SECTION 9

COMMUNICATION SYSTEM
AND
EQUIPMENT

SECTION 9 COMMUNICATION SYSTEM AND EQUIPMENT

Many out-stations (about thirty-three out-stations in 2005) will be arranged in a serial form, extending to about 500 km toward east - west and about 400 km toward south - north, when viewed from Padang where a load dispatching center is proposed to be constructed.

Since the Barisan Mountain Ranges with an approximate elevation of 3,000 m run across the boundary of West Sumatra and Riau Province, the communication system should also be determined by taking into consideration this point, along with future power system and load dispatching system.

9.1 Types and Features of Communication Systems

The following three communication systems are considered to be applicable for the Central Sumatra Power System.

9.1.1 Power Line Carrier (PLC) Communication System

The PLC communication system which uses transmission line has been adopted most widely in Indonesia. Although this system is low in cost and easy in maintenance when compared with the other systems, smooth transmission of information will become difficult in view of transmission time and due to noise, etc. in case the amount of information processing has become large or in case a large number of related out-stations have been arranged in series.

9.1.2 Microwave Communication System

The microwave communication system using parabolic antenna has much larger information processing capacity but its cost is higher than the PLC system, and much influenced by geographical situation, especially on hight of antenna tower and possible communication distance etc,. Meanwhile, communication will sometimes become impossible due to heavy rain.

9.1.3 Optical Fiber Communication System

The optical fiber communication system, which is a system using optical fiber cable, is the most advanced communication system in terms of both quality and quantity and is capable of quickly processing a huge volume of information. This system is expected to be adopted widely for communication system in the world.

Along with decrease of its cost, this system will be competitive enough to the microwave communication system.

As for cable stringing systems, the following two can be considered. One is a so-called OPGW system wherein optical fiber cable is incorporated into overhead grounding wire (GW) of transmission line, and another is a system wherein optical fiber cable is strung on transmission line towers by giving tensile strength to the cable itself. Under this study, it was considered to adopt reinforced fiber cable between the sections of existing transmission lines, and OPGW between the sections of those to be newly constructed.

9.2 Selection of Communication System

9.2.1 Basic Concept

As mentioned above, the individual communication systems have respectively inherent features in terms of construction cost, information transmission capacity, reliability, etc. Under this project, however, the PLC communication system will, in principle, be adopted according to the following two reasons, and other system will be adopted only in case transmission of information by the PLC system is deemed to be difficult.

(1) Required information transmission capacity is rather small

The average amount of information transmitted per one out-station is roughly equivalent to TM = 16, SV = 50 and RC = 15 (Refer to Table 9.2-1) and the PLC system will be sufficient by dividing the out- stations into an appropriate number of groups.

(2) The construction cost of the PLC system is substantially lower than that of the other two systems.

Comparison of Construction Cost (Refer to Table 9.2-2)

(a) In case the distance is 50 km

(Transmission of information is assumed to be possible without any amplifier in both cases of the microwave and optical fiber communication systems)

PLC: Micro: Optical = 1: 6.4: 4.6 (6.3)

The value in parenthesis refers to the ratio in case the reinforced optical fibre cable is stringed on existing transmission towers.

(b) In case the distance is 70 km

(One amplifier is assumed to be provided each for the microwave and optical fiber communication systems)

PLC: Micro: Optical = 1: 10.3: 6.6 (8.8)

The value in parenthesis is the same as in (a) above.

9.2.2 Communication System

Based upon the basic concept described in Clause 9.2.1 above, the communication systems for the power system in Central Sumatra have been studied and the results are presented below.

(1) Prerequisite conditions

In principle, the TM and SV data updating cycles should be as follows:

TM: Within 10 sec.
SV: Within 3 sec.

(2) Configuration of communication system

The center of communication system viewed from the power system in Central Sumatra is roughly between Payakumbuh and Ombilin in West Sumatra. The straight distance from Padang, where load dispatching office are proposed to be constructed, to Payakumbuh, and that from Padang to Ombilin are 90 km and 50 km, and in terms of span length of transmission lines, 129 km and 71 km respectively.

The Payakumbuh Substation is expected to become an information communication center from the power system in Riau Province, while the Ombilin Power Plant is also expected to constitute an information communication center as an interconnecting point with the power system toward Tembilahan and the southern power system in the future. To ensure accurate processing of such complex information, it will be essential to adopt microwave or optical communication system between the Payakumbuh Substation, Ombilin Power Plant and Padang Load Dispatching Center.

As a result of comparative study on both of the communication systems, the optical communication system has been adopted judging from its economic advantage (Refer to Table 9.2-3) and information processing capacity.

(3) PLC system

(a) Communication system

In consideration that many out-stations will be arranged in a serial form and in view of the necessity to transmit the amount of information listed in Table 9.2-1 precisely within limited time, a poling communication system should be adopted, by dividing every three out-station into one communication group.

(b) Circuit configuration

The number of out-stations within the power system is expected to reach about thirty-three in 2005. When every three of these out-stations are divided into one group, then the out-stations are devided into 33 ÷ 3 = 11 communication groups, as shown in Fig. 9.2-1.

(c) No. of PLC channels

Two channels are applied to telephone and then upper bands are allocated to Telemeter, Supervision and Remote control information.

(d) Existing PLC system

At present, the following PLC equipment has been installed among Maninjau Power Plant, Pauh Limo Substation and Salak Substation in the existing transmission line system:

Manufacturer	:	BBC
Applicable Code	:	IEC
Transmission speed	:	200 B
No. of channels	:	2 ch, 4 kHz band width
System	:	Poling

(4) Optical communication system

(a) Reinforced fiber cable (six cores) will be strung on the towers of the existing transmission line (71 km) between Padang Load Dispatching Center and Ombilin Plant. With the Solok Substation as a relay terminal, the terminal equipment will be installed at both of the terminals.

(b) For a 58 km transmission line between Ombilin Power Plant and Payakumbuh Substation, OPGW will be strung. With the Batusangkar Substation as a relay terminal, the terminal equipment will be installed at both of the terminals.

Based upon the results of above study, the communication system for Central Sumatra Power System is as outlined in Fig. 9.2-1.

Table 9.2-1 Required amount of information to be transmitted

TM: Telemeter
SV: Supervision
RC: Remote control

	Out-stations	1995			1996-2005			TOTAL		
		TM	SV	RC	TM	SV	RC	TM	SV	RC
1	Pariaman				14	39	12	14	39	12
2	Lubuk Alung	14	54	17				14	54	17
3	Kandis				16	47	13	16	47	13
4	Pauh Limo	30	79	27				30	79	27
5	Simpangharu	20	52	19				20	52	19
6	Teluk Bayur				14	40	13	14	40	13
7	Painan				13	44	14	13	44	14
8	Indarung	9	36	9				9	36	9
9	Solok	14	42	13				14	42	13
10	Salak	12	48	13				12	48	13
11	Padang Panjang				14	50	15	14	50	15
12	Batusangkar	14	58	19				14	58	19
13	Payakumbuh	16	60	19				16	60	19
14	Padang Luar	16	58	17				16	58	17
15	Lubuk Sikaping				12	42	13	12	42	13
31	Bangkinang	12	50	15				12	50	15
32	Pekanbaru	41	96	35				41	96	35
33	Duri	16	58	17				16	58	17
34	Dumai	30	74	23				30	74	23
35	Bagan Siapi-api				12	42	13	12	42	13
36	Teluk Kuantan				14	62	20	14	62	20
37	Airmolek				13	49	14	13	49	14
38	Rengat				16	54	18	16	54	18
39	Tembilahan				13	45	15	13	45	15
41	PERTAMINA				2	19	3	2	19	3
42	Minas				14	54	15	14	54	15
43	Indah Kiat				2	20	3	2	20	3
	Sub-total	244	765	243	169	607	181	413	1372	424
G1	Maninjau	25	64	18				25	64	18
G2	Singkarak	26	75	18				26	75	18
G3	Ombilin	20	59	16				20	59	16
G4	Kotapanjang	16	40	9				16	40	9
G5					16	43	8	16	43	8
G6	Batang Agam	11	15	7				11	15	7
	Sub-total	98	253	68	16	43	8	114	296	76
①	Total	342	1018	311	185	650	189	527	1668	500
②	Total number of out-stations							33		
③	Average number/out-station ③ = ① - ②							16	50	15

Quantity of information in this table is figured out from out-stations expected into power system by 2005 in Central Sumatra.

Table 9.2-2 Comparison of construction cost for the respective communication systems

(Unit of construction cost : 10^3 Yen)

1. In case the distance is 50 km

(It is assumed possible to transmit information without any relay in both cases of microwave and optical communication system)

(1) PLCT (Metallic return)

Line trap	2,500 x 2 =	5,000	
CCPD	2,000 x 2 =	4,000	31,000
PLC	6,000 x 2 =	12,000	
Power source and others	5,000 x 2 =	10,000	

(2) Microwave communication system

Construction of tower	70,000 x 2 =	140,000	
Antenna work		8,000	
Digital micro	13,000 x 2 =	26,000	198,000
1.5 M mux.	4,000 x 2 =	8,000	
Power source and others	8,000 x 2 =	16,000	

(3) Optical communication system

OPGW (Incremental)	2,000 x 50 =	100,000	
(Fibre cable)	(3,000 x 50 =	150,000)	144,000
Terminal equipment	14,000 x 2 =	28,000	(194,000)
Power source and others	8,000 x 2 =	16,000	

2. In case the distance is 70 km
(Each one relay point is assumed to be provided both for the microwave and optical communication system)

(1) PLCT system
31,000

(2) Microwave communication system

Construction of tower	70,000 x 3 =	210,000	318,000
Antenna work	8,000 x 2 =	16,000	
Digital micro	13,000 x 4 =	52,000	
1.5 M mux.	4,000 x 4 =	16,000	
Power source and others	8,000 x 3 =	24,000	

(3) Optical communication system

OPGW (Incremental)	2,000 x 70 =	140,000	204,000
(Fibre cable)	(3,000 x 70 =	210,000	(274,000)
Terminal equipment	14,000 x 2 =	28,000	
Relay equipment		20,000	
Power source and others	8,000 x 2 =	16,000	

Table 9.2-3 Comparison of construction cost between Microwave and Optical fibre communication system for Padang LDC - Ombilin - Payakumbuh

1. Section between Padang - Ombilin (Length of transmission line : 71 km)

1.1 Conditions

(1) Microwave communication system

Since this route crosses over mountain zones, two relay points are provided.
(Straight distance: 50 km)

(2) Optical communication system

- One relay point is provided.
- Optical fibre cable is strung on existing transmission line towers.

1.2 Comparison of construction cost (unit : 10^3 Yen)

(1) Microwave communication system

Construction of tower	70,000 x 4 = 280,000	438,000
Antenna work	8,000 x 3 = 24,000	
Digital micro	13,000 x 6 = 78,000	
1.5 M mux.	4,000 x 6 = 24,000	
Power source and others	8,000 x 4 = 32,000	

(2) Optical communication system

Fibre cable	3,000 x 51 = 213,000	285,000
Terminal equipment	14,000 x 2 = 28,000	
Relay equipment	20,000	
Power source and others	8,000 x 2 = 16,000	

2. Section between Padang - Payakumbuh (Length of transmission Line : 129 km)

2.1 Conditions

(1) Microwave communication system
Since this route crosses over mountain zones, two relay points are provided (Straight distance : 90 km)

(2) Optical communication system
- Three relay points are provided.
- Optical fibre cable is strung between Padang and Ombilin (71 km), while OPGW is applied between Ombilin and Payakumbuh (58 km)

2.2 Comparison of construction cost (unit : 10^3 Yen)

(1) Microwave communication system
438,000

(2) Optical communication system

Fibre cable	3,000 x 71 = 213,000	457,000
OPGW (Incremental)	2,000 x 58 = 116,000	
Terminal equipment	14,000 x 2 = 28,000	
Relay equipment	20,000 x 3 = 60,000	
Power source and others	8,000 x 5 = 40,000	

3. Sections between Padang - Ombilin and between Padang - Payakumbuh

3.1 Condition

(1) Microwave communication system
Both sections are provided with two relay points.

(2) Optical communication system

- o Relay points are provided with one for each section
- o Optical cable and OPGW are applied to respective section as same as Item 2

3.2 Comparison of construction cost (unit : 10^3 Yen)

(1) Microwave communication system

438,000 x 2 = 876,000

(2) Optical communication system

457,000 - 20,000 + 14,000 x 2 = 537,000

4. Results

Comparison Table of Construction Cost (unit : 10^3 Yen)

No.	Communication section	Microwave (A) 10^3 Yen	Optical (B) 10^3 Yen	Cost difference B/A (%)
1	Padang-Ombilin	438,000	285,000	65
2	Padang-Payakumbuh	438,000	457,000	104
3	Padang-Ombilin Padang-Payakumbuh	876,000	537,000	61

The above Table shows that, in case of No. 3, which is to be applied for communication system in Central Sumatra, "Optical communication system" is much economical compared with Micro communication system.

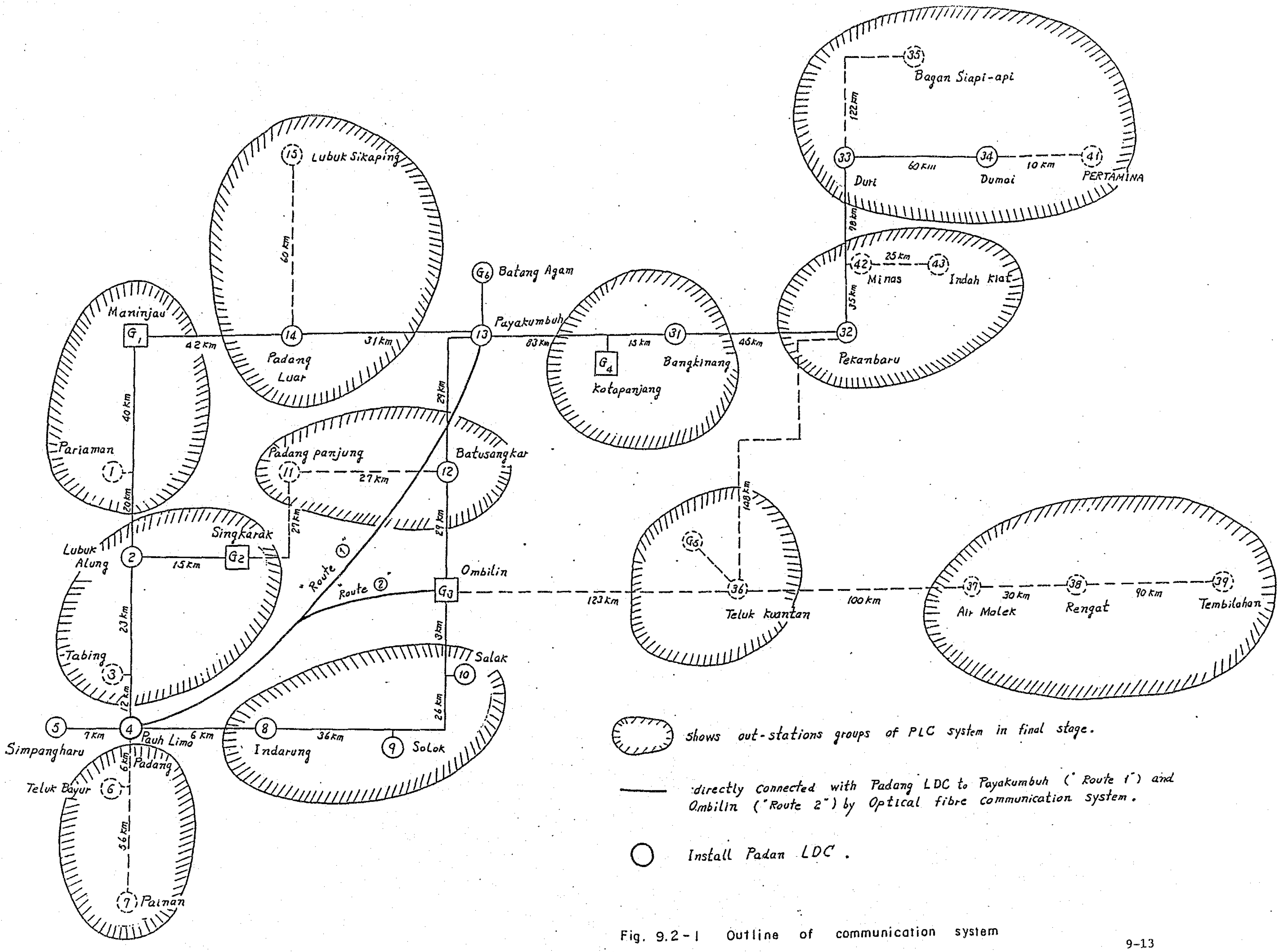

Fig. 9.2-1 Outline of communication system

SECTION 10

CONSTRUCTION SCHEDULE AND CONSTRUCTION COST

SECTION 10 CONSTRUCTION SCHEDULE AND CONSTRUCTION COST

10.1 Construction Plan

Among the Central Sumatra Power Systems investigated under this study, the power systems between Ombilin, Pekanbaru and Dumai and between Pauh Limo and Simpangharu are scheduled to be completed at the end of March 1995 based on the demand forecast and schedule of the project. The results of studying the project implementation plan for these systems are as presented below.

10.1.1 Execution Method

This project will be implemented in the following two stages:

a. Stage I : Site survey (topographical and geological), detailed design, preparation of tender documents, etc.

b. Stage II : Execution of bidding, evaluation of tender documents, assistance in contracting, procurement of equipment and materials, and supervision of construction works, etc.

To ensure smooth progress of these works, maintain specified quality of works and complete the project in accordance with the schedule of construction work, an overseas consultant will execute engineering services in cooperation with an Indonesian consultant.

(1) The site survey (topographical and geological survey) will be carried out by the Indonesian Consultant under instruction and supervision of the overseas consultant. On the basis of the results of this survey, the overseas

consultant will execute detailed design and prepare tender documents, etc.

(2) The construction works of transmission line/s, substation/s, etc. based upon this plan will be executed by dividing the respective works into the following six blocks (1 through 5 include the respectively associated transmission lines, substations and communication equipment):

Block 1: Ombilin - Payakumbuh - Pekanbaru
Block 2: Padang Luar - Payakumbuh
Block 3: Pekanbaru - Dumai
Block 4: Reinforcement of power system in Padang
Block 5: Dumai - PERTAMINA
Block 6: Load dispatching facility (Padang Load Dispatching Center including associated substation and communication equipment)

Moreover, procurement of equipment and materials and construction of transmission lines and substations will be carried out under the supervision of an overseas consultant as follows:

i) Transmission lines

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

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

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

ii) Substations

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

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

Meanwhile, the following requirements should be met to ensure smooth progress of the project:

a) Negotiations for obtaining the right of way for topographical and geological survey required for design of transmission lines and substations, acquisition of the land for transmission tower and substation construction sites as well as acquisition of the right of way under transmission line routes should be completed not later than the respectively specified periods.

b) Since the total length of 150 kV transmission lines will extend to about 420 km, the construction work of these transmission lines will be separated into several blocks and executed by several Indonesian constructors based on their construction capabilities.

10.1.2 Implementation Plan

(1) Transportation Plan

As key ocean transportation terminals in Central Sumatra, there are the Padang Port (West Sumatra Province) on the Indian Ocean side and the Dumai Port (Riau Province) on the Malacca Strait side.

The Padang Port, which is the largest port on Sumatra Island facing the Indian Ocean, is capable of mooring 50,000 or 70,000 DWT class ocean-going vessels and its quay is equipped with rigid facilities sufficient for unloading heavy equipment and materials.

The Dumai Port, which is the largest port in Riau Province, is equipped with oil loading and other public jetties capable of mooring 10,000 DWT class ocean-going vessels.

Regarding the land transportation conditions, a trunk route between Dumai, Pekanbaru, Bukittinggi and Padang connects the Riau Province and West Sumatra Province across the Barisan Mountain Ranges. This road is asphalt-paved and maintained satisfactorily.

Judging from the above road conditions, it is considered advantageous to transport the equipment and materials for transmission line and substation construction to West Sumatra through the Padang Port and to Riau Province through the Dumai Port. However, actual transportation schedules will be determined after taking into account the shipping and other miscellaneous conditions.

(2) Construction of Transmission Lines

Since transmission lines will be constructed along national roads or local trunk roads, the equipment and materials will be transported from these roads to tower construction sites, engine sites, drum sites, etc. for stringing work through access roads to be constructed later as required.

As for tower foundation work, excavation will be carried out by labor force, and concrete be mixed at site using portable concrete mixer and placed by labor force. Meanwhile, piling for pile foundation adopted in soft ground will be carried out with piling machines.

For erection of transmission towers, a gin pole assembly method using gin pole will be adopted judging from the fact that each tower is comparatively small in size and its members are light in weight.

Regarding stringing work, the extension section will be made as long as possible within an extent where conductors and groundwires are not damaged. The towers and arms will be reinforced by attaching temporary support wires in advance. The stringing work will be carried out by using, shoe chain tensioner engine winch and other mechanical equipment. The stringing work across roads, etc. will be carried out after erecting protection scaffolding as a countermeasure for the working and public safety.

(3) Construction of Substations

For construction of each substation, a space sufficient for future extension work, construction of incoming transmission line, etc. should be acquired. Then, the site shall be finished flat by cutting or filling as required after providing catch drains.

Although a desirable site with favorable ground conditions permitting easy transportation of equipment has been selected for construction of each substation, the foundations for transformers, circuit breakers and other heavy weight major equipment will be reinforced with piles, if necessary.

For assembly and installation of circuit breakers, disconnecting switches and other outdoor equipment, crane cars and other heavy duty machines will be mobilized in view of safety and efficiency of the work.

(4) Equipment and Materials for Construction

The major equipment and materials to be used for the construction work under this project are as listed in Table 10.1-1.

Table 10.1-1 Summary of Main Equipment/Facility

		Transmission Line Facility		Substation Facility (Nos. or set)								Load Dispatching and Communication Facility (sets)			
		No. of Tower	Conductor Total Length (km)	Transformer (MVA)				Static Condenser (MVA)		Circuit Breaker (kV)		*1 PLC	*2 OPTICAL	*3 CPU	*4 RTU
				10	20	30	50	3	5	150	20				
Trans-mission Line	Ombilin - Pekanbaru	587	1,243												
	Padang Luar - Payakumbuh	89	95												
	Pekanbaru - Dumai	499	1,064												
	Pauh Limo - Simpangharu	20	41												
	Dumai - PERTAMINA	29	62												
Sub-station	Payakumbuh				2		*5			8	13	3			
	Pekanbaru						2		6	7	15	2			
	Bangkinang			1						2	6	1			
	Ombilin									2		1			
	Batusangkar			1						2	6	1			
	Padang Luar									1		1			
	Dumai				1			2		5	7	1			
	Duri			1+(1)						2	6	1			
	Pauh Limo									2					
	Simpangharu					2				2	8				
Load Dispatch Facility	Load Dispatching Center												2	1	
	Out Station														15
Total		1,224	2,505	3+(1)	3	2	2	2	6	33	61	11	2	1	15

Note: *1 PLC : Powerline Carrier Communication equipment

*2 OPTICAL: OPTICAL Communication facilities

*3. CPU : Duplicated Central Processing Unit with perpheral equipment

*4 RTU : Remote Terminal Unit

*5. Attention to Table 6.3-4

10.2 Construction Schedule

As for construction of the transmission lines and substation facilities which have been determined according to the power system development plan in Section 4, the line from the Ombilin Steam Power Plant and the Padang Luar Substation in West Sumatra through to the Pekanbaru Substation in Riau Province will be constructed preferentially in the first stage and the trunk transmission line through to the Dumai Substation will also be constructed preferentially in the second stage. A schedule chart for constructing these transmission lines is as shown in Table 10.2-1.

Table 10.2-1 Construction Schedule

Item F.Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Project Fund										
Engineering Service			▨	▨	▨	▨	▨	▨	▨	▨
Construction Block 1 (Ombilin ~Pekanbaru)					▨	▨	▨	▨		
Block 2 (Padang Luar ~Payakumbuh)							▨	▨	▨	
Block 3 (Pekanbaru ~Dumai)							▨	▨	▨	
Block 4 (Pauh Limo ~Simpangharu)						▨	▨		▨	▨
Block 5 (Dumai ~PERTAMINA)									▨	▨
Block 6 (Load Dispatching Facilities)							▨	▨	▨	▨

10.3 Construction Cost

10.3.1 Conditions for Estimating the Construction Cost

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

(1) Transmission Line

The construction cost of transmission lines was estimated by calculating the quantity of materials and volume of work for foundation, tower erection, stringing and other works with respect to each block by taking into account the conditions of the site and work in each block.

(2) Substation

The construction cost of each substation was estimated by calculating the quantity of major equipment and materials and volume of work by taking into account the interconnecting conditions to each power system, number and capacity of transformer banks and other conditions.

(3) Load Dispatching Facility

The construction cost of load dispatching facility was estimated by calculating the quantity of equipment and materials and volume of work required for constructing the Padang Load Dispatching Center and for installation of equipment for load dispatching operation at all associated power plants and substations.

(4) Communication Equipment

The cost of communication equipment was estimated by calculating the quantity of communication equipment and materials and volume of work required associated with construction of transmission lines, power plants and substations.

(5) Engineering Service Fees and PLN's Expenditures

The engineering service fees pertaining to execution of site survey, basic and detailed design, preparation of tender documents, evaluation of tender documents and construction supervision were estimated to be 7.5% of the direct cost in Items (1) through (4) above. Moreover, the expenditures of PLN were estimated at 2% of the direct cost in Items (1) through (4) above.

(6) Compensation for Land Acquisition

The compensation for land acquisition shall include the compensation cost required to acquire the tower sites for transmission line (12 m x 12 m = 144 m^2 per tower), substation sites (ranging from 8,000 m^2 to 20,000 m^2 depending on the scale of each substation) and compensation of the right of way under transmission lines.

The unit compensation cost was calculated by referring to that for similar projects in the past.

	Land purchase cost (RP/m^2)	Compensation for right-of-way (RP/km)
Batusangkar area	3,000	1,500,000
Payakumbuh "	3,000 - 5,000	1,500,000
Bangkinang "	3,000	1,500,000
Pekanbaru "	5,000 - 7,500	1,500,000
Duri "	3,000	1,500,000
Dumai "	3,000 - 5,000	1,500,000
Other area	1,500	1,500,000

(7) Contingency

The contingency was estimated to be a sum of 5% of Items (1), (2), (3) and (4) and 20% of Items (5) and (6) above.

(8) Division of Foreign Currency Portion and Local Currency Portion

The foreign currency portion and local currency portion were divided by referring to those of similar projects.

(9) Price Escalation

The price escalation was estimated at 3% per year for foreign currency portion and 10% per year for local currency portion.

(10) Interest rate during construction period

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

10.3.2 Construction Cost

The total construction cost of the Central Sumatra Electric Power System was estimated at ¥17,468 million with the foreign currency portion being ¥12,231 million and local currency portion ¥5,237 million (Refer to Tables 10.3-1 and 10.3-3).

The total construction cost in case price escalation and interest during construction included was estimated at ¥30,944 million.

Meanwhile, the total construction cost in case power supply to PERTAMINA is not taken into account was estimated at ¥17,019 million with foreign currency portion being ¥11,918 million and local currency portion ¥5,101 million. The total construction cost in case price escalation and interest during construction is included was estimated at ¥30,134 million.
(Refer to Tables 10.3-2 and 10.3-4)

Table 10.3-1 Breakdown of Total Construction Cost
(Include PERTAMINA)

(Unit: 10^6 Yen)

Items	Foreign currency portion	Local currency portion	Total	Remarks
1. Direct Cost	10,508	3,920	14,428	
o Block 1 (Ombilin - Pekanbaru)	4,233	1,689	5,922	
o Block 2 (Padang Luar - Payakumbuh)	654	290	944	
o Block 3 (Pekanbaru - Dumai)	2,740	1,197	3,937	
o Block 4 (Pauh Limo - Simpangharu)	705	296	1,001	
o Block 5 (Dumai - PERTAMINA)	270	103	373	
o Block 6 (Load Dispatching Facilities)	1,906	345	2,251	
2. Engineering Fees and Governmental Administration Cost	998	372	1,370	
3. Compensation	0	562	562	
4. Physical Contingency	725	383	1,108	
Total	12,231	5,237	17,468	
5. Price Contingency	3,013	5,323	8,336	
6. Interest during Construction	2,158	2,982	5,140	
Grand Total	17,402	13,542	30,944	

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

(Unit: 10^3 US$)

Items	Foreign currency portion	Local currency portion	Total	Remarks
1. Direct Cost	52,540	19,600	72,140	
o Block 1 (Ombilin - Pekanbaru)	21,165	8,445	29,610	
o Block 2 (Padang Luar - Payakumbuh)	3,270	1,450	4,720	
o Block 3 (Pekanbaru - Dumai)	13,700	5,985	19,685	
o Block 4 (Pauh Limo - Simpangharu)	3,525	1,480	5,005	
o Block 5 (Dumai - PERTAMINA)	1,350	515	1,865	
o Block 6 (Load Dispatching Facilities)	9,530	1,725	11,255	
2. Engineering Fees and Governmental Administration Cost	4,990	1,860	6,850	
3. Compensation	0	2,810	2,810	
4. Physical Contingency	3,625	1,915	5,540	
Total	61,155	26,185	87,340	
5. Price Contingency	15,065	26,615	41,680	
6. Interest during Construction	10,790	14,910	25,700	
Grand Total	87,010	67,710	154,720	

Table 10.3-2 Breakdown of Total Construction Cost
(Without PERTAMINA)

(Unit: 10^6 Yen)

Items	Foreign currency portion	Local currency portion	Total	Remarks
1. Direct Cost	10,238	3,817	14,055	
o Block 1 (Ombilin - Pekanbaru)	4,233	1,689	5,922	
o Block 2 (Padang Luar - Payakumbuh)	654	290	944	
o Block 3 (Pekanbaru - Dumai)	2,740	1,197	3,937	
o Block 4 (Pauh Limo - Simpangharu)	705	296	1,001	
o Block 6 (Load Dispatching Facilities)	1,906	345	2,251	
2. Engineering Fees and Governmental Administration Cost	973	363	1,336	
3. Compensation	0	548	548	
4. Physical Contingency	707	373	1,080	
Total	11,918	5,101	17,019	
5. Price Contingency	2,915	5,131	8,046	
6. Interest during Construction	2,129	2,940	5,069	
Grand Total	16,962	13,172	30,134	

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

(Unit: 10^3 US$)

Items	Foreign currency portion	Local currency portion	Total	Remarks
1. Direct Cost	51,190	19,085	70,275	
o Block 1 (Ombilin - Pekanbaru)	21,165	8,445	29,610	
o Block 2 (Padang Luar - Payakumbuh)	3,270	1,450	4,720	
o Block 3 (Pekanbaru - Dumai)	13,700	5,985	19,685	
o Block 4 (Pauh Limo - Simpangharu)	3,525	1,480	5,005	
o Block 6 (Load Dispatching Facilities)	9,530	1,725	11,255	
2. Engineering Fees and Governmental Administration Cost	4,865	1,815	6,680	
3. Compensation	0	2,740	2,740	
4. Physical Contingency	3,535	1,865	5,400	
Total	59,590	25,505	85,095	
5. Price Contingency	14,575	25,655	40,230	
6. Interest during Construction	10,645	14,700	25,345	
Grand Total	84,810	65,860	150,670	

Table 10.3-3 Yearly Disbursement Schedule of Project Construction Cost (Include PERTAMINA)

(Unit: 10^6 Yen)

Fiscal Year Currency	Summary		1988		1989		1990		1991		1992		1993		1994		1995		Remarks
Items	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	
1. Direct Cost																			
(1) Ombilin - Pakanbaru	4,233	1,689					845	350	1,209	429	1,508	430	671	480					
. Transmission Line	2,238	1,106					845	350	810	256	483	258	100	240					
. Substations	1,861	577							372	170	931	170	558	237					
. Communication facilities	134	6							27	1	94	2	13	3					
(2) Padang Luar - Payakumbuh	654	290									83	44	356	114	215	132			
. Transmission Line	193	122											107	67	86	55			
. Substations	417	166									83	44	209	46	125	76			
. Communication facilities	44	2											40	1	4	1			
(3) Pekanbaru - Dumai	2,740	1,197									750	369	811	312	1,006	431	173	85	
. Transmission Line	1,731	850									750	369	404	198	404	198	173	85	
. Substations	949	345											353	113	*596	*232			
. Communication facilities	60	2											54	1	6	1			
(4) Pauh Limo - Simpangharu	705	296					85	48	251	55	182	172			56	8	131	13	
. Transmission Line	65	32							13	6	52	26							
. Substations	612	260					85	48	213	47	127	144			56	8	131	13	
. Communication facilities	28	4							25	2	3	2							
(5) Dumai - PERTAMINA	270	103											32	10	148	41	90	52	
. Transmission Line	94	53													52	30	42	23	
. Substations	156	46											32	10	78	9	46	27	
. Communication facilities	20	4													18	2	2	2	
(6) Load Dispatching facilities	1,906	345									380	70	700	100	626	75	200	100	
Sub-Total	10,508	3,920					930	398	1,460	484	2,903	1,085	2,570	1,016	2,051	687	594	250	
. Transmission Line	4,321	2,163					845	350	823	264	1,285	653	611	505	542	283	215	108	
. Substations	3,995	1,394					85	48	585	217	1,141	358	1,152	406	855	325	177	40	
. Communication facilities	286	18							52	3	97	4	107	5	28	4	2	2	
. Load Dispatching facilities	1,906	345									380	_70	700	100	626	75	200	100	
2. Engineering Fees and Governmental Administration Cost	998	372	131	49	130	49	65	28	102	34	203	76	180	71	144	48	43	17	
3. Compensation		562						133		151		151		113		14			
4. Physical Contingency	725	383	25	11	26	10	-60	52	93	61	186	99	165	88	131	46	39	16	
Sub-total	1,723	1,317	156	60	156	59	125	213	195	246	389	326	345	272	275	108	82	33	
Total (Total of Items from 1 to 4)	12,231 (17,468)	5,237	156	60	156	59	1,055	611	1,655	730	3,292	1,411	2,915	1,288	2,326	795	676	283	
5. Price Contingency	3,013	5,323	15	20	20	27	169	373	323	563	760	1,338	781	1,472	712	1,079	233	451	
Sub-total (Total of Items from 1 to 5)	15,244	10,560	171	80	176	86	1,224	984	1,978	1,293	4,052	2,749	3,696	2,760	3,038	1,874	909	734	
(Sum up of loan till previous year)					(347)	(166)	(1,571)	(1,150)	(3,549)	(2,443)	(7,601)	(5,192)	(11,297)	(7,952)	(14,335)	(9,826)	(15,244)	(10,560)	
6. Interest during Construction	2,158	2,982			14	13	63	92	142	195	304	415	452	636	573	786	610	845	
Grand total	17,402 (30,944)	13,542	171	80	190	99	1,287	1,076	2,120	1,488	4,356	3,164	4,148	3,396	3,611	2,660	1,519	1,579	

Note: F.C. Foreign Currency Portion.
L.C. Local Currency Portion.

* Include one spare transformer

Table 10.3-4 Yealy Disbursement Schedule of Project Construction Cost (without PERTAMINA)

(Unit: 10^6 Yen)

Fiscal Year / Currency / Items	Summary		1988		1989		1990		1991		1992		1993		1994		1995		Remarks
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	
1. Direct of Cost																			
(1) Ombilin - Pekanbaru	4,233	1,689					845	350	1,209	429	1,508	430	671	480					
. Transmission Line	2,238	1,106					845	350	810	258	483	258	100	240					
. Substations	1,861	577							372	170	931	170	558	237					
. Communication facilities	134	6							27	1	94	2	13	3					
(2) Padang Luar - Payakumbuh	654	290									83	44	356	114	215	132			
. Transmission Line	193	122											107	67	86	55			
. Substations	417	166									83	44	209	46	125	76			
. Communication facilities	44	2											40	1	4	1			
(3) Pekanbaru - Dumai	2,740	1,197									750	369	811	312	1,006	431	173	85	
. Transmission Line	1,731	850									750	369	404	198	404	198	173	85	
. Substations	949	345											353	113	*596	*232			
. Communication facilities	60	2											54	1	6	1			
(4) Pauh Limo - Simpangharu	705	296					85	48	251	55	182	172			56	8	131	13	
. Transmission Line	65	32							13	6	52	26							
. Substations	612	260					85	48	213	47	127	144			56	8	131	13	
. Communication facilities	28	4							25	2	3	2							
(6) Load Dispatching facilities	1,906	345									380	70	700	100	626	75	200	100	
Sub-Total	10,238	3,817					930	398	1,460	484	2,903	1,085	2,538	1,006	1,903	646	504	198	
. Transmission Line	4,227	2,110					845	350	823	264	1,285	653	611	505	490	253	173	85	
. Substations	3,839	1,348					85	48	585	217	1,141	358	1,120	396	777	316	131	13	
. Communication facilities	266	14							52	3	97	4	107	5	10	2			
. Load Dispatching facilities	1,906	345									380	70	700	100	626	75	200	100	
2. Engineering Fees and Governmental Administration Cost	973	363	128	48	128	47	65	28	102	34	203	76	178	70	134	46	35	14	
3. Compensation		548						133		151		151		113					
4. Physical Contingency	707	373	26	11	25	9	60	52	93	61	186	99	163	87	122	41	32	13	
Sub-total	1,680	1,284	154	59	153	56	125	213	195	246	389	326	341	270	256	87	67	27	
Total	11,918	5,101	154	59	153	56	1,055	611	1,655	730	3,292	1,411	2,879	1,276	2,159	733	571	225	
(Total of Items from 1 to 4)	(17,019)																		
5. Price Contingency	2,915	5,131	14	20	19	26	169	373	323	563	760	1,338	772	1,458	661	995	197	358	
Sub-total (Total of Items from 1 to 5)	14,833	10,232	168	79	172	82	1,224	984	1,978	1,293	4,052	2,749	3,651	2,734	2,820	1,728	768	583	
(Sum up to loan till previous year)					(340)	(161)	(1,564)	(1,145)	(3,542)	(2,438)	(7,594)	(5,187)	(11,245)	(7,921)	(14,065)	(9,649)	(14,833)	(10,232)	
6. Interest during Construction	2,129	2,940			14	13	63	92	142	195	304	415	450	634	563	772	593	819	
Grand total	16,962	13,172	168	79	186	95	1,287	1,076	2,120	1,488	4,356	3,164	4,101	3,368	3,383	2,500	1,361	1,402	
	(30,134)																		

Note: F.C. Foreign Currency Portion.
L.C. Local Currency Portion.

* Include one spare transformer

SECTION 11

ECONOMIC
AND
FINANCIAL ANALYSIS

SECTION 11 ECONOMIC AND FINANCIAL ANALYSIS

11.1 Objectives and Scope of Analysis

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

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

This economic analysis was carried out with respect to the following transmission line routes:

A. Padang Luar → Payakumbuh → Pekanbaru
↑
Ombilin → Batusangkar

B. Pekanbaru → Duri → Dumai

C. Duri → Bagan Siapiapi

D. Ombilin → Rengat → Tembilahan

E. Pauh Limo → Painan

The above-mentioned transmission line routes had been selected according to "Preliminary Economic Study" (Refer to Annex 11-1), based upon tentative power demand forecast and cost estimation carried out in the initial stage of this feasibility study. In the case of the routes A and B, the feasibility of implementation by 1995 is concluded highly probable, while in the case of the routes C, D and E, it is questionable to conclude that implementation of the project by 1995 be feasible.

11.2 Economic Analysis

11.2.1 Comparison with alternative plans

This project is intended for supply of electric power generated at the Ombilin Coal-Fired Steam Power Plant, Singkarak Hydro-Power Plant and Kotapanjang Hydro-Power Plant under planning at present to West Sumatra and Riau Provinces by constructing transmission lines. The most realistic alternative plan for this project is to construct diesel power plants and extend these plants successively in proportion to the growth of power demand in individual load centers, as in the most parts in Wilayah III at present. Under this economic analysis, therefore, economic comparison was carried out with respect to the cost of the basic (Transmission line) and alternative (Diesel) plans for respective transmission line routes according to the present value method. The results are as shown below.

(Unit: Rp. 1 billion after 12% discount)

Transmission line routes	Commissioning (Year)	Diesel power plant cost - Transmission line project cost					
		Demand forecast			Reduction ratio of diesel oil price		
		Base case	High	Low	10%	20%	30%
A. Padang Luar/Ombilin →Pekanbaru	1993	+112.337	+118.896	+107.008	+93.694	+75.313	+56.670
B. Pekanbaru →Dumai	1995						
with PERTAMINA		+105.658	+107.954	+103.603	+90.226	+75.011	+59.579
without PERTAMINA		+19.017	+20.944	+16.630	+14.295	+9.640	+4.395
C. Duri →Bagan Siapiapi	1995	-9.633	-8.621	-10,607	-10,352	-11,061	-11,780
D. Ombilin →Tembilahan	1995	-19.470	-15.671	-22.973	-22.405	-25.229	-28.231
E. Pauh Limo →Painan	1995	-3.358	-2.764	-4.357	-4.173	-4.747	-5.330

Note 1/ Refer to "SECTION 3 DEMAND FORECAST".

In the above table, "+" values indicate that the cost of the transmission lines is lower than the cost of alternative diesel power plants and vise versa, provided that the transmission lines are commissioned in the respective years. For example, the cost of the route A is lower than that of the alternative plan even in the case the oil price substantially fall (the alternative diesel power plants become relatively advantageous), while the cost of the Route E becomes higher than that of alternative plan even if high demand forecast is adopted (the transmission line becomes relatively advantageous).

Note 2/ In this analysis, the price of diesel oil and corresponding price of crude oil are assumed to be Rp. 231 per litre and US$28 per barrel, respectively. Although the recent spot price of crude oil is falling sharply, the reduction rate of diesel oil price is considered lower than the spot market price of crude oil since refining and distribution cost is fixed. Therefore, it is considered enough to attain the purpose of this analysis, if diesel oil reduction up to 30% is taken into account.

As a result, the routes, commissioning before 1995 of which can be concluded feasible compared with the alternative plan, are "A. Padang Luar/Ombilin Pekanbaru" and "B. Pekanbaru Dumai."

Meanwhile, the basic approach and major prerequisite conditions used in the above analysis are as follows:

(1) Major cost items used for cost comparison

- o Transmission line project
  - *Cost of power supply from Ombilin, Singkarak and Kotapanjang Power Plants
  - *Construction, maintenance and operation cost of transmission lines/substations
  - *Cost associated with power loss in transmission lines/substations
- o Alternative diesel power plants
  - *Cost of diesel power plants

Meanwhile, the cost for distribution lines was not taken into account since this cost is common for both plans. More precisely speaking, however, the cost associated with distribution line loss was included in the cost comparison because the respective generating unit costs are different.

(2) For all of the above cost, the price in November 1985 was adopted as a constant price. In this case, the foreign exchange rate was assumed to be US$1.00 = ¥200 = Rp.1,100.

(3) The cost was converted from a market price into an economic price. More concretely, 10% of value added tax included in the estimated cost of local currency portion was excluded from the economic price because it is a transfer item. Meanwhile, the shadow wage rate of unskilled workers was set at 96 taking into account the unemployment ratio of 2 or 6% in Indonesia. Moreover, shadow exchange rate was analyzed without adding any special premium to foreign currency portion since the foreign exchange rate is changing

according to actual situations.

(4) The discount rate adopted for calculating the present value is 12%.

(5) The power transmission facilities to be constructed are assumed to meet the power demand by 2000 without major additional investment.

(6) The conditions assumed for transmission line and substation facilities are as follows:

Service life: Twenty-five years

Operation and maintenance cost:
1.5% of initial investment (per year)

Power loss in transmission lines and substations:
3% of electrical energy supplied to transmission line and substation system

(7) The conditions assumed for distribution lines are as follows:

Distribution line loss: 10% of electrical energy supplied to transmission line and substation system

(8) The cost of electrical energy supplied by diesel power plants is estimated at Rp. 107.3/kWh based upon the following conditions:

*Capital cost : Rp.517,200/kW (an output ranging from 3.5 to 6.0 MW was assumed)

*Fuel cost : Rp.74.1/kW (Rp.231/litre)

*Maintenance and operation cost other than fuel cost
: 20% of fuel cost

*Service life : Twenty years

*Auxiliary power consumption:

2.5% of generated electrical energy

*Utilization factor : 60%

*Calculation method : Average incremental cost method (discount rate: 12%)

(9) On the assumption that electric power to the transmission line and distribution system is supplied from the Ombilin, Singkarak and Kotapanjang Power Plants, the power cost was calculated to be Rp.44.9/kWh using the average incremental method (discount rate: 12%) based upon the prerequisite conditions assumed below:

	Ombilin	Singkarak	Kotapanjang
Average generated energy (GWh/year)	437	1,209	495
Construction cost (Rp. 10^3/kW)	755	1,251	1,631
Fuel cost (coal)	Rp. 23.7/kWh (Rp.49,500/ton)	-	-
Maintenance and operation cost other than fuel cost	35% of fuel cost	Rp.4.2/kWh	Rp.4.2/kWh
Service life (years)	25	40	40
Auxiliary power consumption	7% of generated energy	0.5% of generated energy	0.5% of generated energy

11.2.2 Economic internal rate of return (Refer to Table 11.2-1, 2)

The economic internal rate of return (EIRR) was first calculated with respect to the transmission line project from the Padang grid through to Dumai, consiting of the route A (commissioning in 1993) and route B (commissioning in 1995), which were concluded feasible according to cost comparison with alternative plans. As a result, the EIRR was calculated to be 23.0% in case the power demand from PERTAMINA is expected and as high as 16.4% even in case the demand from PERTAMINA is not expected.

Meanwhile, the revenue from power charge according to this project was adopted as a benefit for the EIRR. The cost items are almost the same as the prerequisite conditions used in calculating the present value in item 11.2.1, above, but the cost required for distribution line was considered.

In addition, calculation of section-wise EIRR between Padang grid and Pekanbaru and between Pekanbaru and Dumai as well as analysis of sensibility on the possibility of the reduction of EIRR was carried out. The results are listed below:

	Base case	Low demand case 1/	20% premium for foreign currency portion 2/	Additional 20% investment cost
Padang grid → Dumai				
with PERTAMINA	22.0%	21.5%	19.7%	19.0%
without PERTAMINA	16.4	15.7	14.3	13.8
Padang grid → Pekanbaru	19.3	18.7	17.1	16.5
Pekanbaru → Dumai				
with PERTAMINA	27.2	26.9	24.6	23.8
without PERTAMINA	10.0	9.4	8.6	8.3

Note 1/ Refer to "SECTION 3 POWER DEMAND FORECAST."

2/ On the assumption that Rp. is overevalued by 20% under the present foreign exchange rate, a premium of 20% is added to the cost of foreign currency portion.

The EIRR calculated above exceeds 10% for the lowest value in the base case, namely for the section of Pekanbaru ∿ Dumai without PERTAMINA, and becomes slightly lower than 10% even in the case further disadvantageous conditions are assumed. The benefit used in the above calculation is based on very conservative conditions. Namely, the benefit was based on the revenue based upon the present power charge without taking into account any rise of the charge. Moreover, when considering that the benefit constitutes only a part of the real benefit of the willingness to pay by consumers, the EIRR estimated herein can be said very conservative. Therefore, this project can be concluded sufficiently feasible in view of the EIRR as well.

For EIRR calculation, the following assumptions/prerequisite conditions were adopted in addition to those adopted for least cost solusion.

(1) Average power charge: Present power charge
(Rp.98.3/kWh)

(2) Distribution line cost (Capital cost and maintenance/operation cost): Rp.17.7/kWh

The cost was calculated according to the average incremental cost method (discount rate: 12%) based upon the following conditions:

- o Extension of distribution lines
  Medium voltage line : 7.5 km/1,000 consumers
  Low voltage line : 13.0 km/1,000 consumers
- o Construction cost: Average Rp.20.6 million/km
- o Maintenance/operation cost:
  4.0% of initial investment cost per year
- o Service life: Twenty-five years

Meanwhile, since the contracting charge of new consumers and the cost for installation of incoming lines and meters are roughly equal according to the data of Wilayah III, these revenue and cost items were not included in EIRR calculation.

11.3 Financial Analysis

11.3.1 Financial internal rate of return (Refer to Table 11.3-1,2,3)

Although the EIRR was calculated by converting the market price into economic price, the financial internal rate of return (FIRR) was calculated without the conversion exceeds 10% as follows.

o Padang grid → Dumai	
with PERTAMINA	19.9
without PERTAMINA	14.6
o Padang grid → Pekanbaru	17.4
o Pekanbaru → Dumai	
with PERTAMINA	24.9
without PERTAMINA	8.7

Meanwhile, PLN is required to pay corporate tax for its benefit. However, the tax is not imposed directly on the profit from this project, but is determined according to the overall profit of PLN. Since it is very difficult to estimate the amount of such tax, any corporate tax is not included in the above calculation.

Moreover, although the interest rate during construction is sometimes included in calculating the FIRR, no such interest is included in the calculation to avoid duplication of interest in calculation.

11.3.2 Repayability of loan

The capital for this project was assumed to be procured under the following conditions and the repayability of loan was studied in the severer case where demand of PERTAMINA is not expected.

o Foreign currency portion:

Total amount to be on loan from foreign assistance institution.

Repayment period: 30 years including 10 years of grace period

Annual interest rate: 4%

Repayment method: The principal will be paid in twenty equal installments, and the interest be paid including grace period without transferring to the principal.

- Local currency portion:

  25% from government expenditure, 25% from self-capital, and remaining 50% from bank loan

  Repayment period: 30 years including 10 years of grace period

  Annual interest rate: 16%

  Repayment method: The principal will be paid in twenty equal installments, and the interest be paid including grace period without transferring to the principal.

The balance of annual payment for this project based upon the above analysis will turn to the black immediately after commissioning of the facilities (Padang grid - Pekanbaru) and the amount of deficit cumulated by that time will also be eliminated perfectly two years after the commissioning. Therefore, there is no problem regarding repayment of loan under this project. However, in addition to the investment capital, it will be necessary to procure the capital for interest required during construction period.

11.4 Conclusion

According to the results of economic and financial analysis in this section, the project for construction of transmission lines and substations from the Padang grid to Dumai (Up to Pekanbaru: commissioned in 1993, Up to Dumai: commissioned in 1995) can be concluded feasible.

The reasons are as follows.

(1) When compared with alternative plan, this project is the least cost method for supply of electric power to the respective demand areas.

(2) The EIRR of the overall project is sufficiently as high as 22.0% with PERTAMINA, and 16.4% without PERTAMINA.

Also the sectionwise EIRR from Pekanbaru to Dumai without PERTAMINA, which is the lowest case of EIRR, shows more than 10%.

(3) The FIRR of the overall project is also sufficiently as high as 19.9% with PERTAMINA and 14.6% without PERTAMINA.

(4) The results of sensibility analysis carried out on the above values indicate that the project is feasible enough even when the conditions are somewhat worsened.

(5) With regard to repayment of loan associated with construction of the power system, there will be no particular problem even in case the demand from PERTAMINA is not expected.

(6) These results are based on very conservative prerequisite conditions wherein the level of electric energy charge is kept at the present level by real price.

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

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

Table 11.2-1 Cost/Benefit Streams for Computing EIRR (With PERTAMINA Case)

(Unit : Rp. 10^6)

Year	Power Demand (GWh)	Revenues	Capital Cost	O & M Cost	Power Generation Cost	Distribu-tion Cost	Net Cashflow
0	0	0	9,537	0	0	0	-9,537
1	0	0	10,971	0	0	0	-10,971
2	0	0	19,863	0	0	0	-19,863
3	153.3	15,069	17,406	1,079	7,898	2,713	-14,028
4	326.1	32,055	11,802	1,079	16,801	5,771	-3,399
5	577.3	56,748	2,386	1,079	29,742	10,218	13,323
6	651.6	64,052	0	1,079	33,570	11,533	17,869
7	729.5	71,709	0	1,079	37,584	12,912	20,134
8	783.3	76,998	0	1,079	40,356	13,864	21,699
9	839.6	82,532	0	1,079	43,256	14,860	23,336
10	839.6	82,532	0	1,079	43,256	14,860	23,336
11	839.6	82,532	0	1,079	43,256	14,860	23,336
12	839.6	82,532	0	1,079	43,256	14,860	23,336
13	839.6	82,532	0	1,079	43,256	14,860	23,336
14	839.6	82,532	0	1,079	43,256	14,860	23,336
15	839.6	82,532	0	1,079	43,256	14,860	23,336
16	839.6	82,532	0	1,079	43,256	14,860	23,336
17	839.6	82,532	0	1,079	43,256	14,860	23,336
18	839.9	82,532	0	1,079	43,256	14,860	23,336
19	839.6	82,532	0	1,079	43,256	14,860	23,336
20	839.6	82,532	0	1,079	43,256	14,860	23,336
21	839.6	82,532	0	1,079	43,256	14,860	23,336
22	839.6	82,532	0	1,079	43,256	14,860	23,336
23	839.6	82,532	0	1,079	43,256	14,860	23,336
24	839.6	82,532	0	1,079	43,256	14,860	23,336
25	839.6	82,532	0	1,079	43,256	14,860	23,336
26	839.6	82,532	0	1,079	43,256	14,860	23,336
27	839.6	82,532	0	1,079	43,256	14,860	23,336
28	432.8	42,544	0	1,079	22,298	7,660	11,506
29	432.8	42,544	0	1,079	22,298	7,660	11,506

Table 11.2-2 Cost/Benefit Streams for Computing FIRR
(without PERTAMINA Case)

(Unit : Rp. 10^6)

Year	Power Demand (GWh)	Revenues	Capital Cost	O & M Cost	Power Generation Cost	Distribution Cost	Net Cashflow
0	0	0	9,504	0	0	0	-9,504
1	0	0	10,955	0	0	0	-10,955
2	0	0	20,193	0	0	0	-20,193
3	153.3	15,069	16,801	1,043	7,898	1,713	-13,387
4	326.1	32,055	10,570	1,043	16,801	5,771	-2,130
5	392.3	38,563	1,542	1,043	20,211	6,943	8,822
6	442.6	43,507	0	1,043	22,803	7,834	11,827
7	494.5	48,609	0	1,043	25,477	8,752	13,337
8	522.3	51,342	0	1,043	26,909	9,244	14,145
9	550.6	54,123	0	1,043	28,367	9,745	14,968
10	550.6	54,123	0	1,043	28,367	9,745	14,968
11	550.6	54,123	0	1,043	18,367	9,745	14,968
12	550.6	54,123	0	1,043	28,367	9,745	14,968
13	550.6	54,123	0	1,043	28,367	9,745	14,968
14	550.6	54,123	0	1,043	28,367	9,745	14,968
15	550.6	54,123	0	1,043	28,367	9,745	14,968
16	550.6	54,123	0	1,043	18,367	9,745	14,968
17	550.6	54,123	0	1,043	28,367	9,745	14,968
18	550.6	54,123	0	1,043	28,367	9,745	14,968
19	550.6	54,123	0	1,043	28,367	9,745	14,968
20	550.6	54,123	0	1,043	28,367	9,745	14,968
21	550.6	54,123	0	1,043	28,367	9,745	14,968
22	550.6	54,123	0	1,043	28,367	9,745	14,968
23	550.6	54,123	0	1,043	28,367	9,745	14,968
24	550.6	54,123	0	1,043	28,367	9,745	14,968
25	550.6	54,123	0	1,043	28,367	9,745	14,968
26	550.6	54,123	0	1,043	28,367	9,745	14,968
27	550.6	54,123	0	1,043	28,367	9,745	14,968
28	432.8	42,544	0	1,043	22,298	7,660	11,542
29	432.8	42,544	0	1,043	22,298	7,660	11,542

Notes to Table 11.2-1, 2

1. Revenues = Average Tariff (Rp. 98.3/kWh) x Power Demand

2. Capital Cost: Capital cost of transmission/substation only

3. O & M Cost: Transmission/substation only (annually 1.5% of total capital cost)

4. Power Generation Cost: Unit generation cost (Rp. 44.8/kWh) x Power Demand, in addition, losses of transmission/distribution are included.

5. Distribution Cost: Unit distribution cost (Rp. 17.7/kWh) x Power Demand

6. Net Cashflow = Revenues - (Capital Cost + O & M Cost + Power Generation Cost + Distribution Cost)

7. Unit costs of above 4. and 5. incorporate both capital and O & M costs. They were computed by AIC (Average Incremental Cost) method at 12% discount rate as mentioned in the texts of Chapter 11, i.e., sum of cost streams after discount at 12% divided by sum of power sales streams after discount at 12%.

8. In computing IRR, power demand of those areas, which are/will be connected before commissioning of this project, is not included. Accordingly, costs incurred for power supply to such areas are hot included in this IRR calculation, either.

Table 11.3-1 Cost/Benefit Streams for Capacity FIRR
(With PERTAMINA Case)

(Unit: Rp. 10^6)

Year	Power Demand (GWh)	Revenues	Capital Cost	O & M Cost	Power Generation Cost	Distribu-Cost	Net Cashflow
0	0	0	9,928	0	0	0	-9,928
1	0	0	11,392	0	0	0	-11,392
2	0	0	20,527	0	0	0	-20,527
3	153.3	15,069	18,145	1,121	8,233	2,713	-15,143
4	326.1	32,055	12,255	1,121	17,513	5,771	-4,605
5	577.3	56,748	2,481	1,121	31,004	10,218	11,925
6	651.6	64,052	0	1,121	34,994	11,533	16,404
7	729.5	71,709	0	1,121	39,178	12,912	18,499
8	783.3	76,998	0	1,121	42,067	13,864	19,946
9	839.6	82,532	0	1,121	45,091	14,860	21,460
10	839.6	82,532	0	1,121	45,091	14,860	21,460
11	839.6	82,532	0	1,121	45,091	14,860	21,460
12	839.6	82,532	0	1,121	45,091	14,860	21,460
13	839.6	82,532	0	1,121	45,091	14,860	21,460
14	839.6	82,532	0	1,121	45,091	14,860	21,460
15	839.6	82,532	0	1,121	45,091	14,860	21,460
16	839.6	82,532	0	1,121	45,091	14,860	21,460
17	839.6	82,532	0	1,121	45,091	14,860	21,460
18	839.6	82,532	0	1,121	45,091	14,860	21,460
19	839.6	82,532	0	1,121	45,091	14,860	21,460
20	839.6	82,532	0	1,121	45,091	14,860	21,460
21	839.6	82,532	0	1,121	45,091	14,860	21,460
22	839.6	82,532	0	1,121	45,091	14,860	21,460
23	839.6	82,532	0	1,121	45,091	14,860	21,460
24	839.6	82,532	0	1,121	45,091	14,860	21,460
25	839.6	82,532	0	1,121	45,091	14,860	21,460
26	839.6	82,532	0	1,121	45,091	14,860	21,460
27	839.6	82,532	0	1,121	45,091	14,860	21,460
28	432.8	42,544	0	1,121	23,244	7,660	10,519
29	432.8	42,544	0	1,121	23,244	7,660	10,519

Table 11.3-2 Cost/Benefit Streams for Computing FIRR
(Without PERTAMINA Case)

(Unit: Rp. 10^6)

Year	Power Demand (GWh)	Revenues	Capital Cost	O & M Cost	Power Generation Cost	Distribu- Cost	Net Cashflow
0	0	0	9,895	0	0	0	-9,895
1	0	0	11,375	0	0	0	-11,375
2	0	0	20,527	0	0	0	-20,527
3	153.3	15,069	18,024	1,086	8,233	2,713	-14,987
4	326.1	32,055	10,984	1,086	17,513	5,771	-3,300
5	392.3	38,563	1,601	1,086	21,068	6,943	7,864
6	442.6	43,507	0	1,086	23,770	7,834	10,818
7	494.5	48,609	0	1,086	26,557	8,752	12,214
8	522.3	51,342	0	1,086	28,050	9,244	12,961
9	550.6	54,123	0	1,086	29,570	9,745	13,722
10	550.6	54,123	0	1,086	29,570	9,745	13,722
11	550.6	54,123	0	1,086	29,570	9,745	13,722
12	550.6	54,123	0	1,086	29,570	9,745	13,722
13	550.6	54,123	0	1,086	29,570	9,745	13,722
14	550.6	54,123	0	1,086	29,570	9,745	13,722
15	550.6	54,123	0	1,086	29,570	9,745	13,722
16	550.6	54,123	0	1,086	29,570	9,745	13,722
17	550.6	54,123	0	1,086	29,570	9,745	13,722
18	550.6	54,123	0	1,086	29,570	9,745	13,722
19	550.6	54,123	0	1,086	29,570	9,745	13,722
20	550.6	54,123	0	1,086	29,570	9,745	13,722
21	550.6	54,123	0	1,086	29,570	9,745	13,722
22	550.6	54,123	0	1,086	29,570	9,745	13,722
23	550.6	54,123	0	1,086	29,570	9,745	13,722
24	550.6	54,123	0	1,086	29,570	9,745	13,722
25	550.6	54,123	0	1,086	29,570	9,745	13,722
26	550.6	54,123	0	1,086	29,570	9,745	13,722
27	550.6	54,123	0	1,086	29,570	9,745	13,722
28	432.8	42,544	0	1,086	23,244	7,660	10,554
29	432.8	42,544	0	1,086	23,244	7,660	10,544

Table 11.3-3 Cashflow after Debt-Service
(Without PERTAMINA Case)

(Unit: Rp. 10^6)

Year	1/ Net Cashflow	Grants	Borrowing		Interest		Repayment		Cashflow after Deb-Service
			Foreign	Local	Foreign	Local	Foreign	Local	
0	-9,895	883	6,364	1,765					-883
1	-11,375	923	7,684	1,845	-255	-282			-1,460
2	-20,527	740	14,608	2,595	-562	-578			-3,360
3	-14,987	1,639	11,468	3,278	-1,146	-1,051			-799
4	-3,300	898	7,392	1,796	-1,605	-1,576		-221	3,384
5	7,864	132	1,073	264	-1,901	-1,828		-452	5,152
6	10,818				-1,944	-1,797		-822	6,255
7	12,214				-1,944	-1,666		-1,232	7,372
8	12,961				-1,944	-1,469		-1,457	8,091
9	13,722				-1,944	-1,236		-1,490	9,052
10	13,722				-1,944	-997	-2,429	-1,490	6,862
11	13,722				-1,846	-759	-2,429	-1,490	7,198
12	13,722				-1,749	-520	-2,429	-1,269	7,755
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.									
.									

Note: 1/ From Table 11.3-2

Annex

ANNEX

Annex 2-1 Constituent Ratio of Each Kind of Consumer in Wilayah III

Unit: %

	Residential	Commercial	Industrial	Public	Amount
1974	58	12	8	22	100
1975	56	14	8	22	100
1976	55	14	9	22	100
1977	51	14	10	25	100
1978	54	11	16	19	100
1979	56	15	12	17	100
1980	55	15	10	20	100
1981	56	17	9	18	100
1982	58	14	11	17	100
1983	43	9	34	14	100

Annex 2-2 (1) Installed Capacity of PLN Power Station in West Sumatra Province, April 1985

Name of Power Station	Installed Capacity (kW)	Type of Generator
Simpangharu	25,050	D
Pauh Limo	43,170	G
Maninjau	68,000	H
Batang Agam	10,500	H
Padang Luar	4,560	D
Solok	1,632	"
Suit Air I	80	"
" II	100	"
Saning Bakar	220	"
Koto Anau	160	H
Sirukam	40	D
Alahan Panjang	100	D
Muara Labuh	720	D/H (D 60/H 660)
Sijunjung	580	D
Sungaidareh	100	"
Sungai Nanam	40	"
Muaro Bodi	100	"
Tanjung Ampalu	100	"
Sei Penuh	1,792	"
Tapan	100	"
Lempur	198	D/H (D 110/H 88)
Sei Liman	100	D
Kampung Dalam	40	"
Tiku	40	"
Painan	686	"
Surantih I	100	"
" II	40	"
Kambang	100	"
Batang Kapas	100	"

to be continued

Name of Power Station	Installed Capacity (kW)	Type of Generator
Balai Selasa	100	"
Air Haji	40	D
Indra Pura	220	"
Asam Kumbang	100	"
Siberut	100	"
Lubuk Sikaping	426	"
Panti	116	"
Talu	100	"
Tapus	100	"
Suka Menati	100	"
Simpang Empat	40	"
Bonjol	100	"
Air Bangis	100	"
Ujung Gading	100	"
Pasir Koto Baru	100	"
TOTAL	160,390 (kW)	

Source: PLN Wilayah III

Note: D : Diesel
G : Gas Turbine
H : Hydro

Annex 2-2 (2) Installed Capacity of PLN Power Station in Riau Province, April 1985

Name of Power Station	Installed Capacity (kW)	Type of Generator
Pekanbaru	13,670	D
Rengat	1,156	"
Teluk Kuantan	455	"
Bengkalis	1,376	"
Bangkinang	1,076	"
Dumai	3,778	"
Bagan Siapi-api	1,866	"
Tembilahan	1,492	"
Duri	960	"
Selat Panjang	1,640	"
Air Molek	304	"
Cerenti	68	"
Lipat Kain	140	"
Pasir Panggarayan	100	"
Lubuk Jambi	100	"
Baserah	100	"
Peranap	100	"
Sei Pakning	100	"
Tanjung Pinang	5,904	"
Penyengat	40	"
Senggarang	100	"
Belakang Padang	320	"
Tanjung Uban	220	"
Ranai	440	"
Serasan	100	"
TOTAL	35,605 (kW)	

Source: PLN Wilayah III

Annex 2-3 (1) Installed Capacity of Captive Power in West Sumatra and Riau Provinces, April 1985

Location	Nos. of Company	Capacity of Captive Power (KVA)
Padang	44	6,162
Pariaman	10	259
Painan	2	210
Bukittinggi	2	163
Solok	15	1,172
Pekanbaru	30	34,849
Dumai	8	675
Bengkalis	14	1,189 (1,511 kW)
Rengat	43	17,235
Tembilahan	49	1,093
Began Siapi-api	10	370
Bangkinang	8	606
Duri	51	199 (159 kW)
Selat Panjang	35	956
Cerenti	5	28 (22 kW)
Peranap	15	75 (60 kW)
Tanjung Pinang etc.	34	7,931
TOTAL	375	73,172 KVA

Source: PLN Wilayah III

Annex 2-3 (2) Installed Capacity of Big Captive Power in West Sumatra and Riau Provinces, April 1985

Name of Company	Capacity of Captive Power (kVA)
Padang Cement	24,250
CALTEX Rumbai/Minas CALTEX Central Duri CALTEX Duri	224,500
PERTAMINA Dumai	105,500 (41.5 MW + 68 MW)
TOTAL	354,250

Source: P.T SEMEN PADANG
P.T CALTEX PACIFIC INDONESIA
PERTAMINA

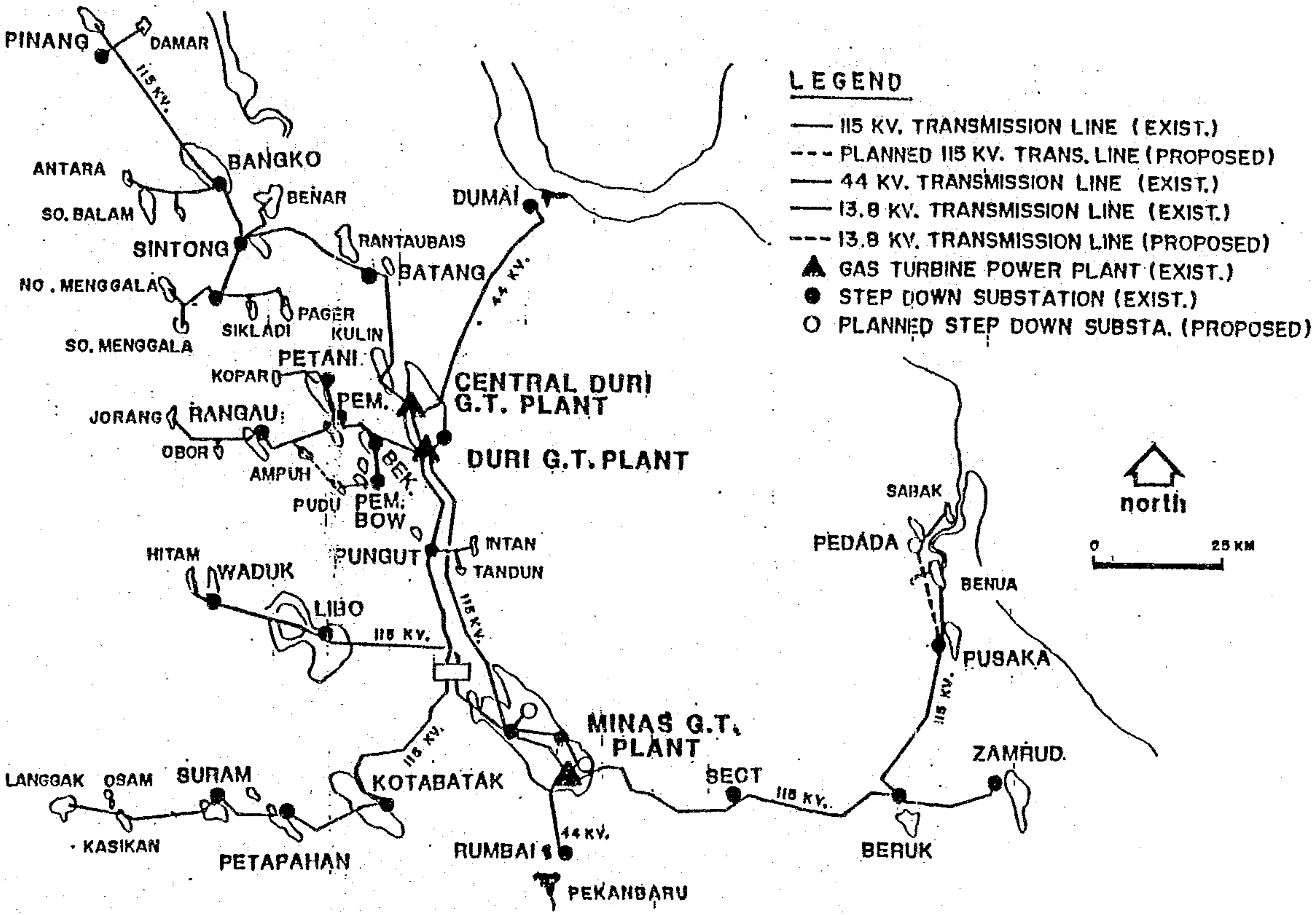
Annex 2-4 Transmission Line and Distribution Line in West Sumatra and Riau Provinces, June 1985

No.	Location	Voltage (kV)	Distance (km)	Conductor (mm^2)	Operation Year
1.	Maninjau HPS - Lubuk Alung	150	60	ACSR 240	1983
2.	Lubuk Alung - Pauh Limo	"	35	"	"
3.	Pauh Limo - Indarung	"	6	"	1986
4.	Indarung - Solok	"	36	"	"
5.	Solok - Salak	"	26	"	"
	Transmission Line		163 km		

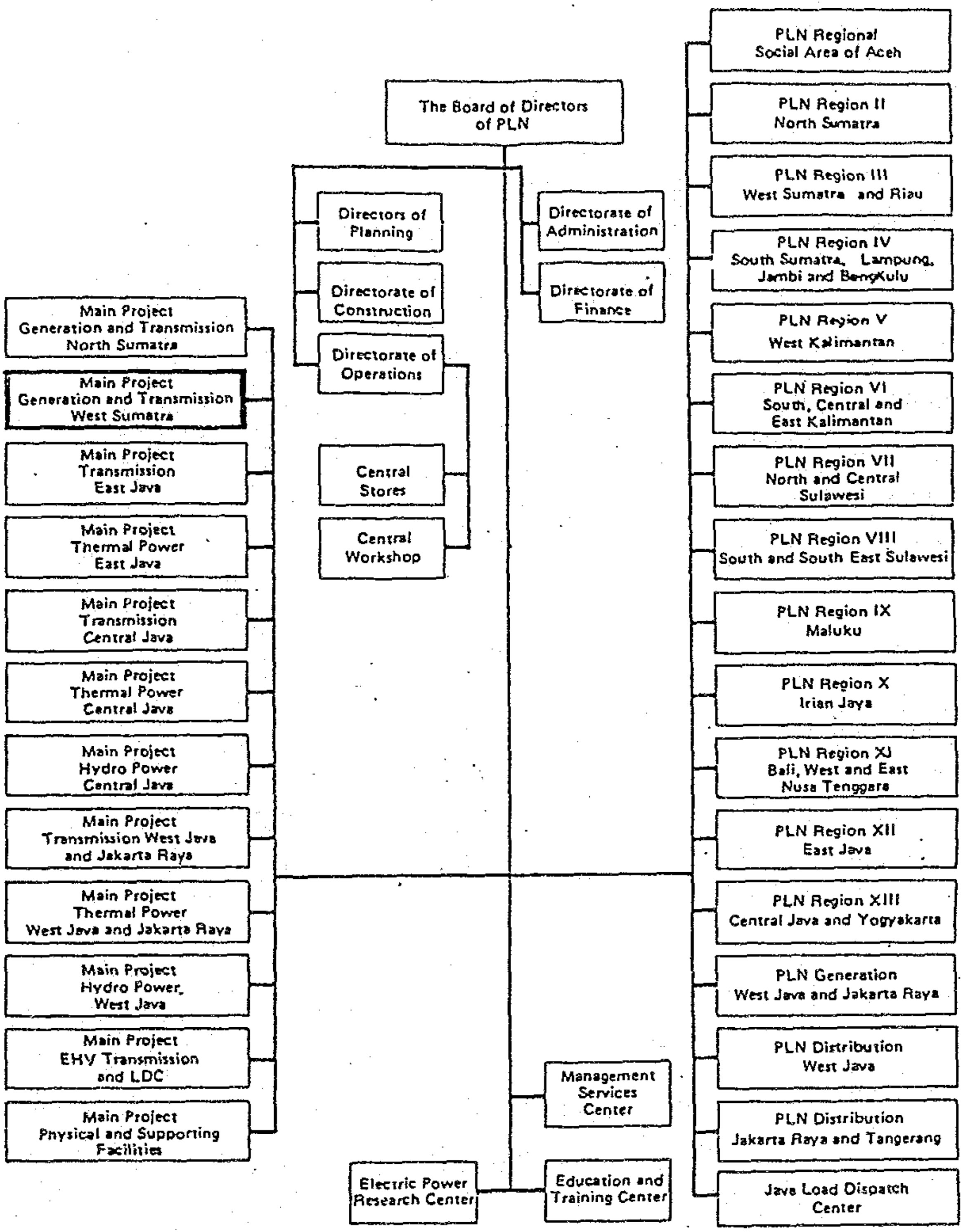
S. No.	Location	Voltage (kV)	Distance (km)
1.	Padang Branch Area	20	193
		6	58
2.	Bukittinggi Branch Area	20	444
		6	48
3.	Solok Branch Area	20	0.04
		6	0.05
4.	Pekanbaru Branch Area	20	108
		6	137
5.	Tanjung Pinang Branch Area	20	35
		6	28
	Distribution Lines	20 kV	780 km
		6 kV	271 km

Source: PLN Wilayah III

Annex 2-5 Power Distribution Plan of CALTEX



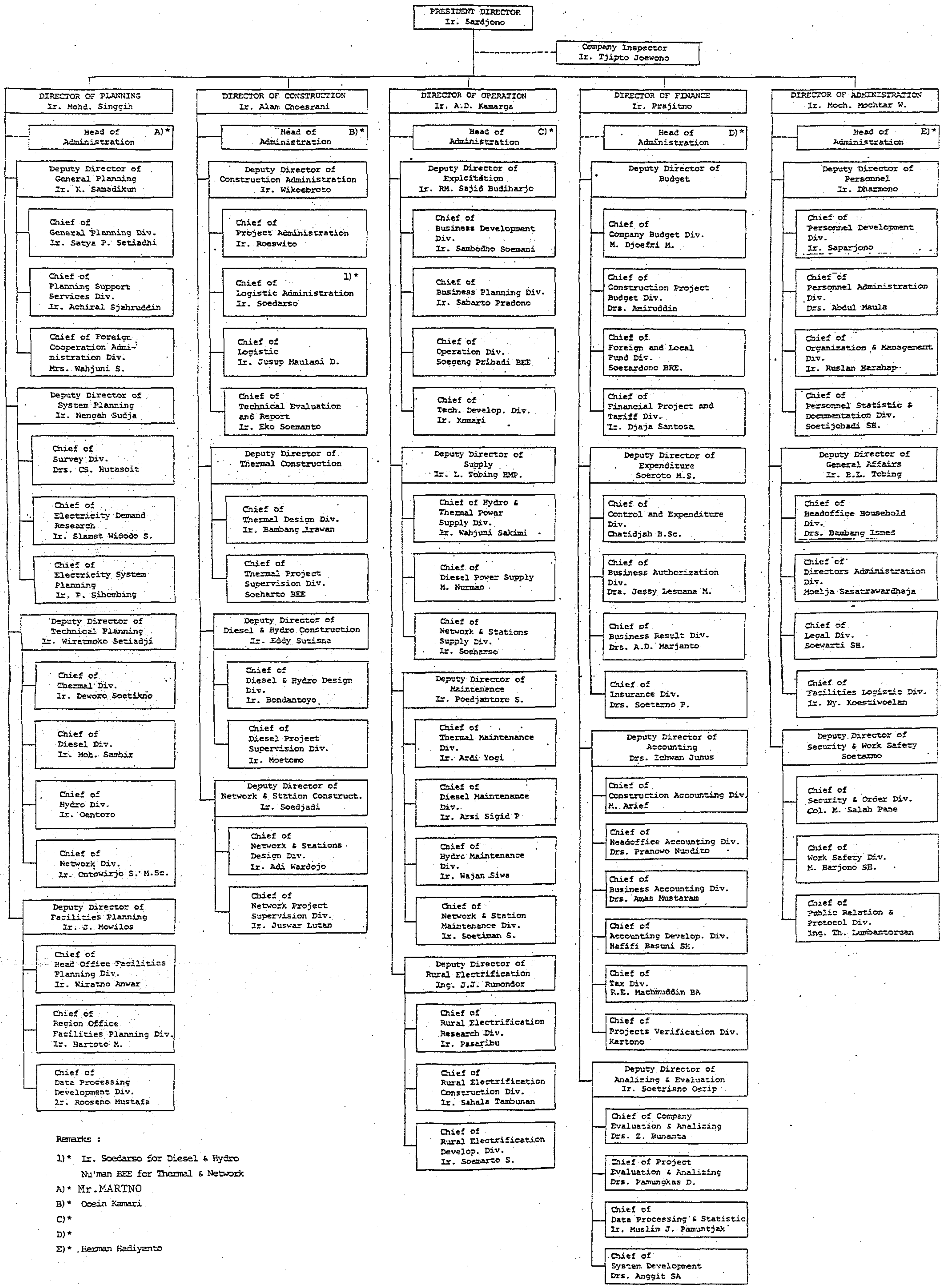
Annex 2-6 Overall Organization of PLN



Source: PLN.

Annex 2 - 7 Organization of PLN Head Office

As of Nov. 1985



Remarks :

1)* Ir. Soedarso for Diesel & Hydro
Nu'man BEE for Thermal & Network

A)* Mr.MARTNO

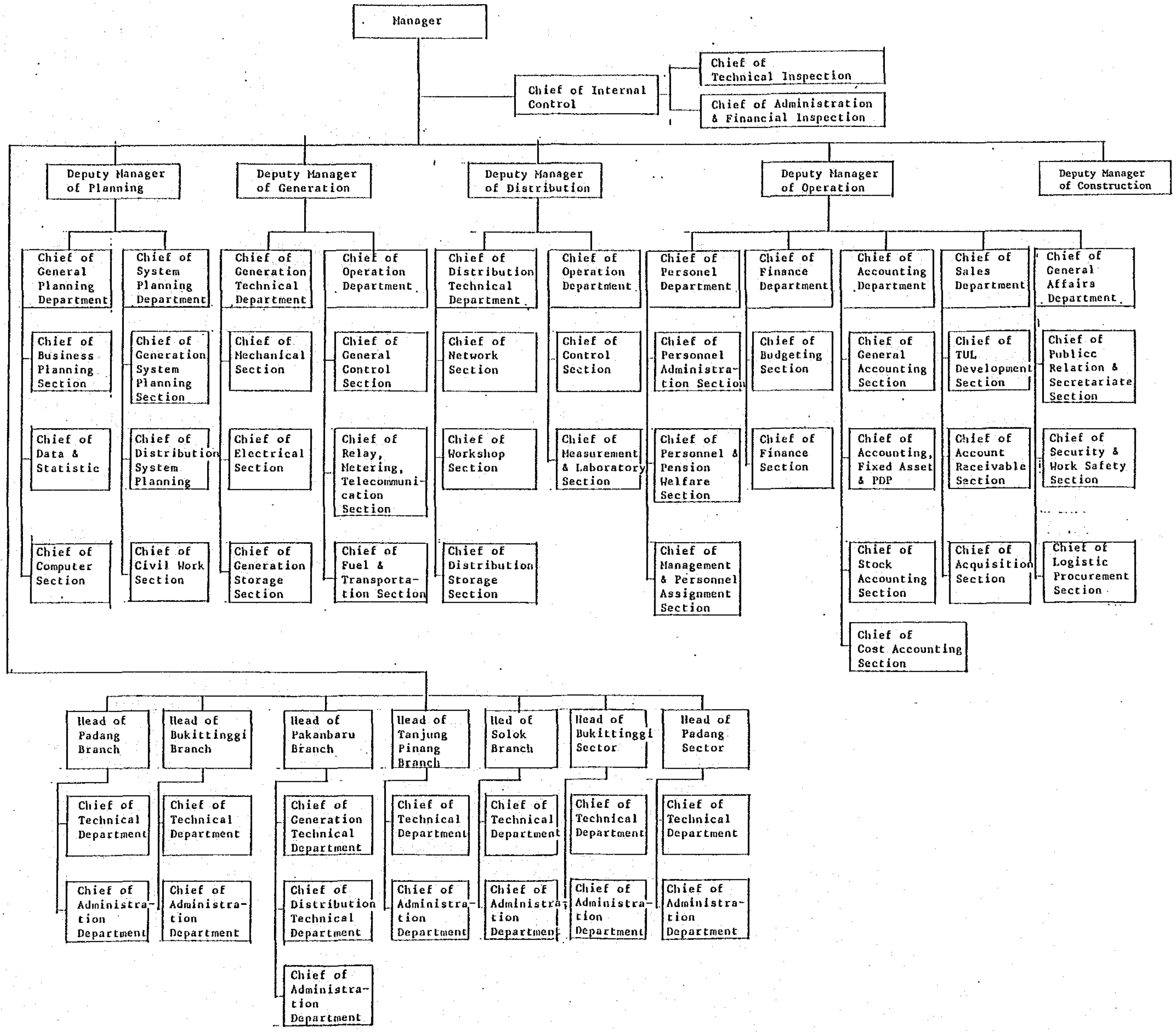
B)* Ocein Kamari

C)*

D)*

E)* Herman Hadiyanto

Annex 2-8 Organization of PLN Wilayah III



Annex 3-1 (1) Break-up of Population Growth in W. Sumatra Province

Year Name of Kodya./Kab	1971 Sep.	1983 Dec.		Total	Growth Rate by Natural Growth (%)	Total Growth Rate (%)
		Nos. of Population by Natural Growth	Nos. of Population by Transmigration			
Kodya. Padang	196,339	509,670	-	509,670	8.27	8.27
Kodya. Bukittinggi	63,132	71,947	-	71,947	1.10	1.10
Kodya. Padang Panjang	30,711	34,660	-	34,660	1.01	1.01
Kodya. Sawahlunto	12,427	14,553	-	14,553	1.32	1.32
Kodya. Payakumbuh	63,388	83,557	-	83,557	2.33	2.33
Kodya. Solok	24,771	33,274	-	33,274	2.49	2.49
Kab. Pasir Selatan	253,606	332,547	9,000	341,547	2.28	2.51
Kab. Solok	295,398	372,351	-	372,351	1.95	1.95
Kab. Sawahlunto/Sijunjung	161,227	219,388	40,000	259,388	2.60	4.04
Kab. Tanan Datar	291,591	338,476	-	338,476	1.25	1.25
Kab. Padang Pariaman	442,649	498,392	-	498,392	0.99	0.99
Kab. Agam	347,044	401,302	-	401,302	1.22	1.22
Kab. 50 Kota	224,056	288,926	-	288,926	2.14	2.14
Kab. Pasaman	274,256	389,370	2,250	391,620	2.96	3.01
Total	2,793,196	3,588,413	51,250	3,639,663	2.11	2.23

Source: Biro Pusat Statistik (1980) and Dalam Angka (1983)

Annex 3-1 (2) Break-up of Population Growth in Riau Province

Year Name of Kodya./Kab.	1971 Sep.	1983 Dec.			Growth Rate by Natural Growth (%)	Total Growth Rate (%)
		Nos. of Population by Natural Growth	Nos. of Population by Transmigration	Total		
Kodya. Pekanbaru	145,030	195,068	-	195,068	2.50	2.50
Kab. Kampar	258,692	374,728	81,333	456,061	2.89	4.84
Kab. Indragiri Hulu	197,156	240,099	32,728	272,827	1.53	2.74
Kab. Indragiri Hilir	286,028	402,345	15,030	417,375	2.66	3.20
Kab. Bengkalis	423,503	604,090	36,286	640,376	2.77	3.51
Kab. Kep. Riau	331,136	-	-	446,201	-	2.52
Total	1,641,545	-	-	2,427,908	-	3.32
	(1,310,409)	(1,816,330)	(165,377)	(1,981,707)	(2.64)	(3.51)

( ) figure does not include island.

Source: Biro Pusat Statistik (1980) and Dalam Angka (1984)

Annex 3-2 (1) Test of Significant Difference of Load Characteristics between Holidays and Week Days in July 1984 in Padang

(Unit: MW, MWh)

	July 1984									
	15 (Sun.)	18 (Wed.)								
Time	x_1	y_1	x_1^2	y_1^2	$x_1 y_1$	$_3\bar{x}_1$	$_3\bar{y}_1$	$_3\bar{x}_1^2$	$_3\bar{y}_1^2$	$_3\bar{x}_1\ _3\bar{y}_1$
1	22.1	29.6	488.4	876.2	654.2					
2	18.8	29.3	353.4	858.5	550.8	17.1	29.5	292.4	870.3	504.5
3	10.5	29.5	110.3	870.3	309.8					
4	14.8	29.4	219.0	864.4	435.1					
5	20.0	26.0	400.0	676.0	520.0	19.6	29.5	384.2	870.3	578.2
6	24.1	33.1	580.8	1095.6	797.7					
7	22.2	25.8	492.8	665.6	572.8					
8	20.3	15.9	412.1	252.8	322.8	21.3	18.7	453.7	349.7	398.3
9	21.3	14.5	453.7	210.3	308.9					
10	21.2	17.5	449.4	306.3	371.0					
11	21.0	15.2	441.0	231.0	319.2	20.7	16.7	428.5	278.9	345.7
12	20.0	17.3	400.0	299.3	346.0					
13	19.4	16.9	376.4	285.6	327.9					
14	19.1	17.3	364.8	299.3	330.4	18.8	17.1	353.4	292.4	321.5
15	18.0	17.2	324.0	295.8	309.6					
16	22.0	16.0	484.0	256.0	352.0					
17	28.0	19.2	784.0	368.6	691.6	26.5	20.0	702.3	400.0	530.0
18	29.5	24.7	870.3	610.1	728.7					
19	32.8	28.7	1075.8	823.7	941.4					
20	35.8	31.7	1281.6	1004.9	1134.9	36.2	31.9	1310.4	1017.6	1154.8
21	40.0	35.4	1600.0	1253.2	1416.0					
22	31.4	32.5	986.0	1056.3	1020.5					
23	27.6	29.2	761.8	852.6	805.9	28.5	29.5	812.3	870.3	840.8
24	26.4	26.8	697.0	718.2	707.5					
Σ	566.3	578.7	14406.6	15030.6	14274.7	188.7	192.9	4737.1	4949.4	4673.7
$\bar{\Sigma}$	23.6	24.1	600.3	626.3	594.8	23.6	24.1	592.1	618.7	584.2

Note: $_3\bar{x}_1$ and $_3\bar{y}_1$ refer respectively to means per every three hours of x_1 and y_1.

1) Unbiased estimate of variances between Sunday and week days

$$V_1 = \frac{14406.6 - 566.3^2/24}{24 - 1} = 45.40, \quad V_2 = \frac{15030.6 - 578.7^2/24}{24 - 1} = 46.81$$

$$F = \frac{V_2}{V_1} = 1.03 \qquad F_{23}^{23}\ (0.05) = 2.00 > F$$

Therefore, there is no difference in the variances.

2) Unbiased estimate of variances on combined data of Sunday and week days

$$V = \frac{14406.6 - 24\ (23.6)^2 + 15030.6 - 24\ (24.1)^2}{23 + 23}$$

$$= \frac{1039.6 + 1091.2}{46} = 46.32$$

$$\sigma_e = \sqrt{46.32} = 6.81$$

$$t = \frac{24.1 - 23.6}{6.81\sqrt{\frac{1}{24} + \frac{1}{24}}} = 0.254 \qquad t_{0.05}(\phi = 46) = 2.021 > t$$

Therefore, there is no difference in the means.

3) Correlation in fluctuation on Sunday and week days

$$r_{\overline{3^{x}1}\ \overline{3^{y}1}} = \frac{8\text{x}4673.7 - 188.7\text{x}192.9}{\sqrt{8\text{x}4737.1-188.7^2}\ \sqrt{8\text{x}4949.4-192.9^2}} = \frac{989.4}{47.84 \text{ x } 48.83} = 0.424$$

$$t = \frac{0.424}{\sqrt{1-0.424^2}}\ \sqrt{8-2} = 0.468 \text{ x } 2.45 = 1.146$$

$$t_{0.05}\ (\phi = 6) = 2.447 > t$$

$$t_{0.01}\ (\phi = 6) = 3.707 > t$$

Therefore, there cannot be said to be any correlation.

Annex 3-2 (2) Test of Significant Difference in Load Characteristics on Holidays and Week Days in Dec. 1984 in Padang

(Unit: MW, MWh)

Time	Dec. 1984									
	16 (Sun.)	19 (Wed.)								
	x_2	y_2	x_2^2	y_2^2	x_2y_2	$_3\bar{x}_2$	$_3\bar{y}_2$	$_3\bar{x}_2^2$	$_3\bar{y}_2^2$	$_3\bar{x}_2\ _3\bar{y}_2$
1	31.1	31.2	967.2	973.4	970.3	27.7	30.6	767.3	936.4	847.6
2	25.7	30.5	660.5	930.3	783.9					
3	26.2	30.2	686.4	912.0	791.2					
4	26.2	29.9	686.4	894.0	783.4	27.4	31.0	750.8	961.0	849.0
5	27.0	30.6	729.0	936.4	826.2					
6	29.0	32.6	841.0	1062.8	945.4					
7	26.5	29.6	702.3	876.2	784.4	27.1	25.7	734.4	660.5	696.5
8	26.0	27.4	676.0	750.8	712.4					
9	28.8	20.0	829.4	400.0	576.0					
10	23.0	19.8	529.0	392.0	455.4	22.9	18.7	524.4	349.7	428.2
11	20.0	19.5	400.0	380.3	390.0					
12	25.7	16.7	660.5	278.9	429.2					
13	24.3	23.0	590.5	529.0	558.9	24.6	22.5	605.2	506.3	553.5
14	26.5	23.5	702.3	552.3	622.8					
15	23.0	21.1	529.0	445.2	485.3					
16	22.4	23.3	501.8	542.9	521.9	29.1	27.2	846.8	739.8	791.5
17	30.2	25.8	912.0	665.6	779.2					
18	34.7	32.4	1204.1	1049.8	1124.3					
19	41.7	38.3	1738.9	1466.9	1597.1	41.3	36.0	1705.7	1296.0	1486.8
20	41.8	33.8	1747.2	1142.4	1412.8					
21	40.4	35.8	1632.2	1281.6	1446.3					
22	33.2	33.3	1102.2	1108.9	1105.6	30.6	29.9	936.4	894.0	914.9
23	29.1	29.0	846.8	841.0	843.9					
24	29.5	27.5	870.3	756.3	811.3					
Σ	692.0	664.8	20700.2	19168.8	19757.1	230.7	221.6	6870.9	6343.6	6568.5
$\bar{\Sigma}$	28.8	27.7	862.5	798.7	823.2	28.8	27.7	858.9	793.0	821.1

1) Unbiased estimate of variances between Sunday and week days

$$V_1 = \frac{20700.2 - 692.0^2/24}{24 - 1} = 32.50, \quad V_2 = \frac{19168.8 - 664.8^2/24}{24 - 1} = 32.78$$

$$F = V_2/V_1 = 1.01 \qquad F_{23}^{23}\ (0.05) = 2.00 > F$$

Therefore, there is no difference in the variances.

2) Unbiased estimate of variances on combined data of Sunday and week days

$$V = \frac{20700.2 - 24(28.8)^2 + 19168.8 - 24\ (27.7)^2}{46}$$

$$= \frac{793.6 + 753.8}{46} = 33.64$$

$$\sigma_e = \sqrt{33.64} = 5.8$$

$$t = \frac{28.8 - 27.7}{5.8\sqrt{\frac{1}{24} + \frac{1}{24}}} = 0.657 \qquad t_{0.05}(\phi = 46) = 2.021 > t$$

Therefore, there is no difference in the means.

3) Correlation in fluctuation on Sunday and week days

$$r_{\overline{{}_3x_2}\ \overline{{}_3y_2}} = \frac{8\text{x}6568.5 - 230.7\text{x}221.6}{\sqrt{8\text{x}6870.9-230.7^2}\ \sqrt{8\text{x}6343.6-221.6^2}} = \frac{1424.9}{41.77 \text{ x } 40.52} = 0.842$$

$$t = \frac{0.842}{\sqrt{1-0.842^2}}\sqrt{8-2} = 1.56 \text{ x } 2.45 = 3.82$$

$$t_{0.05}(\phi = 6) = 2.447 < t$$

Therefore, there is a correlation.

Annex 3-2 (3) Test of Significant Difference in Load Characteristics on Holiday and Week Day in March 1985 in Padang

(Unit: MW, MWh)

Time	March 1985									
	17 (Sun.)	20 (Wed.)								
	x_3	y_3	x_3^2	y_3^2	x_3y_3	$_3\bar{x}_3$	$_3\bar{y}_3$	$_2\bar{x}_3^2$	$_3\bar{y}_3^2$	$_3\bar{x}_3\ _3\bar{y}_3$
1	32.0	31.0	1024.0	961.0	992.0					
2	31.0	31.5	961.0	992.3	976.5	31.3	31.2	979.7	973.4	976.6
3	31.0	31.2	961.0	973.4	967.2					
4	31.5	31.2	992.3	973.4	982.8					
5	31.5	32.0	992.3	1024.0	1008.0	32.3	32.5	1043.3	1056.3	1049.8
6	34.0	34.2	1156.0	1069.6	1162.8					
7	30.3	31.7	918.1	1004.9	960.5					
8	24.5	25.5	600.3	650.3	624.8	28.5	27.3	812.3	745.3	778.1
9	30.7	24.8	942.5	615.0	761.4					
10	29.0	24.9	841.0	620.0	722.1					
11	26.0	24.7	676.0	610.1	642.2	27.8	26.4	772.8	697.0	733.9
12	28.3	29.5	800.9	870.3	834.9					
13	31.5	29.2	992.3	852.6	919.8					
14	27.0	29.5	729.0	870.3	796.5	27.4	28.9	750.8	835.2	791.9
15	23.6	28.0	557.0	784.0	660.8					
16	30.8	28.7	948.6	823.7	884.0					
17	32.5	24.6	1056.3	605.2	799.5	33.3	26.9	1108.9	723.6	895.8
18	36.5	27.5	1332.3	756.3	1003.8					
19	39.7	38.1	1576.1	1451.6	1512.6					
20	40.9	38.8	1672.8	1505.4	1586.9	42.3	38.1	1789.3	1451.6	1611.6
21	46.3	37.5	2143.7	1406.3	1736.3					
22	35.1	34.7	1232.0	1204.1	1218.0					
23	33.2	31.3	1102.2	979.7	1039.2	32.4	31.6	1049.8	998.6	1023.8
24	28.8	28.7	829.4	823.7	826.6					
Σ	765.7	728.8	25036.9	22527.1	23618.8	255.3	242.9	8306.8	7480.9	7861.4
$\bar{\Sigma}$	31.9	30.4	1043.2	938.6	984.1	31.9	30.4	1038.3	935.1	982.7

1) Unbiased estimate of variances between Sunday and week days

$$V_1 = \frac{25036.9 - 765.7^2/24}{24 - 1} = 26.43, \quad V_2 = \frac{22527.1 - 728.8^2/24}{24 - 1} = 17.21$$

$$F = V_1/V_2 = 1.536 \qquad F_{23}^{23}\ (0.05) = 2.00 > F$$

<u>Therefore, there is no difference in the variances.</u>

2) Unbiased estimate of variances on combined data of Sunday and week days

$$V = \frac{25036.9 - 24(31.9)^2 + 22527.1 - 24\ (30.4)^2}{23 + 23}$$

$$= \frac{614.3 + 347.3}{46} = 20.90$$

$$\sigma_e = \sqrt{20.90} = 4.57$$

$$t = \frac{31.9 - 30.4}{4.57\sqrt{\frac{1}{24} + \frac{1}{24}}} = 1.137 \qquad t_{0.05}(\phi = 46) = 2.021 > t$$

<u>Therefore, there is no difference in the means.</u>

3) Correlation in fluctuation on Sunday and week days

$$r_{\overline{{}_3x_3}\ \overline{{}_3y_3}} = \frac{8\text{x}7861.4 - 255.3\text{x}242.9}{\sqrt{8\text{x}8306.8-255.3^2}\ \sqrt{8\text{x}7480.9-242.9^2}} = \frac{878.8}{35.73 \text{ x } 29.10} = 0.845$$

$$t = \frac{0.845}{\sqrt{1-0.845^2}} = \sqrt{8-2} = 3.871$$

$$t_{0.05}(\phi = 6) = 2.447 < t$$

<u>Therefore, there is a correlation.</u>

Annex 3-3 Test of Significant Difference of Load Characteristics in Dec. 1982 and April 1985 in Pekanbaru

(Unit: MW, MWh)

	April 17 (Wed.) 1985		Dec. 20 (Sun.) 1982						
Time	x_1	${}_3\bar{x}_1$	x_2	${}_3\bar{x}_2$	$x_1{}^2$	$x_2{}^2$	${}_3\bar{x}_1{}^2$	${}_3\bar{x}_2{}^2$	${}_2\bar{x}_1\ {}_3\bar{x}_2$
1	5.8		4.5		33.6	20.3			
2	5.7	5.7	4.2	4.3	32.5	17.6	32.5	18.5	24.5
3	5.6		4.1		31.4	16.8			
4	5.6		4.2		31.4	17.6			
5	6.1	6.1	4.5	4.6	37.2	20.3	37.2	21.2	28.1
6	6.7		5.0		44.9	25.0			
7	6.0		4.7		36.0	22.1			
8	5.0	5.2	4.0	4.3	25.0	16.0	27.0	18.5	22.4
9	4.6		4.2		21.2	17.6			
10	5.2		4.3		27.0	18.5			
11	5.9	5.1	4.2	4.3	24.0	19.6	26.0	18.5	21.9
12	5.3		4.3		28.1	18.5			
13	5.2		4.4		27.0	19.4			
14	5.4	5.3	5.0	4.8	29.2	25.0	28.1	23.0	25.4
15	5.4		5.1		29.2	26.0			
16	5.2		4.5		27.0	20.3			
17	4.8	5.2	3.8	4.5	23.0	14.4	27.0	20.3	23.4
18	5.7		5.3		32.5	28.1			
19	8.5		6.5		72.3	42.3			
20	10.1	9.5	7.9	7.4	102.0	62.4	90.3	54.8	70.3
21	9.8		7.9		96.0	62.4			
22	9.5		7.5		90.3	56.3			
23	9.0	9.0	6.6	6.6	81.0	43.6	81.0	43.6	59.4
24	8.5		5.6		72.3	31.4			
Σ		51.1		40.8	1054.1	659.5	349.1	218.4	275.4
$\bar{\Sigma}$		6.4		5.1	43.9	27.5	43.6	27.3	34.4

1) Unbiased estimate of variances when the data in 1985 and 1982 are combined

$$V = \frac{1054.1 - 24\ (6.4)^2 + 659.5 - 24\ (5.1)^2}{46} = 2.31$$

$$\sigma_e = \sqrt{2.31} = 1.52$$

$$t = \frac{6.4 - 5.1.}{1.52\sqrt{\frac{1}{24} + \frac{1}{24}}} = 2.963$$

$$t_{0.05}(\phi = 46) = 2.021 < t$$

Therefore, there cannot be said to be no difference in the means. In this case, the means in 1985 is larger.

2) Correlation of fluctuation between ${}_3\bar{x}_1$ and ${}_3\bar{x}_2$

$$r_{\overline{{}_3x_1}\ \overline{{}_3x_2}} = \frac{8x275.4 - 51.1x40.8}{\sqrt{8x349.1-51.1^2}\ \sqrt{8x218.4-40.8^2}} = \frac{118.32}{13.48 \times 9.09}$$

$$= 0.966$$

$$t = \frac{0.966}{\sqrt{1-0.966^2}}\sqrt{8-2} = 3.736 \times 2.45 = 9.15$$

$$t_{0.05}(\phi = 6) = 2.447 < t$$

$$t_{0.01}(\phi = 6) = 3.707 < t$$

Therefore there is a substantial correlation.

Annex 3-4 Test of the Difference of Daily Energy Consumption between July and December 1984 and March 1985 in Padang

	Daily energy consumption (MWh)							
	1984		1985					
	July	Dec.	March					
	a_1	a_2	a_3		a_1^2	a_2^2	a_3^2	
Sunday Σx	566.3	692.0	765.7		320695.7	478864.0	586296.5	
Week day Σy	578.7	664.8	728.8	$Total_1$	334893.7	441959.0	531149.4	$Total_2$
Total $\Sigma .$	1145.0	1356.8	1494.5	3996.3	655589.4	920823.0	1117445.9	2693858
n	2	2	2	6				
$\bar{\Sigma}$	572.5	678.4	747.3	‖ N				

Total variance $\square = \Sigma\Sigma\, xy_{ij}^2 - \frac{(Total_1)^2}{N} = 2693858 - \frac{15970414}{6} = 32122$

Among-class variance $\Delta = \frac{(\Sigma a_1)^2}{n} + \frac{(\Sigma a_2)^2}{n} + \frac{(\Sigma a_3)^2}{n} - \frac{(Total_1)^2}{N}$

$= 655513 + 920453 + 1116765 - 2661736 = 30995$

Interclass variance $\otimes = \square - \Delta = 32122 - 30995 = 1127$

Variance Matrix

Factors		Fluctuation	Freedom	Unbiased variance	Variance ratio, F_0
Among-class	Δ	30,995	3-1=2	15,498	41.2
Interclass	$\otimes$	1,127	6-3=3	376	
Total	$\square$	32,122	6-1=5		

$F_3^2\,(0.01) = 30.81 < F_0$

Since the daily energy consumption varies extensively in each month, the values cannot be recognized as those in the same population. Therefore the energy demand in each month should be handled individually. Here, the value is assumed to increase successively toward the end of fiscal year.

Annex 3-5 Estimation of Daily Average Power Consumption in April 1984 according to Linear Regression

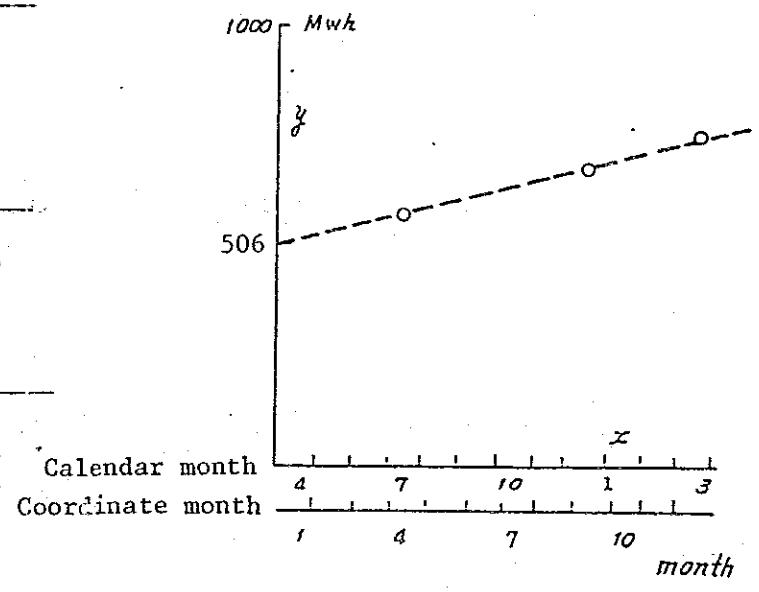
$$y = \bar{\alpha}\ x + \bar{\beta}$$

$$\bar{\alpha} = \left(\sum_{i=1}^{n} x_i y_i - n\ \bar{x}_i \bar{y}_i \right) / \left(\sum_{i=1}^{n} x_i^{\ 2} - n\ \bar{x}_i^{\ 2} \right)$$

$$\bar{\beta} = \left(\bar{y}_i \sum_{i=1}^{n} x_i^{\ 2} - \bar{x}_i\ \Sigma\ x_i y_i \right) / \left(\sum_{i=1}^{n} x_i^{\ 2} - n\ \bar{x}_i^{\ 2} \right)$$

Unit: MWh

Calender month	Coordinate month x	Daily average (Sun. + Wed.)/2, y	x^2	y^2	xy
7	4	572.5	16	327956.3	2270.0
12	9	678.4	81	460226.6	6105.6
3	12	747.3	144	558457.3	8967.6
Σ	25	1998.2	241	1346440.1	17363.2
$\bar{\Sigma}$	8.33	666.07	80.33	448813.4	5787.7



$\bar{\alpha}$ = (17363.2 - 3 x 8.3^2 x 666.07)/(241 - 3 x 8.33^2)

= 712.2/32.7 = 21.79

$\bar{\beta}$ = (666.1 x 241 - 8.33 x 17363.2)/32.83

= 15894.6/32.83 = 484.1

y = 21.79x + 484.1

at x = 1 : y = 506.0 MWh

Annex 3-6 Regression Analysis

Unit : MWh

	x	y	x^2	y^2
	4	572.5	16	327,756.3
	9	678.4	81	460,226.6
	12	747.3	144	558,457.3
Σ	25	1998.2	24	1,346,440.1
Σ	8.33	666.07	80.33	448,813.4

o Total variance □ = 32,122 (From Annex 3-4)

o Among class variance Δ = 30,995 (Same as above)

o Interclass variance ⊗ = □ − Δ = 1,127 (Same as above)

o Variance based on regression

$$S_R = b^2(\Sigma x_i^{\,2} - n\bar{x}_i^{\,2})$$
$$= (21.79)^2(241 - 3 \times 8.33^2) = 15,589$$

o Variance from regression $S_E = \Delta - S_R = 15,406$

Variance Matrix

Factors		Fluctuation	Freedom	Unbiased variance	Variance ratio, Fo	F^{1}_{3} (0.05) F^{1}_{3} (0.01)
Based on regression	S_R	15,589	1	15,589		10.13
Around regression	S_E	15,406	3 − 2 = 1	15,406	15,406/376 = 41	34.12
Among-class	Δ	30,995	3 − 1 = 2	15,498		
Interclass	⊗	1,127	6 − 3 = 3	376		
Total	□	32,122	6 − 3 = 3			

$Fo > F^{1}_{3}$ (0.01)

The difference is highly significant. This fact proves that the data are small in dispersion, and y, namely, the demand grows linearly followed by the change of x along with elapse of months.

Annex 3-7 (1) Example of Preparing Totalized Load Curves: Demand Forecast and Load Curves in Fiscal Year 19xx

Consumer type	Sold energy (GWh)	Daily sales energy (MWh)		Sending and energy (MWh)		Loss ratio, %
		Week day	Holiday	Week day	Holiday	
Residential	178.1	487.9	487.9	587.8	587.8	17
Commercial	46.6	B 130.2	A 117.2	156.9	141.2	17
Public	43.5	B 121.6	A 109.4	146.5	131.8	17
Small Ind.	164.8	D_1 479.9	C_1 335.9	578.2	404.7	17
Medium Ind.	70.6	D_2 205.6	C_2 143.9	247.7	173.4	17
(Industry total)	(235.4)					
Cement	179.0	490.4	490.4	505.6	505.6	3
PERTAMINA	-	-	-	-	-	-
Sub total		1915.6	1684.7	2222.7	1924.5	
Yearly total	682.6	682.6 GWh		π 791.3 GWh		

Note: π is explained later. (Annex 3-13)

Conditions 1. Out of 365 days in one year, 293 and 72 days are assumed to be week days and holidays, respectively.

2. The ratio of sold energy on holidays (A) to that on week days (B) for commercial and public consumers is assumed at 0.9: 1.0.

Therefore,

$$\begin{array}{l}\underline{\text{Commercial: }46.5}\\ \underline{\text{Public }\ :\ 43.5}\end{array}\ \text{GWh} = 72\ A + 293\ B$$

$$\frac{A}{B} = 0.9$$

$$\therefore B = \frac{\text{Commercial or Public}}{357.8} = \begin{array}{c}130.2\\121.6\end{array}\ \text{MWh}$$

$$A = \text{Above} \times 0.9 = 109.4\ \text{MWh}$$

3. The industrial demand is a total of small and medium industry demand with the ratio being:

$$\overset{m}{0.7} : \overset{n}{0.3}$$

a. Small industry = 164.8 GWh, Medium industry = 70.6 GWh

-b. Holiday : Week day for industrial = 0.7: 1.0
C D

Small or medium industry demand, GWh = 72 C + 293 D

$$\frac{C}{D} = 0.7$$

$$\therefore D_1 = \frac{\text{Small ind.}}{343.4} = 479.9\ \text{MWh} \qquad D_2 = \frac{\text{Medium ind.}}{343.4} = 205.6\ \text{MWh}$$

$$C_1 = 0.7 \times D_1 = 335.9 \qquad C_2 = 0.7 \times D_2 = 143.9$$

Annex 3-7 (2) Calculation Chart for Load Curves

(Unit: MW)

Allocation ratio		430	600	560	590	600	690	690	
Type / Time zone		Residen-tial	Commer-cial	Public	Small Ind.	Medium Ind.	Cement	PERTAMINA	Total
Week day	1	22.8	4.4	6.1	16.3	6.7	22.0	-	78.3
	2	27.3	4.4	6.1	16.3	6.7	22.0	-	82.8
	3	18.2	7.0	5.2	26.1	12.0	19.5	-	88.0
	4	13.7	8.7	5.2	32.7	13.3	19.5	-	93.1
	5	13.7	7.8	4.4	31.0	12.7	19.5	-	89.1
	6	18.2	8.7	7.0	32.7	13.3	19.5	-	99.4
	7	45.6	7.0	8.7	21.2	11.3	24.4	-	118.2
	8	36.5	4.4	6.1	16.3	6.7	22.0	-	92.0
		196.0	52.4	48.8	192.6	82.7	168.4	-	740.9
x 3 =		588.0	157.2	146.4	577.8	248.1	505.2	-	2222.7 ← For check
Holiday	1	22.8	3.9	5.5	11.4	4.7	22.0	-	70.3
	2	27.3	3.9	5.5	11.4	4.7	22.0	-	74.8
	3	18.2	6.3	4.7	18.3	8.4	19.5	-	75.4
	4	13.7	7.8	4.7	22.9	9.3	19.5	-	77.9
	5	13.7	7.1	3.9	21.7	8.9	19.5	-	74.8
	6	18.2	7.8	6.3	22.9	9.3	19.5	-	84.0
	7	45.6	6.3	7.8	14.9	7.9	24.4	-	106.9
	8	36.5	3.9	5.5	11.4	4.7	22.0	-	84.0
		196.0	47.0	43.9	134.9	57.9	168.4		648.1
x 3		588.0	141.0	131.7	404.7	173.7	505.2		1944.5 ← For check

Calculation formula: $\frac{\text{Sending end daily energy}}{\text{Allocation ratio x 3}}$ x Time zone allocation ratio

(Refer to Table 3.7-1)

Annex 3-8 (1) Estimation of Load Curves and Test of Goodness of Fit in Padang in 1984

Consumer type	Sold energy (GWw)	Daily sold energy (MWh)		Sending and energy (MWh)		Loss ratio, %
		Week day	Holiday	Week day	Holiday	
Residential	33.32	91.29	91.29	121.7	121.7	25
Commercial	5.15	B 14.39	A 12.95	19.2	17.3	"
Public	14.27	B 39.88	A 35.89	53.2	47.9	"
Small Ind.	11.29	D_1 32.88	C_1 23.01	43.8	30.7	"
Medium Ind.	1.25	D_2 3.64	C_2 2.55	4.9	3.4	"
(Industry total)	(12.54)					
Cement	87.16	238.8	238.8	280.9	280.9	15
PERTAMINA	-	-	-	-	-	-
Sub total		420.88	404.49	523.7	Θ 501.9	
Yearly total	152.44	152.44 GWh		189.58 GWh		

Conditions 1. Out of 365 days in one year, 293 and 72 days are assumed to be week days and holidays, respectively.

2. The ratio of sold energy on holidays (A) to that on week days (B) for commercial and public consumers is assumed at 0.9:- 1.0.

Therefore,

$$\frac{\text{Commercial: } 5.15}{\text{Public : } 14.27} \text{ GWh} = 72\ A + 293\ B$$

$$\frac{B}{A} = 0.9$$

$$B = \frac{\text{Commercial or public}}{357.8} = \begin{matrix} 14.39 \\ 39.88 \end{matrix} \text{ MWh}$$

$$A = \text{Above} \times 0.9 \qquad = \begin{matrix} 12.95 \\ 35.89 \end{matrix} \text{ MWh}$$

3. The industrial demand is a total of small and medium industry demand, with the composition being $\overset{m}{0.9} : \overset{n}{0.1}$

a. $\underset{C}{\text{Holidays}}$: $\underset{D}{\text{Week days}}$ for industrial = 0.7: 1.0

b. Small or medium Industry demand GWh = 72 C + 293 D

$$\frac{C}{D} = 0.7$$

$$\therefore D_1 = \frac{\text{Small ind.}}{343.4} = 32.84 \text{ MWh} \qquad D_2 = \frac{\text{Medium ind.}}{343.4} = 3.64 \text{ MWh}$$

$$C_1 = 0.7 \times D_1 = 23.01 \qquad C_2 = 0.7 \times D_2 = 2.55$$

Annex 3-8 (2) Calculation Chart for Load Curves

(Unit: MW)

Allocation ratio		430	600	560	590	600	690	690	
Type / Time zone		Residential	Commercial	Public	Small Ind.	Medium Ind.	Cement	PERTAMINA	Total
Week day	1	4.7	0.5	2.2	1.2	0.1	12.2	-	20.9
	2	5.7	0.5	2.2	1.2	0.1	12.2	-	21.9
	3	3.8	0.9	1.9	2.0	0.2	10.9	-	19.7
	4	2.8	1.1	1.9	2.5	0.3	10.9	-	19.5
	5	2.8	1.0	1.6	2.4	0.3	10.9	-	19.0
	6	3.8	1.1	2.5	2.5	0.3	10.9	-	21.1
	7	9.4	0.9	3.2	1.6	0.2	13.6	-	28.9
	8	7.5	0.5	2.2	1.2	0.1	12.2	-	23.8
Σ		40.5	6.5	17.7	14.6	1.6	93.8	-	174.8
Σ x 3 =		121.5	19.5	53.1	43.8	4.8	281.4	-	524.1 ← For check
Holiday	1	4.7	0.5	2.0	0.9	0.1	12.2	-	20.4
	2	5.7	0.5	2.0	0.9	0.1	12.2	-	21.4
	3	3.8	0.8	1.7	1.4	0.2	10.9	-	18.8
	4	2.8	1.0	1.7	1.7	0.2	10.9	-	18.3
	5	2.8	0.9	1.4	1.6	0.2	10.9	-	17.8
	6	3.8	1.0	2.3	1.7	0.2	10.9	-	19.9
	7	9.4	0.8	2.9	1.1	0.2	13.6	-	28.0
	8	7.5	0.5	2.0	0.9	0.1	12.2	-	23.2
Σ		40.5	6.0	16.0	10.2	1.3	93.8	-	167.8
Σ x 3 =		121.5	18.0	48.0	30.6	3.9	281.4	-	503.4 ← For check

Annex 3-8 (3)

Test of Goodness of Fit in Padang

(Unit: MW)

	July 18, 1984		$\frac{(y_1 - z_1)^2}{z_1}$	Dec. 19, 1984		$\frac{(y_2 - z_2)^2}{z_2}$	Mar. 20, 1985		$\frac{(y_3 - z_3)^2}{z_3}$
	y_1	z_1, estimated		y_2	z_2, estimated		y_3	z_3, estimated	
1	29.5	23.1	1.773	30.6	27.6	0.326	31.2	29.0	0.167
2	29.5	24.2	1.161	31.0	28.9	0.153	32.5	30.4	0.145
3	18.7	21.7	0.415	25.7	26.0	0.003	27.3	27.4	0.000
4	16.7	21.5	1.072	18.7	25.7	1.907	26.4	27.1	0.018
5	17.1	21.0	0.724	22.5	25.1	0.269	28.9	26.4	0.237
6	20.0	23.3	0.467	27.2	27.8	0.013	26.9	29.3	0.197
7	31.9	31.9	0	36.0	38.1	0.116	38.1	40.2	0.110
8	29.5	26.3	0.389	29.0	31.4	0.183	31.6	33.1	0.068
Σ	192.9	192.9	6.001	230.7	230.7	2.865	242.9	242.9	0.942
			$\parallel$ χ_1^2			$\parallel$ χ_2^2			$\parallel$ χ_3^2

The estimated values were compared with actual energy consumption in the respective time zones so that the daily energy consumption in the load curves obtained in the previous table would match the actual daily energy consumption. Since only the total consumption is affected by the actual values, X^2-test of $n - 1 = 8 - 1 = 7$ was carried out with respect to the freedom.

Regarding the week day in July 1984,

$$\chi_1^2 < \chi^2_{\phi=7}(0.50) = 6.346$$

Therefore, the estimated values have a goodness of fit with the actual values.

Similarly regarding the week day in Dec. 1984,

$$\chi_2^2 < \chi^2_{\phi=7}(0.80) = 3.822$$

Also, the estimated values comply nearly perfectly with the actual values.

Regarding the week days in March 1985, moreover,

$$\chi_3^2 < \chi^2_{\phi=7}(0.99) = 1.239$$

Therefore, the estimated values also comply entirely with the actual values.

Annex 3-9 (1) Estimation of Load Curves and Check of their Applicability in Pekanbaru in 1984

Consumer type	Sold energy (GWh)	Daily sold energy (MWh)		Sending end energy (MWh)		Loss ratio, %
		Week day	Holiday	Week day	Holiday	
Residential	22.70	62.19	62.19	82.9	82.9	25
Commercial	5.66	B 15.82	A 14.24	21.1	19.0	"
Public	6.19	B 17.30	A 15.57	23.1	20.8	"
Small Ind.	5.52	D_1 16.07	C_1 11.25	21.4	15.0	"
Medium Ind.	0.61	D_2 1.78	C_2 1.24	2.4	1.7	"
(Industry total)	(6.13)					
Cement	-	-	-	-		
PERTAMINA	-	-	-	-		
Sub total		113.16	104.49	150.9	Θ 139.4	
Yearly total	40.68	40.68 GWh		54.25 GWh		

Conditions 1. Out of 365 days in one year, 293 and 72 days are assumed to be week days and holidays, respectively.

2. The ratio of sold energy on holidays (A) to that on week days (B) for commercial and public consumers is assumed at 0.9: 1.0.

Therefore,

$$\underline{\begin{array}{l}\text{Commercial: } 5.66\\ \text{Public } \ \ \ :\ 6.19\end{array}}\ \text{GWh} = 72\ A + 293\ B$$

$$\frac{A}{B} = 0.9$$

$$B = \frac{\text{Commercial or public}}{357.8} = \begin{array}{c}15.82\\17.30\end{array}\ \text{MWh}$$

$$A = \text{Above} \times 0.9 \qquad = \begin{array}{c}14.24\\15.57\end{array}\ \text{MWh}$$

3. The industrial demand is a total of small and medium industry demand, with the composition being $\overset{m}{0.9} : \overset{m}{0.1}$

a. Small ind. = 5.52 GWh, Medium ind. = 0.61 GWh

b. $\underset{C}{\text{Holiday}}$: $\underset{D}{\text{Week day}}$ for industry = 0.7: 1.0

Small or medium ind., GWh = 72 C + 293 D

$$\frac{C}{D} = 0.7$$

$$D_1 = \frac{\text{Small ind.}}{343.4} = 16.07\ \text{MWh} \qquad D_2 = \frac{\text{Medium ind.}}{343.4} = 1.98\ \text{MWh}$$

$$C_1 = 0.7 \times D_1 \quad = 11.25 \qquad C_2 = 0.7 \times D_2 \quad = 1.24$$

Annex 3-9 (2) Calculation Chart for Load Curves in 1984

(Unit: MW)

Allocation ratio		430	600	560	590	600	690	690		
Type / Time zone		Residential	Commercial	Public	Small Ind.	Medium Ind.	Cement	PERTAMINA	Total	
Week day	1	3.2	0.6	1.0	0.6	0.1	-	-	5.5	
	2	3.9	0.6	1.0	0.6	0.1	-	-	6.2	
	3	2.6	0.9	0.8	1.0	0.1	-	-	5.4	
	4	1.9	1.2	0.8	1.2	0.1	-	-	5.4	
	5	1.9	1.1	0.7	1.1	0.1	-	-	4.9	
	6	2.6	1.2	1.1	1.2	0.1	-	-	6.2	
	7	6.4	0.9	1.4	0.8	0.1	-	-	9.6	
	8	5.1	0.6	1.0	0.6	0.1	-	-	7.4	
Σ		27.6	7.1	7.8	7.1	0.8	-	-	50.6	
Σ x 3 =		82.8	21.3	23.4	21.3	2.4	-	-	151.8	← For check
Holiday	1	3.2	0.5	0.9	0.4	0.0	-	-	5.0	
	2	3.9	0.5	0.9	0.4	0.0	-	-	5.7	
	3	2.6	0.8	0.7	0.7	0.1	-	-	4.9	
	4	1.9	1.1	0.7	0.8	0.1	-	-	4.6	
	5	1.9	0.9	0.6	0.8	0.1	-	-	4.3	
	6	2.6	1.1	1.0	0.8	0.1	-	-	5.6	
	7	6.4	0.8	1.2	0.6	0.1	-	-	9.1	
	8	5.1	0.5	0.9	0.4	0.0	-	-	6.9	
Σ		27.6	6.2	6.9	4.9	0.5	-	-	46.1	
Σ x 3 =		82.8	18.6	20.7	14.7	1.5	-	-	138.3	← For check

Annex 3-9 (3)

Test of Goodness of Fit in Pekanbaru

(Unit: 10^2 kW)

	April 17, 1984		$\frac{(x_1 - z_1)^2}{z}$	Dec. 20, 1982		$\frac{(x_2 - z_2)^2}{z}$
	x_1	z_1, estimated		x_2	z_2, estimated	
1	57	56	0.018	43	44	0.023
2	61	63	0.063	46	50	0.320
3	52	55	0.164	43	44	0.023
4	51	55	0.291	43	44	0.023
5	53	49	0.327	48	40	1.600
6	52	63	1.921	45	50	0.500
7	95	97	0.041	74	77	0.117
8	90	75	3.000	66	60	0.600
Σ	511	511	5.825	408	408	3.206
			$\Vert$ X_1^2			$\Vert$ X_2^2

The test of goodness of fit for load curves in Pekanbaru was checked with respect to each one day in 1985 and 1982. Since the estimated values have been corrected to match actually daily energy consumption, the freedom for performing X^2-test is $\phi = n - 1 = 7$.

$$X_1^2 < X^2_{\phi=7} (0.5) = 6.35$$

$$X_2^2 < X^2_{\phi=7} (0.75) = 4.25$$

In both cases, the estimated load curves match very well with the actual values.

Annex 3-10 Analysis for Estimating the Maximum Power Demand per Hour from the Model Load Curve

Unit: MW

	July 1984				Dec. 1984				March 1985			
	15 (Sun.)	18 (Wed.)			16 (Sun.)	19 (Wed.)			17 (Sun.)	20 (Wed.)		
Time	x_1	y_1	x_1^2	y_1^2	x_2	y_2	x_2^2	y_2^2	x_3	y_3	x_3^2	y_3^2
1	22.1	x29.6	488.4		31.1	x31.2	967.2		x32.0	x31.0		
2	18.8	29.3	353.4	858.5	x25.7	30.5		930.3	31.0	31.5	961.0	992.3
3	x10.5	29.5		870.3	26.2	30.2	686.4	912.0	31.0	31.2	961.0	973.4
Σ	99.7		2570.6		118.0		3495.9		124.7		3887.7	
$\bar{\Sigma}$	24.9		642.7		29.5		874.0		31.175		971.9	
σ_1	4.76 (19.1%)				1.94 (6.6%)				0.21 (0.7%)			
4	x14.8	29.4		864.4	x26.2	29.9		894.0	31.5	x31.2	992.3	
5	20.0	26.0	400.0	676.0	27.0	30.6	729.0	936.4	31.5	32.0	992.3	1024.0
6	24.1	x33.1	580.8		29.0	x32.6	841.0		34.0	x34.2	1156.0	
Σ	99.5		2521.2		116.5		3400.4		129.0		4164.6	
$\bar{\Sigma}$	24.9		630.3		29.1		850.1		32.25		1041.2	
σ_2	3.21 (12.9%)				1.81 (6.2%)				1.04 (3.2%)			
7	22.2	x25.8	492.8		26.5	x29.6	702.3		30.3	x31.7	918.1	
8	20.3	15.9	412.1	252.8	26.0	27.4	676.0	750.8	x24.5	25.5		650.3
9	21.3	x14.5	453.7		28.8	x20.0	829.4		30.7	24.8	942.5	615.0
Σ	79.7		1611.4		108.7		2958.5		111.3		3125.9	
$\bar{\Sigma}$	19.9		402.9		27.18		739.6		27.83		781.5	
σ_3	2.62 (13.2%)				0.92 (3.4%)				2.64 (9.5%)			
19	32.8	x28.7	1075.8		41.7	38.3	1738.9	1466.9	39.7	38.1	1576.1	1451.6
20	35.8	31.7	1281.6	1004.9	x41.8	x33.8			40.9	38.8	1672.8	1505.4
21	x40.0	35.4		1253.2	40.4	35.8	1632.2	1281.6	x46.3	x37.5		
Σ	135.7		4615.5		156.2		6119.6		157.5		6205.9	
$\bar{\Sigma}$	33.93		1153.9		39.05		1529.9		39.38		1551.5	
σ_7	1.62 (4.8%)				2.24 (5.7%)				0.83 (2.1%)			
22	31.4	x32.5	986.0		33.2	x33.3	1102.2		x35.1	34.7		1204.1
23	27.6	29.2	761.8	852.6	29.1	29.0	846.8	841.0	33.2	31.3	1102.2	979.7
24	x26.4	26.8		718.2	29.5	x27.5	870.3		28.8	x28.7	829.4	
Σ	115.0		3318.6		120.8		3660.3		128.0		4115.4	
$\bar{\Sigma}$	28.75		829.7		30.2		915.1		32.0		1028.9	
σ_8	1.76 (6.1%)				1.74 (5.8%)				2.20 (6.9%)			

Note: The values denoted by x refer to the values calculated from those in statistics excluding the maximum and minimum values from groups x_i and y_i.
The values in parenthesis refer to the ratio to average values.

Annex 3-11 Example of Obtaining Daily Maximum and Minimum Power Demand

The daily maximum and minimum power demand is obtained by calculation from the values in Annex 3-7 (1), (2).

(Unit: MW, MWh)

Week day	Minimum	78.3 - 2 x 0.07 x 78.3 ≒ 67.3	Daily L.F. 68.7%
	Maximum	118.2 + 2 x 0.07 x 118.2 ≒ 134.8	
	Daily	2,222.7	
Holiday	Minimum	70.3 - 2 x 0.07 x 70.3 ≒ 60.5	Daily L.F. 66.5%
	Maximum	106.9 + 2 x 0.07 x 106.9 ≒ 121.9	
	Daily	1,944.5	

Annex 3-12 Example of Obtaining Yearly Maximum and Minimum Power Demand

The yearly maximum and minimum power demand is obtained as follows form the calculation chart in Annex 3-7 (1), (2).

Unit: MW, GWh

Yearly	Minimum	Holiday minimum 70.3 ÷ 1.059 - (14% portion) = 57.1	Yearly L.F 63.3%
	Maximum	Week day maximum 118.2 x 1.059 + (14% portion) = 142.7	
	Yearly	791.3	

Note: Coefficient of increase/6 months $\frac{\text{Sold energy in the next year}}{\text{Sold energy in this year}} \div 2$

$= 1.059$

Annex 3-13 Example of Obtaining Monthly Sending End Energy Demand

Average power $P_A = \frac{\pi}{8{,}760\ \text{hr.}} = 0.09033$ GWh

: from Annex 3-7 (1), (2).

When an increase rate per six months is taken into account, the power demand in one month is,

$$P_{\text{Mar.}} = P_A \times \underset{\text{6 m increase rate}}{1.059} \times 730\ \text{hr.} = 69.83\ \text{GWh}$$

$$P_{\text{Apr.}} = P_A \div 1.059 \times 730\ \text{hr.} = 62.27\ \text{GWh}$$

$$\text{where } \Delta = \frac{P_{\text{Mar.}} - P_{\text{Apr.}}}{11} = 0.687\ \text{GWh}$$

$$P_{\text{Feb.}} = P_{\text{Mar.}} - \Delta$$

$$P_{\text{Jan.}} = P_{\text{Feb.}} - \Delta$$

Months	Monthly allocation (GWh)
4	62.3
5	63.0
6	63.7
7	64.3
8	65.0
9	65.7
10	66.4
11	67.1
12	67.8
1	68.4
2	69.1
3	69.8

Annex 4-1 Effect of Transmission Loss upon the Respective Alternative Plans for Trunk Power System

1. Comparison between Basic 150 kV Plan and Alternative Plans

Year	(A) Basic Plan		(B) Alternative 150 kV Plan		(C) Alternative 150 kV Plan In case no investment is made in 2005	
	T/L loss (MW)	Capacity of converter (MVA)	T/L loss (MW)	Capacity of converter (MVA)	T/L loss (MW)	Capacity of converter (MVA)
1993	2.3	0	2.0	0	2.0	0
1995	5.8	31	8.7	31	8.7	31
2000	9.6	48	10.4	7	10.4	7
2005	18.7	171	23.1	156	23.1	156
2005*	16.0	152	16.0	152	-	

* In case of loop operation

The Plans (B) and (C) are apparently disadvantageous over the basic plan (A) since these plans require higher construction cost and are larger in transmission loss than the basic plan (A).

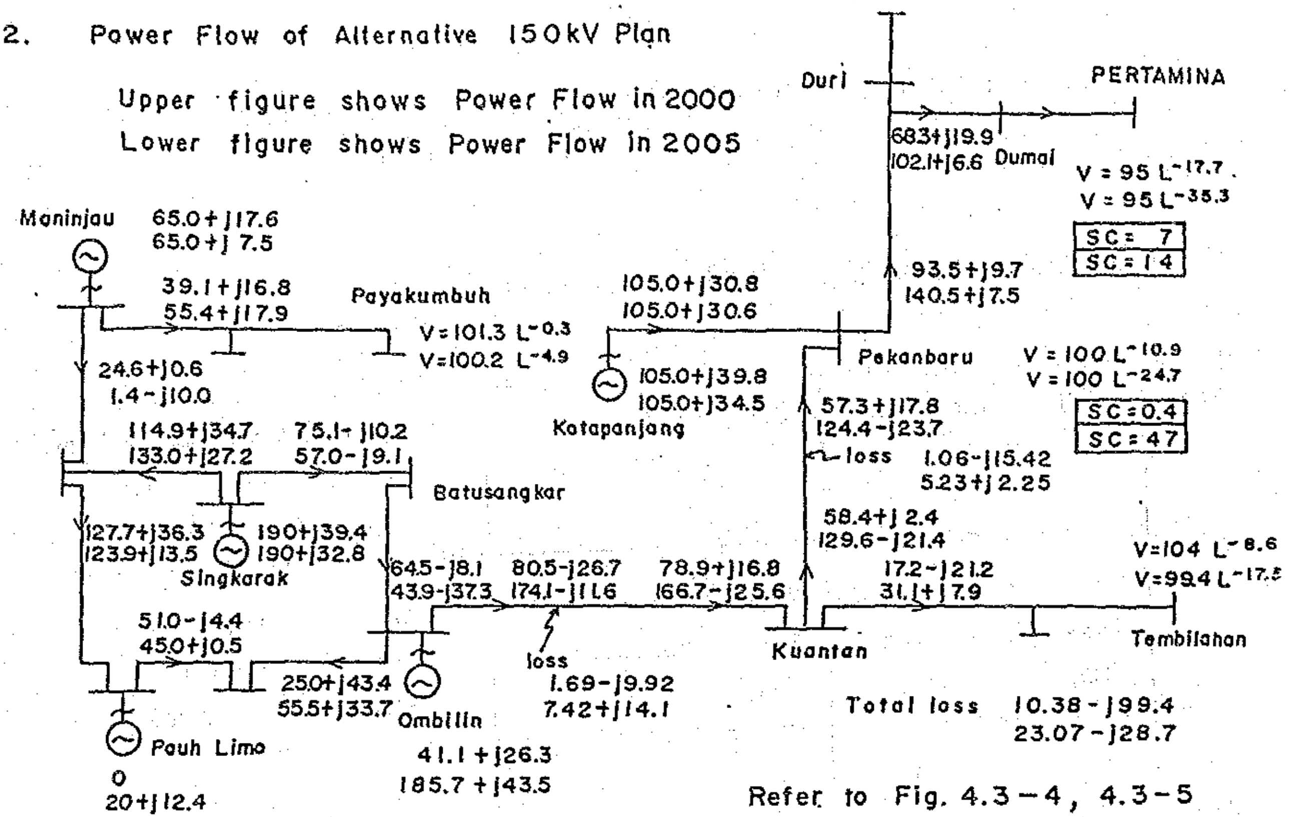
In case a loop configuration is not adopted for the basic plan (A), the capacity of condensers required to be installed is by 15 MVA larger in 2005 than that for the Plans (B) and (C), and a resultant additional cost is about ¥10 million per year. Even in this case, the effect of increase in power loss (4.4 MW, namely, 4.4 MW x 8,760h x 0.432 = 16,650 MWh/year) of Plans (B) and (C) is still greater that in the case of the basic plan (A).

0.432: Loss factor

2. Power Flow of Alternative 150kV Plan

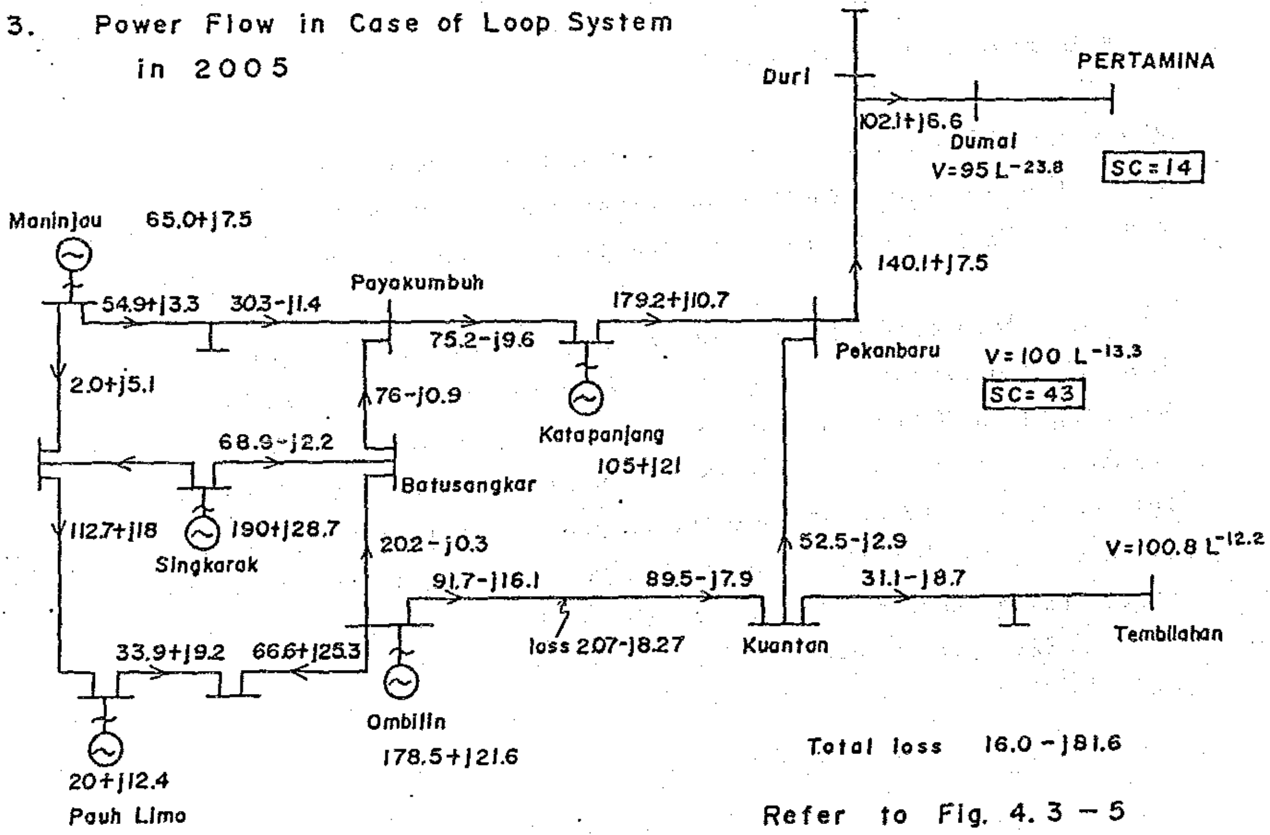
Upper figure shows Power Flow in 2000

Lower figure shows Power Flow in 2005



Refer to Fig. 4.3 - 4, 4.3 - 5

3. Power Flow in Case of Loop System in 2005



Refer to Fig. 4.3 - 5

4. Comparison between 150 kV Plan and 275 kV Introduction Plan

The amount of power loss in the basic plan and alternative 275 kV introduction plan is roughly calculated and compared as listed below.

Transmission loss in 2005

(Unit: MW)

	Ombilin - Kuantan	Kuantan - Pekanbaru	Other sections	Total
Power loss in 150 kV line	7.4	5.2	10.4	23.0
Power loss in 275 kV line *1	1.5	1.1	10.4	13.0
Power loss in 150 kV loop line (Basic Plan)				16.0

*1. This power loss is approximately calculated by taking into account the difference of voltage and resistance between conductors.

In the case of the 275 kV plan, transmission loss is reduced by about 3 MW. This amount is equivalent to about ¥116 million in terms of annual expenditures*2, about ¥935 million in terms of the amount of investment or ¥240 million in terms of present value. The results of economic comparison taking into consideration transmission loss as shown in Table 4.2-3 become as follows:

Unit: 10^6 Yen

	A: Basic 150 kV plan	B: 275 kV plan	C: Initial 150 kV & later 275 kV plan
Present value of construction cost	6,041	11,634	8,321
Reduction of power loss		-240	-240
Total	6,041	11,394	8,081

As listed above, the basic 150 kV plan (A) is apparently advantageous over the other alternative plans even though the amount of power loss is considered.

*2. Regarding conversion of power loss in terms of monetary value, refer to 4.4(d).