywise constituent ratio of power demand did not undergo any remarkable change for the nine years from 1974 through 1982, with the ratio being 51 - 58% for household, 11 - 17% for commercial, 7 - 11% for industrial and 17 - 25% for public consumption, respectively.

However, the ratio of industrial demand indicated a rapid growth, from about 10% in the past to 34% in 1983, while the power demand of other categories indicated a rapid decrease, as much as 43% particularly in the case of household power consumption. This rapid increase of power consumption in the industrial sector is due largely to the rapid increase in power demand by the Padang Cement. (Refer to Annex 2-1).

2.2.2 Present Situations of Power Facilities

(1) Power source facilities

The installed capacity of power source facilities of PLN in Central Sumatra as of April 1985 are as follows (Refer to Annex 2-2 (1), (2)).

Unit: MW

Power Plant / Province	Diesel P.P.	Gas Turbine P.P.	H.P.P.	Total
West Sumatra	38.7	43.2	78.5	160.4
Riau	35.6	-	-	35.6
Total	74.3	43.2	78.5	196.0

The yearly generated output in fiscal year 1984 was 334 GWh, among which 37%, 1% and 62% was generated by diesel power plants, gas turbine power plants and hydro-power plants, respectively.

Judging from the above values, diesel power plants occupy about 40% of the total installed capacity of 196 MW. Among these power sources, the Maninjau Hydro-Power Plant (68 MW) and the Batang Agam Hydro-Power Plant (10.5 MW) in West Sumatra are important and unique examples.

In Central Sumatra, on the other hand, there are a great many industrial plants and enterprises having captive power plants. Namely, there are many captive power plants having a total installed capacity of about 400 MW, including the 24 MW plants of Padang Cement in West Sumatra, 225 MW (60 Hz) of CALTEX and 106 MW of PERTAMINA in Riau Province

(Refer to Annex 2-3 (1), (2)).

(2) Transmission and Distribution Facilities

A 150 kV transmission line is operated along a 163 km route from the Maninjau Hydro-Power Plant in West Sumatra to Salak at the eastern part of the Province through Padang, the capital city of the Province (Refer to Fig. 2.2-1).

In addition, 780 km 20 kV and 271 km 6 kV distribution lines have been in service as of June 1985 (Refer to Annex 2-4).

CALTEX and PERTAMINA have their own captive power plants. However, independent power transmission systems have been extended for exploration, refining and transfer of oil. Notably, CALTEX has particularly long 115 kV and 44 kV transmission lines (Refer to Annex 2-5).

Table 2.2-1 Historical Record for Sold Energy and Generated Energy in Wilayah III

Fiscal Year	1975	76	77	78	79	80	81	82	83	84
West Sumatra										
Sold Energy (GWh)	28.5	32.1	36.0	41.6	52.3	65.4	83.4	93.5	163.1	199.0
									(104.8)	(112.0)
Generated Energy (GWh)	39.2	36.5	53.3	63.2	76.8	93.9	115.8	121.5	209.0	254.1
Loss Rate (%)	27	12	32	34	32	30	28	23	22	22
Growth Rate of Sold Energy (%)	1.9	12.6	12.1	15.6	25.7	27.5	27.5	12.1	75.2	21.5
									(12.1)	(6.9)
Riau (exclude isolated islands)										
Sold Energy (GWh)	16.3	16.8	19.0	23.2	28.2	37.5	45.8	51.3	60.8	65.7
Generated Energy (GWh)	20.0	22.0	24.3	30.0	35.8	46.3	54.7	65.6	77.1	80.0
Loss Rate (%)	19	24	22	23	31	19	16	22	21	18
Growth Rate of Sold Energy (%)	18.1	3.1	16.6	22.1	21.6	33.0	22.1	12.0	18.5	8.4
Total (West Sumatra and Riau)										
Sold Energy (GWh)	44.8	48.9	55.0	64.8	80.5	102.9	129.2	144.8	223.9	264.9
									(165.6)	(177.7)
Generated Energy (GWh)	59.2	58.5	77.6	93.2	111.9	140.2	169.8	187.1	286.1	334.1
Loss Rate (%)	24	17	29	30	28	27	24	23	22	21
Growth Rate of Sold Energy (%)	12.0	9.2	12.5	17.8	25.2	29.8	25.6	12.1	54.6	18.3
									(14.4)	(7.3)

Note : Figure in parenthesis does not include the load of Padang Cement Factory.

Source: PLN Wilayah III

Table 2.2-2 Number of Consumers and its growth rate

Fiscal Year	Residential		Commercial		Public (Office, Build, Lighting etc.)		Industry	
	Nos. of	Growth Rate (%)	Nos. of	Growth Rate (%)	Nos. of	Growth Rate (%)	Nos. of	Growth Rate (%)
1974	27,177		3,753		1,830		213	
		1.7		6.1		4.4		-0.5
75	27,640		3,983		1,910		212	
		4.0		4.9		9.1		5.2
76	28,748		4,176		2,084		223	
		15.3		14.7		13.9		1.4
77	33,142		4,790		2,373		226	
		30.7		21.5		16.1		3.4
78	43,309		5,799		2,756		235	
		33.2		15.6		13.7		11.5
79	57,684		6,701		3,133		262	
		31.5		15.9		12.7		-2.7
80	75,601		7,764		3,532		255	
		20.2		6.9		18.2		63.1
81	90,889		8,297		4,175		416	
		16.9		9.2		15.2		0
82	106,222		9,060		4,811		416	
		21.1		16.9		15.5		13.5
83	128,646		10,588		5,556		472	

Table 2.2 - 3 Present Electrification Ratio

unit:(%)

S.No.	Location	Electrification ratio by year	
		1982	1984
1	Padang	23	33
2	Bukittinggi	33	43
3	Payakumbuh	7	9
4	Batusangkar	13	18
5	Padang Panjang	14	17
6	Pariaman	4	6
7	Solok	7	11
8	Sawahlunto	2	4
9	Painan	7	9
10	Lubuk Sikaping	4	5
11	Surantih	0	4
12	Sungaidareh	0	1
13	Sungai Penuh	5	9
14	Others(W.S)	-	1
15	Pekanbaru	37	46
16	Bangkinang	4	8
17	Dumai	13	18
18	Duri	7	16
19	Minas	0	0
20	B.Siapi-api	13	15
21	Rengat	4	7
22	Tembilahan	6	8
23	Teluk Kuantan	2	3
24	Cerenti	0.1	1
25	Ujungbatu	0.1	1
26	Others(R)	-	2

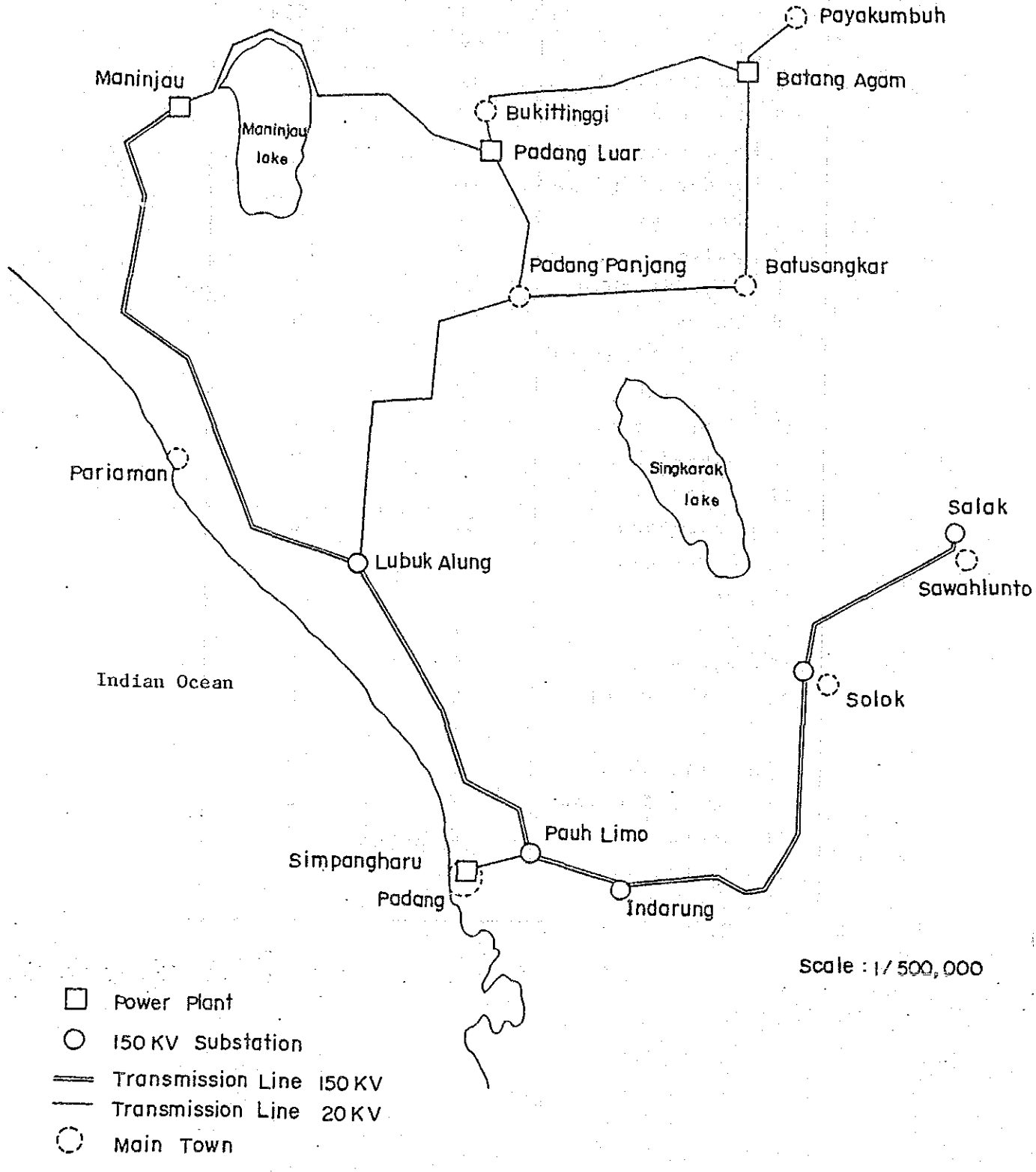

Fig. 2.2 - 1 Present Status of Central Sumatra Transmission Line System

2.3 Organization and Financial Position of PLN

2.3.1 Organization

Perusahaan Umum Listrik Negara (PLN), a national electric power corporation, was established in 1962 and reorganized into the present organization of a public corporation in 1972. PLN has the right of and responsibility for integrated power supply services from generation, transmission to distribution throughout Indonesia under the control of the Minister for Mining and Energy.

With its head office located in Jakarta, the organization of PLN consists of the five departments, namely, planning, construction, operation, financing and general administration, all under the control of the President of PLN. Branch offices and construction offices have been established in the respective districts to operate and manage the power system.

The organization of PLN is as shown in the following tables:

(1) Overall organization of PLN: Annex 2-6

(2) Organization of PLN Head Office: Annex 2-7

(3) Organization of PLN Wilayah III: Annex 2-8

Wilayah III, the third branch of PLN, is located in Padang on Sumatra Island, and undertakes management and operation of the power facilities in Central Sumatra which are directly related to this feasibility study.

Meanwhile, the construction office (indicated by thick lines in Annex 2-6), located in Bukittinggi of West Sumatra, is in charge of construction of power plants, transmission lines and substations in Central Sumatra.

2.3.2 Financial Performance

Major source of PLN's revenues is sales of electricity, which comprised about 95 percent of the total in 1983. In consumer-category-wise, 46 percent of the sales revenues came from Residential followed by Industry (26 percent), Commercial (16 percent), Office (10 percent), and Public Lighting (1 percent).

The sales revenues were almost tripled between 1980 and 1983, due to 53 percent increase in electricity sold and 83 percent increase in tariff level, and reached Rp.760 billion in 1983. Nevertheless, operating costs also increased keeping place with the revenues and, as a result, a rate of return on net fixed assets in operation was less than 1 percent, although positive.

The largest contributer to this cost increase was fuel, which showed almost five-fold increase between 1980 and 1983 and shared 57 percent of the total operating cost. This rapid rise of fuel cost reflected the energy pricing policy of the government aiming at removing subsidies to domestic petroleum products. Now that the fuel price has already reached the international level, PLN's expenses on fuel are not expected to increase from now on as fast as previously.

In addition to PLN Head Office, each Wilayah has been preparing its own financial statements which fundamentally comply with standard accounting practice. According to Wilayah III's report, its financial operation was in the deficit in 1983 and turned to small surplus in 1984, while comprising about 2.4 percent of PLN's total revenue. Note that, since PLN Head Office is solely responsible for meeting debt-service of all the projects undertaken by PLN, neither interest payment nor amortization of principals is recorded in Wilayah's financial statements. (Refer to Table 2.3-1)

Table 2.3-1 Balance of Whole PLN and Wilayah III

(Unit: Rp.billion; percent)

	PLN				Wilayah III	
	1980	1981	1982	1983	1983	1984
Operating Revenues	288	364	543	803	19	28
Operating Expenses 1/	194	261	433	661	17	18
Depreciation	55	84	101	119	6	7
Net Income	39	17	2	5	-4	4
Debt Service:						
Interest	-	2	5	19	-	-
Amortization	-	8	7	21	-	-
Operating Ratio 2/	1.16	1.06	1.02	1.03	0.83	1.12
Rate of Return 3/	5.2	1.8	0.2	0.3	-3.9	3.3
Debt-Service Coverage (times) 4/	-	9.9	6.3	3.1	-	-

Notes: 1/ Operating expenses exclusive of depreciation
2/ Operating revenues/(Operating expenses + Depreciation)
3/ Rate of return on net fixed assets in operation
4/ (Net income + Depreciation)/(Interest + Amortization)

2.3.3 Tariff

The Ministry of Mines and Energy is the authority which gives an approval, after consultation with the President and the members of the Meeting of Ministers for Economic Planning and Development, for revising PLN's tariff level and structure. The latest revision made in March 1984 has brought up the average tariff to almost Rp.100/kWh (Table 2.3-2); however, this tariff level is higher than 1975 level by only 20 percent in real term and is still below the estimated long-run marginal cost of PLN's electricity supply, i.e., about Rp.130/kWh in 1984 price.

Table 2.3-2 Unit Price of PLN's Electric Tariff

(Unit: Rp./kWh)

Year	1975	1982	1983	1984	1984/1975
Average Tariff					
Current Price	21.7	56.6	75.0	98.3	4.53
1975 Price	21.7	18.6	22.8	26.0	1.20

The present tariff system consists of 17 consumer categories. For almost all the consumer categories, two-part charges, i.e., the fixed charge (demand charge) and the charge variable according to energy consumption (energy charge) are applied. The exceptions are Small Consumer which are charged at a monthly fixed rate and Temporary Service which are applied only the energy charge. For Big Commercial, most of Industry, and medium-voltage Office consumers, time-of-day pricing of the energy charge, i.e., peak-hour and off-peak-hour rates, is in effect. As similar to other electricity supply entities, lower-voltage consumers are paying at a higher rate per unit consumption of electricity while Small Consumer, Social Institutions, and Street Lighting are cross-subsidized from other consumers.

The connection charge varies in each PLN's administrative region although a uniform rate is applied throughout Indonesia in the case of the demand and energy charge mentioned above. The connection charge per VA decreases as the size of contracted power increases. A small household in Wilayah III with contracted power of 500 VA, for instance, has to pay Rp.50,000 (Rp.100x500VA) for a new connection. Furthermore, two-month worth of electricity bill is usually required as a guarantee deposit. However, the rate is reduced in some areas where electricity is supplied only in the evening and early in the morning due to high operation cost of isolated diesel power plants. Subsidies/installment payment plan are not available in Wilayah III although, in some other regions, such a scheme is practiced for

promoting connections of low-income families. Obviously, a new connection requires the cost of inhouse wiring to be paid out to private contractors, in addition to the connection charge and deposit, which is about Rp.40,000 - 50,000 in the case of rural small house.

o Billing and Collection

Meter-readers visit customers houses for meter reading once a month and, based on the records, bills are issued. It is not a common practice that bill collectors go to customers' places. Instead, customers come to designated PLN's offices (Cabang, Sub-cabang, Ranting, and Sub-ranting) to make payments against their bills kept in the office. In some areas, arrangements are made for collection at counter of Giro Bank, Bank Bumidaya, and so forth.

Accounts receivable of PLN as a whole and Wilayah III are 2.6 month and 1.8 month worth of monthly billings, respectively, which are not significantly large comparing to the normally considered appropriate size of 1.5 - 2.0 month worth. According to PLN, this satisfactory collection efficiency has been maintained owing to PLN's practice to cut electricity supply when delinquencies in payment continues for a few months.

2.3.4 Investment Finance

Investment in the electric power sector accounts for about 10 percent of the government development expenditures and 19 percent of foreign project aid receipts in 1985 budget. Allocation of funds during REPELITA IV for power stations, transmission lines and substations, distribution lines, and rural electrification is, although subject to change, about 60-70 percent, slightly below 10 percent, 15-20 percent, and slightly below 10 percent, respectively.

Major financing sources and their financing share in about Rp.1,000 billion of PLN's planned investment in 1983 were as follows:

Financing Source	% Share
Sectoral Department Development Budget (APBN)	15%
Grants from Foreign Countries	8%
Foreign Aid Fund (BLN)	37%
PLN's Internal Cash Generation (APLN)	39%
Others (PMP, Local Borrowing, etc.)	1%

APBN, Grants, and PMP are treated as capital in PLN's balance sheet and, therefore, they do not require repayment. Debt-service is required for Local Borrowing, whose typical terms and conditions are 8 year repayment period including 2 year grace period at 16 percent interest rate per annum. Foreign loans from such as IBRD, ADB, and KFW are firstly lend to the Ministry of Finance. Then, the ministry provide "re-loan" to PLN applying the same terms and conditions as the original sources. However, such re-loans are in terms of Rupia and, therefore, foreign exchange risks are borne by the Ministry of Finance. In case of OECF, proceeds are provided to PLN as equity through PMP Fund. In addition to these financing sources, there is small government budget specifically designed for pilot rural electrification programs in Java; however, such finance has not been extended to Wilayah III up to now.

Due to recent stringent condition of the government budget, PLN is expected to rely increasingly on borrowings instead of government equity contributions. Effects of the tight budget has already been appearing in PLN's financial statement. Debt-service payments, which were almost negligeble in 1980, have been growing rapidly, although their impacts on cashflow is still not significant.

SECTION 3

POWER DEMAND FORECAST

SECTION 3 POWER DEMAND FORECAST

In working out a electric power system plan, it is required to forecast the power demand in the future at first. Moreover, it is particularly essential to work out the transmission line and substation plans on the basis of the future trend of district power demand. Although the power system plan under this project covers a period up to 1995, the trend of power demand after 1995 is also required to be predicted properly so as to make it possible to establish an appropriate power system configuration over a long period. On the occasion of executing power demand forecast, therefore, the West Sumatra and Riau Provinces were divided into the fourteen and the twelve blocks, respectively, and yearly power demand forecast in the respective blocks by 2005 was extended by computation.

Meanwhile, in consideration that the values of demand forecast would vary extensively depending upon fluctuation of economic situations, demand forecast was carried out with regard to the following three levels, namely, basic, high and low levels, and the overall demand forecast was checked according to macroscopic power demand forecast method.

In order to make clear the demand in the blocks to be interconnected successively to the high voltage power transmission system to be established across both of the provinces, the "system demand" is also presented separately hereunder.

3.1 Method of Demand Forecast

3.1.1 Demand Forecast Procedures

(1) Selection of related demand blocks.

At first, cities, towns and villages which are to be considered as areal blocks of power consumption in Central Sumatra were selected.

(2) Demand forecast according to the type of consumers.

The power demand in each block was classified into the four categories, namely, residential, commercial, public and industrial consumers, and future power demand was forecasted with respect to each consumer category according to the following methods. Then, the gross power demand was obtained by adding the values of category-wise demand forecast.

a. Demand forecast for residential consumers.

The power demand for residential consumers was forecasted based upon the estimated values of population, number of family members per household, electrification rate and power consumption per consumer.

b. Demand forecast for commercial consumers.

Since the number of commercial consumers generally increases in proportion to the increase of the number of residential consumers or nearly at the same ratio to the number of residential consumers, the power demand for commercial consumers was forecasted by taking into account the predicted constituent ratio of commercial consumers

(ratio of the number of residential consumers to that of commercial consumers) and future trend of power consumption per consumer.

c. Demand forecast for public consumers.

On the assumption that the number of public consumers will increase in proportion to the increase in the total number of residential and commercial consumers, the power demand for public consumers was forecasted by taking into account the predicted constituent ratio of public consumers (ratio of the total number of residential and commercial consumers to that of public consumers) and future trend of power consumption per consumer.

d. Demand forecast for industrial consumers.

i) Existing consumers (excluding Padang Cement)

The power demand for existing industrial consumers was forecasted based on the future growth rate predicted from the growth rate of power demand in the past.

ii) Waiting consumers

. On the assumption that the industrial plants with captive power plants (excluding PERTAMINA and CALTEX) will receive power supply from PLN after expiration of the service life of the existing captive power plants. And the power demand was forecasted based on the present consumption and expected growth rate of demand after expiration of the service life.

. The power demand for potential consumers and new projects was forecasted based upon the pertinent data and growth

rate of power demand expected after receiving power supply from PLN.

e. Big consumers

With respect to the leading three big industries in Central Sumatra, the power demand for these consumers was forecasted based upon whether they intend to receive power from PLN or not.

i) Padang Cement

Since this cement plant has already been receiving power from PLN, the demand for this consumer was forecasted based upon its future production plan.

ii) PERTAMINA, Dumai

On the occasion of investigation in Indonesia, the study team members met with a representative of the oil refinery of PERTAMINA and discussed on the possibility of receiving power from PLN by 1995 when the power transmission system of PLN is scheduled to be constructed up to Dumai. As a result, it was felt highly probable that PERTAMINA would possibly receive power from PLN with respect to the power demand exceeding the installed capacity of its captive power plants required for stable power supply. Since 100% guarantee was not obtained to incorporate the power demand for PERTAMINA into PLN's demand forecast. Therefore the power demand for Central Sumatra was forecasted with regard to the two cases, namely a case where PERTAMINA will receive and not receive power from PLN.

iii) CALTEX

CALTEX has its own independent 60 Hz 115 kV power system, and electric power for exploration and production of oil is supplied to a wide area, extending from Pekanbaru to Dumai in Riau Province.

Therefore, it was judged that there is no possibility of power supply to CALTEX in the near future and then the load estimation of CALTEX is excluded from the demand forecast.

3.1.2 Power Demand Forecast according to Three Levels

On the assumption that the power demand would fluctuate due to fluctuation of economic situations and other factors, power demand forecast was carried out with regard to the three basic, high and low levels with some marginal target electrification ratio in each power demand block.

3.1.3 Concrete Calculation Method for Power Demand Forecast

The collected and compiled data were classified into the input items shown in Table 3.1-1 and calculated according to the block diagram shown in Fig. 3.1-1.

3.2 Basic Conditions for Power Demand Forecast

3.2.1 Collection of Data

The basic data required for demand forecast were obtained as follows:

Basic data	Obtained from:
Population	Statistics Bureau Economic Planning Bureau
Transmigration plan	Transmigration Bureau
Electrification plan	PLN Head Office
Record of sold electrical energy Record of power consumption according to category-wise consumer Record of number of consumers according to category-wise consumers	PLN Wilayah III

Basic data	Obtained from:
Existing captive power plants Waiting consumers New consumers as potential demand	PLN Wilayah III Economic Planning Bureau Economics & Investment Bureau Industry Bureau Mining Bureau Plantation Bureau Forestry Bureau Waterworks Bureau Fishery Bureau
GDP	Economic Planning Bureau Statistics Bureau

3.2.2 Classification and Selection of Blocks for Power Demand Forecast

As the areas pertaining to power demand forecast for Wilayah III excluding isolated islands, the twenty-six blocks were selected (Refer to Table 3.2-1 (1), (2)).

These twenty-six blocks cover all of the areas requiring power supply in Central Sumatra.

3.2.3 Power Demand for Residential Consumers

(1) Prediction of population

(a) Sources

i) "Statistic Indonesia (1980)" published by Statistics Bureau

ii) "Dalan Angka (1984)" published by Economic Planning Bureaus of both of the provinces

(b) Growth rate of population

According to the above two statistics, the annual average growth rate of population in West Sumatra and Riau Province excluding isolated islands from 1971 through 1983 is as follows (Refer to Annex 3-1 (1), (2)):

West Sumatra Province : 2.2%/year
Riau Province : 3.5%/year

The annual population growth rate in the respective power demand forecast blocks by 1995 is assumed to be the same as the annual average growth rate from 1971 through 1983 in Kabupaten or Kotamadya belonging to one of the power demand forecast blocks. The population growth rate in the provinces in and after 1996 is expected to indicate a downward curve, and the average population growth rate per every five years is assumed to become as follows:

	1996 - 2000	2001 - 2005
West Sumatra	2.0% (= 2.2 - 0.2)	1.8% (=2.0 - 0.2)
Riau	3.4% (= 3.5 - 0.2 + 0.1)*	3.3% (=3.4 - 0.2 + 0.1*)

Note: The values denoted by asterisk refer to an additional portion reflecting the transmigration project.

The increase of population due to transmigration was estimated based upon the transmigration plan in the respective provinces according to the fourth five-year development plan (1984 - 1988).

The transmigration plan in and after 1989 was assumed as follows based on the data from the Central Transmigration Bureau in Jakarta:

West Sumatra	:	0 (Zero)
Riau	:	Same by 2005 as in 4th five-year plan

(2) Number of family members per household

On the basis of the national census in Sept. 1971 and Oct. 1981, the number of family members per household was estimated as follows:

From 1985 through 2005: 5 members/household

(3) Electrification ratio

Based on the fourth five-year plan of PLN and the forecast of PLN Head Office, the electrification ratio in 2005 was assumed as shown in Table 3.2-2.

(4) Growth rate of power consumption per consumer

On the basis of data of "Financial information 1983/84" of PLN, the growth rate of power consumption per consumer was assumed as follows:

From 1985 through 2005: 1%/year

3.2.4 Power Demand for Commercial and Public Consumers

(1) Increase rate of power demand per consumer

Based upon the data of "Financial information 1983/84" of PLN, the increase rate of power demand per consumer from 1985 through 2005 was forecasted as follows:

Power demand for commercial : 4.6%/year
Power demand for public : 1%/year

(2) Constituent ratio of number of commercial and public consumers to that for residential consumers

Based upon the records of sold electrical energy over the past ten years from 1975 through 1984 in the respective blocks in Wilayah III, the constituent ratio of commercial and public consumers to that for residential consumers was forecasted as shown in Table 3.2-3.

3.2.5 Power Demand for Industrial Consumers

(1) Existing consumers (excluding Padang Cement)

Based upon the "Financial information 1983/84 of PLN", the growth rate of power consumption per industrial consumer was forecasted as follows:

From 1985 through 2005: 9.5%/year

(2) Waiting consumers

(a) Owners of captive power plants (excluding PERTAMINA and CALTEX)

The data and information pertaining to the types and scales of industrial factories in which there are captive power plants at present were obtained from PLN and competent government agencies. On the assumption that the service life of diesel power plants is fifteen years and electric power would be supplied from PLN to these factories subsequent to expiration of the service life, the power demand increase was forecasted at an annual average rate of 5% by 2005 after they start receiving

power supply from PLN.

(b) Other potential consumers

The power demand for other potential consumers was forecasted based upon the data and information collected from PLN, Economic Planning Bureau, Economics & Investment Bureau, Industry Bureau, Mining Bureau, Plantation Bureau, Forestry Bureau, Waterworks Bureau, Fishery Bureau, etc. in the provinces of West Sumatra and Riau.

As a result, the electric power demand for other potential consumers was forecasted to increase at an average annual rate of 5% by 2005 after they start receiving power supply from PLN.

(3) New power demand

The power demand for new consumers such like coconut oil extraction plants was forecasted on the assumption that 20%* of the total power demand required for the respective captive power consumers will be supplied from PLN. As a result, the power demand in this category was forecasted to increase at the same rate of 5% as that of waiting consumers in 3.2.5 (2) by 2005 after they start receiving power supply from PLN.

*: By operating captive diesel power plants by firing coconut husks after extracting oil, it will be possible to meet the power demand for industrial plants, and only the portion of electric power required for employees' housing, offices, street lighting, etc. will be received from PLN. This portion of electrical energy to be supplied from PLN corresponds to 20% of the total power demand for industrial plants.

(4) Big industrial consumers

(a) Padang Cement

The power demand for Padang Cement was forecasted on the assumption that its 3 million ton/year production system will be established in 1995. As a result, the power demand for this consumer was forecasted to grow at an annual average rate of 5% after 1995.

(b) PERTAMINA, Dumai

The power demand in case electric power is supplied from the power system of PLN was forecasted based upon the following assumptions:

i) The power consumption of PERTAMINA will increase at an annual average rate of 5% after 1985.

ii) The transmission line from Pekanbaru to Dumai will be completed at the end of March 1995.

iii) The transmission line from Dumai to PERTAMINA will be completed by the end of September 1995, and the portion of electric power demand exceeding the installed capacity of its captive power plants required for stable power supply will be supplied from PLN.

3.2.6 Three Levels of Power Demand Forecast

The power demand forecast was carried out based upon the three levels, namely, basic, high and low levels of target electrification rate in 2005 shown in Table 3.2-2.

3.3 Results of Power Demand Forecast

The results of power demand forecast are shown in Table 3.3-1 12 as listed below:

Table No.		Description
3.3-1	Basic	Entire Wilayah III including PERTAMINA
2	Basic	150 kV system including PERTAMINA
3	Basic	Entire Wilayah III excluding PERTAMINA
4	Basic	150 kV system excluding PERTAMINA
5	High	Entire Wilayah III including PERTAMINA
6	High	150 kV system including PERTAMINA
7	High	Entire Wilayah III excluding PERTAIMNA
8	High	150 kV system excluding PERTAMINA
9	Low	Entire Wilayah III including PERTAMINA
10	Low	150 kV system including PERTAMINA
11	Low	Entire Wilayah III excluding PERTAMINA
12	Low	150 kV system excluding PERTAMINA

3.4 Check of Forecasted Power Demand

3.4.1 Power Demand Forecast Based on GDP

Power demand forecast in Wilayah III including isolated islands was carried out based on the following basic assumptions by taking into account the past records of the growth rates of sold electrical energy and GDP or GRDP throughout entire Indonesia and those in Wilayah III.

(1) GDP throughout Indonesia

(a) Records of GDP

The annual average growth rate of GDP in 1978 through 1982

is assumed at 6.5% (Refer to Table 3.4-1).

(b) Estimation of GDP

According to the fourth five-year development plan (REPELITA IV) started in 1984, the target growth rate of real GDP is set to a slightly lower level of 5% a year as a target economic growth rate in Indonesia.

In consideration that the growth rate of GDP which slowed down to 2.2% in 1982 was restored to 6.5% (tentative value) in 1984, the GDP was assumed to grow at a slightly higher rate of 5.5% than 5% as a standard value.

Unit: %

Year	1985 - 1995	1995 - 2005
Standard	5.5	5.0
High	5.8	5.3
Low	5.2	4.7

(2) Elasticity of Energy Demand to GDP

(a) Transition of elasticity of energy demand

The mean elasticity of energy demand from 1979 through 1982 is assumed as 2.6 considering weighted experience on recent 2 ∿ 3 years (Refer to Table 3.4-2).

(b) Estimation of the elasticity of energy demand

Under worldwide economic situations where low growth rate is still expected to prevail continuously further in the

future, the economy of Indonesia cannot said to be exceptional. Therefore, the elasticity of energy demand is predicted to be slightly lowered together with GDP as follows:

Year	1985 - 1995	1995 - 2005
Elasticity	2.5	2.0

(3) Ratio of sold electrical energy in Wilayah III to that in entire Indonesia

As shown in Table 3.4-3, the ratio of the sold electrical energy in Wilayah III to that in entire Indonesia indicated nearly the same level in the past from 1978 through 1982. On the assumption that this trend will continue in the future as well, the ratio was set at 1.7%.

3.4.2 Power Demand Forecast Based on GRDP

Power demand forecast based on GRDP was carried out according to the same procedures in 3.4.1 based upon the following assumptions.

(1) GRDP in Wilayah III (Refer to Table 3.4-1)

(a) Records of GRDP

Annual average growth rate of GRDP from 1975 through 1980 : 7.3%

(b) Estimation of GRDP

According to the fourth five year plan, the target economic growth rate in Wilayah III is set to 6.0% for West Sumatra and 6.5% for Riau Province, each exceeding

the nationwide target ratio of 5%.

This is considered to mean that a greater emphasis is placed on the national policies including transmigration policy than other regions. On the assumption that such preferential policies will still taken continuously in the future, the annual average growth rate of GRDP in both of the provinces was estimated as follows:

Unit: %

Year	1985 - 1995	1995 - 2005
Standard	6.0	5.5
High	6.3	5.8
Low	5.7	5.2

(2) Elasticity of energy demand in Wilayah III

(a) Transition of the elasticity of energy demand

Since the GRDP data only up to 1980 were available, the trend of GRDP in the latest years is not clear. The trend of GRDP from 1975 through 1980 is shown in Table 3.4-3(2).

(b) Estimation of the elasticity of energy demand

The elasticity of energy demand in Wilayah III was estimated similarly as in the case of the nationwide elasticity as shown in the following table.

Year	1985 - 1995	1995 - 2005
Elasticity	2.5	2.0

3.4.3 Results of Power Demand Forecast

The results of macroscopic power demand forecast are shown in Tables 3.4-3 (1), (2).

3.5 Comparison of the Results of Microscopic and Macroscopic Power Demand Forecast

The yearly total power demand obtained as a result of cumulating the power demand forecast with regard to the respective power demand forecast blocks and category of consumers, and the results of macroscopic power demand forecast are compared in the table below.

Since there is a considerable similarity between both the results of macroscopic and microscopic power demand forecast as this table indicates, the results are considered to constitute a sufficiently justifiable base of this power system plan.

Basic case

Unit: GWh

Items \ Year	1990	1995	2000	2005
Forecasted demand	469	827	1,373	2,016
Macroscopic forecast (1)	435	828	1,333	2,147
Macroscopic forecast (2)	426	831	1,340	2,160

Table 3.1 - 1 Input data

Location:

Description	Unit	Fiscal Year	1982/83	1984/85	1985/86 -'90/91	'91/921 -'95/96	'96/97 -2000/01	'01/02 -'05/06
1.Present nos. of population		R2						
2.Its growth rate	:%/year	R21						
3.Nos. of population on transmigration program		R1						
4.Its settlement ratio	:%/year	R11						
5.Nos. of people per household		R23						
6.Present nos. of electrified household (high)		R41						
7.Proposed growth rate on electrification program (high)	:%/year	R31						
6.Present nos. of electrified household (basic)		R41						
7.Proposed growth rate on electrification program(basic)	:%/year	R31						
6.Present nos. of electrified household (low)		R41						
7.Proposed growth rate on electrification program (low)	:%/year	R31						
8.Annual power consumption per household	:kWh/year	R42						
9.Its growth rate	:%/year	R44						
10.Constituent ratio of commercial customer		C11/R41						
11.Annual power consumption per commercial customer	:kWh/year	C12						
12.Its growth rate	:%/year	C14						
13.Constituent ratio of public customer		P11/R41+C11						
14.Annual power consumption per public customer	:kWh/year	P12						
15.Its growth rate	:%/year	P14						
16.Nos. of small industrial customer		I11						
17.Its growth rate	:%/year	I12						
18.Annual power consumption per small industrial customer	:kWh/year	I13						
19.Its growth rate	:%/year	I14						
20.Nos. of large industrial customer		I21						
21.Its growth rate	:%/year	I22						
22.Annual power consumption per large industrial customer	:kWh/year	I23						
23.Its growth rate	:%/year	I24						
24.Annual nos. of waiting customer		I31						
25.Its annual power consumption	:MWh/year	I32						
26.Annual nos. of new project customer		I41						
27.Its annual power consumption	:MWh/year	I42						
28.Load factor	:%							
29.Its growth rate	:%/year							

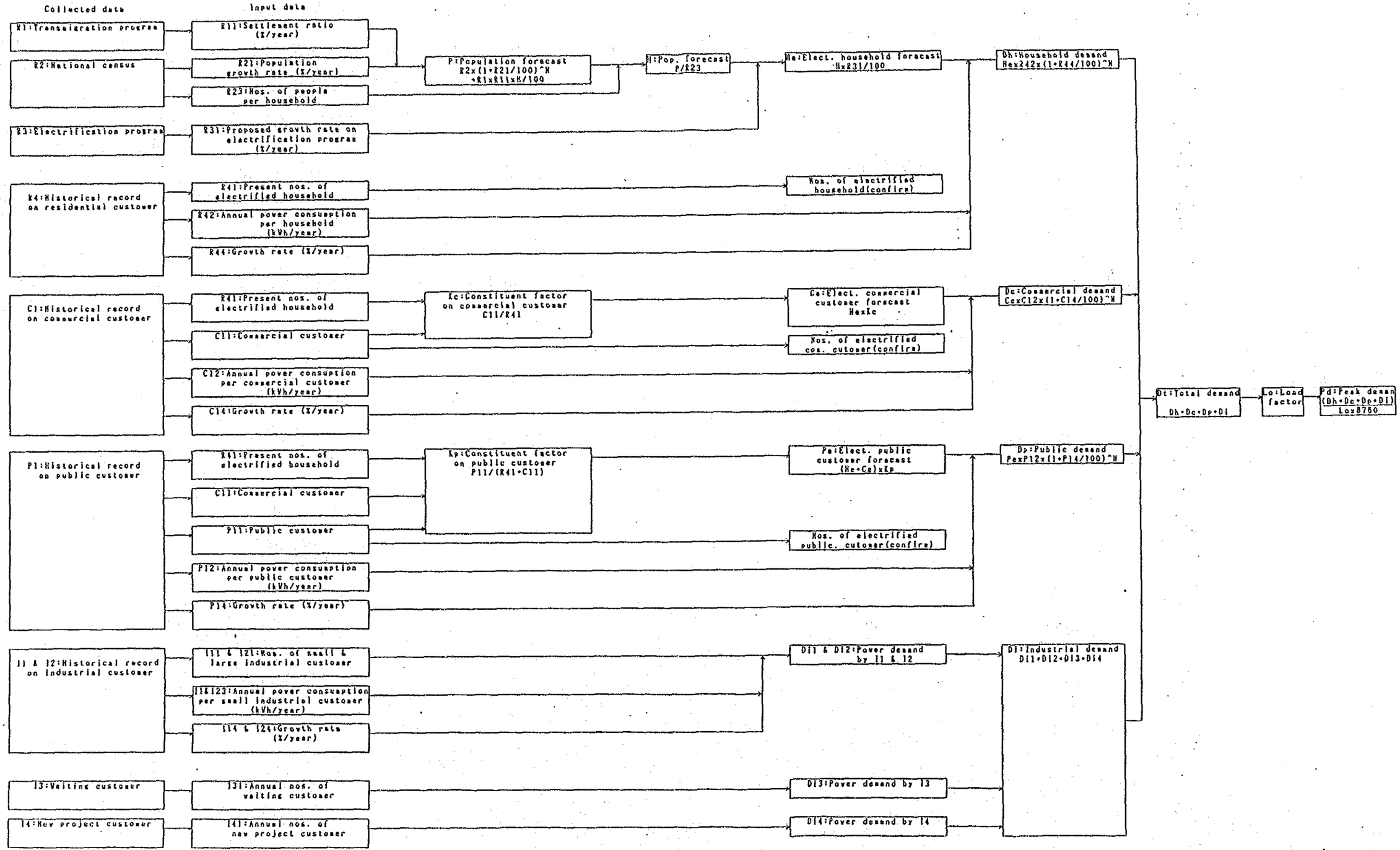

Fig. 3.1 - 1 Block Diagram

Table 3.2-1 (1) Load center & its objected area

Serial No.	Location (Load centre)	Its objected area (Kotamadya & Kecamatan wise)
1.	Padang	Kotamadya Padang
2.	Bukittinggi	Kodya. B. Tinggi, Kec. Sei Puar, Kec. IV Angkat Kec. IV Koto, Kec. Matur, Kec. Kamang, Kec. Baso
3.	Payakumbuh	Kodya. Payakumbuh, Kec. Payakumbuh, Kec. Suliki Kec. Guguk, Kec. Luhak, Kec. Harau
4.	Batusangkar	Kec. Kaum, Kec. Tanjun, Kec. Lintau Buo, Kec. Sungayang, Kec. Sei Tarab, Kec. Rambatan
5.	Padang Panjang	Kodya. P. Panjang, Kec. Pariangan, Kec. Batipuh Kec. Salimpaung
6.	Solok	Kodya. Solok, Kec. Kubung, Kec. IX Koto, Kec. Bukit Sundi, Kec. Gunung Talang Kec. Lembang, Kec. Payung
7.	Sawahlunto	Kodya, Sawahlunto, Kec. Sawahlunto, Kec. Talawi Kec. Koto VII, Kec. Sijunjung, Kec. IV Nagari
8.	Pariaman	Kec. Pariaman, Kec. 2x11 Eman Lingkung, Kec. Nan Sabaris Kec. Lubuk Alung
9.	Painan	Kec. Bayang, Kec. IV Jurai, Kec. Batang Kapas
10.	Lubuk Sikaping	Kec. Pasaman, Kec. Bonjol, Kec. Lubuk Sikaping Kec. Talaman, Kec. Rao Mapat Tunggul
11.	Surantih	Kec. Batang Kapas, Kec. Lengayang
12.	Sungaidareh	Kec. Pulau Pujung, Kec. Tj Gadung
13.	Sungai Penuh	Kabpaten Kerinci
14.	Others in W. Sumatra Province	Other Kecamatan in W. Sumatra Province
15.	Pekanbaru	Kodya, Pakenbaru, Kec. Siak Hulu
16.	Dumai	Kec. Dumai, Kec. Bukit Batu
17.	Bangkinang	Kec. Bangkinang, Kec. Kampar