GOVERNMENT OF THE REPUBLIC OF INDONESIA

MINISTRY OF MINES AND ENERGY

PERUSAHAAN UMUM LISTRIK NEGARA

# REPORT
# OF
# FEASIBILITY STUDY
# ON
# THE NORTH SUMATERA
# TRANSMISSION LINE PROJECT

MAY 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

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# PREFACE

In response to the request of the Government of the Republic of Indonesia, the Japanese Government decided to conduct a survey on the North Sumatera Transmission Line Project and entrusted the Japan International Cooperation Agency with the survey. The J.I.C.A. sent to Indonesia a survey team headed by Mr. Noboru Nozawa from November 26 to December 30, 1979.

The team had discussions with the officials concerned of the Government of the Republic of Indonesia and conducted a field survey in North Sumatera area, Indonesia. After the team returned to Japan, further studies were made and the present report has been prepared.

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

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

June, 1980

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

# LETTER OF TRANSMITTAL

May, 1980

Mr. Keisuke Arita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

We have the pleasure of submitting herewith the Feasibility Report on the North Sumatera Transmission Line Project in compliance with the terms of reference agreed between the Government of Japan and the Government of Indonesia.

For the preparation of this Report, field investigation and engineering studies were made for about four months starting from December, 1979. The results of the studies were compiled into the Draft Report, which was submitted to your Agency at the end of March, 1980. During March 10 to March 15 of 1980, the discussions were made concerning the Draft Report between the survey team and the staff of Persahaan Listrik Negara (PLN). All findings and comments obtained in the discussions have been fully incorporated in the Final Report.

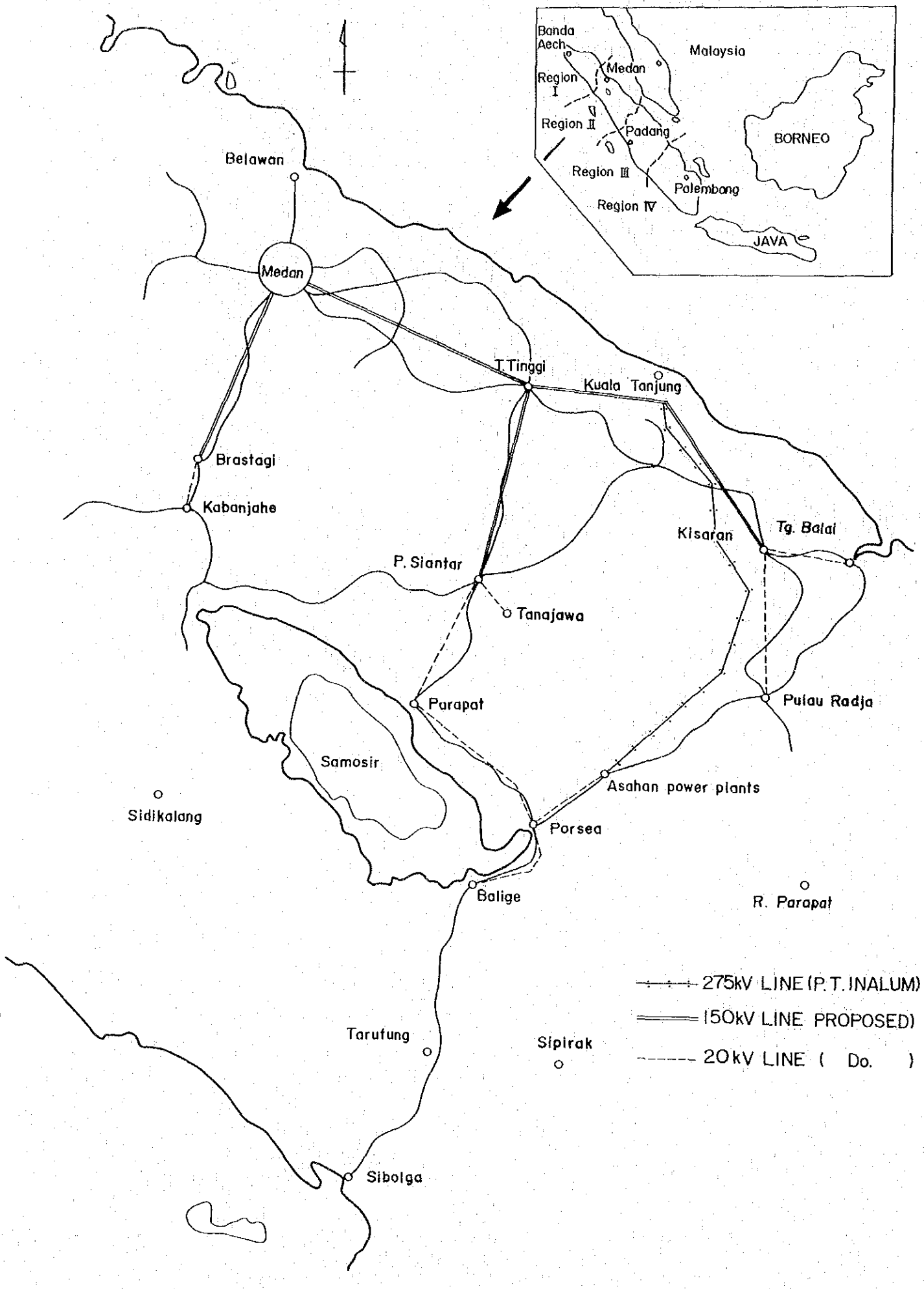
The engineering and economic studies of the Report confirm that the project is technically sound and economically feasible if taking into account the indirect and intangible effect of the project. It is our sincere hope that the project will be proceeded to the next stage of the detailed design for the early realization of the project as soon as possible along the recommendations presented in this Report.

In submitting this Report, we wish to express our sincere appreciation and gratitude to the personnel of your Agency, the Japanese Embassy in Indonesia, and the authorities concerned of the Government of Indonesia for courtesies and cooperation extended to us during our field survey as well as home office work.

Very truly yours,

Noboru Nozawa
Team Leader
The North Sumatera
Transmission Line Project

# LOCATION MAP



# PREFACE

This report is submitted in accordance with the Agreement signed on December 3, 1979 between the Perusahaan Umum Listrik Negara of Ministry of Mines and Energy, Republic of Indonesia (hereinafter referred to as PLN) and the Mission from Japan International Cooperation Agency (hereinafter referred to as JICA) for North Sumatera Transmission Line Project (hereinafter referred to as the Project).

North Sumatera is one of the provinces with the highest economic potential in Indonesia and its energy demand has been rapidly expanding in recent years. Especially in Medan, the capital city of the province and the third biggest city in Indonesia, as well as in local towns in the Project Area, the energy demand is growing with rapid strides. Industrial demand is growing rapidly as the development of small-scale and medium-scale industries accelerates in the area.

The power supply facilities of PLN, however, are yet to be developed except System Medan. The local towns receive energy supply from PLN by small-sized diesel generators independently set in each town, being entirely isolated with each other and from the System Medan. The capacities of the generators are inadequate and a large number of energy consumers are compelled to rely on their own diesel generators for energy supply.

Asahan project, a national development project executed by Asahan Development Authority, the official agency responsible for the social and economic development of Asahan rural area (hereinafter referred to as ADA) and P.T. Indonesia Asahan Aluminium, the investors for Asahan Hydroelectric and Aluminium Project (hereinafter referred to as INALUM), under the Master Agreement between the Government of the Republic of Indonesia and INALUM for the said Project signed on July 7, 1975, (hereinafter referred to as Master Agreement), is now under construction. The project aims at the development of an aluminium smelting plant in Kuala Tanjung with cheap bulk energy supply from the Asahan hydroelectric power stations. According to the said agreement, INALUM is to provide

the hydroelectric power to be generated at its power stations to PLN for public supply, which will amount to 218 GWh per annum with maximum power of 50 MW at the final stage.

North Sumatera Transmission Line Project is conceived with a view to supply the cheap bulk energy from Asahan by constructing transmission lines and substations to the local towns in the Project Area as well as to Medan and its vicinities. Once the Project is implemented, all the load centers in the Project Area will be incorporated into a single power system.

The field survey was carried out from December 3 through December 29, 1979 by JICA survey team, headed by Mr. N. Nozawa, and the home office study was completed in March, 1980. The Study has concluded that the Project is technically feasible and economically viable and strongly recommended early implementation of the Project.

During the period of field survey, the whole-hearted support rendered by the staff of PLN Pusat, PLN Wilayah II and PLN Piktring Sumut was most commendable. Appreciation is forward to Ir. Soejadi, Deputy Director of Construction, Ir. Hartojo, Deputy Director of General Planning, Drs. Hutasoit, Head of Survey Division, Ir. Sjofijan, Project Manager and their colleagues. Personnel concerned with the Study is attached in Appendix I.

FINAL REPORT

ON

THE FEASIBILITY STUDY

ON

NORTH SUMATERA TRANSMISSION LINE PROJECT

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| NSTL-013 | CONTROL BUILDINGS FOR SUBSTATIONS |
| NSTL-014 | POWER LINE CARRIER TELEPHONE SYSTEM |

## ABBREVIATION

| | |
|---|---|
| PLN | Perusahaan Listrik Negara (State General Electricity Enterprise) |
| PLN Pusat | Perusahaan Listrik Negara Pusat (State General Electricity Enterprise, Head Office) |
| PLN Wilayah II (Region II) | Perusahaan Listrik Negara Wilayah II (State General) Electricity Enterprise, Region Office II, North Sumatra) |
| PLN Pikitring | Perusahaan Listrik Negara Proyek Induk Pembangkit & Jaringan (State General Electricity Enterprise, Principal Project for Generation and Transmission) |
| Cabang | Branch Office |
| REPELITA II (PELITA II) | Second Five Year Development Plan |
| REPELITA III (PELITA III) | Third Five Year Development Plan |
| PLTA | Pusat Listrik Tenaga Air (Hydro Power Station) |
| PLTG | Pusat Listrik Tenaga Gas (Gas Power Station) |
| PLTD | Pusat Listrik Tenaga Diesel (Diesel Power Station) |
| PLTU | Pusat Listrik Tenaga Uap (Steam Power Station) |
| ADA | Asahan Development Authority |
| INALUM | Indonesia Asahan Aluminium Co., Ltd. |
| JICA | Japan International Cooperation Agency |
| OECF | Overseas Economic Cooperation Fund of Japan |
| T. Tinggi | Tebing Tinggi |
| P. Siantar | Pematang Siantar |
| Tg. Balai | Tanjung Balai |
| K. Tanjung | Kuala Tanjung |
| T. Kuning | Titi Kuning |

| | | | |
|---|---|---|---|
| S/S | Sub-station | HT | High tension |
| T/L | Transmission line | LT | Low tension |
| D/L | Distribution line | kV | Kilovolt |
| VA | Volt-ampere | kVA | kV-ampere |
| MVA | Mega-VA | kW | Kilowatt |
| MW | Megawatt | kWh | kW-hour |
| MWh | MW-hour | GWh | Gigawatt-hour |
| mm | Millimeter | $mm^2$ | Square mm |
| km | Kilometer | $km^2$ | Square km |
| $m^3$ | Cubic meter | EL | Elevation |
| C.I.F. | Cost, insurance & freight | F.O.B. | Free on board |

## CURRENCY EQUIVALENT

| | |
|---|---|
| Rp. 1 = US$ 0.00160 | US$ 1 = Rp. 625 |
| ¥ 1 = US$ 0.00435 | US$ 1 = ¥ 230 |

# Summary

## Background

Sumatera island has the highest economic potential in Indonesia exporting more than 60 % of the total of Indonesia. Among the eight provinces of the island, North Sumatera is ranked first in terms of gross regional product, about US$370 per capita as of 1978/79, with plantations and oil as its mainstay. Even in the whole nation, it is ranked third following West Java and East Java.

In the Project Area comprising Medan and its vicinities and many local towns in North Sumatera Province, energy demand is growing rapidly with more than 25 % growth rate during these years and is expected to keep growing with rapid strides considering its high economic potential and relatively high per capita income compared with the current energy consumption level of about 30 kWh per capita. The implementation of the Asahan Hydroelectric and Aluminium Project to be executed by Asahan Development Authority and INALUM in which the hydroelectric power of 603 MW will be developed and aluminium of 225,000 t/year is produced, is likely to accelerate the industrialization in the area and thereby further boost the energy demand in the area.

The power supply facilities of PLN in the Project Area are, however, far from satisfactory. System Medan is the only power supply system in the area. Other local towns receive energy supply from PLN by small-sized diesel generators independently set in each town, being entirely isolated with each other and from System Medan. The capacity of public energy supply, amounting to 170 MW in total, falls far behind the demand, leaving a large number of consumers depending upon their own diesel generators, which amount to about 250 MVA in Total.

Demand forecast made for coming 10 years revealed it to grow up with an average rate of 16 % p.a. and to reach about 280 MW in 1990/91 at least.

## Necessity and Objective

According to the Master Agreement arrived at between the Government of Indonesia and INALUM, INALUM is to provide the hydroelectric power of 218 GWh with 50 MW at Kuala Tanjung for public use. The Project is conceived aiming at supplying this cheap bulk energy to the local towns in the Project Area as well as to Medan and its vicinities by linking them with Kuala Tanjung through the construction of 150 kV transmission lines and substations. Once the Project is realized, all the load centers in the Project Area will be incorporated into a single power system. The execution of the Project is sure to contribute to easing the current and expected severe shortage of public energy supply in the area as well as to improving socio-economy of the area by supplying cheap energy. The Project will also meet the government energy policy for oil conservation.

## Principal Features

The Project comprises 150 kV and 20 kV transmission lines, five 150 kV/20 kV transformer substations and interconnecting switchgear at two substations.

### Main Line (Kuala Tanjung - Medan Timor)

| | |
|---|---|
| Rated voltage: | 150 kV |
| No. of circuits: | 2 |
| Conductor: | ASCR, 240 $mm^2$ |
| Support: | Galvanized steel towers of double circuit construction |
| Line length: | 91 km |

### Branch Line (Kuala Tanjung - Kisaran, Tebing Tinggi - Pematang Siantar, & Titikuning - Brastagi)

| | |
|---|---|
| Rated voltage: | 150 kV |
| No. of circuits: | 1 |
| Conductor: | ACSR, 240 $mm^2$ |
| Support: | Galvanized steel towers of single circuit construction |
| Total line length: | 156 km |

20 kV Lines

| | Tower Line | Pole Line |
|---|---|---|
| Rated voltage | 20 kV | 20 kV |
| No. of circuits | 1 | 1 |
| Conductor | ACSR 120 $mm^2$ | HA( 120 $mm^2$ |
| Support | Galvd. steel tower | Concrete or steel pole |
| Line length | 135 km | 90 km |

Substations

| Location | Transformer |
|---|---|
| P. Siantar | 2 x 10 MVA, 150 kV/20 kV |
| T. Tinggi | 1 x 10 MVA, " |
| Kisaran | 2 x 10 MVA, " |
| Brastagi | 1 x 10 MVA, " |
| K. Tanjung | 1 x 10 MVA, " |
| | 2 x 40 MVA, 275 kV/150 kV |
| Medan Timur | (Switchgear only) |
| T. Kuning | ( ditto ) |

Cost

The construction cost of the Project is estimated as follows:-

| | Foreign Component | Local Component | Total |
|---|---|---|---|
| Economic Cost including physical contingency | US$23.0 x $10^6$ (62 %) | US$14.1 x $10^6$ (38 %) | US$37.1 x $10^6$ (100 %) |
| Financial Cost including financial contingency | US$25.2 x $10^6$ (62 %) | US$15.4 x $10^6$ (38 %) | US$40.6 x $10^6$ (100 %) |

Disbursement schedule of the financial construction cost of the Project is as follows:-

| Cost Component (US$$10^3$) | 1st Year | 2nd Year | 3rd Year | 4th Year | Total |
|---|---|---|---|---|---|
| Foreign Component | 685 | 10,717 | 13,019 | 796 | 25,217 |
| Local Component | 1,925 | 5,346 | 5,502 | 2,587 | 15,360 |
| Total | 2,610 | 16,063 | 18,521 | 3,383 | 40,577 |

Project Feasibility

The economic feasibility of the Project is evaluated by benefit cost ratio (B/C) estimated at various discount rates and internal rate of return (IRR) of the Project on the basis of the net benefits and construction and operation and maintenance costs of the Project. IRR of the Project is estimated at 24.9 %. B/C at the discount rates of 20 %, 25 % and 30 % are as follows:-

| Discount Rates (%) | B/C |
|---|---|
| 20 | 1.238 |
| 25 | 0.999 |
| 30 | 0.836 |

B/C figures as well as IRR of the Project clearly shows the strong economic viability of the Project. Even assuming 15 % increase of the energy cost to be supplied by INALUM, the Project still gives the high IRR of 24.0 %.

The Project is technically sound and economically viable. It is strongly recommended that the Project will be implemented at the earliest opportunity.

# CHAPTER 1

# INTRODUCTION

## 1.1 General Circumstances of North Sumatera

Sumatera island has the highest economic potential in Indonesia exporting various commodities such as agricultural products and crude oil. The ratio of its exports to the total of Indonesia exceeds 60 %. Administratively, it consists of eight provinces.

Among these provinces, North Sumatera Province is ranked first in terms of gross regional product with plantations and oil mining as key industries. Even in the whole nation, it is ranked third following West Java and East Java. Rubber, cambor, tea, palm oil and other agricultural products are produced in the plantation estates, which are the main exports of the province. High quality oil with low sulphur are produced in the oil fields located in the northeast coast. Industrial development have also been underway. The Asahan Hydroelectric and Aluminium Project which is now underway in the province as a national development project is expected to further promote the industrialization of the province. At present, however, the economy of the province is underdeveloped compared with its huge economic potential.

Sumatera island is divided into four (4) PLN regional offices, Wilayah as follows:-

| | |
|---|---|
| Region I | Aceh Province |
| Region II | North Sumatera Province including Medan and Lake Toba area |
| Region III | West Sumatera Province, Riau Province and District of Kerinci of Jambi Province |
| Region IV | South Sumatera Province, Jambi Province, Lampung Province and Bengkulu Province including Palembang |

The energy consumption concentrates in Region II and Region IV (39 % and 38 % of whole Sumatera, respectively in 1976) and their demands are expected to increase with higher rates than the average of whole Sumatera.

In Region II, Medan and its vicinity is the highest demand area, about 77 % of whole energy being consumed in the region. There are many local towns in the region, each of which receives energy supply from diesel generators owned either by PLN, rural governments or private consumers. At present, power demand in Medan and its vicinities as well as local towns are growing rapidly and the public energy supply by PLN is far behind the demand. Power demand in the future is expected to keep growing with rapid strides, considering its high economic potential and relatively high per capita income compared with the current energy consumption level. The data of socio-economy in North Sumatera Province is shown in Table 1.1 and Table 1.2.

## 1.2 Asahan Project

Asahan Hydroelectric and Aluminium Project to be executed by Asahan Development Authority and INALUM under the Master Agreement is one of the most important national projects during the Second and Third Five Year Development Plan of Indonesia. Principal objectives of the project are to construct an aluminium smelting plant at Kuala Tanjung and to construct hydropower stations, by which it aims to develop the socio-economy of North Sumatera Province mainly around the Asahan river basin.

Being provided with the plentiful water of Asahan river which flows out from Lake Toba, total capacity of 603 MW will be installed at Siguragura power station and Tangga power station by 1982-84. Generated energy will be supplied to the aluminium smelter to be constructed at Kuala Tanjung located about 120 km away from the power stations through 275 kV transmission line. Utilizing the energy, aluminium production will be commenced in 1982. It will start from 75,000 ton p.a. and reach its final production level of 225,000 ton p.a. in 1984.

According to the Master Agreement, INALUM is to supply the hydroelectric power generated at its power stations to PLN for public supply. The power supply will start from 100 GWh and 25 MW in the initial year, reach its maximum of 218 GWh and 50 MW in the fourth year and keep the constant level thereafter.

## 1.3 Necessity of the Project

Owing to the extreme poor capacities of power generation and limited distribution systems, electric energy consumption had been suppressed for long years in North Sumatera, and such efforts for improving these facilities were made in the beginning and middle of 1970's as installing gas turbine generators in Medan and a number of diesel engine generators with reinforcement and extension of distribution lines, which were financed by foreign and international aids including the Overseas Economic Cooperation Fund (OECF) of Japan for isolated local diesel power plants.

In proportion to these improvement, the power demand in the area is now growing rapidly, with the rates of 25 % to 30 % a year. Yet the energy consumption per capita is at such a low level as about 30 kWh in 1978. Taking into consideration the high economic potential of the area and relatively high per capita income in the area, it is very likely that such a high rate growth will continue for some periods of years.

Although sufficient capacities of power production are available in Medan, the power facilities in local areas currently isolated from Medan will certainly face the fatal shortage within a few years despite additional installation of diesel generators recently completed by the OECF finance.

Under these circumstances, further reinforcement of local isolated power plants or construction of appropriate power transmission systems interconnecting these local areas to bulk power sources is to be planned. Supply of abundant and cheap hydroelectric energy from the Asahan Project naturally gives a preferrence to the construction of transmission systems,

which also meets the government energy policy for oil conservation by providing non-oil energy.

The areas technically and economically coverable by the conceivable transmission lines will be as follows:-

| | |
|---|---|
| Medan Area: | Medan, Binjai and Belawan |
| Local Area: | Brastagi and Kabanjahe |
| | Tebing Tinggi, |
| | Pematang Siantar and Parapat |
| | Kisaran and Tanjung Balai |
| | Porsea and Balige |
| | Tanah Jawa |
| | Pulau Radja |

The Asahan power for the public supply will be available at around the middle of 1982. The early implementation of the Project is, therefore, of vital importance for the people and the economy of the area.

Table 1.1 THE GROSS REGIONAL PRODUCT AND POPULATION IN NORTH SUMATERA

| | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|---|
| Gross Regional Product (GRP) ($Rp.10^9$) | - | 800 | 926 | 1,046 | 1,179 | - |
| Growth rate (%) | - | - | 15.7 | 13.0 | 12.7 | - |
| Population ($10^3$) | 7,006 | 7,191 | 7,370 | 7,576 | 7,711 | 7,941 |
| Growth rate (%) | 1.7 | 2.6 | 2.5 | 2.8 | 1.7 | 3.0 |
| GRP per Capita (Rp.) | - | 108,548 | 125,645 | 138,068 | 152,898 | - |
| Ditto but in US$ | - | 261.56 | 302.76 | 332.69 | 368.43 | - |

Source: Bureau of Statistics of Indonesia, Statistical Pocketbook, 1978/1979

Table 1.2 POPULATION IN THE PROJECT AREA IN 1978

| Location | Population | No. of Houses |
|---|---|---|
| Medan | 1,123,352 | 187,225 |
| Binjai | 73,382 | 12,230 |
| Belawan | 58,148 | 9,691 |
| Tebing Tinggi | 144,025 | 24,004 |
| Pematang Siantar | 273,243 | 45,541 |
| Brastagi/Kabanjahe | 48,370 | 8,062 |
| Parapat | 23,218 | 3,869 |
| Kisaran | 113,590 | 18,932 |
| Tanjung Balai | 91,684 | 15,281 |
| Balige | 34,053 | 5,676 |
| Porsea | 24,144 | 4,024 |
| Tanajawa | 137,835 | 22,972 |

Remarks: Compiled by PLN Wilayah II from Statistical Year Book 1978.
Number of houses: Population/6 (persons)

# CHAPTER 2

# POWER SYSTEM IN NORTH SUMATERA

## 2.1 Outline

The public supply of electric energy in North Sumatera is made by PLN Wilaya II (Region II). Total installed capacity in Region II amounts to 179 MW against the peak load of 54 MW as of 1978/79. A number of private diesel generators are also independently supplying energy for private use in estates and factories. Total installation of such captive power is estimated at about 250 MVA.

The power supply in Region II is divided into five load centers; System Medan, Cabang Binjai/1, Cabang Sibolga, Cabang Pematang Siantar and Cabang Medan/2.

System Medan is the sole power system in Medan, consisting of 150 kV outer ring lines, diesel and gas turbine generators connected thereto and 20 kV/low tension distribution networks. Installed capacity and energy consumption in this system are over 83% and 77% respectively in 1978/79 against the totals in Region II.

Outside System Medan, energy generation and distribution are currently made isolatedly in each town. Most of generators and power distribution systems are rated and operated at 6 kV at present, although new distribution lines of 20 kV design are under construction, due to the PLN's policy of employing 20 kV as the standard distribution voltage.

As for the low tension distribution lines, both of 127 V and 220 V are currently used in mix but it is under standardization with 220 V.

---

/1: Cabang means the sub-region.
Distribution lines in Binjai were recently interconnected to System Medan, and therefore, Cabang Binjai will be soon absorbed to System Medan.

/2: Cabang Medan manages the power supply in the suburbs of Medan, which are not covered by System Medan.

Despite its high economic potential, per capita energy consumption in Region II was recorded as 30.4 kWh in 1978/79, due to the extremely poor facilities in the area.

PLN is now planning to reinforce and extend the power system as follows during the decade of 1980/81 to 1990/91:-

(1) Reinforcement of power generating facilities with 50 MW power supply from the Asahan Project and construction of two units of 65 MW oil-fired thermal generators at Belawan.

(2) Construction of region-wide 150 kV transmission networks to interconnect all major towns in Region II in four stages.

(3) Improvement and extension of distribution lines in each town as well as in its suburbs with new systems of 20 kV/220 V.

## 2.2 Power System in Medan

In spite of its one million population, the generating facilities in Medan was only 24.5 MW in total capacity until 1974. Four sets of 2.5 MW class diesel generators and one unit of 14 MW gas turbine generator, installed at Glugur, were the sole power source. Distribution lines of 7 kV underground cables covered the city center only.

In 1976 to 1977, substantial reinforcement of generating facilities was made by additional installation of:-

| | |
|---|---|
| 2 x 4 MW class diesel generator | at Glugur |
| 1 x 21.5 MW gas turbine generator | " |
| 2 x 4 MW class diesel generators | at Titi Kuning |
| 2 x 14.5 MW gas turbine generator | at Paya Pasir |
| 2 x 29.1 MW gas turbine generator | " |

Thus the total capacity was increased to 148 MW, six times the previous one indeed.

Further, two units of 65 MW oil-fired thermal generators are currently under construction at Belawan with a completion target in December 1983 for the first unit and December 1984 for the second unit.

Distribution systems were also improved and extended in parallel by employing 20 kV overhead lines and/or underground cables, and replacing 7 kV lines with more capacity conductors. A 150 kV ring was planned to interconnect four major stations; Paya Pasir, Medan Timur, Titi Kuning and Paya Geli. The sections of Paya Pasir-Paya Geli-Titi Kuning were completed in 1979 and the remaining under construction. The said Belawan thermal plant will be connected to this 150 kV ring at Paya Pasir.

The power system consisting of the above mentioned generating facilities and transmission/distribution systems is named as System Medan. In 1979, System Medan was extended to Binjai, since then Cabang Binjai was absorbed into System Medan. As of November 1979, System Medan has following facilities (refer to Tables 2.1, 2.2 and Figure 2.1 as for details):-

| | |
|---|---|
| Generating facilities | |
| Diesel generator | 43,478 kW |
| Gas turbine generator | 104,592 kW |
| Total | 148,070 kW |
| 150 kV lines/1 | |
| Paya Pasir-Paya Geli | 21.3 km |
| Paya Geli-Titi Kuning | 30.4 km |
| Total | 51.7 km |
| 150 kV transformers | |
| Titi Kuning, 150 kV/20 kV | 1 x 30,000 kVA |
| Paya Geli " | 1 x 30,000 kVA |
| Paya Pasir " | 2 x 30,000 kVA |
| 150 kV/11 kV/2 | 2 x 18,500 kVA |
| " | 2 x 27,000 kVA |
| Total | 211,000 kVA |

/1: 150 kV ring is designed with two circuits of ACSR 605 MCM, but one circuit only is erected for the time being.

/2: Standard distribution voltage is 20 kV. But, in order to utilize the existing 11 kV and 7 kV (partly rated as 6.3 kV) systems, these transformers were installed for tying the old system to the new systems.

| | | |
|---|---|---|
| 20 kV transformers | | |
| Titi Kuning | 20 kV/7 kV/1 | 2 x 16,000 kVA |
| Glugul | " | 2 x 16,000 kVA |
| | 20 kV/11 kV/7 | 1 x 27,000 kVA |
| | 20 kV/6.3 kV | 1 x 20,000 kVA |
| Total | | 111,000 kVA |

| | |
|---|---|
| Distribution lines and transformers | |
| Distribution lines | 544.8 km in total |
| Distribution transformers | 90,400 kVA " |
| | (1,185 Nos.) |

## 2.3 Power Systems in Other Areas

In other areas than Medan and its vicinity, the public power supply is made by a simple diesel power plant with 6 kV distribution feeders, which cover the town center and its nearby area. The coverage is limited within some-teen km due to the limited transmission capacity of a 6 kV feeder.

The power supply by PLN is available at the following twenty nine towns and villages, and the systems are isolated each other. The typical single connection diagram of PLN's diesel power plants are shown in Figures 2.2 and 2.3.

---

/1: Standard distribution voltage is 20 kV. But, in order to utilize the existing 11 kV and 7 kV (partly rated as 6.3 kV) systems, these transformers were installed for tieing the old system to the new systems.

| | | |
|---|---|---|
| (A) | Project Area/1 | Installed Capacity/3 |
| | Cabang Binjai/2 | |
| | Brastagi | 1,922 kW |
| | Cabang Pematang Siantar | |
| | Pematang Siantar | 6,868 kW |
| | Tebing Tinggi | 2,720 kW |
| | Tanjung Balai | 2,889 kW |
| | Kisaran | 2,286 kW |
| | Parapat | 1,372 kW |
| | Subtotal | 16,135 kW |
| | Cabang Sibolga | |
| | Balige | 1,578 kW |
| | Porsea | 299 kW |
| | Subtotal | 1,877 kW |
| | Total for Project Area (8 sites) | 19,934 kW |
| (B) | Isolated Area (Non-project area) | |
| | Cabang Binjai | |
| | Sidikalang | 720 kW |
| | Tanjung Pura | 650 kW |
| | Port Brandan | 1,004 kW |
| | Other six small towns/villages | 550 kW |
| | Subtotal | 2,924 kW |
| | Cabang Pematang Siantar | |
| | Tanjung Tiram | 400 kW |
| | Rantau Prapat | 1,472 kW |
| | Labuhan Bilik & Ambarita | 277 kW |
| | Subtotal | 2,149 kW |

/1: Project Area means the area to be covered with the proposed transmission system under study in this report.

/2: Remaining area isolated from System Medan.

/3: As for details, see Table 2.1.

| | |
|---|---|
| Cabang Sibolga | |
| Sibolga | 2,451 kW |
| Gunung Sitoli | 972 kW |
| Tarutung | 2,626 kW |
| Other five small towns/villages | 545 kW |
| Subtotal | 6,594 kW |
| Total for Isolated Area (21 sites) | 11,667 kW |
| (C) Total (29 sites) | 31,601 kW |

As for the distribution lines, most towns are served with 6 kV lines. Total length of lines and transformer capacities in the Project Area are reported as 128.62 km and 16,265 kVA, respectively. (Those for the isolated area were not available during the site survey.)

It is noted that the distribution lines recently constructed or currently under construction are designed with 20 kV rating and operated with 6 kV voltage for the time being.

## 2.4 Captive Power

As seen in Table 2.1, the installed capacity not only in Medan but also in other areas was so poor in 1960s as compared below:-

| | Installed Capacity | |
|---|---|---|
| | 1969 | 1979 |
| System Medan | 10,490 kW | 148,070 kW |
| Pematang Siantar | 2,100 kW | 6,868 kW |
| Tebing Tinggi | 600 kW | 2,720 kW |

Therefore, most of plantations and factories were obliged to install their own generators. According to the survey by PLN in 1979, such captive power was recorded as about 500 Nos. and its total installed capacity as 250 MVA.

These private power plants supply the energy not only to their own shops and residential quarters but also to the inhabitants nearby, but the detail is unknown. An interview survey was conducted during the site survey on selected captive power but no data nor useful informations were obtained.

## 2.5 Power Consumption

Typical patterns of power consumption were as follows:-

| | Energy Consumption (GWh) | | |
|---|---|---|---|
| | Medan | P. Siantar | T. Tinggi |
| Residential | 77 (56%) | 5.5 (54%) | 3.0 (61%) |
| Commercial & Public | 38 (27%) | 3.8 (38%) | 1.6 (33%) |
| Industrial | 23 (17%) | 0.8 (8%) | 0.3 (6%) |
| Total | 138 (100%) | 10.1 (100%) | 4.9 (100%) |

As seen above, the residential demand consumes more than a half. Productive consumption by industrial demand is less than 20% even in Medan.

In spite of residential demand type consumption, the load factors in Medan were recorded as high as 68.0% on a weekday and 65.5% on a holiday, probably due to day-time peak of commercial and public demands, in which air conditioners consumption occupies a considerable part. Thus, the peak load in 1979 was recorded as 51,500 kW in Medan, 3,500 kW in Pematang Siantar and 1,700 kW in Tebing Tinggi.

Distribution loss and station use, which were obtained from the balance of production and sales, amount to about one quarter of production, mainly due to over-loaded distribution lines and probably some illegal use.

Further details of consumption are mentioned in the next Chapter with analysises for demand forecasting.

## 2.6 Future Extension Program

In planning the future extension, it is basically presumed that the 150 kV transmission network under study in this report will soon be implemented and forms a backbone of the region-wide power system. The network will then be extended to cover all major towns in Region II and power production be centralized in Medan and Asahan by shutting down all isolated small-scale diesel power stations. It is noted, however, that interim reinforcement of isolated diesel power plants is not avoidable until the network reaches thereto.

The future extension programs in Region II planned by PLN for the decade of 1980s are as follows:-

Generation Plans

Stage I (1980 - 1983)

1) 10.75 MW (4 MW in the Project Area) of diesel generators to be added in 1980
2) Two sets of 4 MW diesel generators to be removed from Medan to Banda Ache and Bali in 1980
3) Asahan power (25 MW initially and 50 MW finally) to be received in 1983
4) No.1 unit of 65 MW thermal generator to be installed in 1983 at Belawan

Stage II (1984 - 1986)

1) No.2 unit of 65 MW thermal generator to be added in 1984 at Belawan
2) 10 MW in total of diesel generators to be removed from the Project Area to the other area in Region II, immediately after receiving Asahan power

Stage III (1987 - 1990)

1) Installation of 100 MW class thermal generators as required
2) Retirement of a 14 MW gas turbine generator at Glugur

Transmission Plans

Stage I (1980 - 1983)

Completion of 150 kV Medan ring and 150 kV lines to cover the Project Area

Stage II (1984 - 1987)

Extension of 150 kV network to Pangkalan, Port Brandan, Tanjung Pura and Labuhan Bilik, and interconnection with Region I (Banda Ache System)

Stage III (1988 - 1990)

Extension of 150 kV lines from Brastagi to Sibolga and further to Labuhan Bilik, thus final completion of region-wide 150 kV network.

Upon completion of the region-wide network, the length of 150 kV line becomes 856 km and 150 kV transformers capacity 986 kVA in total.

Distribution Plans

New construction of 20 kV distribution systems, conversion of existing 7 kV/6 kV systems to 20 kV systems as well as extension and reinforcement of low tension lines will be executed in each load center depending on the growth of demands. In the Project Area, following will be constructed during the period of REPELITA III (1978 - 1982):-

| | |
|---|---|
| High tension lines | 1,115.83 km |
| Low tension lines | 1,360.78 km |
| Distribution transformers | 108.75 MVA |

Table 2.1 EXISTING POWER STATION IN THE PROJECT AREA
(AS OF NOVEMBER, 1979)

| Name | Installed Capacity (kW) | Voltage (kV) | Year of Completion |
|---|---|---|---|
| I. Medan System | | | |
| 1. Glugur | | | |
| Diesel Power | 2,500 x 1 | 7 | 1956 |
| | 2,715 x 2 | 7 | 1962 |
| | 2,560 x 1 | 7 | 1965 |
| | 4,142 x 1 | 7 | 1976 |
| | 4,000 x 1 | 7 | 1977 |
| Gas Power | 14,000 x 1 | 7 | 1968 |
| | 21,500 x 1 | 7 | 1976 |
| 2. Titi Kuning | | | |
| Diesel Power | 4,141 x 6 | 6 | 1976 |
| 3. Paya Pasir | | | |
| Gas Power | 14,446 x 2 | 11.5 | 1976 |
| | 20,100 x 2 | 11.5 | 1977 |
| Sub-total | 148,070 | | |
| Diesel Power | 43,478 | | |
| Gas Power | 104,592 | | |
| II. Cabang Binjai | | | |
| 1. Brastage | | | |
| Diesel Power | 300 x 1 | 6 | 1968 |
| | 250 x 1 | 6 | 1971 |
| | 336 x 1 | 6 | 1974 |
| | 250 x 1 | 6 | 1975 |
| | 536 x 1 | 6 | 1977 |
| | 250 x 1 | 6 | 1978 |
| Sub-total | 1,922 | | |
| Diesel | 1,922 | | |

| Name | Installed Capacity (kW) | Voltage (kV) | Year of Completion |
|---|---|---|---|
| III. Cabang P. Siantar | | | |
| 1. Pematang Siantar | | | |
| Diesel Power | 2,100 x 1 | 6 | 1967 |
| | 584 x 2 | 6 | 1970 |
| | 2,100 x 1 | 6 | 1975 |
| | 750 x 2 | 6 | 1978 |
| 2. Tebing Tinggi | | | |
| Diesel Power | 300 x 2 | 6 | 1961 |
| | 1,000 x 1 | 6 | 1971 |
| | 370 x 1 | 6 | 1976 |
| | 750 x 1 | 6 | 1978 |
| 3. Tanjung Balai | | | |
| Diesel Power | 275 x 1 | 6 | 1961 |
| | 1,000 x 1 | 6 | 1970 |
| | 328 x 1 | 6 | 1976 |
| | 750 x 1 | 6 | 1978 |
| | 536 x 1 | 6 | 1978 |
| 4. Kisaran | | | |
| Diesel Power | 250 x 2 | 6 | 1958 |
| | 250 x 1 | 6 | 1973 |
| | 200 x 1 | 6 | 1975 |
| | 300 x 1 | 6 | 1976 |
| | 250 x 1 | 6 | 1976 |
| | 536 x 1 | 6 | 1977 |
| | 250 x 1 | 6 | 1978 |
| 5. Parapat | | | |
| Diesel Power | 125 x 1 | 6 | 1969 |
| | 125 x 1 | 6 | 1972 |
| | 336 x 1 | 6 | 1977 |
| | 536 x 1 | 6 | 1978 |
| | 250 x 1 | 6 | 1978 |
| Sub-total | 16,135 | | |
| Diesel Power | 16,135 | | |

| Name | Installed Capacity (kW) | Voltage (kV) | Year of Completion |
|---|---|---|---|
| IV. Cabang Sibolga | | | |
| 1. Balige | | | |
| Diesel Power | 328 x 2 | 6 | 1976 |
| | 336 x 2 | 6 | 1976 |
| | 250 x 1 | 6 | 1978 |
| 2. Porsea | | | |
| Diesel Power | 125 x 1 | 0.22 | 1968 |
| | 64 x 1 | 0.22 | 1969 |
| | 110 x 1 | 0.22 | 1977 |
| Sub-total | 1,877 | | |
| Diesel Power | 1,877 | | |
| Total | 168,004 | | |
| Diesel Power | 63,412 | | |
| Gas Power | 104,592 | | |

Source: Annual Records of PLN Wilayah II (State General Electricity Enterprise, North Sumatera) - "Perusahaan Umum Listric Negara, Wilayah II - Sumatera Utara, dalam angha dan grafih".

Table 2.2 DISTRIBUTION SUBSTATIONS AND LINES IN THE PROJECT AREA

Distribution Substation

| Location | 1974/75 | | | 1975/76 | | | 1976/77 | | | 1977/78 | | | 1978/79 | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nos. | km | kVA | Nos. | km | kVA | Nos. | km | kVA | Nos. | km | kVA | Nos. | km | kVA | |
| Medan System | | | | | | | | | | | | | | | | |
| Medan | 919 | 200.60 | 28,115 | 243 | 363.01 | 32,475 | 491 | 322.60 | 42,880 | 898 | 348.60 | 72,856 | 1,160 | 470.90 | 86,540 | |
| Binjei | 6 | 5.95 | 1,150 | 6 | 5.95 | 1,150 | 10 | 70.21 | 1,760 | 10 | 70.21 | 1,700 | 10 | 70.21 | 1,700 | |
| Belawan | 14 | 6.00 | 1,480 | 14 | 6.00 | 1,480 | 9 | 3.70 | 1,170 | 11 | 3.70 | 1,430 | 15 | 3.70 | 2,160 | |
| Brastage/K. Jahe | 19 | 21.00 | 999 | 19 | 21.00 | 999 | 19 | 22.12 | 999 | 19 | 22.12 | 999 | 20 | 22.12 | 1,099 | |
| T. Tinggi | 20 | 15.20 | 1,990 | 20 | 15.20 | 1,990 | 20 | 15.20 | 2,460 | 22 | 16.20 | 2,610 | 28 | 16.20 | 2,220 | |
| P. Siantar | 23 | 19.70 | 2,010 | 24 | 19.70 | 2,060 | 47 | 36.85 | 4,325 | 55 | 59.95 | 4,675 | 62 | 59.95 | 6,874 | |
| Parapat | 2 | 2.10 | 200 | 2 | 2.12 | 200 | 2 | 2.12 | 200 | 4 | 5.12 | 460 | 6 | 5.20 | 660 | |
| Kisaran | 9 | 5.47 | 785 | 9 | 5.47 | 785 | 9 | 5.47 | 785 | 9 | 5.50 | 845 | 19 | 10.20 | 2,080 | |
| T. Balai | 11 | 11.90 | 1,030 | 11 | 11.90 | 1,030 | 14 | 11.90 | 1,880 | 14 | 11.90 | 2,097 | 15 | 11.90 | 2,472 | |
| Balige | 3 | 1.25 | 500 | 3 | 2.55 | 500 | 2 | 2.55 | 350 | 6 | 3.50 | 860 | 6 | 3.05 | 860 | |
| Porsea | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | Only Low Voltage |
| Pulau Radja | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | From Plantation Power Station |
| Tana Jawa | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | From Penda Power Station |

Source: Annual Records of PLN Wilayah II (State General Electricity Enterprise)

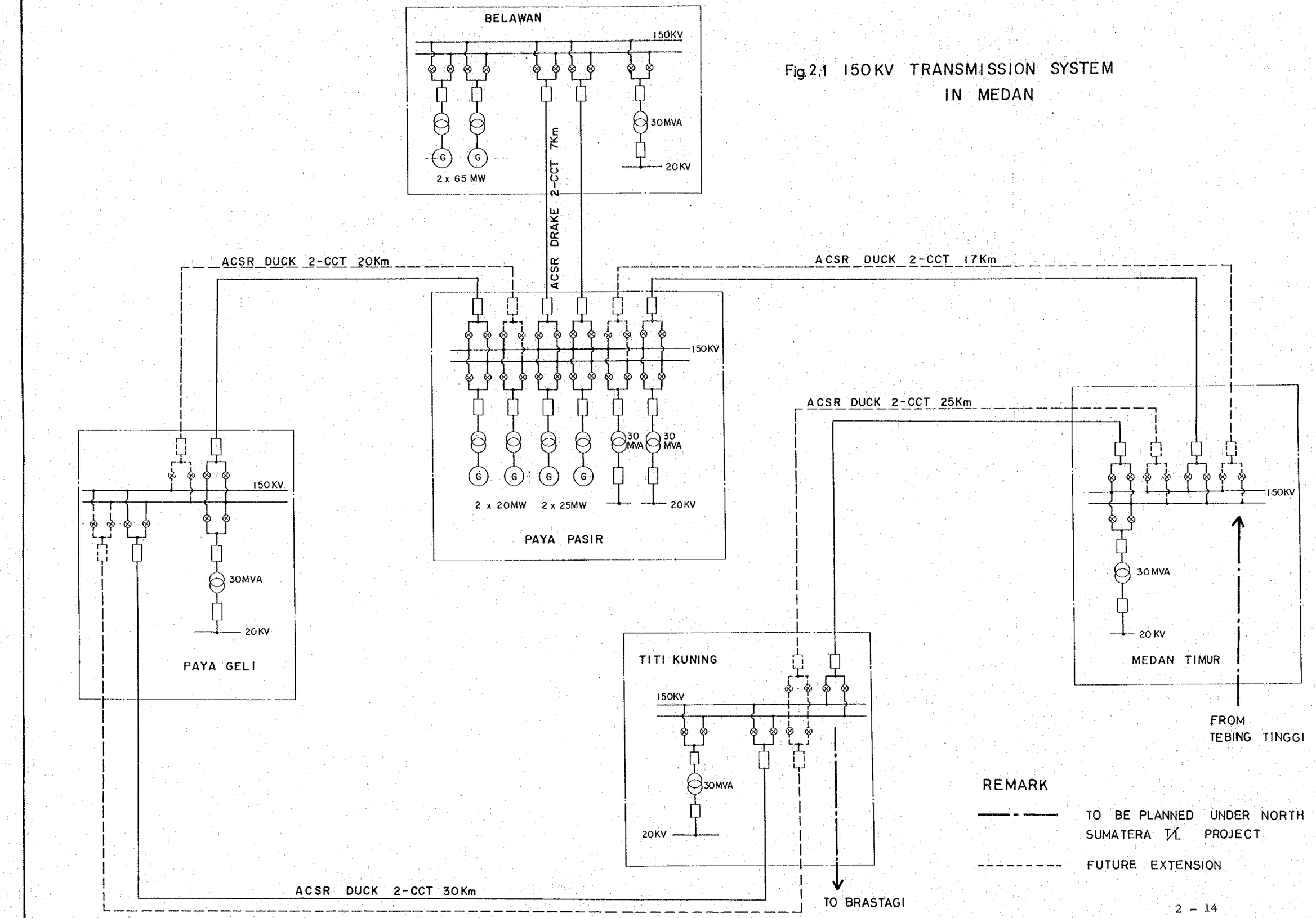



Fig.2.1 150KV TRANSMISSION SYSTEM IN MEDAN

Fig. 2.2 SINGLE LINE DIAGRAM OF T.TINGGI DIESEL P/S

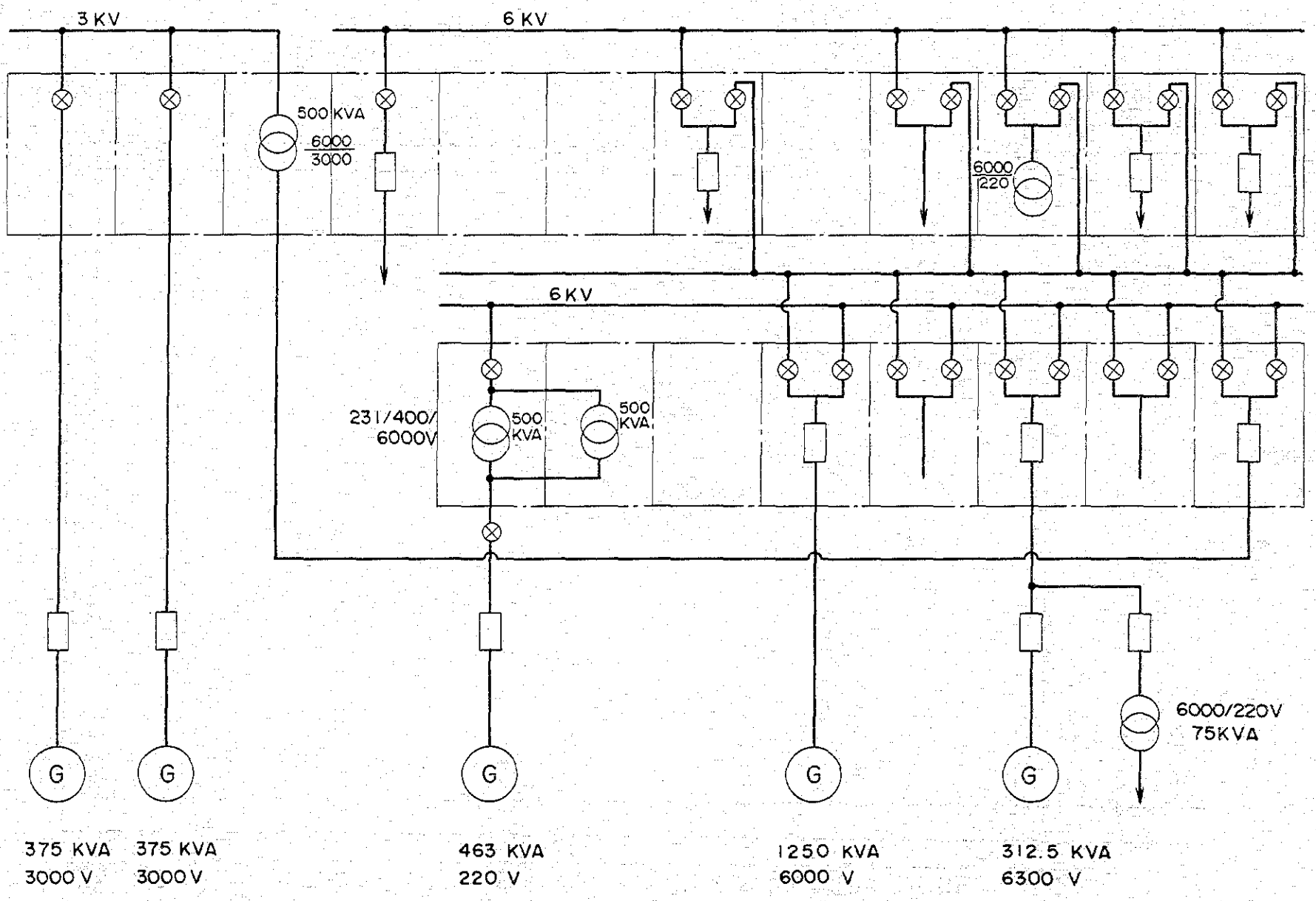
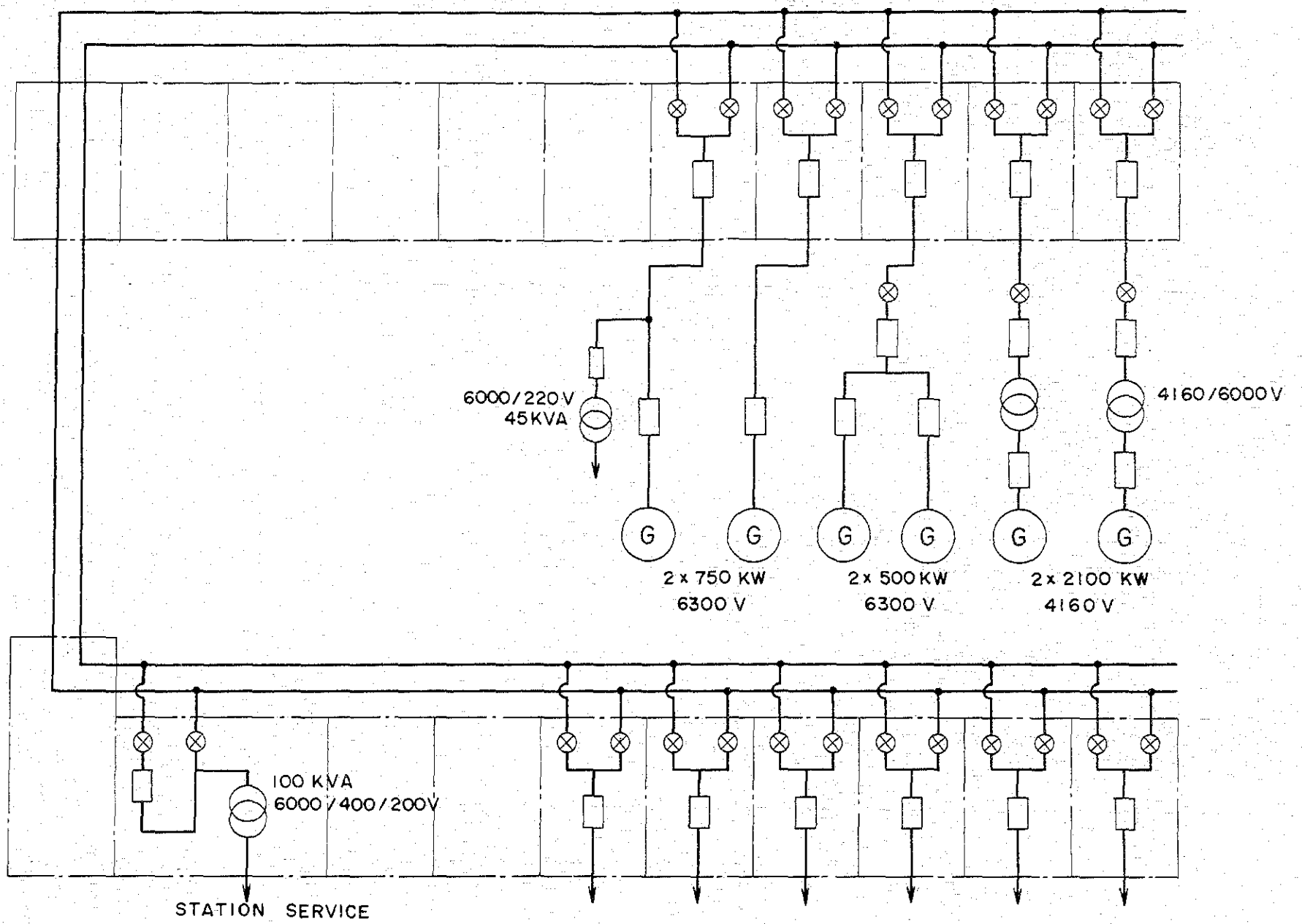


Fig. 2.3 SINGLE LINE DIAGRAM OF P.SIANTAR DIESEL P/S



CHAPTER 3

# DEMAND FORECAST

## 3.1 Analysis of Past Power Consumption

Past trend of power consumption[/1] of the Project Area in each load center is analysed for the five-year period of 1974 through 1978, for the items as follows:-

a) Electrification ratio (%)
b) Unit energy consumption per residential customer (kWh p.a.)
c) Residential demand (MWh p.a.)
d) Commercial and public demand (MWh p.a.)
e) Industrial demand (MWh p.a.)

The past electrification ratios of Medan and Pematang Siantar together with their annual increments are given below.

| | Electrification (%) | | | | |
|---|---|---|---|---|---|
| Load Center | 1974 | 1975 | 1976 | 1977 | 1978 |
| Medan | 16.5 | 16.6 (+0.1) | 17.1 (+0.5) | 22.3 (+5.2) | 29.6 (+7.3) |
| P. Siantar | 19.4 | 20.0 (+0.6) | 21.0 (+1.0) | 23.7 (+2.7) | 33.9 (+10.2) |

As seen in the table, the electrification ratios in the two towns give upward trends. The past improvement, however, does not show any steady trend, beginning with very low improvement rate and ending with quite high rate. The improvement trends in the other load centers show similar characteristics.

---

/1: Consumption of electric power and energy supplies by PLN.

Unit energy consumption per residential customer in Medan and Pematang Siantar together with their annual increments are given below.

| | 1974 | 1975 | 1976 | 1977 | 1978 |
|---|---|---|---|---|---|
| Medan: | | | | | |
| Unit Energy Consumption (kWh p.a.) | 1,295 | 1,300 | 1,458 | 1,378 | 1,378 |
| Increment (kWh p.a.) | | +5 | +158 | -80 | 0 |
| Pematang Siantar: | | | | | |
| Unit Energy Consumption (kWh p.a.) | 516 | 716 | 729 | 451 | 731 |
| Increment (kWh p.a.) | | +200 | +13 | -278 | +180 |

As seen in the table, unit energy consumptions per residental customer in Medan and Pematang Siantar fluctuate widely, showing no clear trend of growth. In the other load centers, similar fluctuations are observed.

Residential demands, commercial demands and industrial demands in Medan Area and Pematang Siantar are given below.

Medan Area

| | 1974 | 1975 | 1976 | 1977 | 1978 | Average |
|---|---|---|---|---|---|---|
| Residential | | | | | | |
| Demand (MWh p.a.) | 29,191 | 30,198 | 32,238 | 42,608 | 58,497 | |
| Growth Rate (% p.a.) | | 3.4 | 6.8 | 32.2 | 37.3 | 19.9 |
| Commercial & Public | | | | | | |
| Demand (MWh p.a.) | 29,380 | 33,918 | 36,260 | 43,211 | 47,082 | |
| Growth Rate (% p.a.) | | 15.4 | 6.9 | 19.2 | 8.9 | 12.6 |
| Ratio to Residential Demand (%) | 100.6 | 112.3 | 112.5 | 101.4 | 80.5 | 98.5 |
| Industrial | | | | | | |
| Demand (MWh p.a.) | 11,491 | 11,542 | 11,783 | 17,454 | 22,622 | |
| Growth Rate (% p.a.) | | 0.4 | 2.1 | 48.1 | 29.6 | 20.1 |
| Ratio to Residential Demand (%) | 39.4 | 38.2 | 36.6 | 40.9 | 38.7 | 38.9 |

P. Siantar including Parapat

| | 1974 | 1975 | 1976 | 1977 | 1978 | Average |
|---|---|---|---|---|---|---|
| Residential | | | | | | |
| Demand (MWh p.a.) | 2,465 | 3,625 | 3,963 | 5,562 | 5,856 | |
| Growth Rate (% p.a.) | | 47.1 | 9.3 | 40.3 | 5.3 | 25.5 |
| Commercial & Public | | | | | | |
| Demand (MWh p.a.) | 2,932 | 2,477 | 2,963 | 4,352 | 4,348 | |
| Growth Rate (% p.a.) | | -15.5 | 19.6 | 46.9 | -0.09 | 12.7 |
| Ratio to Residential Demand (%) | 118.9 | 68.3 | 74.8 | 78.2 | 74.2 | 79.5 |
| Industrial | | | | | | |
| Demand (MWh p.a.) | 401 | 353 | 420 | 876 | 843 | |
| Growth Rate (% p.a.) | -11.9 | 18.9 | 108.6 | -3.8 | | 28.0 |
| Ratio to Residential Demand (%) | 16.3 | 9.7 | 10.6 | 15.7 | 14.4 | 13.5 |

As seen in the tables, the residential demands in Medan and Pematang Siantar were growing during the period, reflecting the improvement in electrification ratio as well as population increase. Their growth rates, however, do not give steady trend.

The commercial and public demands also widely fluctuated during the period with positive and negative growth rates while their ratios to residential demands give declining trend on the whole. During the same period, the ratios of commercial and public demands to residential demands in East Java kept stable as shown below.

Percentage of Commercial and Public Demand to Residential Demand in East Java

| 1974 | 1975 | 1976 | 1977 | 1978 | Average |
|---|---|---|---|---|---|
| 39.2 | 37.5 | 36.0 | 31.8 | 34.6 | 35.8 |

Considering the current development level of the economy of North Sumatera relative to East Java as well as its high economic potential, North Sumatera is likely to make tracks for East Java in the future. The percentage of commercial and public demand to residential demand in North Sumatera is also likely to get close to that in East Java which were stable in recent years in the near future.

The industrial demands fluctuated during the period in a similar manner, giving no clear trend of growth.

The categorical demands in the other load centers during the period give similar characteristics.

## 3.2 Demand Forecast

### 3.2.1 General

Demand forecast for electric power and energy is made for serving the following objectives:-

a. To study the overall supply/demand balance for public energy in the Project Area
b. To estimate the demand of each load center including distribution loss and thereby serve for the system planning as well as cost estimate of the Project and also to determine the appropriate capacity of alternative diesel power plants for benefit estimate for the Project.

The Project Area is consisting of several load centers as follows:-

i) Medan, Binjai and Belawan
ii) Brastagi and Kabanjahe
iii) T. Tinggi
iv) P. Siantar and Parapat
v) Kisaran and Tg. Balai
vi) Balige and Porsea
vii) Kuala Tanjung

For the purpose of the Study, these load centers are divided into two areas, i.e., Medan Area comprising Medan, Binjai and Belawan and Local Area comprising the others.

Demand forecast is made up to 1990, taking into consideration the followings.

a. The demand forecast extends over as long as 10 years from the time of the Study, 1980. Forecast period of 10 years or more is generally considered to be super long-range and the accuracy is quite dubious.

b. The Local Area currently depends on their limited isolated generators for its energy supply and yet much part are even not electrified. Some of the generators are already superannuated and need to be replaced. Even the others have become uneconomical under the sharp increase of oil price. Under these conditions, currently there exists a large latent demand in the area. Therefore, the conventional demand forecast based on the past trend, which is quite generally adopted, is not likely to be reliable.

### 3.2.2 Methods of Forecast

Demand forecast is made for four different coases which are briefly described hereunder.

i) Lower Demand Forecast (Lower Forecast):
Lower forecast is made based on the "microscopic method" by summing up the energy demand of various categories for each load center estimated from population, family size, electrification ratio, tendency of consumption, expected big-scale customers and captive demand.

ii) Upper Demand Forecast (Upper Forecast):
Upper forecast is obtained in exactly the same manner as in lower forecast with a few different basic assumptions.

iii) Modified PLN's Forecast:

Modified PLN's forecast for the Project Area is obtained by adjusting PLN's forecast made in 1979 for the whole area of Region II, North Sumatera, of which the Project Area constitutes a large portion, on the assumption that the demand in the Project Area in 1990 will account for about 80 % of the total demand in Region II according to its population ratio to the total population.

iv) Macroscopic Demand Forecast:

Macroscopic demand forecast is made based on likely growth rates of demand in due consideration for the past growth trend of demand as a whole.

3.2.3 Demand Forecast by Microscopic Method

a) Lower Forecast

Total power demand (customer demand) is divided into the following categories:-

a. Residential Demand
b. Commercial and Public Demand
c. General Industrial Demand excluding Big Customers
d. Industrial Demand by Big Customers

Residential demand is computed as follows:-

Number of household (Population/Household size) x Electrification ratio x Unit consumption per customer

The following assumptions are made for the above variables.

a. Population growth rates are assumed at 2.6 % p.a. during 1979-83 and 2.3 % p.a. during 1984-90 on the basis of REPELITA-III, North Sumatera and REPELITA-III, National Level in due consideration for the past growth rate of 2.8 % p.a. in North Sumatera.

b. Household size is assumed at 6 persons/household throughout the forecast period on the basis of the estimated figure for 1978.

c. Electrification ratio is assumed to be improved by 8.7 % p.a. over the actual ratio in 1978 up to the limit of 80 % on the basis of REPELITA-III, North Sumatera and JICA Report in 1976, "The Third Five-Year Power Development Plan on Sumatera".

d. Although unit consumption in the Project Area did not grow in recent years, it is expected to increase as the economy develops. However, unit consumption is assumed to remain constant throughout the forecast period, considering the low unit consumption level of new customers. The assumed unit consumption in each load center is as follows:-

| Load Center | Unit Consumption (kWh) |
|---|---|
| Medan Area | 1,300 |
| T. Tinggi | 1,000 |
| Brastagi & Kabanjahe | 850 |
| P. Siantar & Parapat | 650 |
| Kisaran & Tg. Balai | 850 |
| Balige & Porsea | 650 |

Residential demand thus obtained for each load center is shown in Table 3.1. Total demand in the Project Area is shown in Table 3.2.

The commercial and public demands in the Project Area widely fluctuated in recent years, giving no stable trend of growth. In this forecast, therefore, it is assumed that the percentage of commercial and public demand to residential demand in each load center in 1990 will basically get close to that in East Java in 1978, about 35 %, considering

the current development level of North Sumatera compared with East Java as well as its high economic potential. The industrial characteristics of each load center is also paid due attention, namely Brastagi and Parapat as tourist resorts and Pematang Siantar as a commercial center. The assumed figures are given below. A linear change during 1979-1990 is also assumed.

| Load Center | Percentage (%) 1979 | 1990 |
|---|---|---|
| Medan System | 80 | 40 |
| T. Tinggi | 54 | 40 |
| Brastagi & Kabanjahe | 90 | 60 |
| P. Siantar & Parapat | 75 | 60 |
| Kisaran & Tg. Balai | 55 | 40 |
| Balige & Porsea | 36 | 40 |

Commercial and public demand thus obtained for each load center is shown in Table 3.1. Total demand in the Project Area is given in Table 3.2.

The industrial demands in the Project Area fluctuated widely in recent years, giving no clear trend of growth. In this forecast, therefore, it is assumed that the percentage of general industrial demand to residential demand in each load center in 1990 will reach a certain figure which is determined by the industrial characteristics of each load center and its resemblance to the towns in East Java on the basis of the figure in 1979. The assumed figures are shown below. Percentage of industrial demand to residential demand in the towns in East Java during 1975-1978 is also given below.

| Load Centers in the Project Area | Percentage (%) 1979 | 1990 |
|---|---|---|
| System Medan | 40 | 90 |
| T. Tinggi | 11 | 40 |
| Brastagi & Kabanjahe | 3 | 20 |
| P. Siantar & Parapat | 14 | 40 |
| Kisaran & T. Balai | 1 | 20 |
| Balige & Porsea | 30 | 30 |

| Town in East Java | Percentage during 1975-1978 (%) |
|---|---|
| Surabaya | 113.3 |
| Madiun | 21.5 |
| Mojokerto | 22.2 |
| Average | 76.8 |

General industrial demand thus obtained for each load center is shown in Table 3.1. Total demand in the Project Area is given in Table 3.2.

In 1978, captive power in the Project Area was estimated at about 250 MVA. In this forecast, 2/3 of the captive power is assumed to be connected to PLN system. As for new big industrial schemes, only definite plans are considered and assumed to be connected to the system. The demand comprising captive power and new big industrial schemes for each load center is shown in Table 3.1 under the title of "Big Customers". Total demand in the Project Area is given in Table 3.2.

Total categorical demands and total energy demand including distribution loss for the whole Project Area are given in Table 3.2.

Total system demand including system loss (transmission loss and station use) is summarized below. Details are shown in Table 3.3.and illustrated in Figure 3.1 through Figure 3.3.

| Total System Demand | 1983 | 1987 | 1990 |
|---|---|---|---|
| Energy demand (GWh) | 674.0 | 1,189.8 | 1,604.4 |
| Peak load (MW)/1 | 130 | 218 | 282 |

/1: Peak load is computed from the energy demand by applying appropriately assumed load factors, 55 % in 1978 to 65 % in 1990, as given in Table 3.4.

b) Upper Forecast

The upper demand forecast is made in exactly the same manner as in lower demand forecast except a few basic assumptions as follows:-

i) Unit consumption per customer is assumed to be constant till 1982 and to increase from 1983 at the growth rate of 3 % p.a.

ii) Big industrial demand, i.e., demand of captive power and new big industry, is assumed to be identical with Lower Forecast up to 1982/83. After 1983/84, the demand is assumed to grow at the annual rate which is 5 % higher than that of Lower Forecast on the grounds that the commencement of the operation of the Asahan smelter, which is scheduled in 1982, may accelerate the industrialization of the Project Area.

Total demand in the Project Area is summarized below. Details are shown in Table 3.5 and illustrated in Figure 3.1.

| Demand | 1983 | 1987 | 1990 |
|---|---|---|---|
| Total energy demand including distribution loss (GWh) | 625.62 | 1,430.23 | 2,065.40 |
| Total system demand: | | | |
| Energy Demand (GWh) | 672.62 | 1,394.93 | 2,294.87 |
| Peak Load (MW) | 130 | 255 | 403 |

3.2.4 Modified PLN's Forecast and Macroscopic Demand Forecast

a) Modified PLN's Forecast

PLN made a demand forecast in 1979 for the whole area of Region II (North Sumatera) for 1980/81 - 1990/91 period which is summarized as follows:-

| Demand | 1983 | 1987 | 1990 |
|---|---|---|---|
| Energy Demand (GWh) | 678 | 1,671 | 2,876 |
| Peak Load (MW) | 129 | 298 | 490 |

In 1978/79, the energy consumption in the Isolated Area, which is located within Region II but outside the Project Area and has been supplied with electric energy through PLN, was only about 65 % of the total consumption in Region II. With the reinforcement of public energy supply capacity in the future, however, the demand in the Isolated Area is most likely to grow rapidly. The demand of the Area in 1990 is, therefore, assumed at 20 % of the total demand in Region II on the basis of the town population ratio of the Area to the total town population of the Region II, i.e., about 23 % as of 1978.

PLN's Forecast for Region II is modified in this study to obtain the demand forecast for the Project Area only by subtracting the demand in Isolated Area from the total demand in Region II. The modified PLN's Forecast is summarized below and illustrated in Figure 3.1.

| Demand | 1983 | 1987 | 1990 |
|---|---|---|---|
| Energy Demand (GWh) | 542.4 | 1,336.8 | 2,300.8 |
| Peak Load (MW) | 103.2 | 238.4 | 392.0 |

b) Macroscopic Demand Forecast

Macroscopis demand forecast is made for the Project Area for 1980/81 - 1990/91 period on the basis of the power growth trend in the past years. Average annual growth rate is assumed as follows for each year during the period, reflecting the high growth rates in the past three years and expecting the rate to be converged to a moderate rate of 12.5 %, which is in due compliance with the agreements arrived at during the discussion made between PLN and the JICA Survey Team on December 10, 1979.

| | 1979/80 | 80/81 | 81/82 | 82/83 | 83/84 | 84/85 | 85/86 | 86/87-90/91 |
|---|---|---|---|---|---|---|---|---|
| Assumed Annual Average Growth Rate (%) | 30.0 | 27.5 | 25.0 | 22.5 | 20.0 | 17.5 | 15.0 | 12.5 |

The demand forecast thus obtained is shown in Figure 3.1.

### 3.2.5 Comparison of the Forecasts

The four forecasts made for the total energy demand and peak load in the Project Area are given in Figure 3.1 and briefly tabulated below.

| Forecasts | Energy Demand (GWh) 1983 | 1987 | 1990 |
|---|---|---|---|
| Lower Forecast | 673 | 1,190 | 1,604 |
| Upper Forecast | 673 | 1,395 | 2,295 |
| Modified PLN's Forecast | 542 | 1,337 | 2,301 |
| Macroscopic Forecast | 730 | 1,250 | 1,780 |

As can be seen in the figure and the table, Lower Forecast gives the lowest value among the forecasts. Upper Forecast and Modified PLN's Forecast are almost identical with each other and give the highest value. The demand forecast made by macroscopic method goes in between.

## 3.3 Demand/Supply Balance

In the Medan power system, thermal plants are expected to be completed in Belawan to reinforce the existing capacity, one unit of 65 MW at around December 1983 and another unit of 65 MW at around December 1984. According to the Master Agreement, hydropower to be generated at Asahan is also to be provided to the Project Area from INALUM following the schedule as given below.

| Supply | 1983/84 | 84/85 | 85/86 | 86/87-2017/18 |
|---|---|---|---|---|
| Energy (GWh) | 100 | 150 | 190 | 218 |
| Power (MW) | 25 | 35 | 45 | 50 |

Meanwhile, removal of diesel plants to the Isolated Area of the Region II as well as scrapping of some obsolete units are under

consideration by PLN. In this study the following removal schedule/1 is assumed for the existing diesel plants in the Project Area.

| 1979/80 | 83/84 | 84/85 |
|---|---|---|
| 8 MW/2 | 10 MW/3 | 20 MW/3 |

The gas turbine plants in Glugur with the total capacity of 40 MW is assumed to be kept in operation.

In case of Lower Forecast, the total energy demand at generating end (system demand) in the Project Area is as illustrated in the lower portion of Figure 3.3. The supply schedule is drawn up to meet this power demand fully until 1990, paying due attention to the existing plans for installation and removal in compliance with the agreements arrived at on the discussion meeting held between PLN and JICA Survey Team on December 10, 1979.

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/1: As stated in Section 3.2.4, the demand in the Isolated Area in 1990 is assumed to be about 20 % of the total demand in Region II, i.e., one quarter of that in the Project Area (20 %/80 %). According to the Lower Forecast, the demand in the Project Area in 1990 is estimated at 282 MW, indicating that the demand in the Isolated Area will be around 70 MW, well over the total capacity of the diesel plants to be removed to the area. The removal schedule, therefore, is fully justified.

/2: To be removed to Java.

/3: To be removed to the Isolated Area in North Sumatera.

The supply schedule obtained under these assumptions is illustrated in the upper portion of Figure 3.3 . Even for the Lower Forecast which gives the lowest value of the demand, the total installed capacity is narrowly above the peak load up to 1990. The firm supply capacity/1 will be, however, exceeded by the peak load after 1988/89. In this Study, the shortage of supply capacity is assumed to be met by the reinforcement of the Medan Power System./2

System demand in the Project Area is estimated to be fully met with the energy supply from various sources as specified in the figure.

In case of Macroscopic demand forecast, firm supply capacity will be exceeded by the peak load after 1987/88 and after 1986/87 in case of the others.

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/1: Firm supply capacity is obtained by deducting reserve capacity (periodic inspecting capacity + marginal supply capability) from installed capacity. In this Study, reserve capacity is assumed to be equivalent to the unit having the maximum capacity in the whole system.

/2: Because reinforcement of the Medan System is most economical due to the economy of scale.

TABLE 3.1.a SUMMARY OF ENERGY DEMAND FORECAST INCLUDING DISTRIBUTION LOSS IN SYSTEM MEDAN (MEDAN, BINJAI, BELAWAN)

(BY MICROSCOPIC METHOD, LOWER FORECAST)

| | 1978 (Actual) | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Residential Demand | | | | | | | | | | | | | |
| 1-1 Population ($10^3$) | 1,220 | 1,252 | 1,285 | 1,318 | 1,352 | 1,387 | 1,419 | 1,452 | 1,485 | 1,519 | 1,554 | 1,590 | 1,627 |
| 1-2 Electrification Ratio (%) | 28.6 | 31.1 | 33.8 | 36.7 | 39.9 | 43.4 | 47.2 | 51.3 | 55.8 | 60.7 | 66.0 | 71.4 | 77.6 |
| 1-3 Customers ($10^3$) /1 | 58 | 65 | 72 | 81 | 90 | 100 | 112 | 124 | 138 | 154 | 171 | 189 | 210 |
| 1-4 Sub-total /2 (GWh) | 77 | 85 | 94 | 105 | 117 | 130 | 146 | 161 | 179 | 200 | 222 | 246 | 273 |
| 2. Commercial & Public Demand | | | | | | | | | | | | | |
| 2-1 Ratio to Residential Demand (%) | 80.5 | 77.1 | 73.7 | 70.3 | 66.9 | 63.5 | 60.1 | 56.7 | 53.3 | 49.9 | 46.5 | 43.1 | 40.0 |
| 2-2 Sub-total (GWh) | 47 | 66 | 69 | 74 | 78 | 83 | 88 | 91 | 95 | 100 | 103 | 106 | 109 |
| 3. Industrial Demand | | | | | | | | | | | | | |
| 3-1 Ratio to Residential Demand (%) | 38.9 | 43.1 | 47.3 | 51.5 | 55.7 | 59.9 | 64.1 | 68.3 | 72.5 | 76.7 | 83.9 | 88.1 | 90.0 |
| 3-2 General Industrial Demand (GWh) | 23 | 37 | 44 | 54 | 65 | 78 | 94 | 110 | 130 | 153 | 186 | 217 | 246 |
| 3-3 Big Customers (GWh) | - | 7 | 35 | 65 | 100 | 139 | 176 | 228 | 266 | 297 | 304 | 321 | 350 |
| 3-4 Sub-total (GWh) | 23 | 44 | 79 | 119 | 165 | 217 | 270 | 338 | 396 | 450 | 490 | 538 | 596 |
| 4. Total Customers' Demand (GWh) | 147 | 195 | 242 | 298 | 360 | 430 | 504 | 590 | 670 | 750 | 815 | 890 | 978 |
| 5. Distribution Loss (GWh) (Loss factor (%)) | - | 25.0 | 24.5 | 24.0 | 23.0 | 22.0 | 21.0 | 20.0 | 19.0 | 18.0 | 17.0 | 16.0 | 15.0 |
| 6. Total Energy Demand Inc. Distri. Loss (GWh) | 199 | 260 | 321 | 392 | 468 | 551 | 638 | 738 | 827 | 915 | 982 | 1,060 | 1,515 |

/1 Population + 6 (persons/family) x Electrification Ratio

/2 Consumption per customer 1,300 kWh x Customer

/3 Ratio of General Industrial Demand to Residential Demand

TABLE 3.1.b SUMMARY OF ENERGY DEMAND FORECAST INCLUDING DISTRIBUTION LOSS IN BRASTAGI/KABANJAHE

(BY MICROSCOPIC METHOD, LOWER FORECAST)

| | 1978 (Actual) | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Residential Demand | | | | | | | | | | | | | |
| 1-1 Population ($10^3$) | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 |
| 1-2 Electrification Ratio (%) | 25.0 | 27.2 | 29.6 | 32.2 | 35.0 | 38.0 | 41.3 | 44.9 | 48.8 | 53.0 | 57.6 | 62.6 | 68.0 |
| 1-3 Customers ($10^3$)/1 | 2.0 | 2.3 | 2.6 | 2.8 | 3.2 | 3.5 | 3.9 | 4.3 | 4.7 | 5.2 | 5.8 | 6.4 | 7.0 |
| 1-4 Sub-total/2 (GWh) | 2.02 | 1.96 | 2.21 | 2.38 | 2.72 | 2.98 | 3.32 | 3.66 | 4.00 | 4.42 | 4.93 | 5.44 | 5.95 |
| 2. Commercial & Public Demand | | | | | | | | | | | | | |
| 2-1 Ratio to Residential Demand (%) | 93.0 | 90.0 | 87.3 | 84.6 | 81.9 | 79.2 | 76.5 | 73.8 | 71.1 | 68.4 | 65.7 | 63.0 | 60.0 |
| 2-2 Sub-total (GWh) | 1.88 | 1.76 | 1.93 | 2.01 | 2.23 | 2.36 | 2.54 | 2.70 | 2.84 | 3.02 | 3.24 | 3.43 | 3.58 |
| 3. Industrial Demand | | | | | | | | | | | | | |
| 3-1 Ratio to Residential Demand (%) | 2.5 | 3.9 | 5.3 | 6.7 | 8.1 | 9.6 | 11.1 | 12.6 | 14.1 | 15.6 | 17.1 | 18.6 | 20.0 |
| 3-2 General Industrial Demand (GWh) | 0.05 | 0.08 | 0.12 | 0.16 | 0.22 | 0.29 | 0.37 | 0.46 | 0.56 | 0.69 | 0.84 | 1.01 | 1.19 |
| 3-3 Big Customers (GWh) | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3-4 Sub-total (GWh) | 0.05 | 0.08 | 0.12 | 0.16 | 0.22 | 0.29 | 0.37 | 0.46 | 0.56 | 0.69 | 0.84 | 1.01 | 1.19 |
| 4. Total Customers' Demand (GWh) | 3.95 | 3.80 | 4.26 | 4.55 | 5.17 | 5.63 | 6.23 | 6.82 | 7.40 | 8.13 | 9.01 | 9.88 | 10.72 |
| 5. Distribution Loss (%) | - | 25.0 | 24.5 | 24.0 | 23.0 | 22.0 | 21.0 | 20.0 | 19.0 | 18.0 | 17.0 | 16.0 | 15.0 |
| 6. Total Energy Demand Inc. Distri. Loss (GWh) | 4.98 | 5.07 | 5.64 | 5.99 | 6.71 | 7.22 | 7.89 | 8.53 | 9.14 | 9.91 | 10.86 | 11.76 | 12.61 |

/1 Population ÷ 6 (persons/family) x Electrification Ratio

/2 Consumption per customer 850 kWh x Customer

/3 Ratio of General Industrial Demand to Residential Demand

TABLE 3.1.c SUMMARY OF ENERGY DEMAND FORECAST INCLUDING DISTRIBUTION LOSS IN T. TINGGI

(BY MICROSCOPIC METHOD, LOWER FORECAST)

| | 1978 (Actual) | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Residential Demand | | | | | | | | | | | | | |
| 1-1 Population ($10^3$) | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
| 1-2 Electrification Ratio (%) | 54.0 | 58.7 | 63.8 | 69.4 | 75.4 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 |
| 1-3 Customers ($10^3$)/1 | 2.9 | 3.2 | 3.7 | 4.2 | 4.6 | 4.8 | 5.2 | 5.3 | 5.5 | 5.6 | 5.7 | 5.9 | 6.0 |
| 1-4 Sub-total/2 (GWh) | 2.99 | 3.20 | 3.70 | 4.20 | 4.60 | 4.80 | 5.20 | 5.30 | 5.50 | 5.60 | 5.70 | 5.90 | 6.00 |
| 2. Commercial & Public Demand | | | | | | | | | | | | | |
| 2-1 Ratio to Residential Demand (%) | 53.7 | 52.6 | 51.5 | 50.4 | 49.3 | 48.2 | 47.1 | 46.0 | 44.8 | 43.6 | 42.4 | 41.2 | 40.0 |
| 2-2 Sub-total (GWh) | 1.61 | 1.68 | 1.90 | 2.12 | 2.27 | 2.31 | 2.45 | 2.45 | 2.46 | 2.46 | 2.47 | 2.47 | 2.48 |
| 3. Industrial Demand | | | | | | | | | | | | | |
| 3-1 Ratio to Residential Demand (%) | 10.8 | 13.2 | 15.6 | 18.0 | 20.4 | 22.8 | 25.2 | 27.6 | 30.0 | 32.5 | 35.0 | 37.5 | 40.0 |
| 3-2 General Industrial Demand (GWh) | 0.32 | 0.42 | 0.58 | 0.76 | 0.94 | 1.09 | 1.31 | 1.46 | 1.65 | 1.82 | 2.00 | 2.21 | 2.40 |
| 3-3 Big Customers (GWh) | - | - | - | - | - | 0.45 | 0.84 | 3.09 | 6.59 | 14.62 | 20.33 | 25.82 | 31.42 |
| 3-4 Sub-total (GWh) | 0.32 | 0.42 | 0.58 | 0.76 | 0.94 | 1.54 | 2.15 | 4.55 | 8.24 | 16.44 | 22.33 | 28.03 | 33.82 |
| 4. Total Customers' Demand (GWh) | 4.92 | 5.30 | 6.18 | 7.08 | 7.81 | 8.65 | 9.80 | 12.30 | 16.20 | 24.50 | 30.50 | 36.40 | 42.30 |
| 5. Distribution Loss (%) | - | 25.0 | 24.5 | 24.0 | 23.0 | 22.0 | 21.0 | 20.0 | 19.0 | 18.0 | 17.0 | 16.0 | 15.0 |
| 6. Total Energy Demand Inc. Distri. Loss (GWh) | 6.28 | 7.07 | 8.19 | 9.32 | 10.14 | 11.09 | 12.41 | 15.38 | 20.00 | 29.88 | 36.75 | 43.33 | 49.77 |

/1 Population ÷ 6 (persons/family) x Electrification Ratio

/2 Consumption per customer 1,000 kWh x Customer

/3 Ratio of General Industrial Demand to Residential Demand

TABLE 3.1.d SUMMARY OF ENERGY DEMAND FORECAST INCLUDING DISTRIBUTION LOSS IN P. SIANTAR/PARAPAT

(BY MICROSCOPIC METHOD, LOWER FORECAST)

| | 1978 (Actual) | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Residential Demand | | | | | | | | | | | | | |
| 1-1 Population ($10^3$) | 163 | 167 | 171 | 175 | 180 | 185 | 189 | 193 | 197 | 202 | 207 | 212 | 217 |
| 1-2 Electrification Ratio (%) | 33.8 | 36.7 | 39.9 | 43.3 | 47.0 | 51.0 | 55.4 | 60.2 | 65.3 | 70.9 | 77.0 | 80.0 | 80.0 |
| 1-3 Customers ($10^3$) /1 | 9 | 10 | 11 | 13 | 14 | 16 | 17 | 19 | 21 | 24 | 27 | 28 | 29 |
| 1-4 Sub-total /2 (GWh) | 5.86 | 6.50 | 7.15 | 8.45 | 9.10 | 10.40 | 11.05 | 12.35 | 13.65 | 15.60 | 17.55 | 18.20 | 18.85 |
| 2. Commercial & Public Demand | | | | | | | | | | | | | |
| 2-1 Ratio to Residential Demand (%) | 74.2 | 73.1 | 71.9 | 70.7 | 69.5 | 68.3 | 67.1 | 65.9 | 64.7 | 63.5 | 62.3 | 61.1 | 60.0 |
| 2-2 Sub-total (GWh) | 4.35 | 4.75 | 5.14 | 5.97 | 6.32 | 7.10 | 7.41 | 8.14 | 8.83 | 9.91 | 10.93 | 11.12 | 11.31 |
| 3. Industrial Demand | | | | | | | | | | | | | |
| 3-1 Ratio to Residential Demand (%) | 14.4 | 16.5 | 18.6 | 20.7 | 22.8 | 24.9 | 27.0 | 29.1 | 31.2 | 33.4 | 35.6 | 37.8 | 40.0 |
| 3-2 General Industrial Demand (GWh) | 0.84 | 1.07 | 1.33 | 1.75 | 2.07 | 2.59 | 2.98 | 3.59 | 4.26 | 5.21 | 6.25 | 6.88 | 7.54 |
| 3-3 Big Customers (GWh) | - | - | - | - | - | 1.41 | 4.06 | 7.42 | 18.46 | 26.28 | 31.77 | 36.80 | 44.40 |
| 3-4 Sub-total (GWh) | 0.84 | 1.07 | 1.33 | 1.75 | 2.07 | 4.00 | 7.04 | 11.01 | 22.72 | 31.49 | 38.02 | 43.68 | 51.94 |
| 4. Total Customers' Demand (GWh) | 11.05 | 12.32 | 13.62 | 16.17 | 17.49 | 21.50 | 25.50 | 31.50 | 45.20 | 57.00 | 66.50 | 73.00 | 82.10 |
| 5. Distribution Loss (%) | 26.0 | 25.0 | 24.5 | 24.0 | 23.0 | 22.0 | 21.0 | 20.0 | 19.0 | 18.0 | 17.0 | 16.0 | 15.0 |
| 6. Total Energy Demand Inc. Distri. Loss (GWh) | 12.97 | 16.43 | 18.04 | 21.28 | 22.71 | 27.56 | 32.28 | 39.38 | 55.80 | 65.51 | 80.12 | 86.90 | 96.59 |

/1 Population ÷ 6 (persons/family) x Electrification Ratio

/2 Consumption per customer 650 kWh x Customer

/3 Ratio of General Industrial Demand to Residential Demand

TABLE 3.1.e SUMMARY OF ENERGY DEMAND FORECAST INCLUDING DISTRIBUTION LOSS IN KISARAN/TG.BALAI

(BY MICROSCOPIC METHOD, LOWER FORECAST)

| | 1978 (Actual) | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Residential Demand | | | | | | | | | | | | | |
| 1-1 Population ($10^3$) | 155 | 159 | 163 | 167 | 171 | 175 | 179 | 183 | 187 | 191 | 195 | 199 | 204 |
| 1-2 Electrification Ratio (%) | 20.9 | 22.7 | 24.7 | 26.8 | 29.1 | 31.6 | 34.3 | 37.2 | 40.4 | 43.9 | 47.7 | 51.8 | 56.3 |
| 1-3 Customers ($10^3$) /1 | 5.4 | 6.0 | 6.7 | 7.5 | 8.3 | 9.2 | 10.2 | 11.3 | 12.6 | 14.0 | 15.5 | 17.2 | 19.1 |
| 1-4 Sub-total /2 (GWh) | 4.54 | 5.10 | 5.70 | 6.38 | 7.06 | 7.82 | 8.67 | 9.61 | 10.71 | 11.90 | 13.18 | 14.62 | 16.15 |
| 2. Commercial & Public Demand | | | | | | | | | | | | | |
| 2-1 Ratio to Residential Demand (%) | 54.3 | 53.1 | 51.9 | 50.7 | 49.5 | 48.3 | 47.1 | 45.9 | 44.7 | 43.5 | 42.3 | 41.1 | 40.0 |
| 2-2 Sub-total (GWh) | 2.46 | 2.71 | 2.96 | 3.23 | 3.49 | 3.78 | 4.08 | 4.41 | 4.79 | 5.18 | 5.58 | 6.01 | 6.46 |
| 3. Industrial Demand | | | | | | | | | | | | | |
| 3-1 Ratio to Residential Demand (%) | 1.1 | 2.7 | 4.3 | 5.9 | 7.5 | 9.1 | 10.7 | 12.3 | 13.9 | 15.5 | 17.1 | 18.7 | 20.0 |
| 3-2 General Industrial Demand (GWh) | 0.05 | 0.14 | 0.25 | 0.38 | 0.53 | 0.71 | 0.93 | 1.18 | 1.49 | 1.84 | 2.25 | 2.73 | 3.23 |
| 3-3 Big Customers (GWh) | - | - | - | - | - | 0.89 | 2.22 | 4.60 | 8.71 | 15.98 | 29.69 | 41.44 | 53.10 |
| 3-4 Sub-total (GWh) | 0.05 | 0.14 | 0.25 | 0.38 | 0.53 | 1.60 | 3.15 | 5.78 | 10.20 | 17.82 | 31.94 | 44.17 | 56.23 |
| 4. Total Customers' Demand (GWh) | 7.05 | 7.95 | 8.91 | 9.99 | 11.08 | 13.20 | 15.90 | 19.80 | 25.7 | 34.90 | 50.70 | 64.80 | 78.94 |
| 5. Distribution Loss (%) | 26.0 | 25.0 | 24.5 | 24.0 | 23.0 | 22.0 | 21.0 | 20.0 | 19.0 | 18.0 | 17.0 | 16.0 | 15.0 |
| 6. Total Energy Demand Inc. Distri. Loss (GWh) | 8.91 | 10.60 | 11.80 | 13.14 | 14.39 | 16.92 | 20.13 | 24.75 | 31.73 | 42.56 | 61.08 | 77.14 | 92.87 |

/1 Population ÷ 6 (persons/family) x Electrification Ratio

/2 Consumption per customer 850 kWh x Customer

/3 Ratio of General Industrial Demand to Residential Demand

TABLE 3.1.f SUMMARY OF ENERGY DEMAND FORECAST INCLUDING DISTRIBUTION LOSS IN BALIGE/PORSEA

(BY MICROSCOPIC METHOD, LOWER FORECAST)

| | 1978 (Actual) | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Residential Demand | | | | | | | | | | | | | |
| 1-1 Population ($10^3$) | 60 | 62 | 64 | 66 | 68 | 70 | 72 | 74 | 76 | 78 | 80 | 82 | 84 |
| 1-2 Electrification Ratio (%) | 16.8 | 18.2 | 19.8 | 21.5 | 23.3 | 25.3 | 27.5 | 29.9 | 32.5 | 35.3 | 38.3 | 41.6 | 45.2 |
| 1-3 Customers ($10^3$)/1 | 1.8 | 1.9 | 2.1 | 2.4 | 2.6 | 2.9 | 3.0 | 3.7 | 4.1 | 4.6 | 5.1 | 5.7 | 6.3 |
| 1-4 Sub-total/2 (GWh) | 1.13 | 1.24 | 1.37 | 1.56 | 1.69 | 1.89 | 2.15 | 2.41 | 2.67 | 2.99 | 3.32 | 3.71 | 4.10 |
| 2. Commercial & Public Demand | | | | | | | | | | | | | |
| 2-1 Ratio to Residential Demand (%) | 36.0 | 36.3 | 36.6 | 36.9 | 37.2 | 37.5 | 37.8 | 38.1 | 38.5 | 38.8 | 39.2 | 39.6 | 40.0 |
| 2-2 Sub-total (GWh) | 0.41 | 0.45 | 0.50 | 0.58 | 0.63 | 0.71 | 0.81 | 0.93 | 1.03 | 1.16 | 1.30 | 1.47 | 1.64 |
| 3. Industrial Demand | | | | | | | | | | | | | |
| 3-1 Ratio to Residential Demand (%) | 28.8 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |
| 3-2 General Industrial Demand (GWh) | 0.33 | 0.37 | 0.41 | 0.46 | 0.51 | 0.57 | 0.65 | 0.72 | 0.80 | 0.90 | 1.00 | 1.11 | 1.23 |
| 3-3 Big Customers (GWh) | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3-4 Sub-total (GWh) | 0.33 | 0.37 | 0.41 | 0.46 | 0.51 | 0.57 | 0.65 | 0.72 | 0.80 | 0.90 | 1.00 | 1.11 | 1.23 |
| 4. Total Customers' Demand (GWh) | 1.87 | 2.06 | 2.28 | 2.60 | 2.83 | 3.17 | 3.61 | 4.06 | 4.50 | 5.05 | 5.62 | 6.29 | 6.97 |
| 5. Distribution Loss (%) | - | 25.0 | 24.5 | 24.0 | 23.0 | 22.0 | 21.0 | 20.0 | 19.0 | 18.0 | 17.0 | 16.0 | 15.0 |
| 6. Total Energy Demand Inc. Distri. Loss (GWh) | 2.21 | 2.75 | 3.02 | 3.42 | 3.68 | 4.06 | 4.57 | 5.08 | 5.55 | 6.16 | 6.77 | 7.49 | 8.20 |

/1 Population ÷ 6 (persons/family) x Electrification Ratio

/2 Consumption per customer 650 kWh x Customer

/3 Ratio of General Industrial Demand to Residential Demand

TABLE 3.1.g SUMMARY OF ENERGY DEMAND FORECAST INCLUDING DISTRIBUTION LOSS IN KUALA TANJUNG

(BY MICROSCOPIC METHOD, LOWER FORECAST)

| | 1978 (Actual) | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Residential Demand | | | | | | | | | | | | | |
| 1-1 Population ($10^3$) | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1-2 Electrification (%) | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1-3 Customer ($10^3$)/1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1-4 Sub-total/2 (GWh) | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2. Commercial & Public Demand | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2-1 Ratio to Residential Demand (%) | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2-2 Sub-total (GWh) | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3. Industrial Demand | | | | | | | | | | | | | |
| 3-1 Ratio to Residential Demand (%) | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3-2 General Industrial Demand (GWh) | - | - | - | - | - | 7.0 | 7.0/1 | 7.0/1 | 7.0/1 | 7.0/1 | 7.0/1 | 7.0/1 | 7.0/1 |
| 3-3 Big Customers (GWh) | - | - | - | - | - | - | 0.8 | 1.9 | 3.6 | 6.2 | 11.4 | 16.0 | 21.0 |
| 3-4 Sub-total (GWh) | - | - | - | - | - | 7.0 | 7.8 | 8.9 | 10.6 | 13.2 | 18.4 | 23.0 | 28.0 |
| 4. Total Customers' Demand (GWh) | - | - | - | | | 7.0 | 7.8 | 8.9 | 10.6 | 13.2 | 18.4 | 23.0 | 28.0 |
| 5. Distribution Loss (%) | - | - | - | | | 22.0 | 21.0 | 20.0 | 19.0 | 18.0 | 17.0 | 16.0 | 15.0 |
| 6. Total Energy Demand Inc. Distri. Loss (GWh) | - | - | - | | | 9.0 | 9.8 | 11.1 | 13.1 | 16.1 | 22.2 | 27.4 | 32.9 |

/1 Asahan Smelts Residential Quater including Commercial & Public Demand

TABLE 3.2 SUMMARY OF ENERGY DEMAND FORECAST INCLUDING DISTRIBUTION LOSS IN THE PROJECT AREA

(BY MICROSCOPIC METHOD, LOWER FORECAST)

| | 1978 (Actual) | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Residential Demand | | | | | | | | | | | | | |
| 1-1 Population ($10^3$) | 1,681 | 1,725 | 1,770 | 1,815 | 1,862 | 1,910 | 1,954 | 1,999 | 2,044 | 2,091 | 2,139 | 2,188 | 2,239 |
| 1-2 Electrification Ratio (%) | 29.9 | 32.4 | 35.3 | 38.3 | 41.6 | 44.9 | 47.6 | 50.6 | 53.8 | 57.3 | 61.1 | 64.6 | 67.9 |
| 1-3 Customers ($10^3$)/1 | 79.2 | 88.4 | 98.1 | 110.9 | 122.7 | 136.4 | 151.3 | 167.6 | 185.9 | 207.4 | 230.1 | 252.2 | 277.4 |
| 1-4 Sub-total/2 (GWh) | 93.54 | 103.00 | 114.13 | 127.97 | 142.17 | 157.89 | 176.49 | 194.33 | 215.53 | 240.51 | 266.68 | 293.87 | 324.05 |
| 2. Commercial & Public Demand | | | | | | | | | | | | | |
| 2-1 Ratio to Residential Demand (%) | 61.7 | 75.2 | 71.4 | 68.6 | 65.3 | 62.9 | 59.7 | 56.4 | 53.3 | 50.6 | 47.4 | 44.4 | 41.4 |
| 2-2 Sub-total (GWh) | 57.71 | 77.35 | 81.43 | 87.91 | 92.94 | 99.26 | 105.29 | 109.63 | 114.95 | 121.73 | 126.52 | 130.50 | 134.47 |
| 3. Industrial Demand | | | | | | | | | | | | | |
| 3-1 Ratio to Residential/3 Demand (%) | 26.3 | 38.0 | 40.8 | 44.9 | 48.7 | 57.2 | 60.8 | 64.0 | 67.6 | 70.9 | 77.0 | 81.0 | 82.9 |
| 3-2 General Industrial Demand (GWh) | 24.59 | 39.08 | 46.69 | 57.51 | 69.27 | 90.25 | 107.24 | 124.41 | 138.76 | 170.46 | 205.34 | 237.94 | 268.59 |
| 3-3 Big Customers (GWh) | - | 7.0 | 35.00 | 65.00 | 100.00 | 141.75 | 183.77 | 247.37 | 309.82 | 358.75 | 397.19 | 440.77 | 499.92 |
| 3-4 Sub-total (GWh) | 24.59 | 46.08 | 81.69 | 122.51 | 169.27 | 232.00 | 291.01 | 371.78 | 448.58 | 529.21 | 602.53 | 678.71 | 768.51 |
| 4. Total Customers' Demand (GWh) | 175.84 | 226.43 | 277.25 | 338.39 | 404.38 | 489.15 | 572.79 | 675.74 | 779.06 | 891.45 | 995.73 | 1,103.08 | 1,227.03 |
| 5. Distribution Loss (%) | - | 25.0 | 24.5 | 24.0 | 23.0 | 22.0 | 21.0 | 20.0 | 19.0 | 18.0 | 17.0 | 16.0 | 15.0 |
| 6. Total Energy Demand Inc. Distri. Loss (GWh) | 234.35 | 301.92 | 367.69 | 445.15 | 525.63 | 625.62 | 725.34 | 847.06 | 961.69 | 1,083.54 | 1,199.67 | 1,313.68 | 1,443.94 |

/1 Population ÷ 6 (persons/family) x Electrification Ratio

/2 Consumption per customer x Customer

/3 Ratio of General Industrial Demand to Residential Demand

TABLE 3.3 SYSTEM DEMAND FORECAST IN THE PROJECT AREA
(BY MICROSCOPIC METHOD, LOWER FORECAST)

| | | 1978 (Actual) | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | Energy Demand Inc. Distri. Loss (GWh) | 234.4 | 301.9 | 367.7 | 445.2 | 525.6 | 625.6 | 725.3 | 847.1 | 961.7 | 1,083.5 | 1,199.7 | 1,313.7 | 1,443.9 |
| (2) | Transmission Loss & Station use (%) | - | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 7.9 | 8.3 | 8.8 | 9.2 | 9.6 | 10.0 |
| (3) | Total System Demand (GWh) | 240.1 | 317.8 | 389.1 | 473.6 | 562.2 | 674.0 | 783.9 | 914.5 | 1,049.4 | 1,189.8 | 1,321.3 | 1,453.6 | 1,604.4 |
| (4) | Load Factor (%) | 55.0 | 55.8 | 56.6 | 57.4 | 58.2 | 59.0 | 59.8 | 60.6 | 61.5 | 62.4 | 63.3 | 64.2 | 65 |
| (5) | Peak Load (MW) | 50 | 65 | 78 | 94 | 110 | 130 | 150 | 172 | 195 | 218 | 238 | 258 | 282 |

Figure 3.1 DEMAND FORECAST IN PLN REGION-I

(PROJECT AREA)

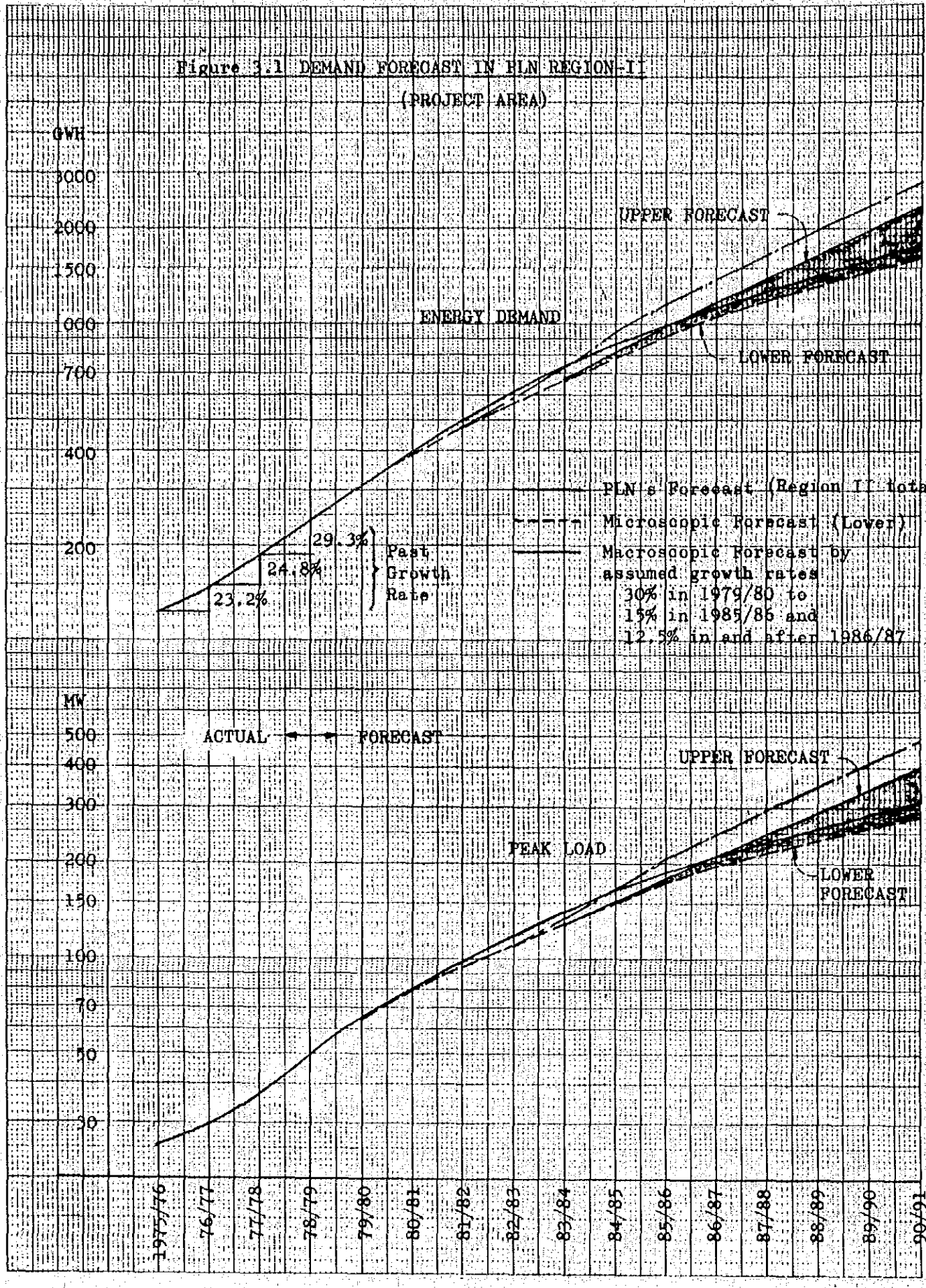

Figure 3.2 ENERGY DEMAND FORECAST (BY LOWER FORECAST)
(MICROSCOPIC METHOD)
LOWER FORECAST