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THE REPUBLIC OF PARAGUAY
ADMINISTRACION NACIONAL DE ELECTRICIDAD

FEASIBILITY STUDY ON POWER DISTRIBUTION SYSTEM IMPROVEMENT PROJECT IN THE METROPOLITAN AREA OF THE REPUBLIC OF PARAGUAY

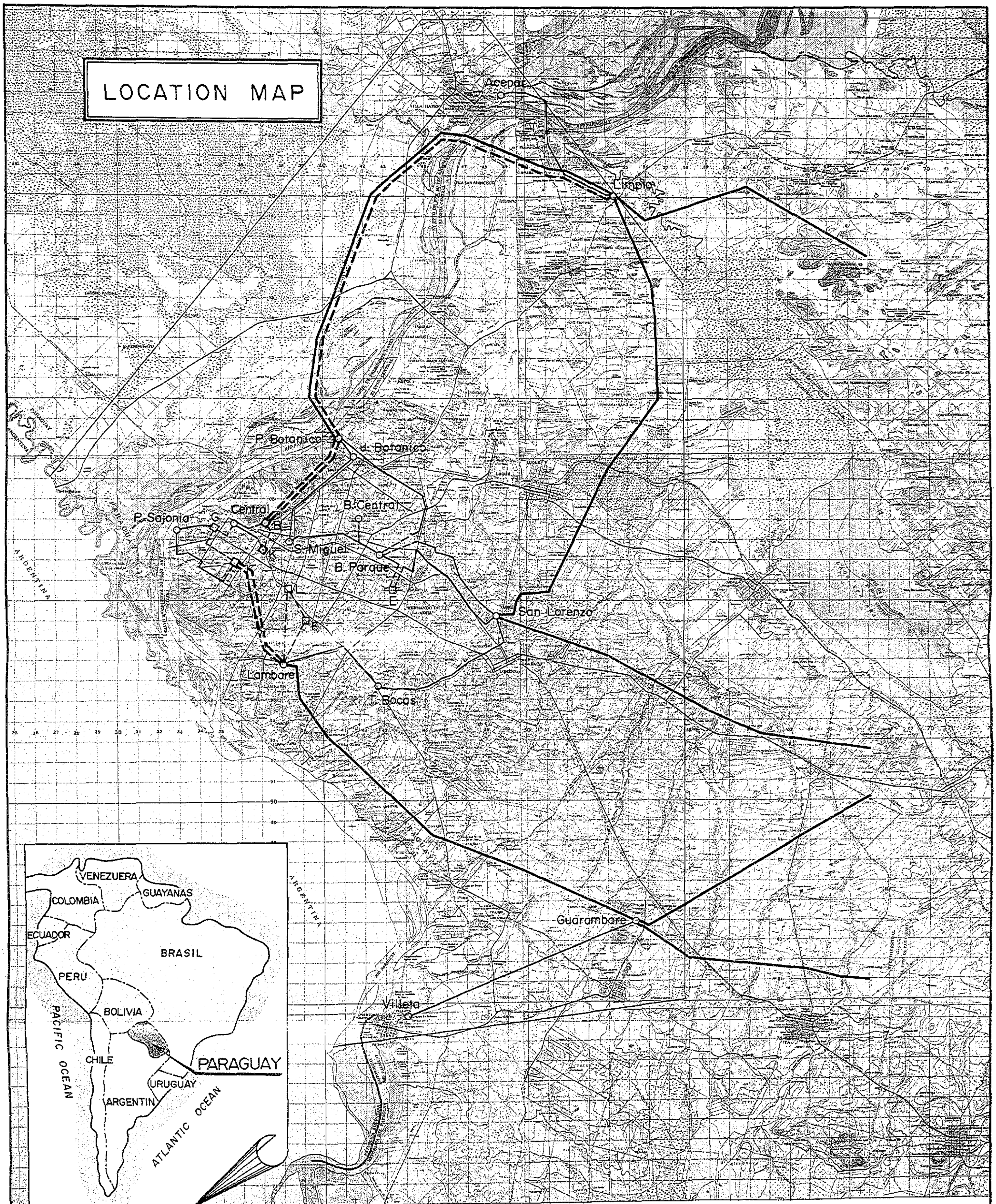
FINAL REPORT

(SUMMARY)

MAY, 1990

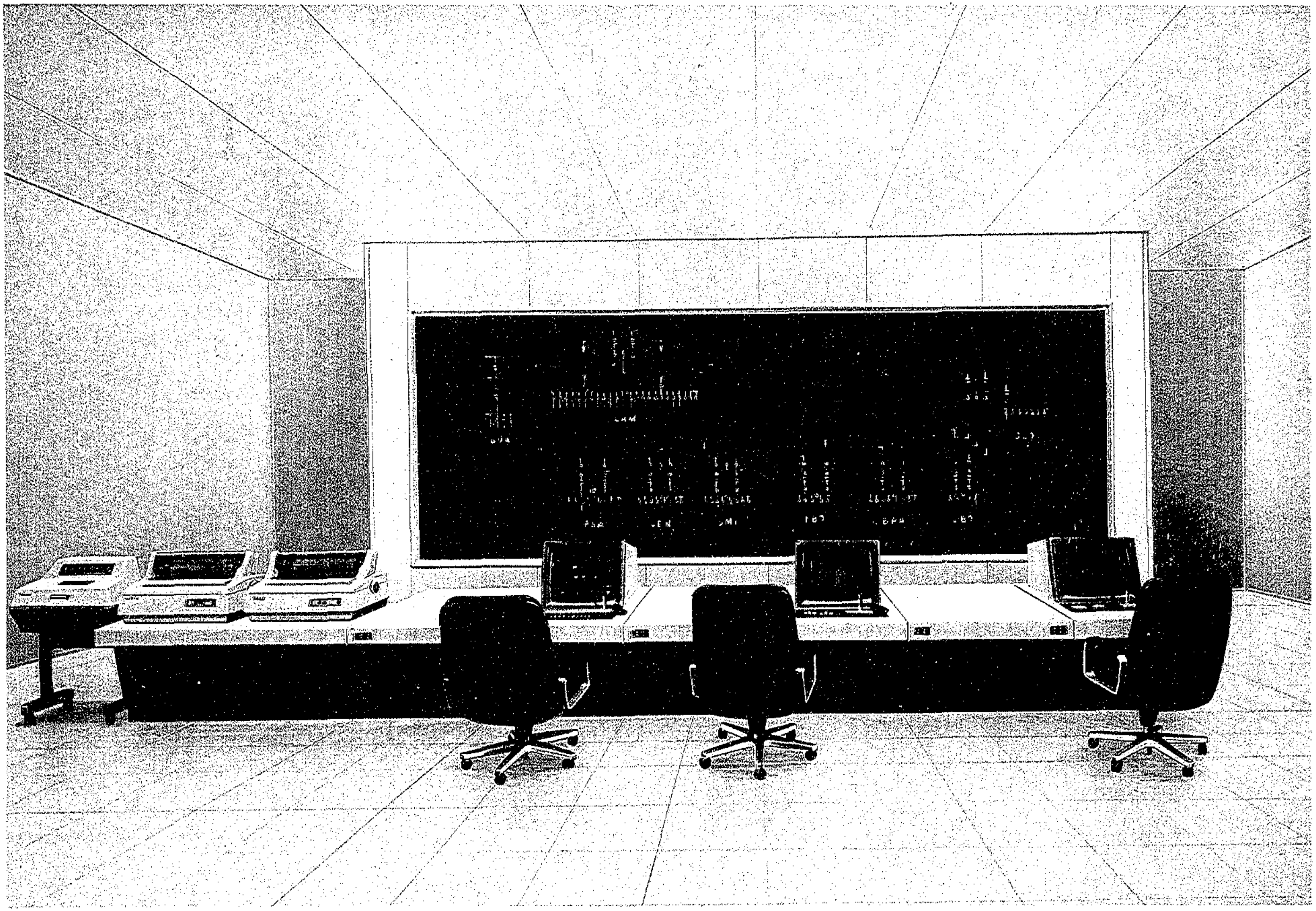
JAPAN INTERNATIONAL COOPERATION AGENCY

LOCATION MAP



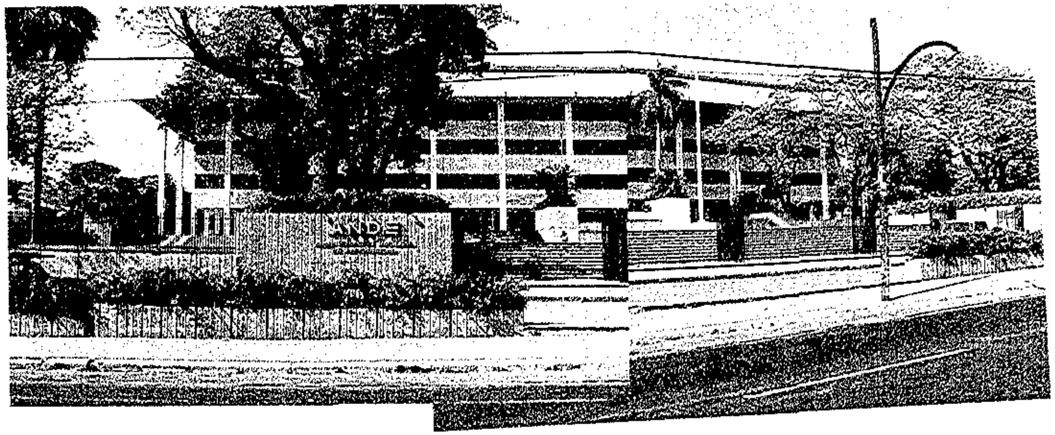
LEGEND

- : 220kV T/L existing
- : 220kV T/L to be constructed
- : 66 kV T/L existing
- : 66 kV T/L to be constructed
- ○ : Substation existing
- □ : Substation to be constructed

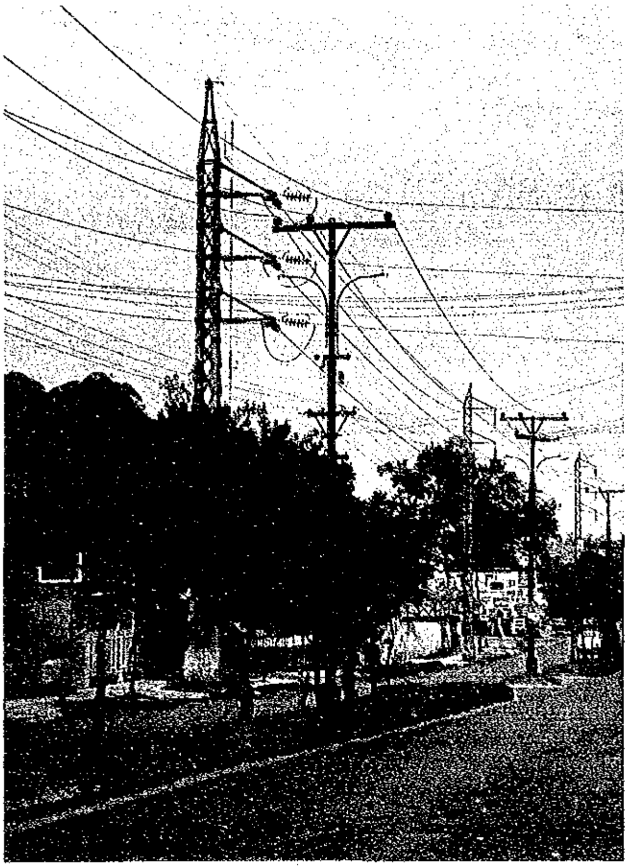


NEW DISTRIBUTION CONTROL CENTER

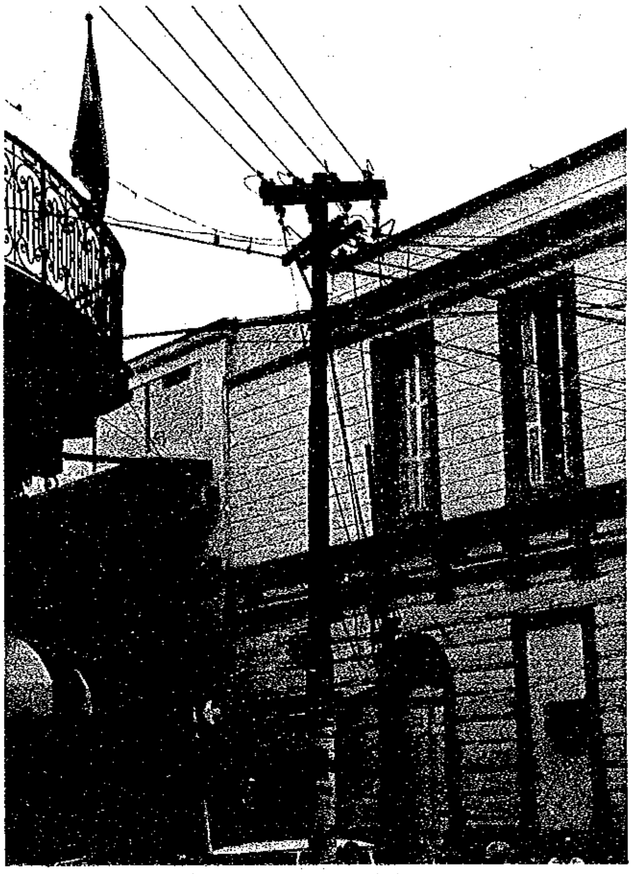
Asuncion City



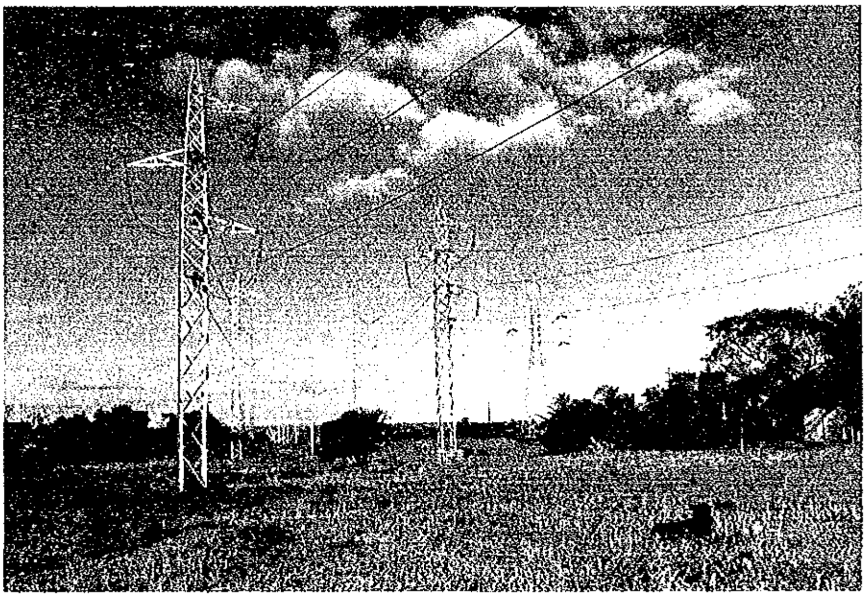
Head Office of ANDE



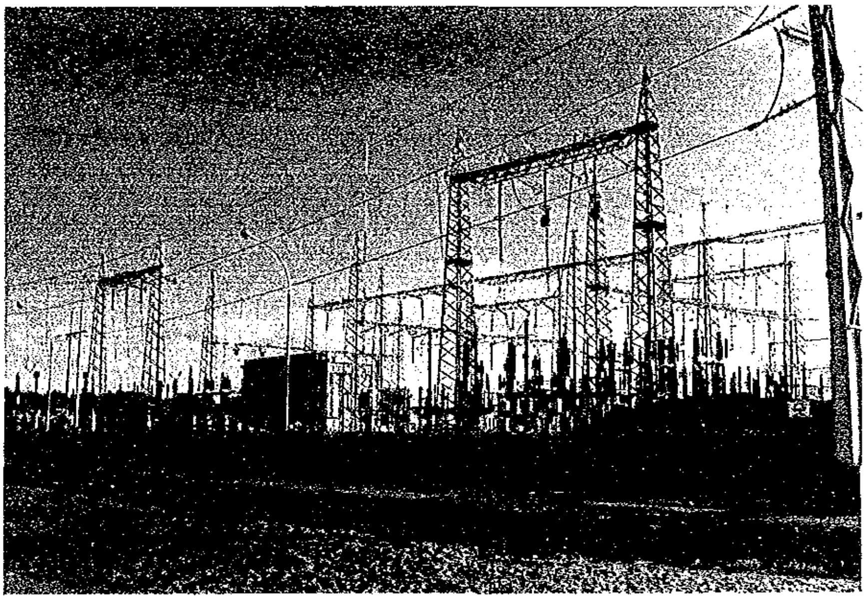
66 kV Transmission Line and
23 kV Distribution Line



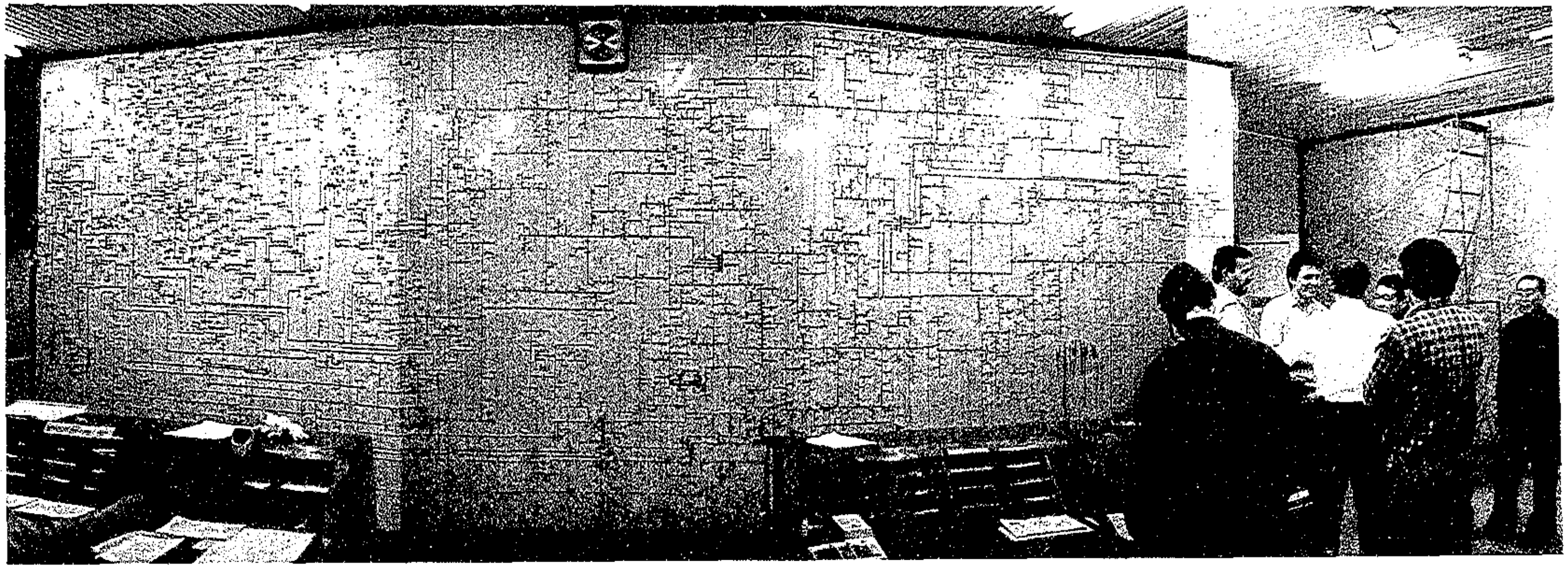
Low Voltage Distribution Line



220 kV Transmission Line



San Lorenzo Substation



Distribution Dispatching Center

The Location of New Distribution Dispatching Center

CONTENTS

1. Introduction

1.1 Background and Past Development of Study

The Republic of Paraguay has been actively engaged in development of nation's abundant hydroelectric resources. Following the development of Acaray Power Plant (190 MW), the part of the huge Itaipu Power Plant which is to be owned by Paraguay (6,300 MW out of the total plant capacity of 12,600 MW) has been completed. With these projects, Paraguay today is an exporter of electric power, and sufficient supply of electric power for domestic use has been assured for a long time to come.

Concerning the power transmission systems that are required to supply the power of these hydroelectric resources to the Metropolitan Area, 220 kV transmission lines are now being constructed from Itaipu Power Plant, in addition to the existing 220 kV lines from Acaray Power Plant, and the trunk transmission system of sufficient capacity will be assured for some time to come.

On the other hand, the power distribution systems in the Metropolitan Area have been in service for more than 20 years since construction. Although some expansion and improvement works have been implemented on these facilities from time to time, their supply capacity is today insufficient as no fundamental refurbishment/expansion plan has been implemented so far. Today, many supply failures occur in these systems by facility failures. Under these power supply failures, the facilities are shut down for a long time because operation of these distribution systems depend on communication systems operated on UHF and VHF radios only, and this situation has created a lot of complaints on the side of customers.

The projected growth of power demands in the Metropolitan Area is still high, and it is anticipated that there will be even stronger social demands on high reliability power supply in this area.

In view of these circumstances, the Government of Paraguay intends to formulate a long term improvement project for the power distribution systems in the Metropolitan Area. The Government of Paraguay therefore placed a request for technical assistance on implementation of this improvement project on the Government of Japan as of January, 1988.

In response to this request, the Government of Japan had the Japan International Cooperation Agency (to be termed JICA hereafter) dispatch the Pre-study Mission, which was composed of experts on the distribution system refurbishment/development programs in March, 1988, and this Pre-study Mission surveyed the background of the request, conducted on-site surveys, collected information and data, and conducted a preliminary study on future study policies and other relevant matters.

In March, 1989, the Preliminary Study Team of JICA and ANDE reached an agreement on "the Scope of Work for Feasibility Study on Power Distribution System Improvement Project in the Metropolitan Area of the Republic of Paraguay".

Based on the Agreement, the Government of Japan decided to conduct a feasibility study on the Improvement Project, and assigned this task to JICA.

1.2 Objective of Study, Areas Studied, and Scope of Study

1.2.1 Objective of Study

The objective of this study is to conduct on-site surveys and domestic works on the Power Distribution System Improvement Project for Metropolitan Area of the Republic of Paraguay, to formulate the development program which is optimal in terms of engineering, economic and financial aspects, and to develop the Feasibility Report for the Project.

At the same time, it is planned to transfer the related technologies to the Paraguayan counterparts through the processes of study.

The time covered by this Project shall be until year 2000.

1.2.2 Areas Covered by the Study

Concerning the areas to be covered by this Study (to be termed the Project Area hereafter), the JICA Pre-study Mission and the National Administration of Electricity of Paraguay (La Administracion Nacional de Electricidad, to be termed "ANDE" hereafter) consulted together, and agreed that the Project Area shall be those defined on the map of Figure 1-1, because it was difficult to define the Project Area in terms of administrative divisions or supply areas of ANDE's business offices. The cities, towns and villages included in this Project Area had populations of 581,000 and 807,000 as of 1972 and 1982 respectively according to the Statistical Year Book 1985/86 by the United Nations.

1.2.3 Scope of Study

The scope of this study includes the following major study items.

(1) Collection of existing materials and information related to this Improvement Project.

(2) On-site surveys.

(3) Analysis and evaluation of collected materials and information.

(4) Study of Power Distribution System Improvement Project.

(5) Study of monitoring and control system for power distribution systems.

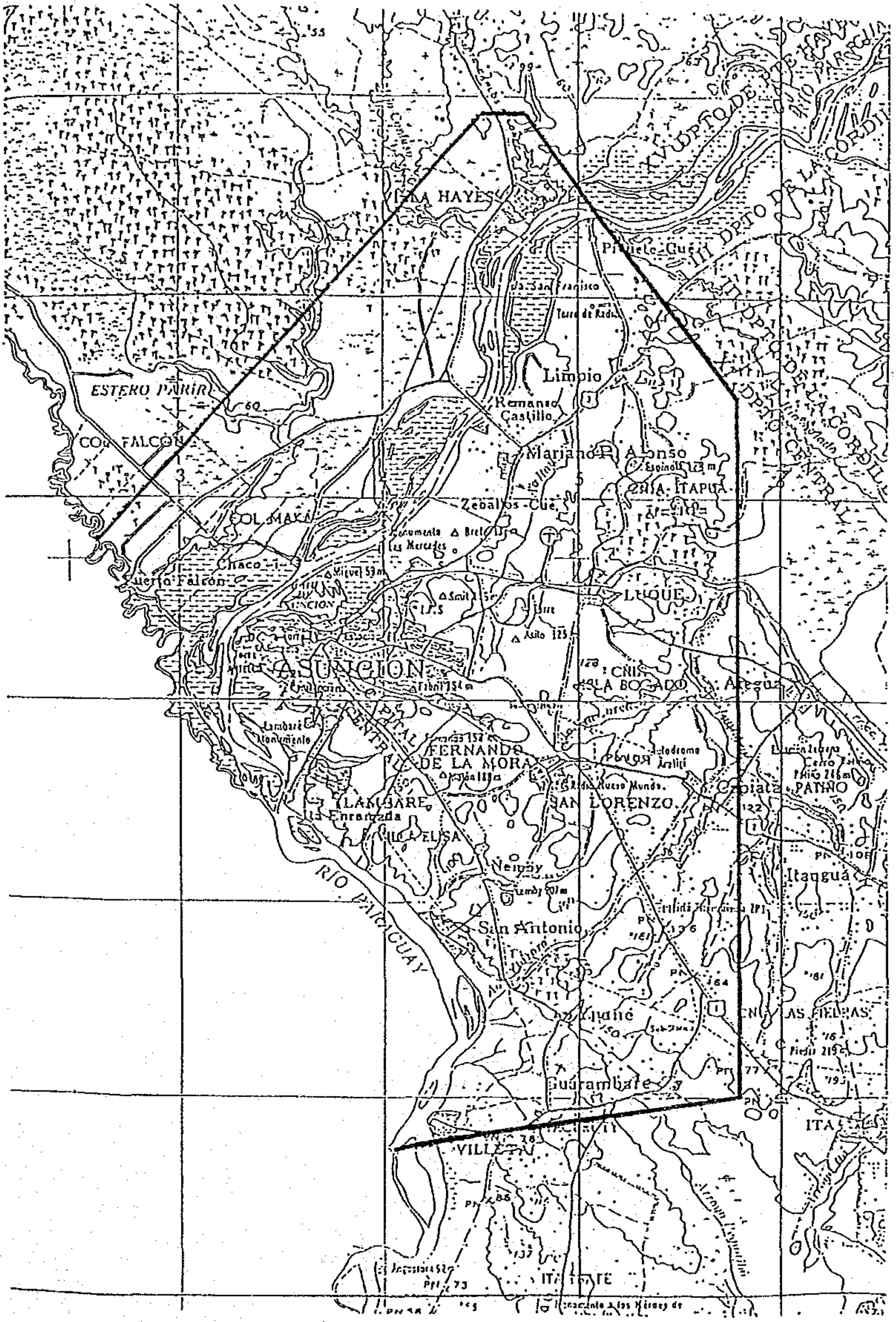
(6) Economic Evaluation and Financial Analysis of this Improvement Project.

1.3 On-Site Survey and Domestic Works

1.3.1 On-Site Survey

The on-site survey for development of the feasibility study for the Power Distribution System Improvement Project for Metropolitan Area of the Republic of Paraguay has been conducted for 45 days, starting from July 5 in 1989 and ending in August 18.

Fig. 1-1 PROJECT AREA



The Study Team for this survey consisted of the following 9 experts belonging to the Electric Power Development Co., Ltd. (EPDC), who worked on their respective areas of expertise.

Leader/Coordination	Ryuuhei Oyama
Power System Planning	Mitsuhiro Omori
Power Transmission	Kazuhiko Hashimoto
Substations	Tadashi Takayanagi
Distributions and Distribution Control System	Takayoshi Sano
Distributions and Distribution Control System	Toshimasa Fujiuchi
Communication System	Akitoshi Ikeda
Architectural Engineering	Mitsumoto Himeno
Economic Evaluation	Takashi Fukushima

This Study Team made study tours mainly in the Capital City of Asuncion collecting information/data and conducting on-site surveys in order to gather materials required for the Feasibility Study, and tripped to the candidate routes or sites of new transmission lines and new substations to perform on-site surveys.

Engineers of ANDE, who are experts in respective fields, and lead by Ing. Guillermo Krauch (Manager of Business Department, Business Bureau) of ANDE took the labor of accompanying the Study Team all through on-site survey tours, and the coordination required for the survey have been performed by these engineers.

In the following part of this report, the Study Team is termed the "JICA Study Team".

1.3.2 Domestic Works

The Study Team, after returning from their on-site survey trip, conducted the "domestic works" in Japan during the period from August of 1989 to May of 1990, and formulated this Report.

Among ANDE counterparts, Ing. Alcibiades Cantero and Ing. Lucio Adorno visited Japan on the status of cadets invited by JICA on

October 12, 1989 to take part in surveys and studies for development of this Report, and stayed in Japan for one month.

The 5 members of the Study Team including the Leader visited ANDE with the Interim Report from December 2 to December 16 in 1989, and again 3 members of the Study Team including the Leader visited ANDE, to report the progress and hold discussions on the content of the Report.

2. General Description of Paraguay

2.1 Conditions of National Territory

2.1.1 Geography

The Republic of Paraguay is situated a little to the south in the central part of South American Continent. It is an inland nation neighboring with Bolivia to the north, Brazil to the east, and Argentina to the south and west. The national territory lies between 17°56' and 27°30' south latitude, and between 54°45' and 63°27' west longitude.

The area of the national territory is 402,752 km^2, which is roughly divided into two parts by the Paraguay River that run from north to the south through this country.

2.1.2 Climate

Although Paraguay is situated at a sub-tropical zone, its climate is very continental as it is an inland country. The temperature difference between daytime and nighttime is large, and annual change of climate is also large. The maximum temperature is 42°C, the minimum temperature 0°C, and the average temperature 22.6°C.

The average precipitation of a year and the average humidity in the metropolitan area are 1,400 mm and 70% respectively.

2.1.3 Population

The population of Paraguay was 3,029 thousands as of 1982 according to the United Nations statistics. The annual average population growth was 2.54% in the 10 years ending in 1982.

The presumed population in 1988 was 4,039 thousands. The average annual population growth from 1982 is 2.92% per year according to this figure.

As of 1982, 454 thousand people out of the above total population lived in Asuncion City, and 497 thousands in Central Prefecture (with urban population of 298 thousands). This means that approximately 1/3 of the total population live in the Metropolitan Area.

2.2 Status of Economy

In the 1980s, the Paraguayan economy marked a negative growth of 2% up the preceding year in 1982. This was caused by various domestic factors including drought, flood and inadequate governmental policy in addition to the world wide economic recession.

However, the economic activities turned to a gradual recovery, although the high growth rate experienced in the 1970s had not been regained. The annual average growth rate from 1983 to 1988 was 3.5%.

The gross domestic products (GDP) of Paraguay is presented in Table 2-1.

In the figure, the low GDP growth rate of 1986 represents the drop of agricultural products in that year due to a drought, and it was a temporary fluctuation.

2.2.1 Agriculture and Stock Farming

The contribution of agriculture and stock farming to the Paraguayan GDP is substantial, being 27.4% in 1988. The contribution of agriculture was the largest in this sector, which was 62%.

As Paraguay is blessed with vast, and relatively flat fertile lands, the Government of Paraguay encourages development of colonies by immigrants, and this policy has created remarkable achievement in recent years.

The immigrants came from Japan (the first Japanese immigrant entering this country in 1936), Brazil, Germany, Italy, Poland and other nations.

The major products of these colonies consist of soy bean, cotton and wheat. The contribution of soy bean and cotton to the national export was 36% and 29% respectively (in 1988 dollar values), indicating the importance of these products in the national industry.

Table 2-1 Gross Domestic Product of the Republic of Paraguay

(Price of 1982: 10^6 ₲)

	1983	1984	1985	1986	1987	1988	Annual Growth Rate (1988/1983)(%)
Agriculture	111,418	119,663	126,865	110,880	121,635	143,934	
Stock Farming	55,489	57,771	58,706	60,619	62,134	64,455	
Forestry	18,039	18,490	19,311	20,837	22,087	23,274	
Fishing	1,045	1,066	1,098	1,131	1,165	1,200	
(Sub Total)	(185,991) 26.0	(196,990) 26.7	(205,980) 26.9	(193,467) 25.2	(207,021) 25.9	(232,863) 27.4	4.6
Mining	2,912	2,942	3,089	3,440	3,646	3,920	
Industry	115,861	121,075	127,129	125,345	129,732	136,610	
Construction	46,720	45,604	45,148	45,600	46,512	47,503	
(Sub Total)	(165,493) 23.1	(169,621) 23.0	(175,366) 22.9	(174,385) 22.8	(179,890) 22.5	(188,033) 22.2	2.6
Electric Power	15,014	15,344	16,221	18,060	19,605	21,542	
Water Service	2,765	2,820	2,961	3,158	3,315	3,448	
Transportation	30,742	31,852	33,468	35,142	36,699	39,101	
(Sub Total)	(48,521) 6.8	(50,016) 6.8	(52,650) 6.9	(56,360) 7.4	(59,619) 7.5	(64,091) 7.6	5.7
Commercial	190,171	193,634	202,871	209,437	216,767	224,741	
Government Disbursement	32,172	32,953	33,941	34,620	35,312	35,666	
Household	21,448	21,448	21,662	22,096	22,538	22,974	
Other Services	71,133	72,243	73,688	75,858	78,134	80,476	
(Sub Total)	(314,924) 44.1	(320,278) 43.5	(332,162) 43.3	(342,011) 44.6	(352,751) 44.1	(363,857) 42.8	2.9
Total	714,929 100.0	736,905 100.0	766,158 100.0	766,223 100.0	799,281 100.0	848,844 100.0	3.5
Growth Rate(%)	3.0	3.1	4.0	-	4.3	6.2	

Source: Banco Central

2.2.2 Manufacturing Industry

The contribution of manufacturing industry to GDP is relatively small, being 16% in 1988. This is due to the fact that only small manufacturing industries, such as vegetable oil production and traditional industries (such as leather products, textile, timber and sugar) have been developed so far, except for the two public corporations, which are steel industry (ACEPAR) and cement industry (INC) built under foreign loans.

2.2.3 Balance of International Trade

To describe the import and export status of Paraguay in 1987, while the agricultural, stock and timber products account for 96% of the total national export, industrial products excluding foods (mainly wheat), beverage and tobacco account for 76% of the total import, and the ordinary balance of international trade has been constantly in deficit.

This deficit in ordinary trade balance has been made up by drawing down the foreign currency reserves, and this has caused delay in payment of foreign currency accounts. The net foreign currency reserve of the Central Bank has dwindled from 720 million dollars of 1981 to 278 million dollars of 1988.

Of this 278 million dollars, 177 million dollars are on the type of foreign currencies that can be transferred to abroad, while the remaining 101 million dollars are not transferable.

The cumulative liabilities to foreign countries has reached 2,002 million dollars by the end of 1988.

Major export and import commodities are presented in Table 2-2 and Table 2-3.

The trend of international trade balance is presented in Table 2-4.

The Central Bank has provided subsidies to make up for the loss incurred by public corporations due to exchange rate fluctuation, and this subsidy automatically caused unrecoverable losses on the

Table 2-2 Exports (FOB)

(1,000 US$: %)

Year / Items	1983		1984		1985		1986		1987		1988	
Lumber	20,391	7.6	22,245	6.7	9,731	3.2	17,657	7.6	26,854	7.6		
Stock Farming Products	12,626	4.7	11,701	3.5	6,789	2.2	43,877	18.9	35,200	10.0		
Tobacco	10,171	3.8	15,253	4.5	6,033	2.0	5,448	2.3	9,860	2.8		
Soy Bean	88,487	32.9	101,572	30.4	106,328	35.0	45,776	19.7	125,011	35.4		
Vegetable	2,723	1.0	3,837	1.1	990	-	5,252	2.3	4,508	1.3		
Cotton	85,126	31.6	131,156	39.2	141,811	46.7	80,745	34.7	100,967	28.6		
Sugar	5,438	2.0	4,183	1.3	-	-	3,588	1.5	2,581	0.7		
Vegetable Oil	19,487	7.2	18,965	5.7	13,656	9.0	9,206	4.0	9,555	2.7		
Plant Lees	13,839	5.1	12,392	3.7	6,396	2.1	8,766	3.8	12,502	3.5		
Others	7,345	2.7	9,896	3.0	9,865	3.2	8,042	3.5	12,230	3.4		
Sub Total	265,633	98.7	331,200	99.1	301,599	99.4	228,357	98.5	339,288	96.2		
Industrial Goods	3,152	1.2	2,945	0.9	1,956	0.6	3,463	1.5	13,567	3.8		
Others	391		357		347		713		522			
Total	269,176	100.0	334,502	100.0	303,902	100.0	232,533	100.0	353,377	100.0		
Growth Rates	-18.4		24.3		-9.1		-23.5		52.0			

Source: Banco Central

Table 2-3 Imports (FOB)

(1,000 US$: %)

Items \ Year	1983		1984		1985		1986		1987		1988	
Foods (Mainly wheat)	31,250	6.5	14,321	12.8	19,812	4.5	17,014	3.3	8,971	1.7		
Tobacco	15,569	3.3	25,483	5.0	25,059	5.7	33,945	6.7	41,627	8.1		
Fuel Oil	120,024	25.1	137,556	26.8	114,571	25.9	96,919	19.0	102,773	19.9		
Paper	7,045	1.5	7,803	1.5	9,303	2.1	8,801	1.7	10,464	2.0		
Chemicals	28,326	5.9	29,449	5.7	34,424	7.8	29,561	5.8	25,874	5.0		
Transport Equipment	29,437	6.2	102,636	20.0	30,515	6.9	30,663	6.0	47,869	9.3		
Textile Goods	8,546	1.8	6,075	1.2	8,698	2.0	10,347	2.0	12,375	2.4		
Agricultural Equipment	6,896	1.4	11,790	2.3	11,660	2.6	6,362	1.2	8,302	1.6		
Iron and Steel	39,584	8.3	23,460	4.6	17,855	4.0	28,803	5.7	24,371	4.7		
Nonferrous Metals	11,350	2.4	5,562	1.1	7,094	1.6	8,860	1.7	9,080	1.8		
Mechanical Goods	107,802	22.5	92,160	1.8	101,700	23.0	163,529	32.1	151,952	29.4		
Others	72,433	15.1	56,752	11.1	61,592	13.9	74,588	14.8	73,819	14.3		
Total	478,264	100.0	513,054	100.0	442,281	100.0	509,392	100.0	517,477	100.0		
Growth Rates	-17.7		7.3		-13.8		15.2		1.6			

Source: Banco Central

Table 2-4 Balance of International Payments

(10^6 US$)

	1983	1984	1985	1986	1987	1988
Trade Balance	-282.2	-327.2	-191.5	-162.4	-97.2	
Service, Balance of Transfer Account	-120.7	-88.1	-34.0	-196.5	-36.2	
Current Balance	-402.9	-415.3	-225.5	-358.5	-133.4	
Capital Balance	371.8	296.3	61.6	190.0	175.3	
Total Balance	-39.6	-95.5	-115.3	-147.6	51.3	
Rate of Exchange (¢/US$)			306.7	339.2	550	

Source: IMF, IFS

Central Bank. This system has been abolished after the current Administration was established.

2.2.4 Domestic Commodity Prices

Although high economic growth is desirable in order to keep stable commodity prices, inflation is accelerating in recent years.

The rate of price rise in 1987 and 1988 was 21.8% and 23.0% respectively, and the annual average price hike rate from 1983 to 1988 was 24.3%.

The minimum wage has been raised by 40% in 1987 and 35% in 1988 in order to help household living expenditures and to mitigate the impact of inflation.

2.2.5 New Economic Development Plan

The political reformation in February, 1989 removed the Stroessner Administration, and General Rodriguez established a tentative administration.

Rodriguez Administration, which has been supported by the people in the election of May 1, 1989, announced the Social-Economic Development Plan for the period from 1989 to 1990.

The economic growth expected by the Long Term Economic Plan for the period from 1989 to 2005 is presented in Table 2-5.

In this plan, three cases of economic growth, the high, medium, and low cases, are projected.

In the "medium case", the annual average GDP growth from 1990 to 1995 is 5.3%, and that from 1995 to 2005 is 5.0%.

The new government had abolished the plural exchange rate to adopt the single floating exchange rate. (As of Nov. 1988, the following three different rate were used: 400₲/US$, 550₲/US$, 950₲/US$ [Free Rate]).

Table 2-5 FORECAST of GROSS DOMESTIC PRODUCTS

(Constant Price of 1982, 10^6 ¢ ;%)

		1988	1990	1995	2000	2005	Annual Increasement	
							1995/1990	2000/1995
CASE 1 (High)	Primary Sector	236,783	287,760	469,633	709,256	1,084,023	10.3	8.7
	Secondary Sector	184,113	205,129	267,773	332,268	413,595	5.5	4.4
	Tertiary Sector	427,848	460,169	557,150	671,420	813,439	3.9	3.9
	GDP	848,744	953,058	1,294,555	1,712,944	2,311,057	6.3	6.0
CASE 2 (Medium)	Primary Sector	236,783	287,760	425,957	594,074	834,406	8.2	7.0
	Secondary Sector	184,113	205,129	265,581	332,188	416,120	5.3	4.6
	Tertiary Sector	427,848	460,169	545,147	646,324	769,079	3.4	3.5
	GDP	848,744	953,058	1,236,685	1,572,586	2,019,605	5.3	5.0
CASE 3 (Low)	Primary Sector	236,783	287,760	397,287	510,439	658,492	6.7	5.2
	Secondary Sector	184,113	205,129	257,973	301,786	353,342	4.7	3.2
	Tertiary Sector	427,848	460,169	543,232	641,948	761,579	3.4	3.4
	GDP	848,744	953,058	1,198,493	1,454,174	1,773,413	4.7	4.0

2.2.6 Energy Resources

The primary energy resources of Paraguay mostly consist of woods, wood and vegetable wastes, and oil. All of oil used in this country is imported. According to an estimation of the Planning Agency, the energy consumption will grow at an annual rate of 4.3% from 1985 to 2000. Of this increase, the growth of electricity and oil will be high, the former being 11.0% per annum and the latter 8.2%.

This estimation of energy consumption growth (in terms of 103 tons oil equivalent) is quoted below.

	1985	2000	Average Growth Rate
Woods	1,249.3 (53.8)	1,203.1 (27.4)	- 5.3
Oil	555.0 (23.9)	1,807.7 (41.1)	8.2
Wood and Vegetable Wastes	327.5 (14.1)	655.3 (15.0)	4.8
Electricity	108.4 (4.7)	516.4 (11.7)	11.4
Charcoal	68.9 (3.0)	183.7 (4.2)	6.8
Others	13.1 (0.5)	27.1 (0.6)	5.0
Total	2,322.2(100.0)	4,397.3(100.0)	4.3

2.2.7 Electric Power Supply Structures

The electric utility industry of Paraguay is being operated by the National Administration of Electricity (ANDE) and Itaipu Binational (which is a joint venture of Paraguay and Brazil).

ANDE operates the whole power supply systems including power generation and power distribution, and Itaipu Binational supplies (sells) the output of Itaipu Power Plant (18 x 700 MW units, with total output of 12,600 MW) to ANDE and Brazil.

In addition to this system, there are small diesel power plants for in-house use in the areas where electrification has not been introduced.

This organization consists of the Engineering Bureau (in charge of power generation, transmission and substation), Business Bureau (in charge of distribution), General Affairs Bureau and Accounting Bureau which are engaged in daily operations, plus the Planning Office that supports the President.

The capital of ANDE is 228 billion ₲ as of 1988, and ANDE employs 2,509 persons.

The Itaipu Binational has been established in April 1973 with a capital of 100,000,000 US$ (equally financed by the two nations). Itaipu Power Plant started commercial operation in March 1, 1985. 15 turbine generator units, out of the total of 18 of the power plant, have been completed as of 1989.

2.2.8 Electric Power Demand and Supply

The past trend of electric power consumption in Paraguay is illustrated in Table 2-6.

The domestic power supply capacity of ANDE in 1988 was 1,766 GWh. The energy consumption in this year was 1,509 GWh, with a loss factor of 14.5% and annual load factor of 56.4%. Out of this total consumption, 1,238 GWh, or 74% of the total, is consumed in the Metropolitan Area.

While the residential energy consumption grew steadily, being 10.2% in annual average. The growth of industrial consumption was very high, being 18.2%. This high growth rate was due to the steel plant that started to operate in 1986, the factories in Vallemi in the north and Pilar in the south, and the transport equipment in eastern agricultural villages.

The rate of electrification as of the end of 1988 was 49.4%.

The number of customers demanding 1,000 kW or more is 62. Of these, 7 customers use 3,000 kW or more.

Table 2-6 Power Demand and Supply

		Unit	1983	1984	1985	1986	1987	1988
Capable Capacity	ANDE	MW	274	274	274	274	274	274
	Itaipu	"	-	-	2,100	2,800	4,200	6,300
	Sub Total	"	274	274	2,374	3,074	4,474	6,574
Energy Generated by ANDE	ANDE	GWh	793.0	894.4	868.0	804.8	621.4	677.9
	Itaipu	"	-	161.6	391.2	837.8	1,114.6	1,414.8
	Import	"	226.2	62.0	2.3	1.8	2.1	2.6
	Sub Total	"	1,019.2	1,118.0	1,261.5	1,644.4	1,738.1	2,095.3
Energy Supplied by ANDE	SIN	"	995.2	1,090.4	1,211.4	1,331.9	1,489.3	1,766.3
	Export	"	24.0	27.6	50.1	312.5	248.8	326.9
	Sub Total	"	1,019.2	1,118.0	1,261.5	1,644.4	1,738.1	2,095.3
Power	SIN	MW	202.0	217.5	242.0	271.5	303.1	357
	SIN + Export	"	204.0	221.5	246.0	276.5	339.0	
Consumed Energy	SIN	GWh	827.2	907.3	999.9	1,110.0	1,275.9	1,509.6
Loss Factor	SIN	%	16.9	16.8	17.5	16.7	14.3	14.5
Load Factor	SIN	"	56.2	58.7	57.1	56.0	56.1	56.4

Source: ANDE

Note: "Import" : from Brasil
"Export" : to Brasil and Argentina, Power of Construction Use for Itaipu P.S. and Yacyreta P.S.
"SIN" : Sistema Interconectado Nacional

2.2.9 Power Facilities

(1) Power Generation Facilities

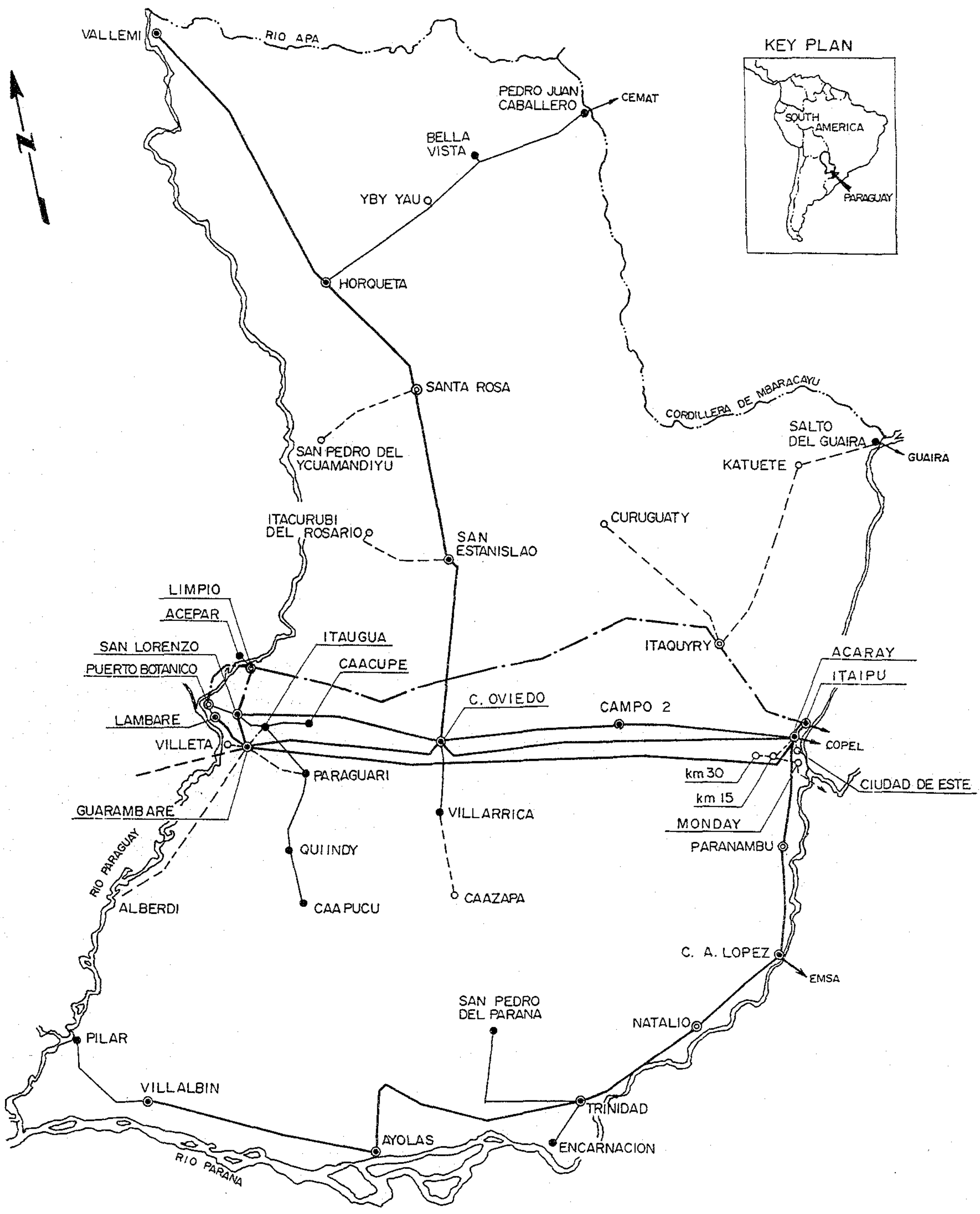
The total generation capacity of 6,574 MW as of the end of 1988 can be broken down to, 6,490 MW hydroelectric plants and 84 MW diesel plants. They are all rated at 50 Hz. There are two hydroelectric plants, the 190 MW Acaray Power Plant and 6,300 MW Itaipu Plant. There are diesel plants with total capacity of 73 MW in Asuncion City, and others amounting to 11 MW in local cities. The diesel plants in Asuncion City are now retained as reserve capacity as the power supply facilities expanded. Those being operated today are small units in areas where electrification has not be introduced yet.

As for the construction programs, the Phase 1 project (2,700 MW) of Yacyreta Power Plant (with a final capacity of 6,750 MW) is now in progress with the target commissioning date in 1994.

(2) Power Transmission Facilities

The power system diagram of ANDE's power systems is presented in Figure 2-1.

The standard transmission voltage is either 220 kV and 66 kV. The 220 kV transmission system has a radial configuration running from Acaray Power Plant, and consists of the trunk lines leading to the Metropolitan area, the southern trunk system, and the northern trunk system. They have been commissioned in 1968, 1982 and 1984 respectively, and became to have the current power system configuration after a series of expansion programs. The trunk system reaching the Metropolitan Area consists of 3 circuits, and another circuit (to be strung on existing double circuit towers) is under construction with the scheduled commissioning date of 1990. Local trunk systems have sufficient capacity, but they have radial configuration despite the fact that they transmit power for long distances.



LEGEND

- 66kV OVER HEAD LINE IN OPERATION
- 66kV OVER HEAD LINE UNDER CONSTRUCTION
- 66kV OVER HEAD LINE IN PLANNING
- 220kV OVER HEAD LINE IN OPERATION
- 220kV OVER HEAD LINE UNDER CONSTRUCTION
- 220kV OVER HEAD LINE IN PLANNING
- PRIMARY SUBSTATION IN OPERATION
- PRIMARY SUBSTATION IN PLANNING
- SECONDARY SUBSTATION IN OPERATION
- SECONDARY SUBSTATION IN PLANNING

POWER DISTRIBUTION SYSTEM IMPROVEMENT PROJECT IN THE METROPOLITAN AREA

TRANSMISSION SYSTEM DIAGRAM

Fig. 2-1

(3) Substation Facilities

As of the end of 1988, there are 29 substations. They consist of 9, 220 kV primary system substations, and 20 substations (consisting of 3, 220 kV substations and 17, 66 kV substations). All these substations are outdoor type, with the exception of Centro Substation in Asuncion City.

The total number of transformer banks in these substations amounts to 43 banks as of the end of 1988, with the aggregate installed capacity of 1,080 MVA. The total supply capacity is 708 MVA on the 220 kV side, and 638 MVA on the 23 kV side.

(4) Distribution Facilities

The distribution line voltage is 23 kV for the medium voltage class and 380/220 V for the low voltage class.

The aggregate length of distribution lines as of the end of 1988 is 5,774 km, and they consist of 5,451 km overhead lines and 323 km underground cable lines.

There are 8,768 banks of 23 kV distribution transformers, with the total installed capacity of 888 MVA.

The aggregate length of low voltage distribution lines amounts to 6,647 km, consisting of 6,639 km of overhead lines and 8 km of underground lines.

2.2.10 Electricity Tariff

The tariff system of ANDE are defined for each customer class, supply voltage and metering point, and it is a complex system. The low voltage supplies are charged by energy consumption only, and customers supplied by medium or higher voltage class are charged with the base charge and kWh charge, and different rates are assigned to time bands.

The tariff system has been revised in June, 1989. The average unit price in ANDE's revenue was 24.79 ₲/kWh in the old system, and it is 47.31 G/kWh in the revised system.

ANDE contracts with the Itaipu Binational Entity to purchase electricity at a price of 14.85US$ per kilowatt per month.

3. Power Demand Projection

(1) The Study Team has developed the power demand projection of the Project Area with the objective of establishing the bases for transmission and substation plan of this area, and arrived at the conclusion that the energy demand of the Project Area will be 2,776.3 GWh by the year 2000, the maximum power demand will be 674.1 MW, the average growth from 1989 to 2000 9.08%, and the average annual load factor at the transmission end will be 54.8%.

The results of this power demand projection are presented in Table 3-1.

(2) ANDE has studied the projected maximum demands for each 1 km^2 mesh for the year 2000, and the Study Team judged that the power demand project developed by ANDE is generally appropriate.

This power demand projections for the year 2000 in each 1 km^2 mesh in the Project Area are presented in Figure 3-1.

(3) In a long term power demand project such as forecast up to 2000, the actual future demand may be substantially different from the projection developed by the Study Team, in particular for a long future, due to changes in social conditions and economic trend.

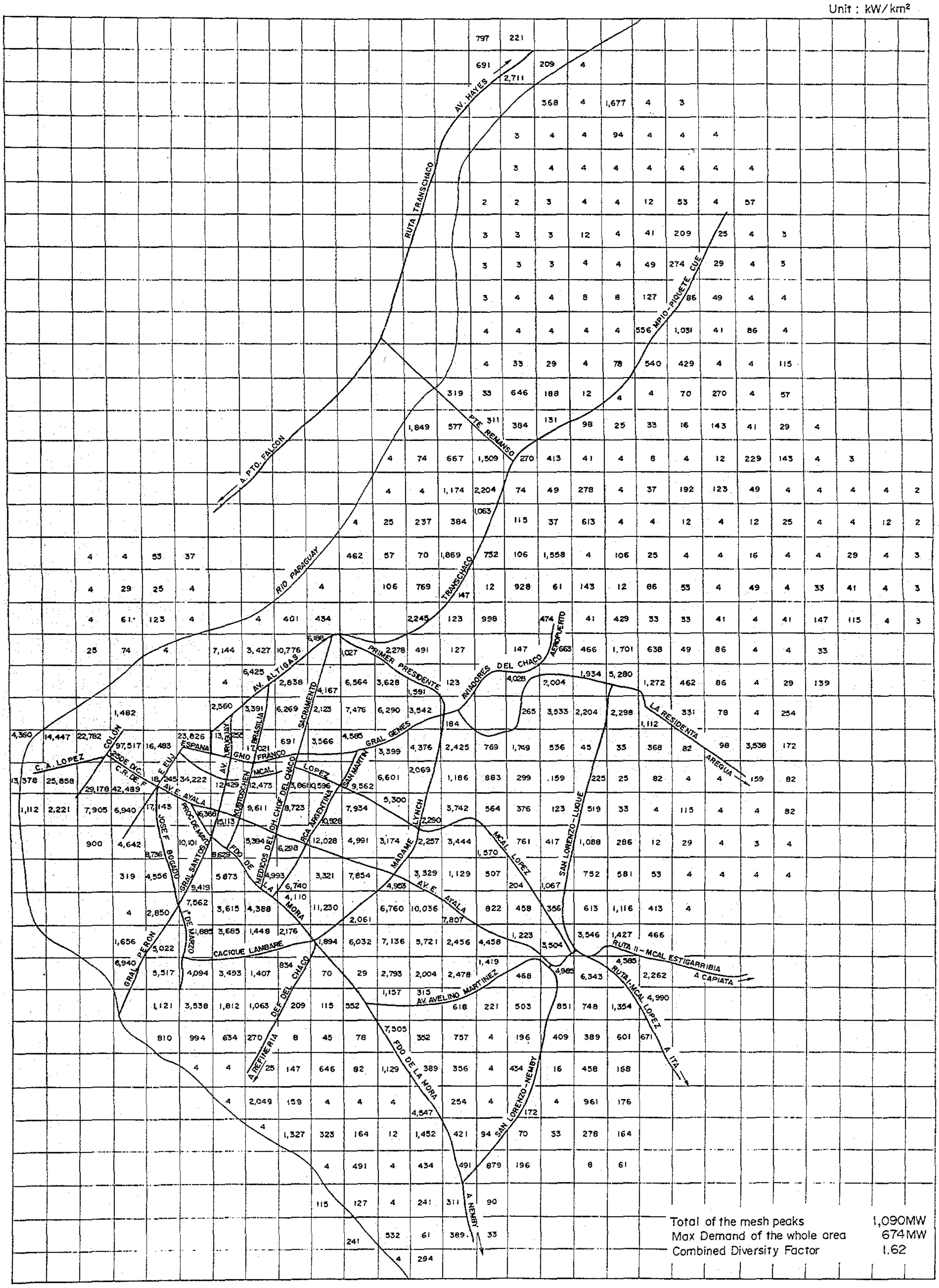
It is required to review the projected values in every few years in order to develop facility plans which are technically and economically appropriate.

Table 3-1 Power Demand Projection for the Project Area

Year	Energy Demand at Consumer's Level (GWH)	Energy Demand at Sending End		Trans-mission Losses (%)	Maximum Demand		Annual Load Factor (%)
		(GWH)	% Increase		(MW)	% Increase	
1981	485.9	576.7	16.3	15.7	124.8	-	52.8
1982	545.8	639.8	10.9	14.7	133.7	7.1	54.6
1983	591.9	695.1	8.6	14.9	145.5	8.8	54.5
1984	631.4	754.5	8.6	16.3	157.7	8.4	54.6
1985	705.7	826.7	9.6	14.6	171.1	8.5	55.2
1986	784.3	893.9	8.1	12.3	185.7	8.5	55.0
1987	882.3	994.0	10.1	11.2	207.2	11.6	54.8
1988	960.6	1,118.5	12.5	14.1	225.9	9.0	56.5
1989	1,067.5	1,244.2	11.2	14.2	259.2	14.7	54.8
1990	1,178.9	1,374.0	10.4	14.2	286.2	10.4	54.8
1991	1,299.0	1,514.0	10.2	14.2	315.4	10.2	54.8
1992	1,428.0	1,664.3	9.9	14.2	346.6	9.9	54.8
1993	1,565.7	1,824.8	9.6	14.2	380.1	9.7	54.8
1994	1,712.2	1,995.6	9.4	14.2	415.7	9.4	54.8
1995	1,867.6	2,176.7	9.1	14.2	453.4	9.1	54.8
1996	2,031.7	2,367.9	8.8	14.2	493.3	8.8	54.8
1997	2,204.7	2,569.6	8.5	14.2	535.3	8.5	54.8
1998	2,386.4	2,781.4	8.2	14.2	579.4	8.2	54.8
1999	2,576.9	3,003.4	8.0	14.2	625.6	8.0	54.8
2000	2,776.3	3,235.8	7.7	14.2	674.1	7.8	54.8
2001	2,984.4	3,478.3	7.5	14.2	724.6	7.5	54.8

Fig. 3-1 Predicted Load Density in the Project Area in 2000

Unit : kW/km²



4. Power System Plan

(1) The Study Team surveyed the current status of transmission, substation and distribution facilities in the Project Area, the power system expansion plans of ANDE, new transmission line routes and candidate sites of new substations. Then the Study Team conducted various studies on power system reliability and power flow control, and developed the following two alternative plans for expansion of power systems in the Projected Area.

(a) Alternative-1

220 kV transmission systems will be introduced to the urban center area, and Primary Substation-A (120 MVA x 3) and Primary Substation-B (120 MVA x 3) will be newly constructed. These stations will be linked to the existing Lambare, Guarambare, San Lorenzo, Limpio and Puerto Botanico Substations, for 220 kV ring transmission networks that surrounds the Metropolitan Area. The 66 kV power systems that supply the secondary substations will be consists of either two routed of radial, single transmission lines or ring transmission systems.

(b) Alternative-2

Primary Substations (220 kV/66 kV) M and N (120 MVA x 3 each) will be constructed around the Metropolitan Area, to increase the power supply capability to the urban center, and the supply to the secondary substations will be secured by radial, multiple circuit 66 kV transmission lines or ring transmission lines. Substation-A and Barrio Parque Substation will become the key substations for the secondary system.

(2) The Study Team has compared and evaluated the above two alternatives, and judged that Alternative 1 is more advantageous in terms of construction cost and power system characteristics such as transmission voltage, transmission loss, etc. However, in discussions with ANDE, the Alternative 3, which has lower construction cost, but with somewhat reduced supply reliability

and of power flow control performance, has been studied. The outline of this alternative is described below.

(a) The 220 kV transmission systems are introduced to the urban center and Primary Substation-A and Primary Substation-B will be newly constructed. The ring transmission network surrounding the Metropolitan Area will be formed by the 220 kV transmission lines that link Lambare, Guarambare, San Lorenzo, Limpio and Puerto Botanico Substations, and the 66 kV transmission lines that link Substation-A and Substation-B.

(b) In both primary and secondary substations, the limit of transformer loading will be set at 80% of each bank capacity.

Therefore, as margin of transformer overloading is smaller in 2-bank substations, it is assumed that prompt load switching and/or load management can be implemented on the 23 kV side when there is a bank failure.

The power system expansion plan based on this Alternative-3 is presented in Figure 4-1 through Figure 4-4. The facility expansion plan is presented in Table 4-1 and Table 4-2.

(3) The bulk power supply to the Metropolitan Area must be implemented from the eastern power source area comprising Itaipu and Acaray Power Plants. However, the capacity of existing transmission lines for this purpose is expected to fall short in near future, and these transmission systems must be expanded promptly.

The total number of circuits of these 220 kV transmission lines running from the eastern power source area to the Metropolitan Area must be increased to at least 5 circuits by 1994 when a part of the improvement program under this Project is completed.

Even these 5 circuits of 220 kV transmission lines will fall short in power carrying capacity by 1997, and future expansion program must be studied.

Fig. 4-1 Power System Diagram in and around Asuncion by Alternative 3 (1994-95)

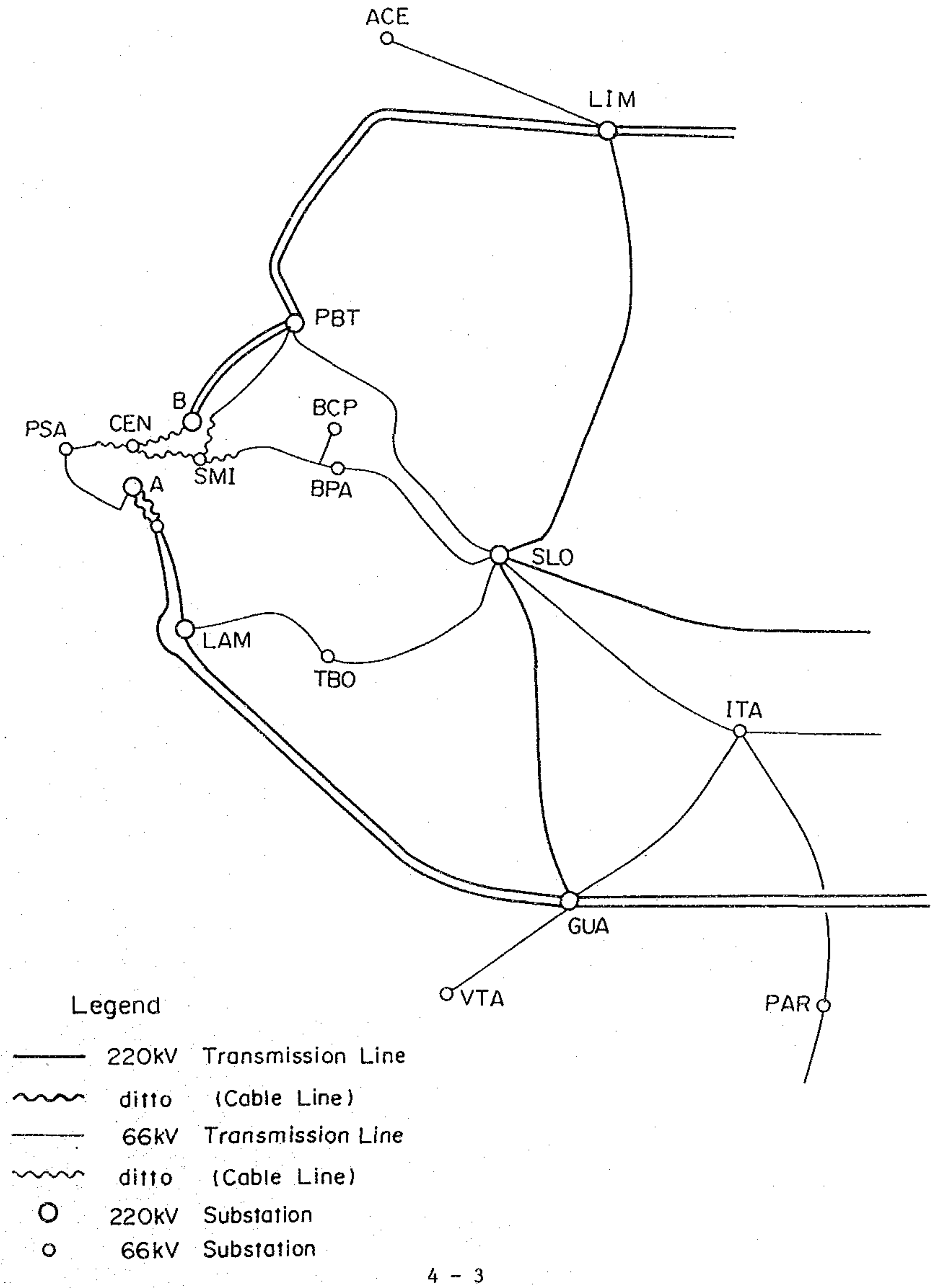


Fig. 4-2 Power System Diagram in and around Asuncion by Alternative 3 (1996-97)

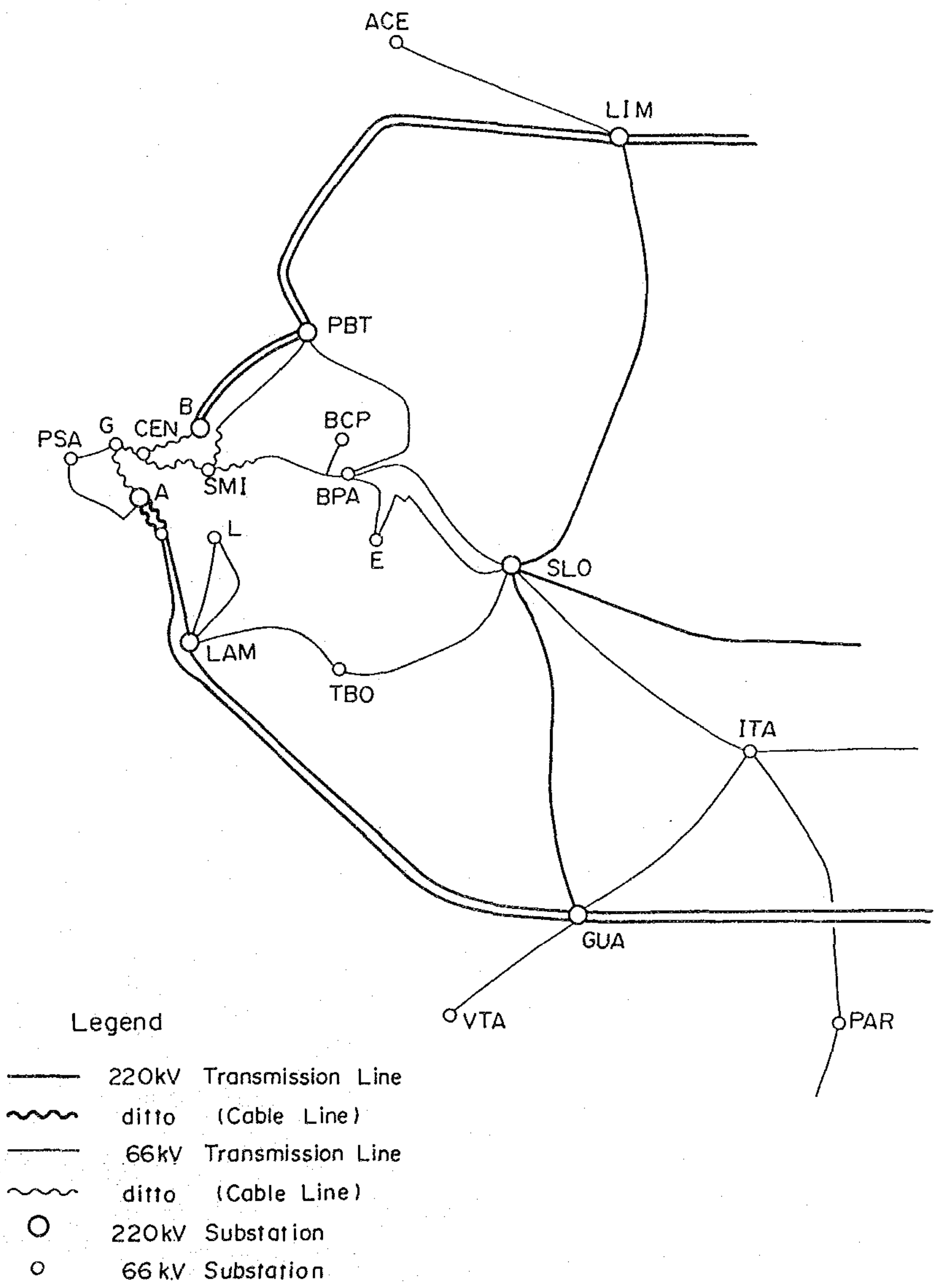


Fig. 4-3 Power System Diagram in and around Asuncion by Alternative 3 (1998-99)

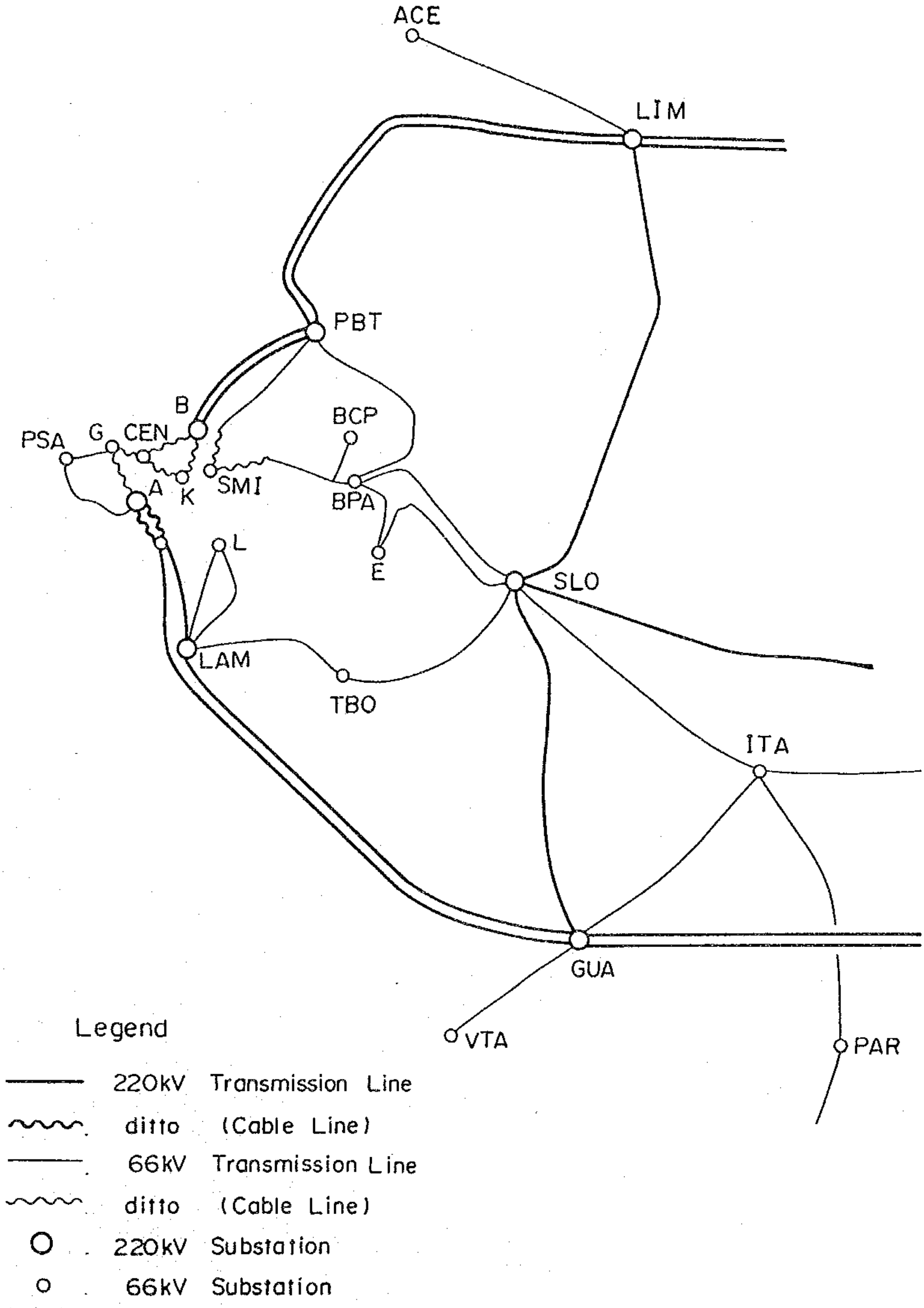
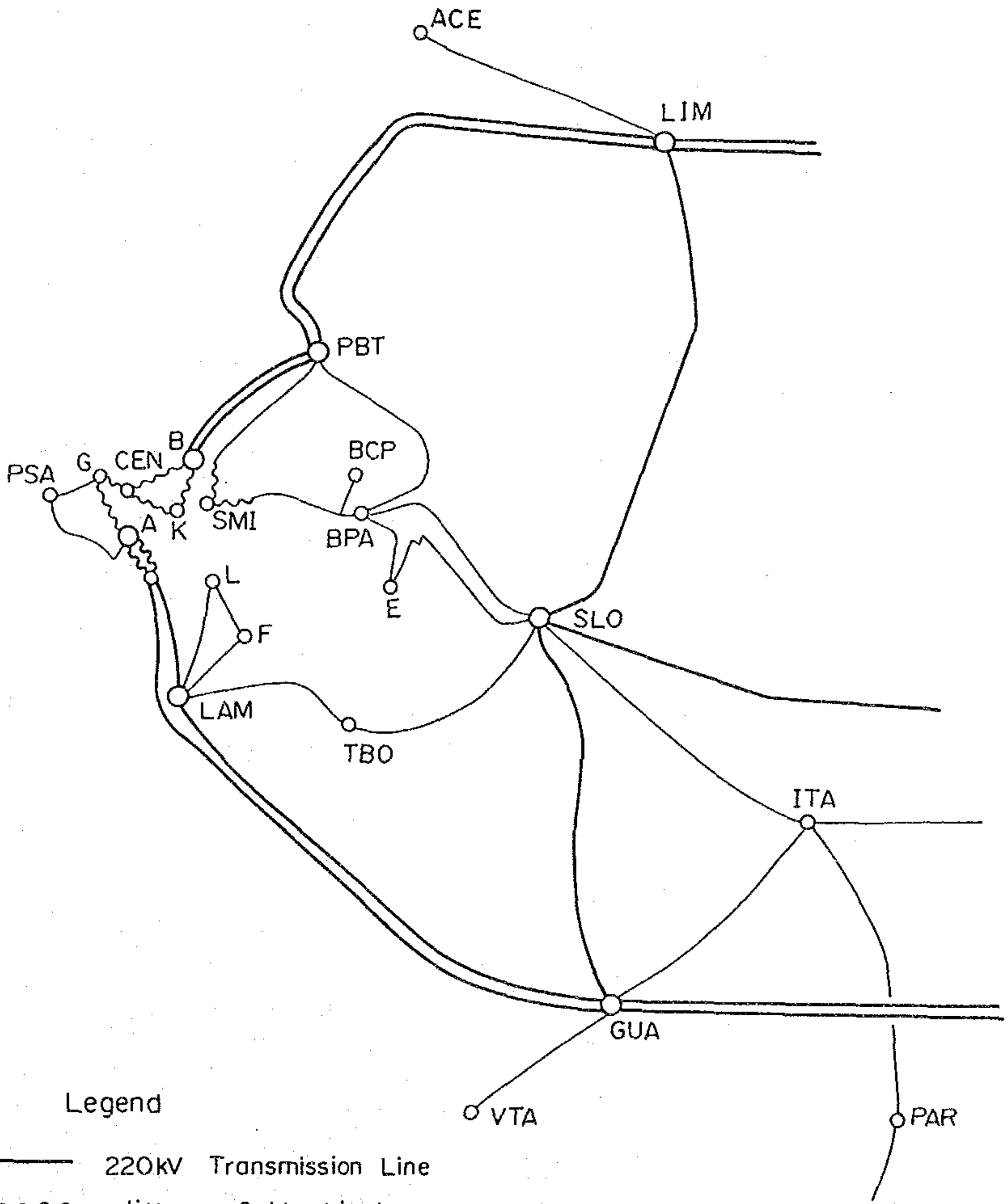


Fig. 4-4 Power System Diagram in and around Asuncion by Alternative 3 (2000)



Legend

(thick line)	220kV Transmission Line
(thick wavy line)	ditto (Cable Line)
(thin line)	66kV Transmission Line
(thin wavy line)	ditto (Cable Line)
O	220kV Substation
o	66kV Substation

Table 4-1 Outline of the Installation Plan of Alternative 3

Transmission Lines

Voltage (kV)	Transmission Lines		From - To	Transmission Capacity (MVA)	Commissioning
220	1 double cct.	OL	Lambare - Cable head	250/cct.	1994
220	2 single cct.	UC	Cable head - A	250/cct.	1994
220	1/2 double cct.	OL	Limpio - Puerto Botanico	250/cct.	1994
220	1 double cct.	OL	Puerto Botanico - B	250/cct.	1994
66	1 single cct.	OL	Puerto Sajonia - A	50	1994
66	1 single cct.	UC	B - Centro	100	1994
66	1 single cct.	OL	Puerto Botanico - Barrio Parque	50	1994
66	1 single cct.	UC	A - G	100	1996
66	1 single cct.	UC	G - CEN	100	1996
66	1 single cct.	OL	Puerto Sajonia - G	50	1996
66	1 single cct.	OL	San Lorenzo - Barrio Parque	50	1996
66	1 single cct.	OL	Barrio Parque - E	50	1996
66	1 single cct.	OL	San Lorenzo - E	50/cct.	1996
66	2 single cct.	OL	Lambara - L	100/cct.	1996
66	1 single cct.	UC	B - K	100	1998
66	1 single cct.	UC	K - Centro	60	1998
66	1 double cct.	OL	F - 66kV line	100/cct.	2000

Note: Abbreviations

cct. circuit
OL Overhead Line
UC Underground Cable

Table 4-2 Outline of the Installation Plan of Alternative 3

Substations

Substation	Installation Plan			Equipment as of the End of the Commissioning Year	
	Transformer	Line Equipment	Commissioning		
A	220/66/23kV 99/60/39MVAx2	220kV,2cct 66kV,1cct	1994	220/66/23kV 99/60/39MVAx2	220kV,2cct 66kV,1cct
B	220/66/23kV 99/60/39MVAx2	220kV,2cct 66kV,1cct	1994	220/66/23kV 99/60/39MVAx2	220kV,2cct 66kV,1cct
Limpio	-	220kV,1cct	1994	220/66/13.8kV 37.5/37.5/ 12.5MVAx1 66/23kV, 20MVAx1	220kV,5cct 66kV,1cct
Puerto Botanico	220/66/23kV 120/60/60MVAx1	220kV,3cct	1994	220/66/23kV 120/60/60MVAx2	220kV,4cct 66kV,2cct
San Lorenzo	220/23kV, 40MVAx1	-	1994	220/66kV, 60MVAx2 220/23kV, 40MVAx2	220kV,3cct 66kV,4cct
Puerto Sajonia	66/23kV,20MVAx1	-	1994	66/23kV, 20MVAx3	66kV,2cct
L	66/23kV,20MVAx1	66kV,2cct	1996	66/23kV, 20MVAx1	66kV,2cct
E	66/23kV,20MVAx1	66kV,2cct	1996	66/23kV, 20MVAx1	66kV,2cct
G	66/23kV,20MVAx3	66kV,3cct	1996	66/23kV, 20MVAx3	66kV,3cct
A	-	66kV,1cct	1996	220/66/23kV 99/60/39MVAx2	220kV,2cct 66kV,2cct
Barrio Parque	-	66kV,2cct	1996	66/23kV, 20MVAx2	66kV,4cct
San Miguel	66/23kV,20MVAx1	-	1997	66/23kV, 20MVAx3	66kV,3cct
K	66/23kV,20MVAx3	66kV,2cct	1998	66/23kV, 20MVAx3	66kV,2cct
B	-	66kV,1cct	1998	220/66/23kV 99/60/39MVAx2	220kV,2cct 66kV,2cct
L	66/23kV,20MVAx1	-	1998	66/23kV, 20MVAx2	66kV,2cct
Barrio Parque	66/23kV,20MVAx1	-	1998	66/23kV, 20MVAx3	66kV,4cct
E	66/23kV,20MVAx1	-	1998	66/23kV, 20MVAx2	66kV,2cct
Guarambare	220/66kV, 37.5MVAx1	-	1998	220/66kV, 37.5MVAx2 66/23kV, 20MVAx1	220kV,5cct 66kV,4cct
L	66/23kV,20MVAx1	-	1999	66/23kV, 20MVAx3	66kV,2cct
F	66/23kV,20MVAx2	66kV,2cct	2000	66/23kV, 20MVAx2	66kV,2cct
Guarambare	66/23kV,20MVAx1	-	2000	220/66kV, 37.5MVAx2 66/23kV, 20MVAx2	220kV,5cct 66kV,4cct

4.2 Power System Analysis

(1) The power flows and short circuit capacities of the future power systems have been analyzed by using the CASTLE computer code which is owned by the Electric Power Development Co., Ltd. The power flow analysis studies have been conducted on the power systems in 1990, 1994, 1997 and 2000 under the peak load condition. The short circuit capacity calculations were done on the power systems in 1990 and 2000.

(2) The supply capability of the current power system may fall short even under normal operating conditions within a few years. However, when a part of this Project is completed in 1994, the power system will have no bottleneck point under normal operating conditions thereafter. However, the 23 kV systems connected to substations having 2 transformer banks will have to be controlled for load switching and/or load management when a transformer failure occurs.

It is required to install power capacitor banks in new substations in order to maintain proper power system voltage values. It is also required to equip the new transformer banks with tap changing devices which are similar to those in existing facilities.

The capacity of shunt capacitors to be installed to each primary substations will have to be studied when the expansion program of main transmission lines connecting the eastern power source area and Metropolitan Area is studied.

(3) The values of short circuit current are high on the 23 kV busses of San Lorenzo, Lambare, Puerto Botanico and New Substations A and B. As the short circuit current on the 23 kV bus of San Lorenzo and Lambare Substations will exceed the rated short-time current of existing circuit breakers by 2000, these circuit breakers will have to be replaced or some measure of limiting short circuit current will have to be introduced.

5. Transmission and Substation Plan

The maximum power demand in the Project Area was 226 MW as of 1988. The total transformer capacities supplying this power demand was 384 MVA, and the demand is met by appropriately distributing load on the 9 substations.

The maximum demand in 2000 is projected as 674 MW (3 times the demand in 1998), and there is not question that the transformer bank capacity in substations must be increased in meeting this demand.

The Study Team has formulated the specific facility expansion plan based on the power system plan for 2000 which had been developed with discussions with ANDE.

(1) *Construction of 220 kV Transmission Lines*

(a) A 220 kV, *double circuit transmission line will be* constructed between Lambare Substation and Substation-A (Barrio Obrero). One circuit of the double circuit 220 kV line, running between Guarambare Substation and Lambare Substation, will be branched into Lambare Substation, and extended to Substation-A. It has been judged that this expansion can not be implemented by overhead lines for all sections, as the line passes congested urban areas, a cable head site was selected at an intermediate point, and the connection to Substation-A will be made by underground line.

(b) The 220 kV transmission line between Limpio Substation and Puerto Botanico Substation (currently being constructed with only one circuit), will be expanded to a double circuit line.

(c) A double circuit, 220 kV line will be constructed from Puerto Botanico Substation to Substation-B (Parque Caballero).

(2) Construction of Primary Substation

New substations will be constructed at Site-A and Site-B in urban center. These substations will be equipped with 2 banks of 3-phase, 220/66/23 kV, 99/60/39 MVA transformers, and connection equipment for 2 circuits of 220 kV lines and 2 circuits of 66 kV lines.

These Substations A and B are so designed that the 23 kV side capacity of transformer is increased and the 66 kV side decreased so that the number of secondary substations to be newly installed at Micro Centro district is reduced.

The general arrangement plan and the single line diagram of new primary substation are presented in Fig. 5-1 and Fig. 5-2 respectively.

(3) Configuration of 66 kV System

Substation-A and Substation-B are linked by 66 kV systems, and this link, together with 220 kV systems, form the ring power system surrounding the Project Area. Existing 66 kV lines will be connected to Barrio Parque Substation, and the interconnection between San Lorenzo Substation and Puerto Botanico Substation will be strengthened.

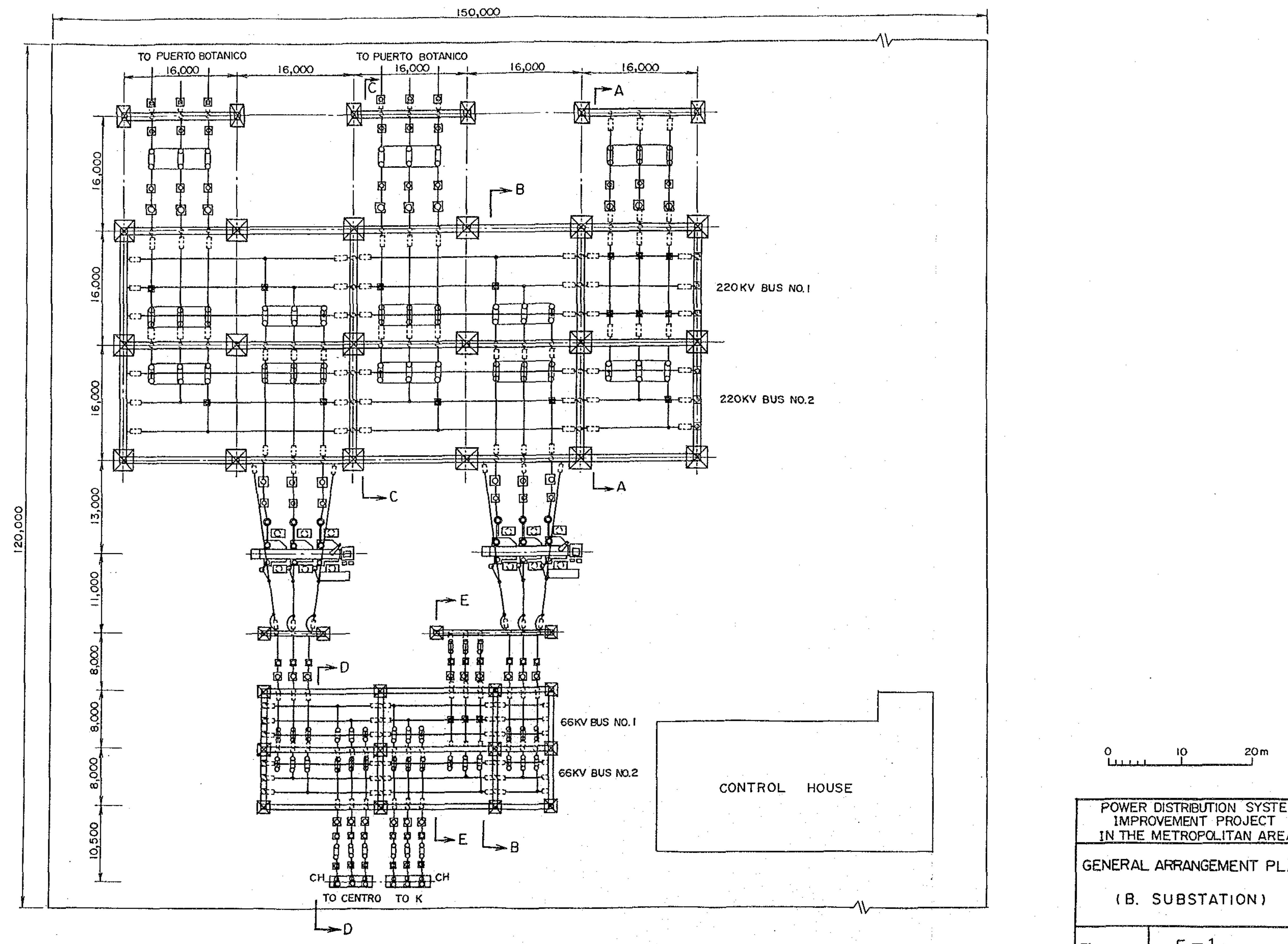
The new transmission lines will be so designed that there will be no power failure when one circuit of them is stopped.

Concerning the secondary substations, the new substations will be equipped with 3 banks of 66 kV/23 kV, 20 MVA transformers (in the final phase), and existing substations will be expanded to have up to 3 banks of transformers having the same rating as with existing transformers. These transformer banks will be operated with loading limit of 80% so that there will be no supply failure when one transformer bank fails. When only 2 transformer banks are operated and one bank fails, a prompt load management and/or load switching will be implemented.

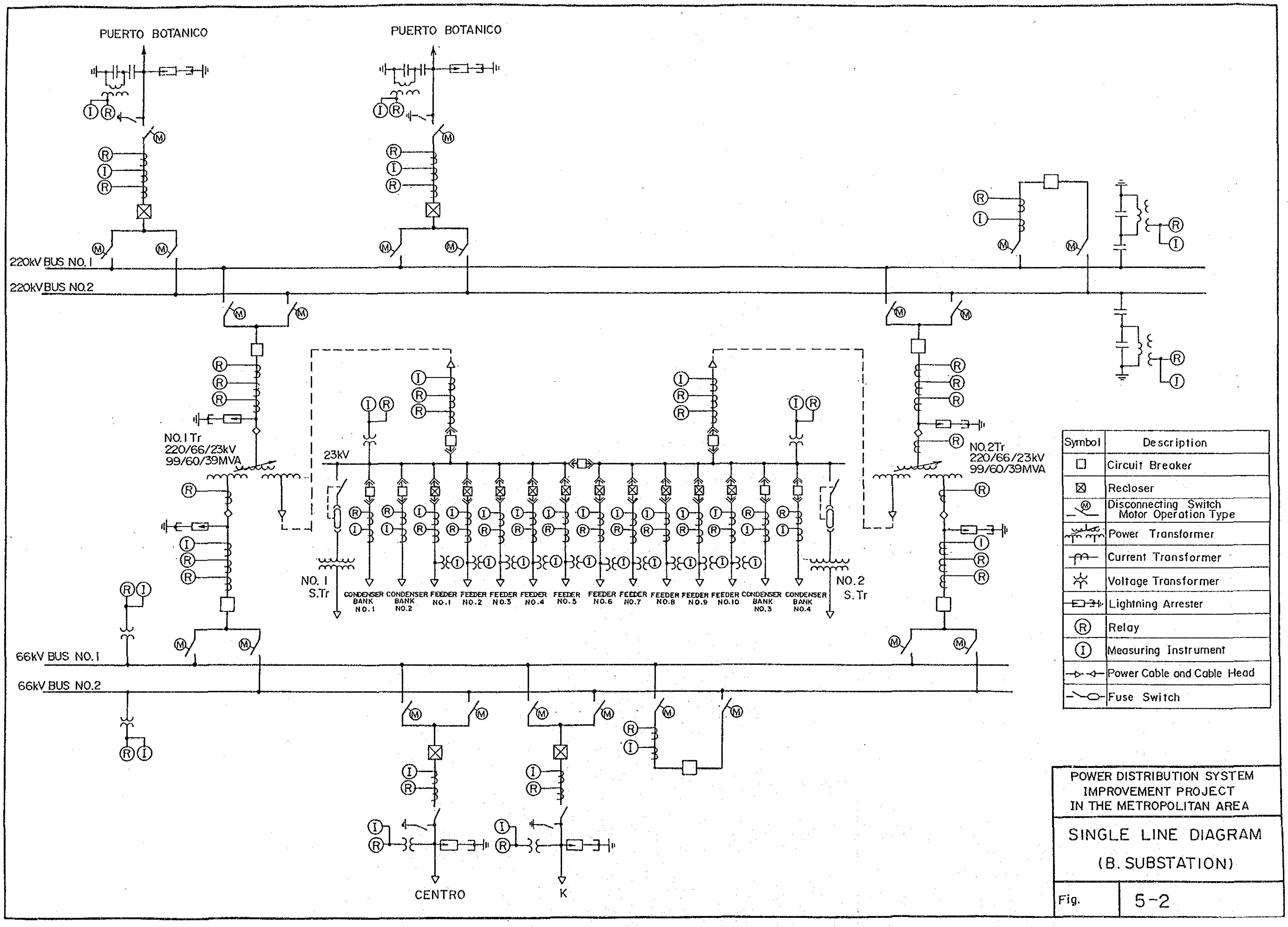
The general arrangement plan and the single line diagram of a typical new secondary substation are presented in Fig. 5-3 and Fig. 5-4 respectively.

(4) Shunt Capacitor

It is required to install power capacitor banks in almost all substations in order to maintain proper operating voltage. The capacity values required have been determined by power flow calcu-



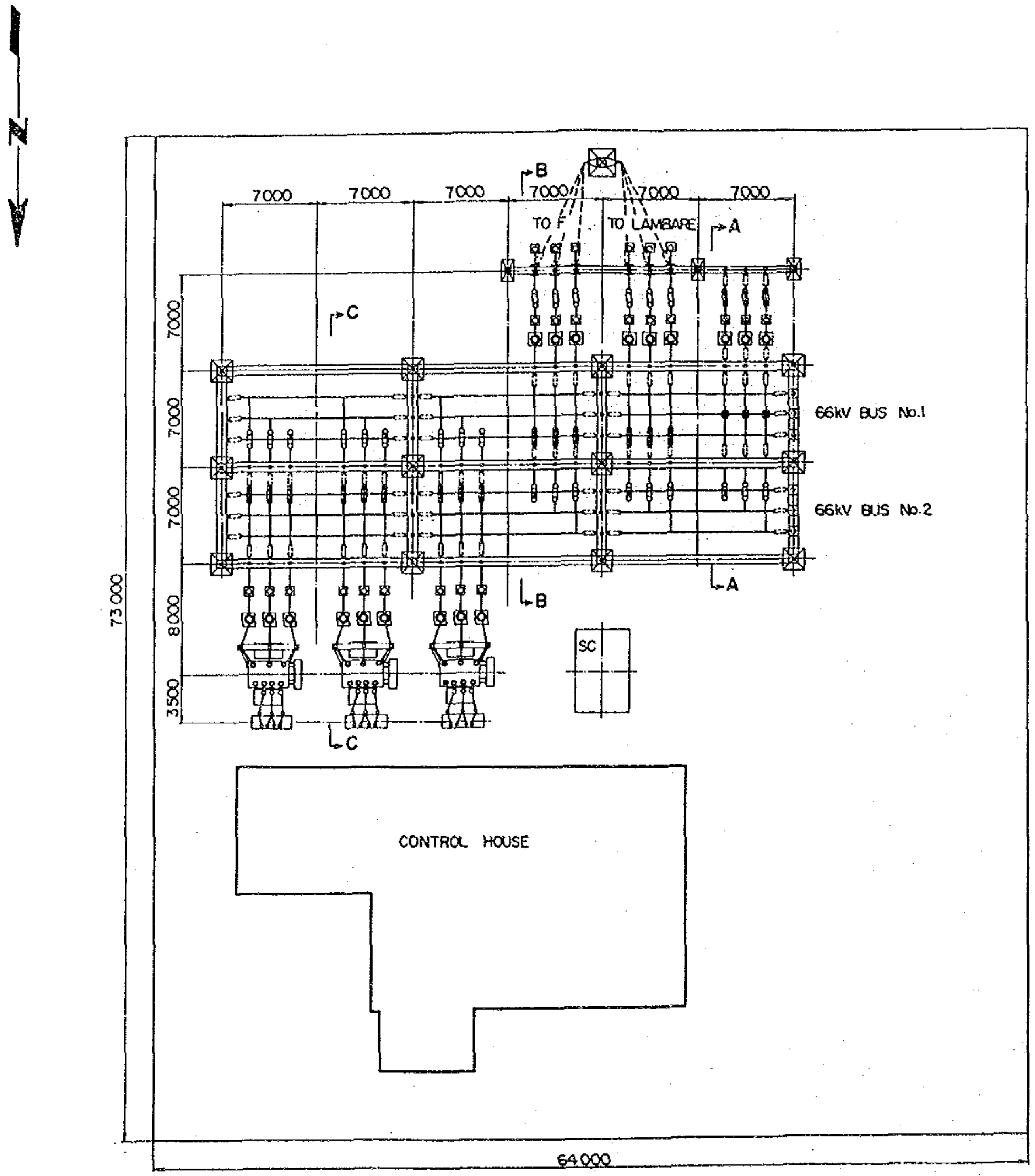
POWER DISTRIBUTION SYSTEM IMPROVEMENT PROJECT IN THE METROPOLITAN AREA	
GENERAL ARRANGEMENT PLAN (B. SUBSTATION)	
Fig.	5-1



POWER DISTRIBUTION SYSTEM IMPROVEMENT PROJECT IN THE METROPOLITAN AREA

SINGLE LINE DIAGRAM (B. SUBSTATION)

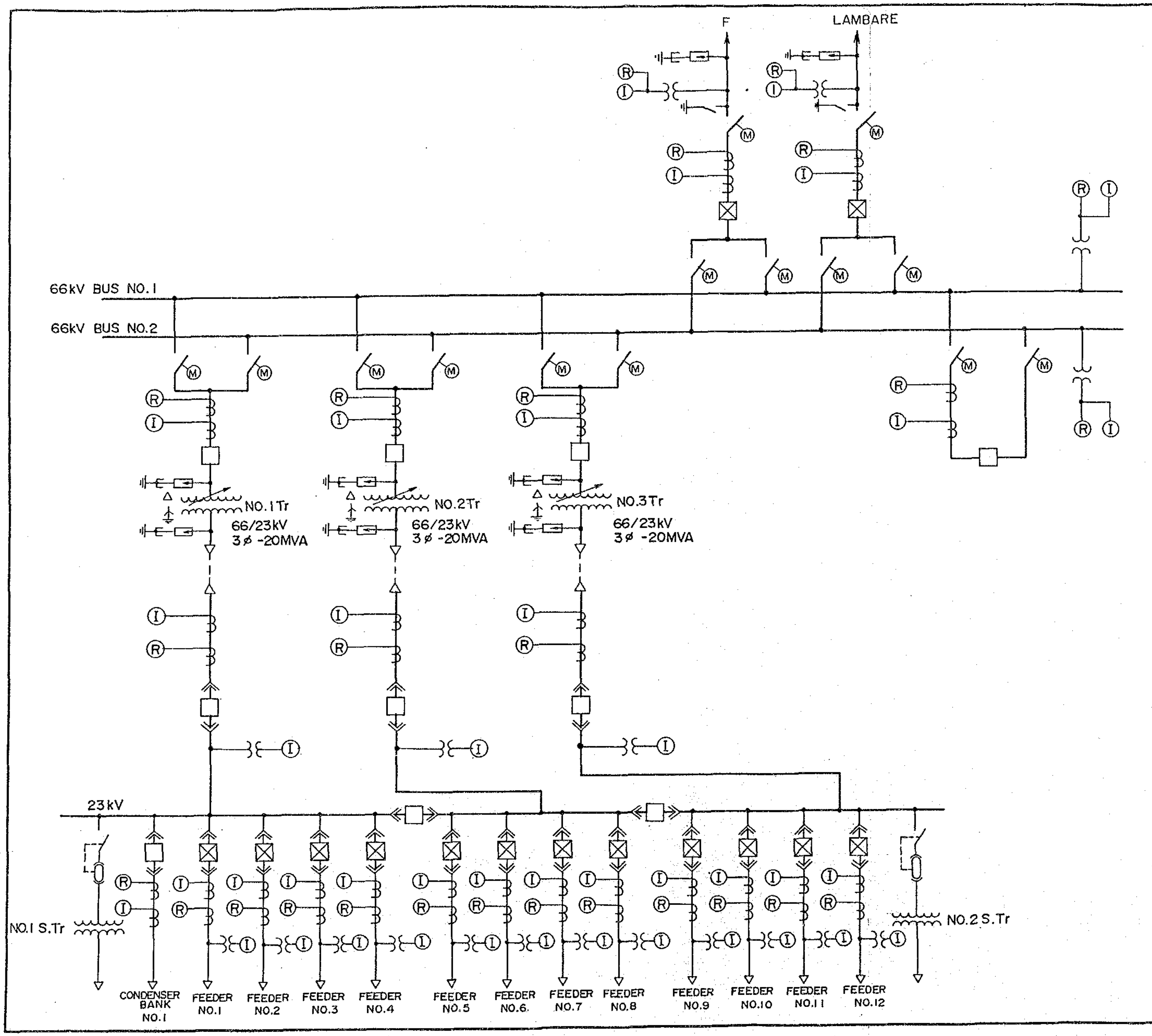
Fig. 5-2



POWER DISTRIBUTION SYSTEM IMPROVEMENT PROJECT IN THE METROPOLITAN AREA

GENERAL ARRAGEMENT PLAN
(L. SUBSTATION)

Fig. 5-3



Symbol	Description
□	Circuit Breaker
⊠	Recloser
	Disconnecting Switch Motor Operation Type
	Power Transformer
	Current Transformer
	Voltage Transformer
	Lightning Arrester
(R)	Relay
(I)	Measuring Instrument
	Power Cable and Cable Head
	Fuse Switch
	Earthing Switch

POWER DISTRIBUTION SYSTEM IMPROVEMENT PROJECT IN THE METROPOLITAN AREA

SINGLE LINE DIAGRAM
(L. SUBSTATION)

Fig. 5-4

lations. It has been set down in this calculation that power capacitors having sufficient capacity to maintain the 23 kV sending end voltage within the range roughly from 100% to 104%.

The capacitor banks will be installed in units of 6 MVAR in the secondary substations, and in units of 12 MVAR in primary substations, and capacitor banks will be connected to the 23 kV busses in principle.

(5) In meeting the expected maximum demand of 674 MW which has been projected for the year 2000, 417 MVA of transformer banks must be installed in 7 new substations, and additional 180 MVA must be installed in 6 existing substations, or a total of 596 MVA. When this value is added to 482 MVA of transformers to be existing in 1993 (with 2 banks of 12 MVA transformers at Jardin Botanico Substation to be decommissioned in 1990), the total transformer capacity will be 1,078 MVA, which is sufficient to meet the demand projected for year 2000.

5.2 Distribution Network Plan

(1) System Configuration of Distribution Lines

The distribution system configuration can be selected from radial distribution system, loop distribution system, banking system and network system.

JICA Study Team studied the scale and economy of distribution facilities of ANDE in year 2000, and selected the loop distribution system for 23 kV main feeders. To be specific, this is a 3-loop, 3-division system. Three feeders are defined as one group, and two automatic sectionalizing switches are provided on each feeder, and three feeders are interconnected together by manual sectionalizing switches (which is normally open).

(2) Distribution Facility Plan

The distribution facilities in the Project Area comprises 56 feeders, 1,075 km of 23 kV distribution lines, 2,415 km of low voltage distribution lines and 485 MVA of distribution transformers. Although these distribution facilities meet the current demand satisfactorily, some distribution lines are being operated near their capacity limits, and there are many problems with facilities as they are aged and bare conductors are used in overhead lines. For this reason, power supply failures occur frequently under current circumstances. In addition, the sectionalizing switches installed on distribution lines are small in number and they manually operated, and this leads to such situation that, once a fault occurs, it takes a long time to identify and remove the fault, resulting in long duration of power supply failure.

The following measures will be implemented to reduce the number of occurrence of faults, shorten the duration of power supply failure, and sufficiently expand the distribution facilities so that they can deal with demand increase that will occur until the year 2000.

(a) Insulation of some distribution lines and conversion to underground cables.

(b) Introduction of automatic sectionalizing switches.

(c) Expansion of distribution lines in pace with demand increase.

(d) Expansion of distribution transformers in pace with demand increase.

In implementing these measures, the construction works will be done in 3 phases in order to avoid concentration of work in a short time. These works will be implemented basically in phase with construction works of substations.

The amount of construction work will be as presented below.

(a)	Introduction of Insulated Distribution Lines	23 kV Lines	86 km
		Low Voltage Lines	105 km

(b)	Conversion of Distribution Lines to Underground Cables	23 kV Lines	44
(c)	Expansion of Distribution Lines	23 kV Lines Low Voltage Lines	1,225 km 3,070 km
(d)	Expansion of Distribution Transformers		432 kVA
(e)	Installation of Sectionalizing Switches	Automatic Section Switches	344
		Manual Section Switches	258

Basically, these works will be realized in accordance with the demand increase.

The adoption of insulated lines and underground cables will be executed being divided into three stages during the construction period of this project as a consequence of discussion with ANDE.

(3) Distribution Network Reliability Enhancement Measures and Their Evaluation

Although the faults on distribution systems is decreasing in recent years, their frequency is still high, and demand for stable supply of power will become more stringent in future as the power demand increases.

As discussed before, the current situation is such that it generally takes a long time to recover power supply once a fault occurs.

In view of this status, the following measures will be implemented to reduce the area affected by supply failure and shorten the time of power failure on 23 kV feeders in coordination with the facility plan presented in the previous Section.

(a) Reduction of Area Affected by Failure

The 23 kV feeders will be divided into 3 sections, and the automatic sectionalizing switches discussed above will be introduced to reduce the areas affected by failures.

(b) Shortening Time Required for Recovery

By introducing the computer aided SCADA System into the Distribution Control Center, the information of failures on 23 kV feeders will be instantly identified by the system. This information shortens the time required mobilize workers. The computer also identifies the faulted section to improve the work efficiency and reduce failure duration.

Concerning this plan, the effect of reliability enhancement to be brought about in 2000 by this new system has been evaluated by a computer program.

This evaluation indicated that the energy loss during the 23 kV feeder failures is reduced, the failure duration is substantially shortened, and the time required for workers to deal with failures can be reduced.

5.3 Control and Monitoring System in Distribution Control Center

In moving the Distribution Dispatching Center, it is indispensable to introduce the computer aided SCADA (Supervisory Control and Data Acquisition) System in order to enhance the distribution system reliability and improve the work efficiency.

This system has the following advantage.

o Quick and Accurate Identification of Fault Information

At present, the information of faults on 23 kV systems is first reported from substations to the Central Load Dispatching Center, and then transmitted to the Distribution Dispatching Center by UHF radio communication. For this reason, the action on the side of the Distribution Dispatching Center for recovery of failure is generally delayed. When this new system is introduced, the Distribution Control Center can instantly identify and evaluate the information of faults on 23 kV feeders, thereby reducing the time required to mobilize workers.

o Monitoring of Distribution Network Operation under Normal Conditions

As the status of operation of distribution networks can be constantly monitored, thereby enabling more prompt operations in failure recovery and distribution line control.

o As various data are processed and edited by computer software, the information can be used as valuable basic data for operators' actions. Also, it will become possible to perform statistical processing of various data which can serve as the basis for automatic operation of substations and distribution network planning.

o This system will be operated with close coordination with the SCADA System to be introduced into the Central Load Dispatching Office, to bring about improved supply reliability to the whole power systems and distribution systems in Metropolitan Area.

(1) System Functions

(a) Monitoring Function

(i) The mimic monitoring board, on which the operating status (circuit breaker positions) of the whole transmission and distribution networks of Metropolitan City Area is displayed, will be installed in the control room where operators are stationed.

(ii) The operating conditions (voltage, current power) and circuit breaker positions of each substation will be displayed on CRT screens.

(iii) The monitoring of the switch status of distribution systems, which is current practices, is available on CRTs.

(b) Control Functions

(i) The 23 kV circuit breakers on the distribution transformer secondary side plus all circuit breakers downstream of the above, can be controlled by this Center.

(c) Recording Functions

(i) The daily and monthly operation records (23 kV system voltage, current power) are output as operation logs on typewriter at specified time.

(ii) The fault and operation records are output on typewriter each time they occur.

(iii) The CRT screens can be copied by the CRT hard copier.

(d) Other Functions

(i) The data of maximum current power of each feeder for the pasts two years can be displayed on CRT as trend graphs.

(ii) The system is interfaced with the automatic sectionalizing switches described before, and it is equipped with the function of identifying the failure section in faults.

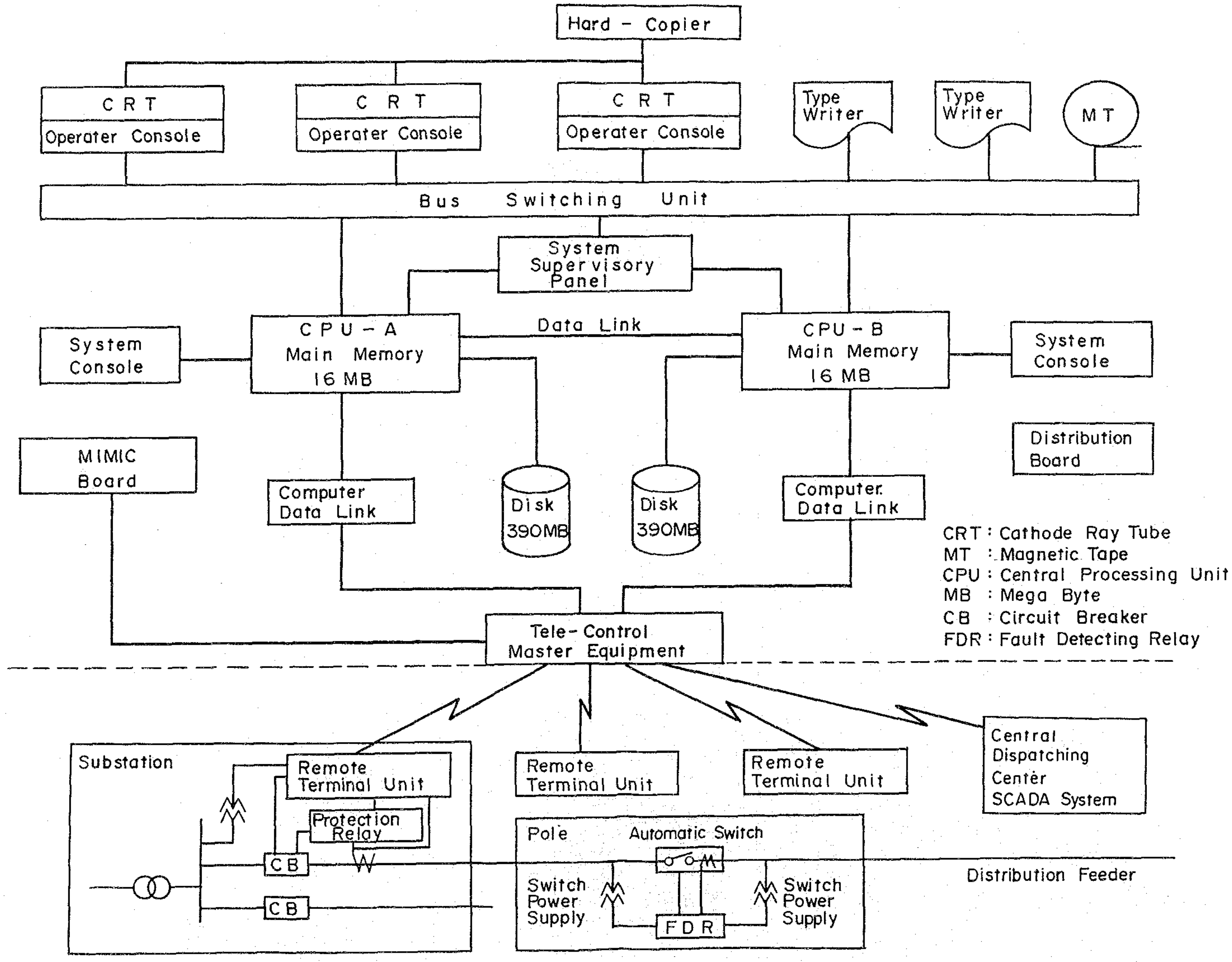
(iii) When the distribution systems are modified or expanded, this can be reflected in the system by simple operation on CRT.

(2) Hardware Configuration

(a) The computer system has duplicated CPUs based on the design of SCADA System (Fig.5-5).

These CPUs are operated by online and standby mode.

Fig. 5-5 Configuration of Proposed SCADA System



(b) Man-Machine Interface Function

(i) One CRT is provided to each operator.

(ii) The system is equipped with 2 typewriters and one CRT hard copier.

(c) The main memory and auxiliary memory have sufficient capacity so that they can deal with the information of the power system expected to be realized by 2010.

5.4 Telecommunication System Planning

The telecommunication systems used for transmission and distribution line maintenance work in Asuncion City and its surrounding area in the Project Area consist of from 3 to 5 channels of UHF and VHF for mobile radio and the power line carrier channels for operation of substations. These facilities are far from preventing obstacles against efficient operation of transmission and distribution lines. In this Project, it is planned to construct 7 substations anew in addition to the existing substations, and to drastically expand the transmission and distribution lines. It is also planned to construct a new Distribution Control Center at the Boggiani district, which will be equipped with modern facilities for supervision and control of distribution substations and efficient operation of power distribution systems. For this purpose, it is required to construct the following new communication channels and information transmission systems.

(1) Mobile Telecommunication Channels for Distribution Line Maintenance

As many as 50,000 maintenance works are being conducted annually to operate the distribution lines in the Project Area. These works can not be efficiently implemented by the simplex radio channels currently in use, and it usually takes a long time to recover power supply failure. In order to improve this situation, 400 MHz band radio channels will be introduced with the Distribution Control Center functioning as the base station and serving the project area. The basic specification of this telecommunication system is illustrated in the following Table.

General Specification of Distribution Line Operation Mobile Radio Equipment

System	FDMA
Number of Channels	8
Number of Subscribers	96
Radio Frequency	335 - 470 MHz
Transmission Power Output	25 W (44 dBm)
Antenna Tower	Guyed Type, 100 m

This system will serve 50 vehicles with radio equipment, and constitute an individual calling telephone network employing 8 common channels. These channels will be used for data transmission while there is no telephone speech to remotely indicate the vehicle positions between the maintenance vehicles, to transmit work plan instructions by facsimile, and to transmit work reports by handy terminals. A processing system will be installed to store and display these data to further increase the maintenance work efficiency.

(2) Telecommunication Channels for Substation Remote Monitoring and Control

These telecommunication channels will be designed to remotely monitor and control the 17 substations in the Project Area from the Distribution Control Center at Boggiani. The telecommunication channels will employ 1,500 MHz, multi-directional radio terminals to form stationary radio channels which radially extend to each substation from the Distribution Control Center. The basic specification of this equipment is presented in the following Table.

General Specification of Distribution Substation Supervision Radio Equipment

System	TDMA
Access System	Demand Assign/Preassign
Number of Access Channels	15
Number of Subscribers	128
Radio Frequency	1500 MHz band (1427 - 1535 MHz)
Transmission Power Output	1 W
Antenna Height	A 95 meter tower which is commonly used with distribution line operation mobile radio.

Out of 15 common channels, 5 channels will be assigned to data transmission only, and 10 channels will be used for telephone network. The data transmission system will be a polling system which is controlled by a separately constructed control computer at Distribution Control Center. The data transmission speed will be 1,200 bits/second.

(3) Telecommunication Channels for 220 kV Transmission Line Protection System

Two circuits of new transmission lines will be constructed between Puerto Botanico Substation and the new Substation-B. One circuit of the double circuit line running from Guarambare Substation to Lambare Substation will be extended to the new Substation-A, and a new single circuit line will be constructed from Lambare Substation to the new Substation-A. 2,000 MHz band radio channels will be installed from Puerto Botanico Substation and to the new Substation-B, and from Lambare Substation to the new Substation-A. As a single circuit transmission line will be constructed from Limpio Substation to Puerto Botanico Substation, a power line carrier channel will be introduced into this section.

In these radio equipment, a redundant radio sets will be provided to assure the necessary reliability, and an economical construction will be realized by using the common antenna tower with the substation supervision/control radio channels. The signal transmission systems will be newly installed in accordance with the existing systems except for the new Substation-A, to where the existing system at Lambare Substation will be moved.

As the radio wave transmission is greatly affected by geography, a field test was conducted by using a 400 MHz portable radio set and field intensity measuring instrument in formulating this telecommunication channel plan.

6. Construction Work Schedule and Construction Cost

6.1 Construction Work Schedule

(1) Scope of Construction Work

The improvement of transmission and distribution systems in the Project Area must be implemented immediately. The start of construction work has been set at 1993, considering the time required to develop detailed designs and bid invitation document, to award contract, and to close agreement with the contractors. Therefore, the first step of this Project will be completed by the end of 1994.

At the end of 1994, the 220 kV transmission lines to be introduced to the Metropolitan Area, the primary substations, the Distribution Control Center, and the monitoring/control systems and telecommunication systems will be completed. Following this, the 66 kV transmission lines, the secondary substations and the distribution systems will be completed in succession by keeping pace with the growth of power demand in the Project Area.

(2) Construction Method

The construction works of transmission lines, substations, telecommunication systems and Distribution Control Center will be awarded to contractors in full turn key basis including architectural and civil engineering works, purchase, shipment and installation, and test of equipments.

The construction works for the distribution facilities will be implemented by ANDE by dividing the Project Area into a number of areas based on the improvement plans are developed for each supply area.

(3) Construction Work Schedule

The construction work schedule, which has been developed according to the scope of construction and construction method described above is presented in Table 6-1.

Table 6-1 Construction Schedule

Works \ Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
(1) Tender Document, Bidding	■								
(2) Transmission Line									
1. 220 kV Line LIM-PBT, PBT-B, LAM-A		■	■						
2. 66 kV Line									
i) B-CEN, PSA-A			■						
ii) PSA-G, PBT-BPA, SLO-BPA, SLO-E, BPA-E LAM-L, A-G, G-CEN				■	■				
iii) CEN-K, B-K							■		
iv) F-L, F-LAM									■
(3) Substation									
1. Construction of Substations									
i) A, B		■	■						
ii) L, E, G			■	■	■				
iii) K						■	■		
iv) F							■	■	■
2. Extension of Substations									
i) LIM, PBT, SLO, PSA		■	■						
ii) A, BPA			■	■	■				
iii) SMI					■	■			
iv) B, E, L, BPA, GUA						■	■		
v) L							■	■	
vi) GUA								■	■
(4) Distribution									
1. Distribution Control Center		■	■						
2. Replacement of Lines and Switches		■	■		■	■	■	■	■
3. Extension of Lines		■	■	■	■	■	■	■	■
(5) Communication System		■	■		■		■		■

6.2 Construction Cost

The construction cost added up for each item of transmission lines, substations, distribution lines, architectural works, and telecommunication systems is presented in Table 6-2. These costs were calculated by foreign currency (US$) and local currency (guarani).

(1) Basic Conditions for Cost Calculation

The construction costs have been calculated based on the following conditions.

(a) The FOB price is based on 1989 price level, and escalation is not taken into account.

(b) Freight and Insurance Premium

CIF price is applied for construction cost, which is to be calculated by adding freight (marine and land) and insurance premium to the FOB prices by the following rates.

- Freight : 10% of FOB price.
- Insurance premium : 1% of FOB price.

As it is expected that the import tax exemption is applied to the commodities imported for this project, the import tax is not taken into account in the calculation.

(c) Foreign Currency Exchange Rate

1 US$ = 1,200 guarani

(d) Labor Cost

The labor costs (for decommissioning of old facilities and installation of new facilities) have been estimated based on the following rates. The labor costs in distribution sector, however, are based on the values indicated by ANDE.

Table 6-2 Construction Cost

	Foreign Currency Portion (Thousand US$)	Local Currency Portion (Million Guarani)	(US$ Equivalent) (Thousand US$)	Total (Thousand US$)
1. Construction Cost				
(1) Transmission	11,416.0	3,721.0	(3,100.8)	14,516.8
(2) Substation	44,289.0	11,187.0	(9,322.5)	53,611.5
(3) Distribution	42,662.0	18,018.0	(15,015.0)	57,677.0
(4) Architecture	0	2,519.0	(2,099.2)	2,099.2
(5) Communication	3,309.5	329.4	(274.5)	3,584.0
Sub-Total	101,676.5	35,774.4	(29,812.0)	131,488.5
2. Engineering Fee and Administration Cost	9,204.2	0	(0)	9,204.2
3. Contingency	10,167.7	3,577.4	(2,981.1)	13,148.8
Total	121,048.4	39,351.8	(32,793.1)	153,841.5

Substation Sector	:	20%
Transmission Sector	:	30%
Distribution Sector	:	(To be determined on discussion with ANDE)
Telecommunication Sector	:	20%

(e) Engineering Fee and Construction Management Fee

A 7% portion of construction cost has been added to the construction cost in foreign currency.

(f) Contingency Cost

10% each of the sums of foreign currency prices and local currency prices of construction costs have been assumed as contingency.

(2) Division of Foreign Currency and Local Currency

The construction costs have been divided into the foreign currency portion and the local currency portion by the following rules.

(a) Foreign Currency Portion

(i) Materials and equipments used in transmission, substation, distribution and telecommunication facilities.

(ii) Freight and insurance premium.

(iii) Cost incurred by having manufacturers' technicians for installation and adjustment of equipments used in substations, distribution control facilities and telecommunication systems.

(iv) Engineering fees.

(b) Local Currency Portion

(i) Contracted construction costs in Paraguay of transmission, substation, distribution and telecommunication facilities.

(ii) Gravels, sand, cement and other materials to be procured in Paraguay for construction works.

(iii) Architectural construction costs of Distribution Control Center and new substations.

7. Economic Evaluation and Financial Analysis

7.1 Economic Evaluation

(1) Methodology and Basic Conditions of Economic Evaluation

(a) The economic evaluation of this Project is calculated by the following cost and benefit.

Cost: The total investment of the Project plus operation and maintenance costs of completed facilities.

Benefit: Incremental electric energy which is made available to the customers by this Project.

(b) Basic Conditions

(i)	Total Investment:	Total construction cost not including interest during construction
(ii)	Foreign Currency Exchange Rate:	US$ = 1,200 guarani
(iii)	Operation and Maintenance Costs:	4%/year of the total investment
(iv)	Period of Calculation:	Until 2023
(v)	Discount Rate:	12% p.a.
(vi)	Unit Value of Benefit:	25.54 guarani/kWh*

* The average electricity rate as of end of 1989 is multiplied by the ratio of transmission, substation and distribution facility values to the total values of ANDE's facilities to obtain the unit value of this Project.

(2) Economic Evaluation

The flow of cost and benefit of this Project is presented in Table 7-1.

The equivalent discount rate (EIRR; economic internal rate of return), surplus benefit (B - C) and benefit to cost ratio (B/C) are as presented below.

EIRR	:	14.9%
B - C	:	25,236.3 thousand US$
B/C	:	1.18

Judging upon these values, this Project is sufficiently sound economically. As this project has various social contributions which can not be quantified, the real economic feasibility is even high, and this Project is worth implementing.

7.2 Financial Analysis

(1) Methodology and Basic Conditions of Financial Analysis

(a) The following two indices have been calculated in this financial analysis.

(i) Debt Service Ratio

(ii) Equivalent Discount Rate (FIRR: Financial Internal Rate of Return)

(b) Basic Conditions

(i) Financing Conditions:

o Foreign currency: 7% p.a. interest rate, equal reimbursement in 20 years o Local currency: 35% p.a. interest rate on 50% of local currency portion, equal reimbursement in 10 years

(ii) Construction Cost, Operation and Maintenance Cost, Energy Sales Revenue: The same with in economic evaluation

(iii) Depreciation: Depreciation by fixed rate on diminishing value, 10% residual value, with amortization period of 27 years

(iv) Escalation: Not considered

(2) Financial Analysis

(a) Debt Service Ratio

The calculations of reimbursement plan, profit and loss statement, cash flow and debt service ratio are presented in Table 7-2, Table 7-3, Table 7-4 and Table 7-5.

The debt service ratio is 1.31, which is not a very high value as an index of project's profitability. But this is deemed an appropriate value considering the fact that this Project is an improvement program for distribution networks and generally has low profitability.

As the high interest rate of domestic financing, such as 35%, reduces the profitability of this Project. It is therefore very important that the local, as well as foreign, financing can be arranged under favorable conditions.

(b) Equivalent Discount Rate (FIRR: Financial Internal Rate of Return)

The flows of expenditure and revenue of this project is given in Table 7-6. FIRR is calculated as 10.7%.

This analysis indicates that the Project is financially sound.

Table 7-1 Benefit Flow and Cost Flow of the Adopted Improvement Plan

(Unit: Thousand US$)

Serial No.	No. after Completion	Cost				Benefit		B - C
		Inves. Cost	O&M Cost	Total	N.P.V.	Total	N.P.V.	
0		0.0		0.0	0.0		0.0	0.0
1		36304.9		36304.9	32415.1		0.0	-36304.9
2		46259.5		46259.5	36877.8		0.0	-46259.5
3		8612.5	3302.6	11915.1	8480.9	12101.7	8613.8	186.6
4		11698.1	3647.1	15345.2	9752.2	15594.3	9910.5	249.1
5		8325.4	4115.0	12440.4	7059.0	19276.3	10937.9	6835.9
6		10555.4	4448.0	15003.4	7601.2	23143.5	11725.2	8140.1
7		7269.8	4870.2	12140.0	5491.5	27198.0	12303.0	15058.0
8		24815.9	5161.0	29976.9	12107.2	31441.9	12698.9	1465.0
9	1		6153.7	6153.7	2219.1	31441.9	11338.3	25288.2
10	2		6153.7	6153.7	1981.3	31441.9	10123.5	25288.2
11	3		6153.7	6153.7	1769.0	31441.9	9038.8	25288.2
12	4		6153.7	6153.7	1579.5	31441.9	8070.4	25288.2
13	5		6153.7	6153.7	1410.3	31441.9	7205.7	25288.2
14	6		6153.7	6153.7	1259.2	31441.9	6433.6	25288.2
15	7		6153.7	6153.7	1124.3	31441.9	5744.3	25288.2
16	8		6153.7	6153.7	1003.8	31441.9	5128.9	25288.2
17	9		6153.7	6153.7	896.3	31441.9	4579.3	25288.2
18	10		6153.7	6153.7	800.2	31441.9	4088.7	25288.2
19	11		6153.7	6153.7	714.5	31441.9	3650.6	25288.2
20	12		6153.7	6153.7	637.9	31441.9	3259.5	25288.2
21	13		6153.7	6153.7	569.6	31441.9	2910.3	25288.2
22	14		6153.7	6153.7	508.6	31441.9	2598.4	25288.2
23	15		6153.7	6153.7	454.1	31441.9	2320.0	25288.2
24	16		6153.7	6153.7	405.4	31441.9	2071.5	25288.2
25	17		6153.7	6153.7	362.0	31441.9	1849.5	25288.2
26	18		6153.7	6153.7	323.2	31441.9	1651.4	25288.2
27	19		6153.7	6153.7	288.6	31441.9	1474.4	25288.2
28	20		6153.7	6153.7	257.7	31441.9	1316.4	25288.2
29	21		6153.7	6153.7	230.0	31441.9	1175.4	25288.2
30	22		6153.7	6153.7	205.4	31441.9	1049.5	25288.2
31	23		6153.7	6153.7	183.4	31441.9	937.0	25288.2
Total		153841.5	167079	320920.5	138968.1	851919.4	164204.4	530998.9

I R R	0.1495049
B - C	25236.377
B / C	1.1815983

Table 7-2 Repayment Schedule of Debt

(Unit: Thousand US$)

No.	Year	Financing for Construction			Repayment of Foreign Currency				Repayment of Local Currency			
		F.C.	L.C.	Total	Interest	Principal	Total	Balance	Interest	Principal	Total	Balance
	1993	30240.8	4163.5	34404.3								
	1994	42053.5	5707.7	47761.2								
	1995	11124.4	4013.2	15137.6								
	1996	13701.9	5037.1	18739.0								
	1997	11928.3	4996.1	16924.4								
	1998	14140.9	5700.9	19841.8								
	1999	12212.1	5671.6	17883.7								
	2000	27596.5	7800.9	35397.4				162998.4				43091.0
1	2001				11409.9	3976.0	15385.9	159022.4	15081.9	789.4	15871.2	42301.6
2	2002				11131.6	4254.3	15385.9	154768.1	14805.6	1065.6	15871.2	41236.0
3	2003				10833.8	4552.1	15385.9	150215.9	14432.6	1438.6	15871.2	39797.4
4	2004				10515.1	4870.8	15385.9	145345.2	13929.1	1942.1	15871.2	37855.3
5	2005				10174.2	5211.7	15385.9	140133.4	13249.4	2621.8	15871.2	35233.5
6	2006				9809.3	5576.6	15385.9	134556.9	12331.7	3539.5	15871.2	31694.0
7	2007				9419.0	5966.9	15385.9	128589.9	11092.9	4778.3	15871.2	26915.7
8	2008				9001.3	6384.6	15385.9	122205.3	9420.5	6450.7	15871.2	20464.9
9	2009				8554.4	6831.5	15385.9	115373.8	7162.7	8708.5	15871.2	11756.4
10	2010				8076.2	7309.7	15385.9	108064.1	4114.8	11756.4	15871.2	0.0
11	2011				7564.5	7821.4	15385.9	100242.7				
12	2012				7017.0	8368.9	15385.9	91873.8				
13	2013				6431.2	8954.7	15385.9	82919.0				
14	2014				5804.3	9581.6	15385.9	73337.5				
15	2015				5133.6	10252.3	15385.9	63085.2				
16	2016				4416.0	10969.9	15385.9	52115.3				
17	2017				3648.1	11737.8	15385.9	40377.5				
18	2018				2826.4	12559.5	15385.9	27818.0				
19	2019				1947.3	13438.6	15385.9	14379.3				
20	2020				1006.6	14379.3	15385.9	0.0				
	Total	162998.4	43091.0	206089.4	144719.5	162998.4	307717.9		115621.0	43091.0	158712.0	

Table 7-3 Statement of Profit and Loss

(Unit: Thousand US$)

No.	Year	Revenue	Business Expenses			Business Profit	Financial Cost		Net Profit
			O&M Cost	Depreciation	Total		Interest Dur.Const.	Interest	
	1993						1642.7		-1642.7
	1994						5303.8		-5303.8
	1995	12101.7	3302.6		3302.6	8799.1	7752.5		1046.6
	1996	15594.3	3647.1		3647.1	11947.2	8774.1		3173.1
	1997	19276.3	4115.0		4115.0	15161.3	9781.0		5380.3
	1998	23143.5	4448.0		4448.0	18695.5	10716.2		7979.3
	1999	27198.0	4870.2		4870.2	22327.8	11592.9		10734.9
	2000	31441.9	5161.0		5161.0	26280.9	13081.1		13199.8
1	2001	31441.9	6153.7	18187.3	24341.0	7100.9		26491.7	-19390.8
2	2002	31441.9	6153.7	16700.5	22854.2	8587.7		25937.1	-17349.5
3	2003	31441.9	6153.7	15335.3	21489.0	9952.9		25266.4	-15313.5
4	2004	31441.9	6153.7	14081.7	20235.4	11206.5		24444.2	-13237.7
5	2005	31441.9	6153.7	12930.6	19084.3	12357.6		23423.5	-11065.9
6	2006	31441.9	6153.7	11873.6	18027.3	13414.6		22141.1	-8726.4
7	2007	31441.9	6153.7	10903.0	17056.7	14385.2		20511.9	-6126.6
8	2008	31441.9	6153.7	10011.7	16165.4	15276.5		18421.8	-3145.3
9	2009	31441.9	6153.7	9193.3	15347.0	16094.9		15717.1	377.8
10	2010	31441.9	6153.7	8441.8	14595.5	16846.4		12190.9	4655.5
11	2011	31441.9	6153.7	7751.7	13905.4	17536.5		7564.5	9972.0
12	2012	31441.9	6153.7	7118.0	13271.7	18170.2		7017.0	11153.2
13	2013	31441.9	6153.7	6536.2	12689.9	18752.0		6431.2	12320.9
14	2014	31441.9	6153.7	6001.9	12155.6	19286.3		5804.3	13482.0
15	2015	31441.9	6153.7	5511.2	11664.9	19777.0		5133.6	14643.3
16	2016	31441.9	6153.7	5060.7	11214.4	20227.5		4416.0	15811.5
17	2017	31441.9	6153.7	4647.0	10800.7	20641.2		3648.1	16993.1
18	2018	31441.9	6153.7	4267.1	10420.8	21021.1		2826.4	18194.6
19	2019	31441.9	6153.7	3918.3	10072.0	21369.9		1947.3	19422.6
20	2020	31441.9	6153.7	3598.0	9751.7	21690.2		1006.6	20683.6
	Total	757593.7	148617.9	182069.0	330686.9	426906.8	68644.3	260340.6	97921.9

Table 7-4 Cash Flow

(Unit: Thousand US$)

No.	Year	Cash Inflow				Cash Outflow			Balance	
		Financing	Net Profit	Depreciation	Total	Investment	Repayment of Princi.	Total	Year	Accumlated
	1993	34404.3	-1642.7		32761.6	34404.3		34404.3	-1642.7	-1642.7
	1994	47761.2	-5303.8		42457.4	47761.2		47761.2	-5303.8	-6946.5
	1995	15137.6	1046.6		16184.2	15137.6		15137.6	1046.6	-5899.9
	1996	18739.0	3173.1		21912.1	18739.0		18739.0	3173.1	-2726.8
	1997	16924.4	5380.3		22304.7	16924.4		16924.4	5380.3	2653.5
	1998	19841.8	7979.3		27821.1	19841.8		19841.8	7979.3	10632.8
	1999	17883.7	10734.9		28618.6	17883.7		17883.7	10734.9	21367.7
	2000	35397.4	13199.8		48597.2	35397.4		35397.4	13199.8	34567.5
1	2001		-19390.8	18187.3	-1203.5		4765.4	4765.4	-5968.9	28598.6
2	2002		-17349.5	16700.5	-648.9		5320.0	5320.0	-5968.9	22629.7
3	2003		-15313.5	15335.3	21.8		5990.7	5990.7	-5968.9	16660.8
4	2004		-13237.7	14081.7	844.0		6812.9	6812.9	-5968.9	10691.9
5	2005		-11065.9	12930.6	1864.7		7833.6	7833.6	-5968.9	4723.0
6	2006		-8726.4	11873.6	3147.1		9116.0	9116.0	-5968.9	-1245.9
7	2007		-6126.6	10903.0	4776.3		10745.2	10745.2	-5968.9	-7214.8
8	2008		-3145.3	10011.7	6866.4		12835.3	12835.3	-5968.9	-13183.7
9	2009		377.8	9193.3	9571.1		15540.0	15540.0	-5968.9	-19152.6
10	2010		4655.5	8441.8	13097.3		19066.2	19066.2	-5968.9	-25121.5
11	2011		9972.0	7751.7	17723.7		7821.4	7821.4	9902.3	-15219.2
12	2012		11153.2	7118.0	18271.2		8368.9	8368.9	9902.3	-5316.9
13	2013		12320.9	6536.2	18857.0		8954.7	8954.7	9902.3	4585.4
14	2014		13482.0	6001.9	19483.9		9581.6	9581.6	9902.3	14487.7
15	2015		14643.3	5511.2	20154.6		10252.3	10252.3	9902.3	24390.0
16	2016		15811.5	5060.7	20872.2		10969.9	10969.9	9902.3	34292.3
17	2017		16993.1	4647.0	21640.1		11737.8	11737.8	9902.3	44194.6
18	2018		18194.6	4267.1	22461.8		12559.5	12559.5	9902.3	54096.9
19	2019		19422.6	3918.3	23340.9		13438.6	13438.6	9902.3	63999.2
20	2020		20683.6	3598.0	24281.6		14379.3	14379.3	9902.3	73901.5
	Total	206089.4	97921.9	182069.0	486080.3	206089.4	206089.4	412178.8	73901.5	

Table 7-5 Calculation of Debt Service Ratio

(Unit: Thousand US$)

No.	Year	Internal Fund Procured: Business Profit	Internal Fund Procured: Depreciation	Internal Fund Procured: Total	Internal Fund Procured: Accumlated	Repayment of Debt: Interest	Repayment of Debt: Principal	Repayment of Debt: Total	Repayment of Debt: Accumlated	Debt Service Ratio
					(A)				(B)	(A)/(B)
	1993									
	1994									
	1995	8799.1		8799.1	8799.1					
	1996	11947.2		11947.2	20746.3					
	1997	15161.3		15161.3	35907.6					
	1998	18695.5		18695.5	54603.1					
	1999	22327.8		22327.8	76930.9					
	2000	26280.9		26280.9	103211.8					
1	2001	7100.9	18187.3	25288.2	128500.0	26491.7	4765.4	31257.1	31257.1	
2	2002	8587.7	16700.5	25288.2	153788.2	25937.1	5320.0	31257.1	62514.2	
3	2003	9952.9	15335.3	25288.2	179076.4	25266.4	5990.7	31257.1	93771.3	
4	2004	11206.5	14081.7	25288.2	204364.6	24444.2	6812.9	31257.1	125028.4	
5	2005	12357.6	12930.6	25288.2	229652.8	23423.5	7833.6	31257.1	156285.5	1.47
6	2006	13414.6	11873.6	25288.2	254941.0	22141.1	9116.0	31257.1	187542.6	
7	2007	14385.2	10903.0	25288.2	280229.2	20511.9	10745.2	31257.1	218799.7	
8	2008	15276.5	10011.7	25288.2	305517.4	18421.8	12835.3	31257.1	250056.8	
9	2009	16094.9	9193.3	25288.2	330805.6	15717.1	15540.0	31257.1	281313.9	
10	2010	16846.4	8441.8	25288.2	356093.8	12190.9	19066.2	31257.1	312571.0	1.14
11	2011	17536.5	7751.7	25288.2	381382.0	7564.5	7821.4	15385.9	327956.9	
12	2012	18170.2	7118.0	25288.2	406670.2	7017.0	8368.9	15385.9	343342.8	
13	2013	18752.0	6536.2	25288.2	431958.4	6431.2	8954.7	15385.9	358728.7	
14	2014	19286.3	6001.9	25288.2	457246.6	5804.3	9581.6	15385.9	374114.6	
15	2015	19777.0	5511.2	25288.2	482534.8	5133.6	10252.3	15385.9	389500.5	1.24
16	2016	20227.5	5060.7	25288.2	507823.0	4416.0	10969.9	15385.9	404886.4	
17	2017	20641.2	4647.0	25288.2	533111.2	3648.1	11737.8	15385.9	420272.3	
18	2018	21021.1	4267.1	25288.2	558399.4	2826.4	12559.5	15385.9	435658.2	
19	2019	21369.9	3918.3	25288.2	583687.6	1947.3	13438.6	15385.9	451044.1	
20	2020	21690.2	3598.0	25288.2	608975.8	1006.6	14379.3	15385.9	466430.0	1.31
	Total	426906.8	182069.0	608975.8		260340.6	206089.4	466430.0		

Table 7-6 Cost Flow and Revenue Flow of Adopted Improvement Plan

(Unit: Thousand US$)

Serial Number	Year	Cost			Revenue	B - C
		Investment Cost	O&M Cost	Total		
0	1992			0.0		0.0
1	1993	37947.6		37947.6		-37947.6
2	1994	51563.3		51563.3		-51563.3
3	1995	16365.0	3302.6	19667.6	12101.7	-7565.9
4	1996	20472.2	3647.1	24119.3	15594.3	-8525.0
5	1997	18106.4	4115.0	22221.4	19276.3	-2945.1
6	1998	21271.6	4448.0	25719.6	23143.5	-2576.1
7	1999	18862.7	4870.2	23732.9	27198.0	3465.1
8	2000	37897.0	5161.0	43058.0	31441.9	-11616.1
9	2001		6153.7	6153.7	31441.9	25288.2
10	2002		6153.7	6153.7	31441.9	25288.2
11	2003		6153.7	6153.7	31441.9	25288.2
12	2004		6153.7	6153.7	31441.9	25288.2
13	2005		6153.7	6153.7	31441.9	25288.2
14	2006		6153.7	6153.7	31441.9	25288.2
15	2007		6153.7	6153.7	31441.9	25288.2
16	2008		6153.7	6153.7	31441.9	25288.2
17	2009		6153.7	6153.7	31441.9	25288.2
18	2010		6153.7	6153.7	31441.9	25288.2
19	2011		6153.7	6153.7	31441.9	25288.2
20	2012		6153.7	6153.7	31441.9	25288.2
21	2013		6153.7	6153.7	31441.9	25288.2
22	2014		6153.7	6153.7	31441.9	25288.2
23	2015		6153.7	6153.7	31441.9	25288.2
24	2016		6153.7	6153.7	31441.9	25288.2
25	2017		6153.7	6153.7	31441.9	25288.2
26	2018		6153.7	6153.7	31441.9	25288.2
27	2019		6153.7	6153.7	31441.9	25288.2
28	2020		6153.7	6153.7	31441.9	25288.2
29	2021		6153.7	6153.7	31441.9	25288.2
30	2022		6153.7	6153.7	31441.9	25288.2
31	2023		6153.7	6153.7	31441.9	25288.2
		222485.8	167079.0	389564.8		462354.6

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8. Conclusion and Recommendation

Conclusion

(1) The current maximum power demand and the energy consumption of the Project Area (which is a little narrower than what is termed the "Metropolitan Area"), are 225 MW and 960 GWh respectively, and their annual growth rates are projected to be 9.1% and 9.9% respectively for the period from 1982 to 1988.

The JICA Study Team has projected the future power demand by a macroscopic method based on the time series trend of energy consumption, and at the same time reviewed the demand projection developed by ANDE for each 1 km^2 mesh for the year 2000. Based on these studies, the JICA Study Team estimated that the maximum power demand will be 674 MW in the year 2000, and the energy consumption will be 2,776 GWh in the same year.

In dealing with this growth of power demand, it is necessary to strengthen the power systems consisting of the 220 kV and 66 kV transmission lines and the related substations. That is:

(a) Two 2-circuits of 220 kV transmission lines shall be introduced into the urban center.

(b) Two substations, "A" and "B", shall be constructed as key stations to supply power to the secondary substations and also to the 23 kV distribution systems.

(c) The new substations "A" and "B", and the existing 220 kV systems shall form a ring power system together with the 66 kV systems.

(d) Five secondary substations will be newly constructed.

(2) In a long term power demand forecast projecting into year 2000, the actual future demand may be substantially different from such projection in years of long future due to changes in social conditions and economic trend.

It is necessary to review such demand projection as time goes on in implementing power facility programs which are technically and economically suitable.

The macroscopic demand projection used by JICA Study Team for this Project tends to predict higher values in years in long future, and it is required to review this demand projection by 1995 or so.

(3) The power systems in the Project Area in 1994, when a part of facilities of this Project is commissioned, and later years, will present no problem under normal power system operation. However, as the limit of transformer loading is set at 80% of the rated capacity, it will be required, in case of a transformer failure in a substation having 2 banks, to quickly implement load switching and/or load control in order to prevent overloading of sound transformers.

(4) In the distribution system planning, it has been planned to expand facilities in accordance with demand increase. For enhancement of distribution system reliability, followings are took into account.

(a) The medium voltage (23 kV) distribution lines, low voltage (380 V/220 V) distribution lines, and distribution transformers shall be expanded.

(b) Insulated conductors shall be fully used for the medium and low voltage distribution lines in Centro district and in the eastern neighboring area.

(c) Underground cables shall be used in particular for the 23 kV distribution lines in Centro district.

(d) The 3-division, 3-loop system will be adopted to the distribution system. For this purpose, 2 automatic section switches will be installed in each main 23 kV feeder. At the same time, a pair of such feeders shall be interconnected together by a manual section switch (normally open).

(5) The computer aided SCADA System shall be introduced to the new Distribution Control Center in order to improve the efficiency of distribution network operation and to speed up the supply failure recovery operation.

(6) The telecommunication system shall be designed to be a system supporting the monitoring and control functions over the medium and low voltage distribution facilities in the 17 substations in the year 2000, and UHF band 1,500 MHz radio system shall be introduced. In addition, UHF band 400 MHz radio system shall be provided to communicate with the 50 radio equipped vehicles from the Distribution Control Center, to support data transmission for handy terminals facsimiles, etc. as well as telephone communication.

(7) Although it is important to implement this Project promptly, the start of construction work will be below 1993, considering the time required for financing procedures, detailed designs, bidding procedures, etc. Therefore, the first facility under this Project will be completed by the end of 1994, and the construction work will continue to the year 2000 in pace with the growth of power demand. This construction schedule is presented in Table 11-1.

(8) The total investment for this Improvement Program has been calculated as 121,084.4 thousand dollars of foreign currency plus 39,351.8 million guarani (32,793.1 thousand dollars) of local currency.

(9) Economic Evaluation and Financial Analysis

The result of economic evaluation indicated an economic internal rate of return (EIRR) of 14.9%, excess benefit (B - C) of 25,236.3 thousand dollars, benefit to cost ratio (B/C) of 1.18, leading to the conclusion that this Project is well economically feasible in terms of any of these indices.

The financial analysis indicated a debt service ratio of 1.31, financial internal rate of return (FIRR) of 10.7%, verifying that this Project is financially sound.

(10) With respect to the environmental impact of this Project, there will be no adverse effect on natural environment since certain transmission lines passing urban areas will be made of underground cables and measures will be taken to protect natural

scenery. In the area of social environmental impact, the electromagnetic interference to radio and television can be sufficiently prevented by adequate line conductor design that prevents corona noise.

Recommendation

(1) In order to implement this Project according to the schedule given in Table 6-1, the detailed design stage must be entered as soon as possible.

It is recommended that the lands of candidate sites for primary substations "A" and "B", and secondary substations "E", "F", "G", "K" and "L" are secured before the start of detailed design.

(2) This Project is designed to cover the period up to year 2000, and the power facilities will not have particular marginal capacity by the time when the Project is completed. It is recommended, therefore, that ANDE starts the technical study for the new distribution facility plan for 2001 and after as this Project begins to be in progress.

(3) Although the portion of domestic currency in the construction cost is small, being 21%, the interest rate of this financing is very high reflecting the inflation rate of the nation, and this substantially affects the profitability of this Project.

It is recommended that an interest rate lower than 7% shall be negotiated and obtained for foreign currency financing by ANDE, to say nothing of local currency financing under as advantageous condition as possible.

(4) The 220 kV transmission lines supplying power from the eastern power source area to the Metropolitan Area will consist of 4 circuits by 1990. The transmission capacity at this stage can be inferred as approximately 420 MW by a simplified calculation. The power demand at the project area in 1994 is expected to reach the transmission capacity. Therefore, the construction of the fifth circuit for expansion of this 220 kV transmission system must be completed by 1994 when a part of power facilities under this

Project is commissioned. As it is expected that for even this 5-circuit transmission system the power demand will reach its transmission capability by 1997, it is recommended that survey and study are started for expansion of this trunk transmission system.