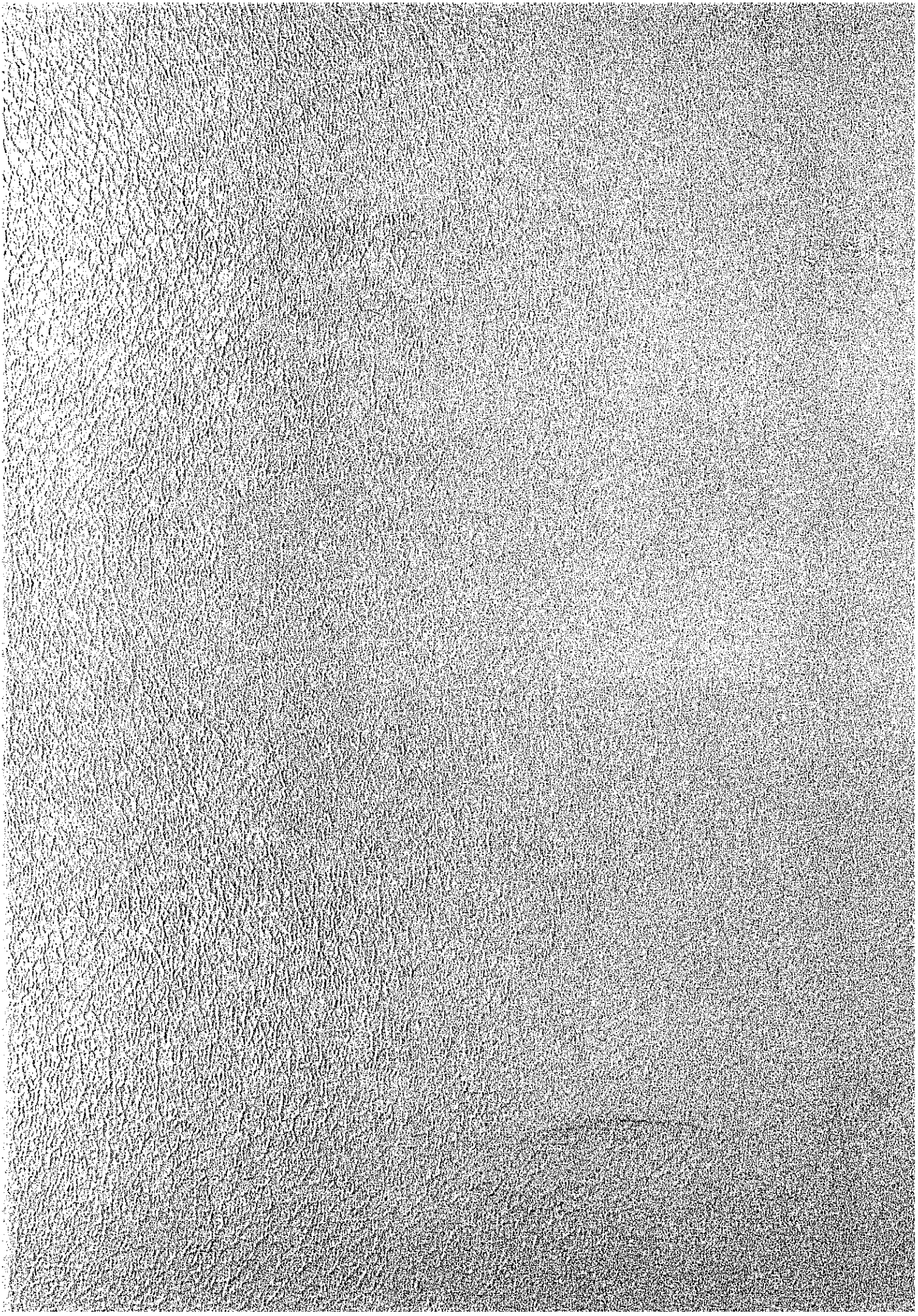


THE REPUBLIC OF INDONESIA

FEASIBILITY STUDY REPORT
ON
CONSTRUCTION
OF
BUKIT ASAM COAL-FIRED THERMAL POWER STATION, SUMATERA

MAY 1978

VOL. I

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

At the compliance of a request made by the Government of the Republic of Indonesia, the Government of Japan decided to undertake a feasibility study on the construction of Bukit Asam Coal-Fired Thermal Power Station and entrusted this study to the Japan International Co-operation Agency.

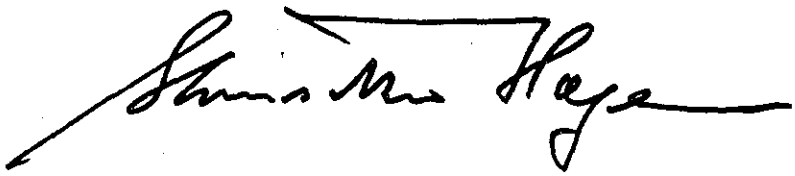
This study includes ascertainment of the viability of constructing a coal-fired thermal power station by utilization of coal produced in Bukit Asam and ajacent places in order to cope with the increasing power demand in Palembang and Bukit Asam area. With the said aim in mind, the Japan International Cooperation organized a survey team with the cooperation of the Japanese authorities concerned and had them to conduct the field studies during the period from September 25 through October 22, 1977.

The survey team is composed of nine (9) experts, in the respective fields headed by Mr. Masashi Mikuni, Assistant Manager of Thermal Power Engineering Department of Electric Power Development Co., Ltd., of Japan. They carried out forecast on power demand and power development, in South Sumatra, locational conditions for construction of a coal-fired thermal power station, progress of and schedule for coal production, etc, in the Republic of Indonesia.

After their return to Tokyo, the survey team elaborated required studies based on the data and information, which they gathered and collected during their study in Indonesia and also with the collaboration of many specialists in various fields. The report submitted herewith is the fruitful outcome of their efforts.

It is my sincere hope that this report will be of great help to the social and economics advancement of Indonesia and will make outstanding contributions to the further promotion of friendship between the two countries.

In closing, I would like to extend my heartfelt gratitude to persons concerned of PERUSAAN UMUM LISTRIC NEGARA (PLN) and officials of other Indonesian government agencies and to those of the Japanese Embassy in Indonesia, Ministry of Foreign Affairs and Ministry of International Trade and Industry of Japan for their valuable assistance and co-operation given to the team in preparing this report.



Shinsaku Hogen
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen, President
Japan International Cooperation Agency

Dear Sir:

Submitted herewith is a Feasibility Report on construction of a coal-fired thermal power station at Bukit Asam Mine on the island of Sumatera, Republic of Indonesia, and a plant for supply of electric power to the city of Palembang, municipalities in its surrounding area, and to the mine, utilizing the coal from the mine.

The Survey Team, upon the request of the Japan International Cooperation Agency, the sole executing agency of the Japanese overseas cooperation, was organized of nine experts for the purpose of undertaking a feasibility study on the Project and for a period of twenty-eight (28) days from September 25 to October 22, 1977, collected data and information, and exchanged opinions with Perusahaan Umum Listrik Negara (PLN) of Indonesia and its related agencies, and carried out field reconnaissances of the Project areas and of related places. Masashi Mikuni, Team Leader, revisited Indonesia for a period of seven (7) days from 5 to 11 March, 1978 in order to explain to the staff of PLN and related agencies the contents of the report in draft form.

This Report deals with a feasibility study on the construction of Bukit Asam Coal-Fired Thermal Power Station and includes development programs for construction of transmission lines and substations to be required for the said Power Station.

In this Report two alternatives are incorporated. They are; Alternative I which deals with construction of Bukit Asam Coal-Fired Thermal Power Station of 100 MW (50 MW x 2 units) by 1984 for supply of electric power in accordance with the increase in power demand in Palembang, its surrounding municipalities and the mine site to cope with the coal production increases of P.N. Tambang Batubara (TABA), and Alternative II that is related to construction of Bukit Asam Coal-Fired Thermal Power Station, 150 MW (50 MW x 3 units), 100 MW by 1984 and an additional 50 MW by 1987 taking into consideration power supply accompanying the mine development plan for the Shell mining concession.

Economic and financial analyses were made for Alternative I and Alternative II. As a result, it is judged that these are technically, financially and economically feasible as indicated in this Report.

Regarding the electric power system, a study was made of the possibility of interconnection among three provinces; Sumatera Selatan Province, Lampung Province, and Bengkulu Province.

Further, the problems involved in interconnection between the islands of Sumatera and Java have also been cited.

It is our sincere hope that through realization of this Bukit Asam Coal-Fired Thermal Power Station Construction Project stable and good-qualied power supply will be carried out thereby contributing to the economic development of Palembang and surrounding municipalities and improvement of the welfare of the residents in the area, to the smooth execution of the large-scale coal-mine development scheme planned by the Government of the Republic of Indonesia, and to the economic development of the Republic of Indonesia.

We would like to take this opportunity of expressing our deepest gratitude to Perusahaan Umum Listrik Negara (PLN), PLN Welayah IV, the Japanese Embassy in Jakarta, the Japan International Cooperation Agency, and the various government agencies concerned for their very great cooperation in connection with submittal of this Report.

May 1978

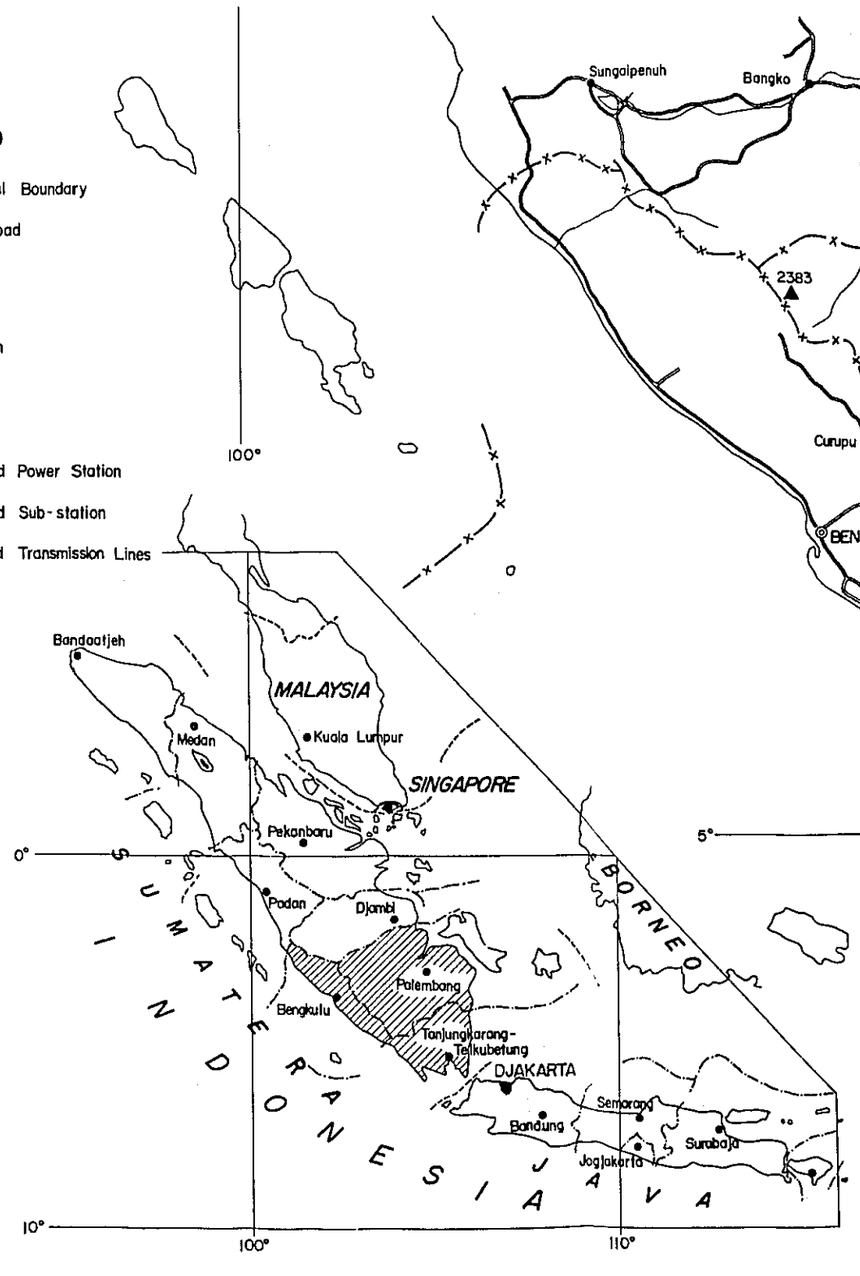
M. Mikuni

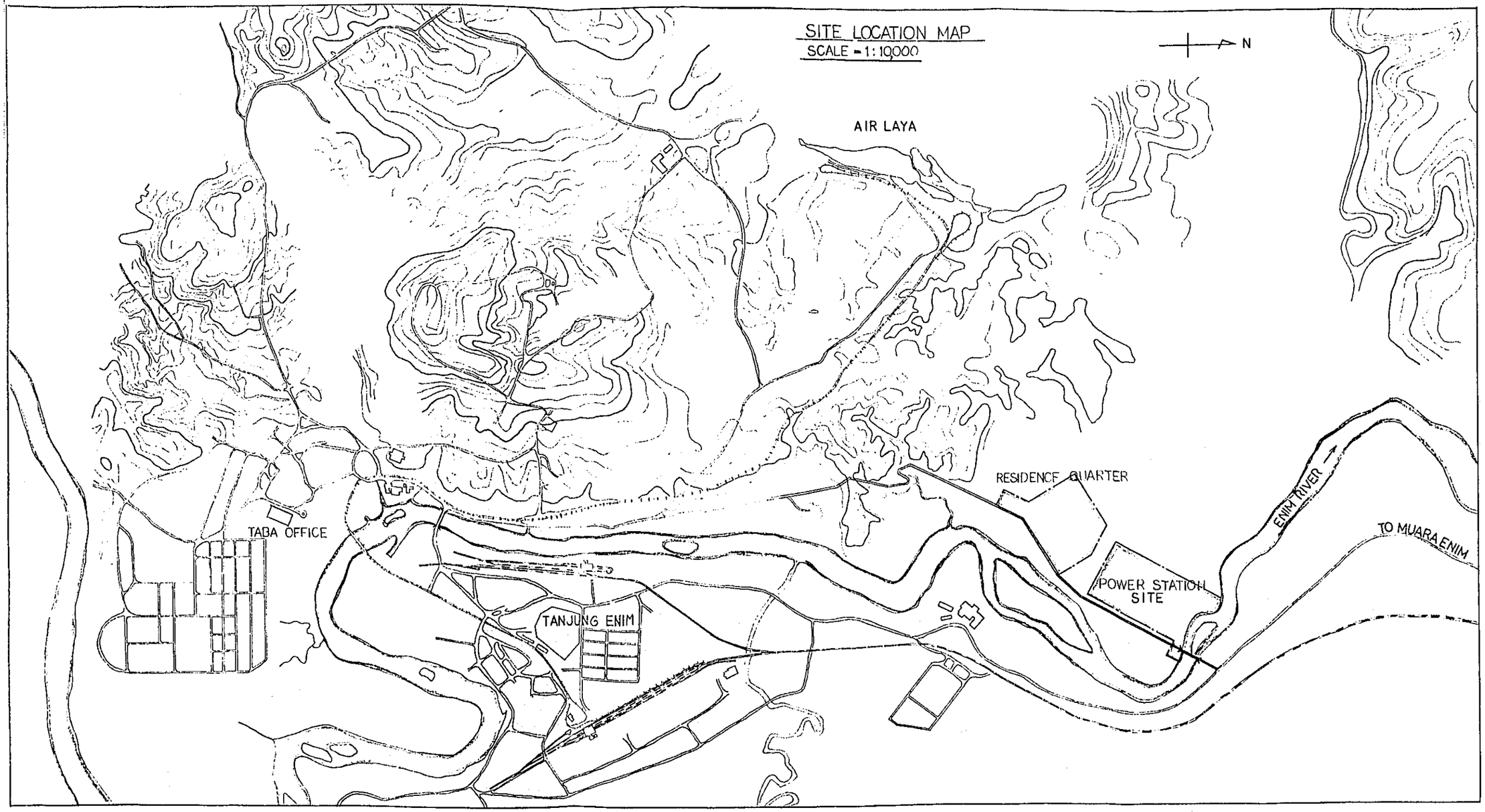
Masashi Mikuni, Leader
Bukit Asam Coal-Fired Thermal Power
Station Construction Project Survey
Team

Key Map of Sumatera Selatan

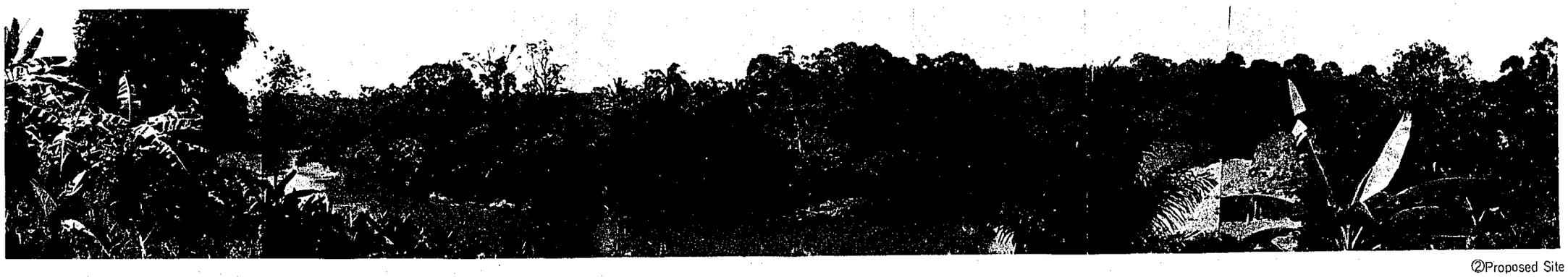
LEGEND

- —x—x— : Provincial Boundary
- ═══ : Main Road
- +++++++ : Railway
- ~~~~~ : River
- ▲ ▲ : Mountain
- ◎ : City
- ● : Town
- ○ : Proposed Power Station
- □ : Proposed Sub-station
- ═══ : Proposed Transmission Lines



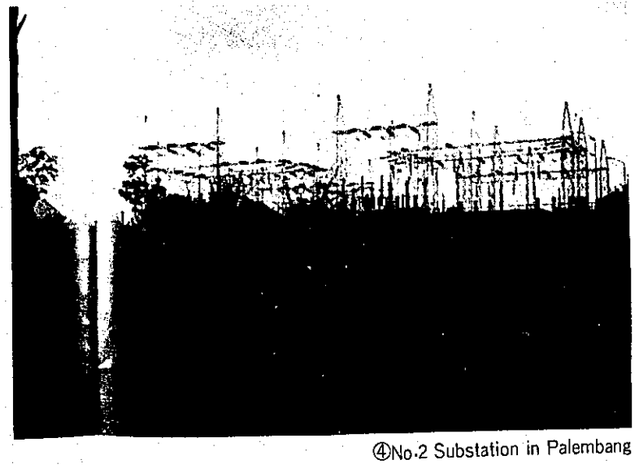

SITE LOCATION MAP
SCALE = 1: 10000
N
AIR LAYA
RESIDENCE QUARTER
ENIM RIVER
TO MUARA ENIM
POWER STATION SITE
TABA OFFICE
TANJUNG ENIM

①Bukit Asam coal mine



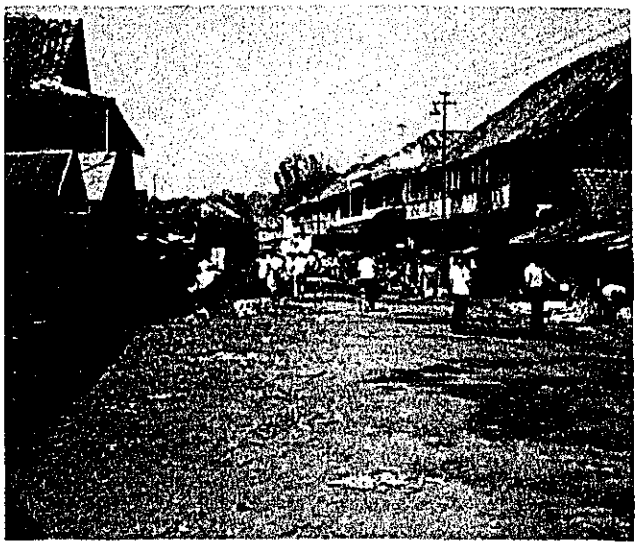
②Proposed Site

③Palembang

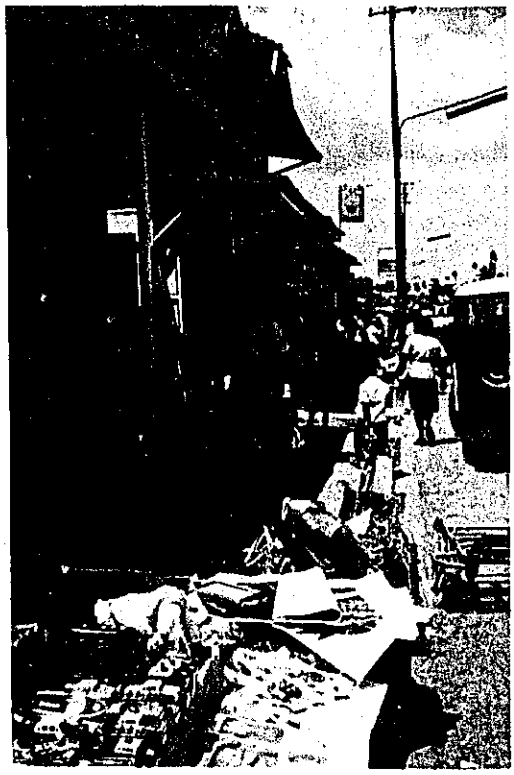


④No.2 Substation in Palembang

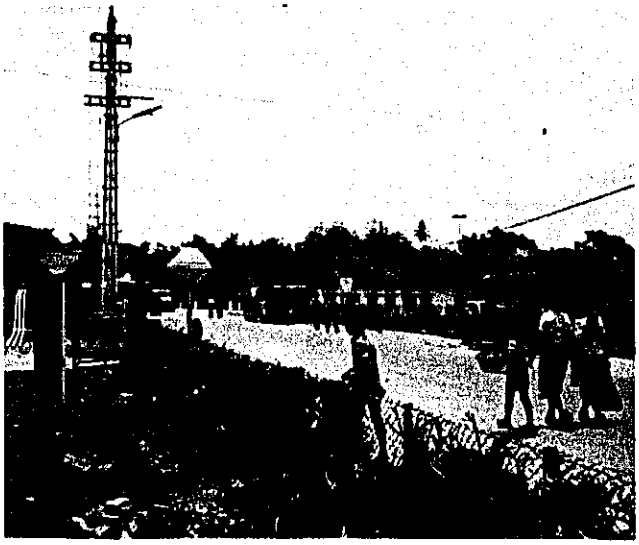
⑤Muara Enim



⑥Tanjung Enim



⑦Lahat



⑧Batu Raja

⑨Tanjung karang

CONTENTS

CHAPTER I

INTRODUCTION

CHAPTER 1. INTRODUCTION

1.1 Antecedents

The Government of the Republic of Indonesia has been contemplating to construct a thermal power station, utilizing coal produced at Bukit Asam Coal Mine located approximately 130km southwest of Palembang, Sumatera Selatan Province on the island of Sumatera of that country in order to supply electric power to be required in Palembang, its neighboring cities and at Bukit Asam Coal Mine as it is developed, and has conducted various surveys in this connection. Just as a project finding team of the Japan International Cooperation Agency visited Indonesia in January 1977, an informal request was made by the Government of the Republic of Indonesia for Japanese technical cooperation regarding a feasibility study for construction of Bukit Asam Coal-Fired Thermal Power Station, upon which the said team immediately reported the Government of Japan on the intent of the Indonesian Government, and at that time it also suggested to the Indonesian Government that formal procedures for a request be followed. The Government of the Republic of Indonesia, responding to this suggestion, formally requested the Government of Japan in May 1977 to conduct a feasibility study for construction of Bukit Asam Coal-Fired Thermal Power Station.

In view of the abovementioned background, the Japan International Cooperation Agency, the sole executing agency of the Japanese overseas cooperation, organized a Survey Team composed of 9 experts headed by Masashi Mikuni (affiliation: Electric Power Development Co., Ltd.). The team visited Indonesia for investigations for a period of 28 days from September 25, 1977.

1.2 Objectives of Survey

The objectives of this survey, in accordance with the request of the Government of the Republic of Indonesia, were to conduct a feasibility study whether electric power could be supplied to Palembang City and surrounding municipalities, and to the mine site, by constructing a coal-fired thermal power station utilizing the coal of Bukit Asam Mine (current annual production approximately 80,000 to 100,000 tons) located on the island of Sumatera, Indonesia, and in addition, to evaluate the possibilities of interconnecting the three provinces of Sumatera Selatan, Lampung and Bengkulu, and to cite the problems involved in interconnecting the islands of Sumatera and Java.

Further, to carry out the above, the objectives were to undertake field reconnaissances, collect data, inquire about the situation from Perusahaan Umum Listrik Negara (PLN) and related organs, and exchange opinions with the above.

1.3 Scope of Survey

The area made the object of the survey was Sumatera Selatan Province, Lampung Province, Bengkulu Province and related areas. However, Bangka Island was excluded from the survey area.

Regarding Sumatera Selatan Province, the scope of the survey included a feasibility study of constructing a coal-fired thermal power station near Bukit Asam Coal Mine to supply electric power to the city of Palembang which shows a prominent growth in power demand, adjunct places and to Bukit Asam Coal Mine, and to the Shell Concession, if necessary. The scope also included a study of the possibility of interconnecting the three provinces of Sumatera Selatan, Lampung and Bengkulu in case the power demands of these provinces increase, and also suggesting problematic points which should be considered with respect to interconnection

between the islands of Sumatera and Java.

1.4 Investigation Items

The JICA Survey Team, based on the results of field reconnaissances, data collection and inquiries about prevailing circumstances, formulated the plan for construction of Bukit Asam Coal-Fired Thermal Power Station with the items having the contents below as the main points.

(1) Fuel (Coal)
  1) Past History and Present State of Bukit Asam Mine
  2) Analyses of Coal Samples from Bukit Asam
  3) Coal Output Plan of Bukit Asam Mine and Coal Quality
  4) Cost of Coal Production at Bukit Asam Mine

(2) Electric Power Demand Forecast

(3) Electric Power Development Program
  1) Scale of Power Facilities
  2) Timing of Construction

(4) Electric Power System

(5) Coal-Fired Thermal Power Station
  1) Locational Conditions
  2) Preliminary Design and Construction Cost
  3) Economics of the Said Power Station
  4) Environmental Countermeasures

(6) Transmission Lines and Substations
  1) Locational Conditions
  2) Preliminary Design and Construction Cost

(7) Implementation Schedule

(8) Economic and Financial Analyses

(9) Others

1.4.1 Field Investigations

Of the Survey Team of nine members indicated in 1.5, the six of Masashi Mikuni, Tetsuya Fukuda, Takayuki Hamazaki, Akira Minami, Koki Tanaka and Toshiyuki Watanabe, and the three of Juichi Kokubo, Junji Matsumoto and Ryuzaburo Nishimura carried out field investigations for 28 days from September 25 to October 22, 1977, and 21 days from September 25 to October 15, 1977, respectively. The principal establishments visited in connection with the field investigations in order to collect data and to inquire about prevailing situations were the following:

PLN Pusat – Pusat, Perusahaan Umum Listrik Negara
PLN Wilayah IV – Wilayah IV, Perusahaan Umum Listrik Negara
Bappenas – Badan Perecanan Pembangunan Nasional
TABA – P.N. Tambang Batubara
P.J.K.A. – Perusahaan Jawatan Kereta Api
Kantor Administrasi Pelabuhan Palembang
Kantor Tambang Batubara Bukit Asam
Bapindo, Palembang – Bank Pembangunam Palembang
B.S. – Biro Statistik
Universitas Lampung
Universitas Sriwijaya

1.4.2 Work in Japan

Upon returning to Japan, the members of the Survey Team made analyses of the data and information obtained in field investigations and worked on the items of the beforementioned "Contents of Survey" culminating in the form of this Report submitted in May 1978.

1.4.3 Explanations of Draft Report to Indonesian Government

The Leader of the JICA Survey Team, Masashi Mikuni, gave explanations to the staff of PLN and other Indonesian governmental agencies the contents of this Report (Draft) during a period of seven days from March 5, 1978.

1.5 Composition of Survey Team

The names of members of the Survey Team, their affilations and work assignments are as listed below.

Leader	Masashi Mikuni, Electric Power Development Co., Ltd., General Supervision
Member	Tetsuya Fukuda, EPDC International, Ltd., Power Economics
Member	Takayuki Hamazaki, West Japan Engineering Consultants, Inc., Thermal Power & Mechanical Engineering
Member	Akira Minami, Electric Power Development Co., Ltd., Power Transmission & Substation Planning
Member	Koki Tanaka, West Japan Engineering Consultants, Inc., Thermal Power & Electrical Engineering
Member	Toshiyuki Watanabe, West Japan Engineering Consultants, Inc., Thermal Power & Civil Engineering
Member	Juichi Kokubo, Japan International Cooperation Agency, Coordination
Member	Junji Matsumoto, Electric Power Development Co., Ltd., Power System Planning
Member	Ryuzaburo Nishimura, Mitsui Mining Overseas Co., Ltd., Coal Planning

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

2.1 Conclusions

The Bukit Asam Coal-Fired Thermal Power Station Project, from an overall judgment of the aspects of fuel, engineering, economics and finance, is considered to be feasible with construction of the following at the Bukit Asam Mine site.

Alternative I	50 MW x 2 units, commercial operation 1984
Alternative II	50 MW x 2 units, commercial operation 1984
	50 MW x 1 unit, commercial operation 1987

In addition, it is thought possible to realize this Project in the years indicated above from the standpoint of the implementation schedule also.

2.1.1 Plan for Supply of Coal for Electric Power

At present a large-scale development plan has been formulated for Bukit Asam Coal Mine, the details of which are being discussed with the World Bank (IBRD). According to the plan, annual production is to reach 2 to 2.5 million tons in 1984 – 1985, and supply of the annual consumption of coal of 320 to 480 thousand tons required by Bukit Asam Coal-Fired Thermal Power Station, 100 MW or 150 MW, will be no problem if a part of the total production is diverted to the station. Descriptions by item are given below.

(1) Coal Reserves

As a result of exploration of the Air Laya Area of Bukit Asam Mine, a total of 96 million tons of mineable coal reserves consisting of approximately 83 million tons of measured and indicated reserves and approximately 13 million tons of inferred reserves are calculated for the site.

Taking into consideration a geological safety factor and a mining recoverable factor, approximately 70 million tons can be looked forward to as recoverable coal reserves with just the A and B seams of the Air Laya Area.

This quantity of reserves means a life of 20 to 30 years or more with annual production of 2 to 3 million tons, the quantity being sufficient even for a largescale coal production plan, and there is no problem of course in supplying coal to Bukit Asam Coal-Fired Thermal Power Station.

(2) Coal Quality

The coal quality is low ash (5 to 7% with run-of-the-mine coal including dilution by rock accompanying mining) and low sulfur (approximately 0.5%), and is suitable as coal for electric power generation. Moisture content is slightly high (12 – 14% in terms of inherent moisture), while calorific value of 6,300 to 6,500 kcal/kg (air dry basis) can be expected.

(3) Mining System

The strip ratio (ratio between overburden stripping and coal output) in strip mining is an average of 2.91 for the planned area, which is relatively low and a favorable condition.

However, the overburden is clayey and the surface layer will be softened by heavy rains if over a long period to lower efficiency of stripping operations. What will be of essential importance in procurement of heavy duty equipment will be how the operating ratio of the equipment is to be improved, and in determination of the mining method and

selection of mining equipment, the geological and weather conditions at the site must be given thorough consideration.

(4) Coal Transportation and Storage

Coal preparation is to consists only of screening to remove large-size refuse and the run-of-the-mine coal is to be sent out unwashed, while there will be no problem about transportation to Bukit Asam Coal-Fired Thermal Power Station as it will be constructed at the mine site.

It will be necessary for some amount of coal storage at the mine site or the power station to be prepared for reduction in coal output due to lowering of work efficiency during the rainy season. Since this coal is of a nature relatively prone to spontaneous combustion, storage should be planned taking this aspect into consideration.

(5) Production Cost

The present free on rail price of coal at the mine is RP6,500 per ton and the production cost is slightly higher than this price. However, when annual production exceeds 1 million tons and attains 2 to 2.5 million tons, the production cost will be diminished by scale merit, and if the mining plan is appropriate, the plan will amply pay for itself at the present price (not considering escalation). Further, if it is assumed that the price of coal in 1984 at the start of operation of Bukit Asam Coal-Fired Thermal Power Station will rise thereafter at a rate of 5% annually, it will become RP8,170.

Summarizing the above, there is no great obstacle to coal supply regarding the following which may be considered as principal factors.

Securing of stable quantity of supply
Stable quality of coal supplied
Stable coal price

2.1.2 Power Demand Forecast

A power demand forecast was made for Sumatera Selatan Province for the 14-year period from 1977 through 1990. In effect, a demand forecast was made for Palembang, Bukit Asam Coal Mine and other principal municipalities as well as a demand forecast for the Shell Company.

Next, from the standpoint of examining the possibility of interconnection of the provinces of Sumatera Selatan, Lampung and Bengkulu included in the scope of the present survey, demand forecasts for the three provinces were made for the 24-year period form 1977 to 2000.

(1) Demand Forecast for Sumatera Selatan Province (1977 – 1990)

Power demand forecasts up to 1990 were made according to the categories of residential, commercial, public and industrial demands. Especially, since electrification ratio, the mark of the spread of electric power and the very basis of electric power demand, is related to the electric power policy of PLN, the ratios planned by PLN up to the year 2000 were adopted.

1) Palembang System (Palembang, Lahat, Muara Enim, Bukit Asam) – Alternative I

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1984	358,217	83,045
1990	553,373	123,302

2) Palembang System (Alternative I plus Shell Mine) – Alternative II

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1984	407,117	100,462
1990	699,973	175,469

3) Batu Raja

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1990	13,692	3,908

4) Lubuk Linggau

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1990	12,587	3,592

5) Kayu Agung

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1990	5,872	1,676

6) Sekayu

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1990	498	142

7) Other Rural Areas

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1990	10,065	2,872

(2) Demand Forecast for Three Provinces

1) Sumatera Selatan Province

a) Alternative I

The total of the power demand forcasts for the individual municipalities from 1977 to 1990 described in (1) above is the demand forecast for the entire province. For the period from 1991 to 2000, the energy requirements of the various municipalities were forcast based on the figures for 1990 and taking into account annual population growth rates and per capita annual energy consumption growth rates.The total of the annual energy requirements of the individual municipalities obtained in this manner was considered as the annual energy requirement of Sumatera Seletan Province.

The results are as follows:

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1990	596,087	135,492
1995	834,943	197,425
2000	1,165,872	281,437

b) Alternative II

The energy demand accompanying operation at the Sehll Concession was added to the forecast of Alternative I, and the annual energy requirements and maximum demands of Alternative II obtained will be the following:

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1990	742,682	187,659
1995	981,543	249,592
2000	1,312,472	333,604

2) Lampung Province

For Tanjung Karang-Telukbetung, Metro, Kotabumi and other rural areas, demand forecases were made employing the same technique as for Sumatera Selatan Province.

The results were the following:

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1990	97,164	27,729
1995	155,222	44,299
2000	247,334	70,586

3) Bengkulu Province

There were very little data on Bengkulu Province at PLN and the Survey Team made a demand forecast based on what little data were obtained from PLN Wilayah IV and the meager information available in Japan. Since population estimations by municipality could not be obtained in making a demand forecast for Bengkulu Province, Bengkulu and Curup were considered as one group, while Kepahyang, Tes, Muara Aman and others were considered as other rural areas. Dividing into these two groups classifications were made by categories similarly to Sumatera Selatan Province and Lampung Province and forecasts of annual energy requirements for each year were made tentatively by cumulative methods. The annual energy requirements and maximum demands from 1991 through 2000 were also forecast by techniques similar to Sumatera Selatan Province and Lampung Province.

The results are as indicated below.

	Annual Energy Demand (MWh)	Maximum Demand (kW)
1990	31,770	9,067
1995	50,600	14,441
2000	80,727	23,039

(3) Power Demand and Supply Balance

The maximum demand and supply balance was calculated for the 10-year period from 1978 through 1987 taking into consideration reserve supply capacity, economic service lives of facilities, etc. The results are as described below and annual demand and supply balances will be maintained in all cases if the electric power development under 2.1.3 is carried out.

1) The balances of demand and supply by year from 1975 through 1983 of Palembang and of Lahat, Muara Enim and Bukit Asam Mine operated as isolated systems will be as indicated below, and it can be seen that balances will be maintained while securing the necessary reserve capacities.

Demand-Supply Balance (Palembang)

		1975	1976	1977	1978	1979	1980	1981	1982	1983
Installed Capacity	(KW)	39,600	54,373	54,373	54,373	54,373	54,373	72,573	72,573	72,573
Max. Demand x 1.2	(KW)	24,469	26,766	27,778	39,586	43,236	46,684	50,114	53,538	57,701
Reserve Capacity	(KW)	15,131	27,607	26,595	14,787	11,137	7,689	22,459	19,038	14,876
Reserve Ratio	(%)	62	103	96	37	26	16	45	36	26

Demand-Supply Balance (Lahat, Muara Enim, Bukit Asam Mine)

		1975	1976	1977	1978	1979	1980	1981	1982	1983
Installed Capacity	(KW)	14,150	14,150	14,150	14,350	14,350	14,350	14,350	14,350	19,350
Max. Demand x 1.2	(KW)	2,624	2,737	2,999	3,222	3,358	3,708	4,079	5,195	9,618
Reserve Capacity	(KW)	11,526	11,413	11,151	11,128	10,992	10,642	10,271	9,155	9,732
Reserve Ratio	(%)	439	417	372	345	327	287	252	176	101

2) In 1984, Bukit Asam Coal-Fired Thermal Power Station and Palembang will be interconnected by a 150 kV transmission line. The balance of demand and supply of the Palembang System, Alternative I, from 1984 through 1987 will be as indicated in the table below.

Demand-Supply Balance (Alternative I)

		1984	1985	1986	1987
Installed Capacity	(KW)	181,323	181,323	181,323	166,550
Max. Demand x 1.2	(KW)	99,654	105,512	109,607	114,078
Reserved Capacity	(KW)	81,669	75,811	71,716	52,472
Reserved Ratio	(%)	82	72	65	46

3) The balance of demand and supply of Alternative II in case of considering the power demand for the Shell Mine development project will be according to the table below.

Demand-Supply Balance (Alternative II)

		1984	1985	1986	1987
Installed Capacity	(KW)	190,323	190,323	190,323	225,550
Max. Demand	(KW)	120,554	132,612	143,007	155,778
Reserved Capacity	(KW)	69,769	57,711	47,316	69,772
Reserved Ratio	(%)	58	44	33	45

4) Regarding Batu Raja, Lubuk Linggau, Kayu Agung, Sekayu and others, the balances of demand and supply by year from 1975 to 1987 will be as indicated in the table below.

Demand-Supply Balance
(Batu Raja, Lubuk Linggau, Kayu Agung, Sekayu)

		1977	1979	1981	1983	1985	1987
Batu Raja							
Installed Capacity	(KW)	672	1,422	1,422	2,922	2,922	4,422
Max. Demand x 1.2	(KW)	730	1,022	1,396	1,901	2,411	3,184
Reserve Capacity	(KW)	-58	400	26	1,021	511	1,238
Reserve Ratio	(%)	-8	39	2	54	21	39
Lubuk Linggau							
Installed Capacity	(KW)	1,658	1,908	1,908	2,908	2,908	3,908
Max. Demand x 1.2	(KW)	737	1,037	1,385	1,811	2,327	3,052
Reserve Capacity	(KW)	921	871	523	1,097	581	856
Reserve Ratio	(%)	125	84	38	61	25	28
Kayu Agung							
Installed Capacity	(KW)	550	800	800	1,550	1,550	2,050
Max. Demand x 1.2	(KW)	353	492	661	863	1,151	1,440
Reserve Capacity	(KW)	197	308	139	687	399	610
Reserve Ratio	(%)	59	63	21	80	35	42
Sekayu							
Installed Capctity	(KW)	436	436	436	436	436	436
Max. Demand x 1.2	(KW)	20	29	38	53	77	103
Reserve Capacity	(KW)	416	407	398	383	359	333
Reserve Ratio	(%)	2,080	1,403	1,047	722	466	323

Other Rural Area				
Installed Capacity	(KW)	1,000	2,500	4,500
Max. Demand x 1.2	(KW)	756	1,207	1,853
Reserve Capacity	(KW)	244	1,293	2,647
Reserve Ratio	(%)	32	107	143

2.1.3 Optimum Electric Power Development Plan

On considering the capacity and timing of electric power development, reserve capacity and conditions for suspension or retirement of facilities from the balance of demand and supply, the optimum development plans will be the following:

(1) Palembang Isolated System

Timing of start of power generation	1981
Generation capacity	32 MW (16 MW x 2) Diesel or gas turbine

(2) Lahat, Muara Enim, Bukit Asam Mine System

One 5 MW unit of the existing new coal-fired thermal power station owned by TABA is presently shut down due to trouble and it will be necessary for repair work to be completed to restore this unit to the system by 1983.

(3) Palembnag System (Alternative I)

Start of power generation	1984
Generator capacity	100 MW (50 MW x 2) Coal-fired

Regarding adoption of a unit capacity of 50 MW, it will be impossible for power transmission to be carried out from Bukit Asam to Palembang by a 150 kV transmission line unless the capacity is at least 45 MVA, while further, considering shutdown due to faulting of a unit at Bukit Asam Power Station which will be the main power source of the system, or shutdown due to periodic inspection, two 50 MW units are to be adopted.

(4) Palaembang System (Alternative II)

Start of power generation	1984	1987
Generator capacity	100 MW (50 MW x 2) Coal-tired thermal	50 MW x 1 Same as left

(5) Batu Raja

Start of power generation	1987	1979	1982	1986
Generator capacity	250kW Diesel	500kW	1,500kW	1,500kW

(6) Lubuk Linggau

Start of power generation	1978	1983	1987
Generator capacity	250kW Diesel	1,500kW	1,500kW

(7) Kayu Agung

Start of power generation	1978	1982	1987
Generator capacity	250kW Diesel	750kW	500kW

(8) Sekayu

Start of power generation	1986
Generator capacity	100kW, diesel

(9) Other Rural Areas

Start of power generation	1983	1985
Generator capacity	1,000kW Diesel	1,500kW

1) Considerations in Formulation of Optimum Plan

In planning construction of Bukit Asam Coal-Fired Thermal Power Station, 100 MW (50 MW x 2 units) at the mine site along with a 150 kV transmission line and substations by 1984, the following two were considered as alternative facilities

for examination of the economics of the construction plan.

a) As a result of comparison of the cumulative amount of annual costs during the economic service life in case of this plan and the cumulative amount of annual costs of coalfired thermal power stations corresponding to the power demands of the individual municipalities considered (isolated power system), the cumulative amount of annual costs of this plan will be approximately 67% of that of the isolated power systems, and this plan was judged to be more advantageous.

b) As a result of comparison of the cumulative amounts of annual costs during the economic service lives of this plan and a heavy oilfired thermal power station of equal capacity, the cumulative amount of annual costs for this plan will be approximately 60% of that for the heavy oil-fired thermal power station, and it was judged that this plan would be more advantageous.

The result of examination of a) and b) above indicates the following:

Construction site: mine site

Power generating system: coal-fired thermal

2) Method of Power Supply to Other Principal Municipalities in Sumatera Selatan Province

A study was made of the economics up to the year 2000 of the Rural Isolated System (RIS) in which diesel power generation would be continued at each of the municipalities and the Interconnected System (ICS) in which electric power would be supplied by transmission line from Bukit Asam Coal-Fired Thermal Power Station to see which of the two systems should be adopted.

The results are as indicated below.

Municipality	Power Supply System
a) Batu Raja	RIS
b) Lubuk Linggau	RIS
c) Kayu Agung	RIS
d) Sekayu	RIS

2.1.4 Site Location for Coal-Fired Thermal Power Station

As a result of investigations and study on the conditions for selection of a site for the coal-fired thermal power station, the three locations of Tanjung Enim, Muara Enim and Palembang may be cited as the leading candidate sites. However, on an overall judgment taking into consideration the economics previously described, the optimum site will be at Tanjung Enim.

2.1.5 Electric Power System

(1) Electric Power System of Sumatera Selatan

A study was made of whether interconnection between the Palembang System and the systems of Lampung Province and Bengkulu Province would be feasible during the period up to the year 2000. As a result, it is judged that there will be no possibility for interconnection with either Lampung Province or Bengkulu Province.

(2) Interconnection with Java

It is looked forward to by PLN that a necessity and a possibility for interconnection with Java will arise in the distant future. Since it may be considered that investigation of

the possibility of interconnection with Java will be carried out separately, this Report does not go farther than to point out a number of problematic items conceivable in interconnection. The main points are as follows:

1) Scrutinies of the demand trends of Lampung Province and West Java, and of scales of electric power development sources
2) Detail invesitigations of Sunda Strait
3) Investigations of transmission-line routes on the Sumatera and Java sides
4) Investigation of submarine cable technology
5) Establishment of load dispatching system for integrated system operation
6) Technical examination of adoption of AC or DC interconnection
7) Study on Economics

(3) Palembang System Analysis

In analysis of the Palembang System, studies were made of the patterns below. The point of time studied was the year 1987.

– Pattern A ..... Case of receiving location made Palembang No. 2 Substation
– Pattern B ..... Case of receiving location made Keramasan Power Station

The results of the studies are as indicated below.

1) Receiving Point at Palembang

The receiving point with which the estimated power flow of the 70 kV, 2-cct Palembang Transmission System will not be unbalanced to a part of the transmission lines so far as possible will be that of Pattern A, or Palembang No. 2 Substation.

2) Stability

Both Patterns A and B will be stable with respect to transient stability and steady-state stability.

3) Short Circuit Capacity

Since short circuit currents will be less than the circuit breaker rating of 12.5 kA, there will be no problem with either Pattern A or Pattern B.

4) Voltage Regulation

There is little difference between Pattern A and Pattern B regarding aspects of voltage regulation and there will be no problem.

2.1.6 Implementation Schedule for Coal-Fired Thermal Power Station Development Project

(1) Scope of Implementation Schedule

The following are included in the scope of the implementation schedule for the Bukit Asam Coal-Fired Thermal Power Station Construction Project according to Alternative I and Alternative II.

1) Approach to a source of funds with the time of submittal of this Feasibility Report as the starting point
2) Conclusion of loan agreement
3) Rendering of engineering service by consultant
4) Performance by contractor(s) of construction works
5) Acceptance tests
6) Final disbursement

It will require a period of approximately three years from the time this Report is submitted until commencement of actual construction work.

(2) Construction Schedule

1) In case of Alternative I, completion of the No. 1 unit, 50 MW (commercial operation from August 1984), would call for a schedule of 40 months from start of preparatory work (April 1981), while completion of the No. 2 unit, 50 MW, would be three months after the No. 1 unit for a schedule of 43 months (commercial operation from November 1984).

2) For the case of Alternative II, facilities in common with Alternative I are to be considered as having been completed through advance investment, and the schedule from start of building foundation work (October 1985) until commercial operation (November 1987) is to be 25 months.
Further, final disbursements are to be made making adjustments such as of borrowings by the ends of the appropriat fiscal years.

2.1.7 Funding Plan

(1) Investment Amount Required and Applicable Interest Rates

Alternative I

Foreign currency portion	US$ 123,431,000
Domestic currency portion	63,591,000
Total	187,022,000

Alternative II

Foreign currency portion	US$ 177,239,000
Domestic currency portion	83,681,000
Total	260,920,000

The above construction costs do not include interest during construction.

It was predicated that the required foreign currency would be borrowed from the World Bank or an international financing institution of similar nature, and an annual interest rate of 8.5% was assumed.

(2) Repayment Conditions

For both domestic and foreign currencies, the premises were that repayment of principal and interest during construction would be deferred during the construction period, with the terms being principal and interest repaid in equal installments over 19 years in case of foreign currency, and 9 years in case of domestic currency.

(3) Operating Balance of Revenues and Expeditures

Assuming that the electricity charge in 1976 of 78.24 mill/kWh will rise at an annual rate of 5% up to the year of start of sales considering increase in expenses including fuel costs to become 116 mill/kWh in 1985, the balance of income and outgo will be sound as seen from the income and cash flow statements under the loan conditions hypothesized.

2.1.8 Outline of Coal-Fired Thermal Power Station Project

(1) Construction Cost

	Alternative I	Alternative II
Foreign currency portion	US$ 148,991,000	US$ 213,040,000
Domestic currency portion	87,128,000	112,873,000
Total	236,119,000	325,913,000

The above construction costs include interest during construction.

(2) Power Generation Cost at Completion of Project

1) Alternative I 68.1 mill/kWh (as of 1984)

2) Alternative II 76.6 " (1984, 1st Stage)

67.0 " (1987, 2nd Stage)

Depreciation costs were considered based on the economic service lives of the individual facilities and annual load factor was assumed to be 70%.

(3) Time Table

	Alternative I	Alternative II	
Opening L/C for consultant	Jun. 1979	Jun. 1979	
Construction Start	Mar. 1982	Mar. 1982	
Commercial operation			
No. 1 Unit	Aug. 1984	Aug. 1984	1st Stage
No. 2 Unit	Nov. 1984	Nov. 1984	1st Stage
No. 3 Unit		Nov. 1987	2nd Stage
Final disbursement	Mar. 1985	Mar. 1985	1st Stage
		Mar. 1988	2nd Stage

(4) Facilities in Power Station

1) Location: Tanjung Enim District, Sumatera Selatan Province, Republic of Indonesia

2) Proposed capacity: Alternative I, 50 MW x 2 units
Alternative II, 50 MW x 1 unit

3) Outline of Equipment

a) Boiler
Type: Drum-type natural circulation, outdoor
Evaporation: 210 ton/hr (at max. continuous rating)
Steam condition: 91 kg/cm^{2}G, 513°C (at super heater outlet)
Fuel used: Coal

b) Turbine
Type: Impulse type condensing turbine
Rated output: 50,000 kW
Steam condition: 88 kg/cm^{2}G, 510°C (at main stop valve)
Speed: 3,000 rpm

c) Generator
Type: Horizontal shaft, totally enclosed type
Rating: 62.5 MVA, 50 Hz, 13.8 kV, power factor 80%
Short circuit ratio: 0.58

d) Main Transformer
Type: Outdoor, 3-phase, forced oil, forced air-cooled, elephant type
Rating: 13.8/154 kV, 60 MVA

(5) Transmission Line Facilities

1) Bukit Asam No. 1 SS – Palembang No. 2 SS
Distance: 180 km
Voltage: 154 kV
Number of Circuits: 2 ccts
Conductor: TACSR 330 mm^2

2) Bukit Asam No. 1 SS – Bukit Asam No. 3 SS
(Case of Alternative II only)
Distance: 17 km
Others: Same as 1)

3) Bukit Asam No. 1 SS – Bukit Asam No. 2 SS
Distance: 4 km
Voltage: 30 kV
Number of Circuits: 2 ccts
Conductor: TACSR 240 mm^2

4) Bukit Asam No. 2 SS – Lahat SS
Distance: 2 km (newly construction portion)
Others: Same as 3)

5) Bukit Asam No. 1 SS – Muara Enim SS
Distance: 12 km
Voltage: 30 kV
Number of Circuits: 1 cct
Conductor: ACSR 58 mm^2

6) Substation Facilities

1) Palembang No. 2 SS (Additional Portion)

a) Load area: Palembang

b) 154 kV switching facilities
Quantity: 5 sets
Type, specifications: SF_6 gas-insulated switchgear type, 168 kV, 1,200 A, 12.5 kA

c) 70 kV switching facilities
Quantity: 2 sets
Type, specifications: SF_6 gas-insulated switchgear type, 72 kV, 800 A, 12.5 kA

d) Transformer
Quantity: 2 units
Type, specifications: Outdoor, oilimmersed, low noise transformer, 154/70 kV, 70 MVA, with OLTC

2) Bukit Asam No. 1 SS

a) Load area: Accessory to Bukit Asam PS

b) 154 kV switching facilities
Quantity: Alternative I 7 sets
Alternative II 10 sets
Type, specifications: SF_6 gas-insulated switchgear type, 168 kV, 1,200 A, 12.5 kA

c) 30 kV switching facilities
Quantity: 5 sets
Type, specifications: Outdoor, cubicle type vacuum circuit breaker, 36 kV, 1,200 A, 25 kA

d) Transformer
Quantity: 2 units
Type, specifications: Outdoor, oilimmersed, 3-winding transformer, 154/30/3.3 kV, 45/40/6 MVA

3) Bukit Asam No. 2 SS

a) Load area: Bukit Asam TABA Mine

b) 30 kV switching facilities
Quantity: 6 sets
Type, specifications: Outdoor, cubicle type vacuum circuit breaker

c) Transformer
Quantity: 2 units
Type, specifications: Outdoor oilimmersed transformer, 30/6.6 kV, 25 MVA

4) Bukit Asam No. 3 SS
(Case of Alternative II only)
a) Load area: Bukit Asam Shell Mine
b) 154 kV switching facilities
Quantity: 4 sets
Type, specifications: SF_6 gas-insulated switchgear type, 168 kV, 1,200 A, 12.5 kA
c) Transformer
Quantity: 2 units
Type, specifications: Outdoor, oilimmersed, 3-winding, transformer, 154/6.6/6.6 kV, 50/25/25 MVA

5) Muara Enim SS
a) Load area: Muara Enim
b) 30 kV switching facilities
Quantity: 1 set
Type, specifications: Outdoor, cubicle type vacuum circuit breaker, 36 kV, 1,200 A, 25 kA
c) Transformer
Quantity: 1 unit
Type, specifications: Outdoor, oilimmersed transformer, 30/6.6 kV, 6 MVA, with OLTC

6) Lahat SS
a) Load area: Lahat
b) 30 kV switching facilities
Quantity: 4 sets
Type, specifications: Outdoor, cubicle type vacuum circuit breaker, 36 kV, 1,200 A, 25 kA
c) Transformer
Quantity: 2 units
Type, specifications: Outdoor, oilimmersed transformer, 30/6.6 kV, 15 MVA, with OLTC

2.2 Recommendations

In order to realize this Project it is considered necessary for preparations to be made relative to the aspects of funds and engineering.

(1) Firstly, with regard to the aspect of funds, it will be necessary to approach overseas sources of funds with respect to foreign currency, and to make budget appropriations for domestic currency in order to secure funds. Especially, with regard to borrowing of foreign currency, seen from the schedule for a loan agreement to be concluded within 6 months from April 1978 as mentioned in Chapter 11, it will be essential for the necessary data for approaching the source of funds to be readied as soon as possible. Since the Survey Team is not in a position to know the state of implementation and administration of all of the projects of PLN and of the financial position of PLN in connection with the above, it will be necessary for PLN to handle