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



MAY, 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

# PREFACE

In response to a request from the Government of the Republic of Paraguay, the Government of Japan decided to conduct a feasibility study on Power Distribution System Improvement Project in the Metropolitan Area and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Paraguay a study team headed by Mr. Ryuhei Oyama of Electric Power Development Co., Ltd. from July 1989 to March 1990.

The team held discussions on the Study with the officials concerned of the Government of Paraguay and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

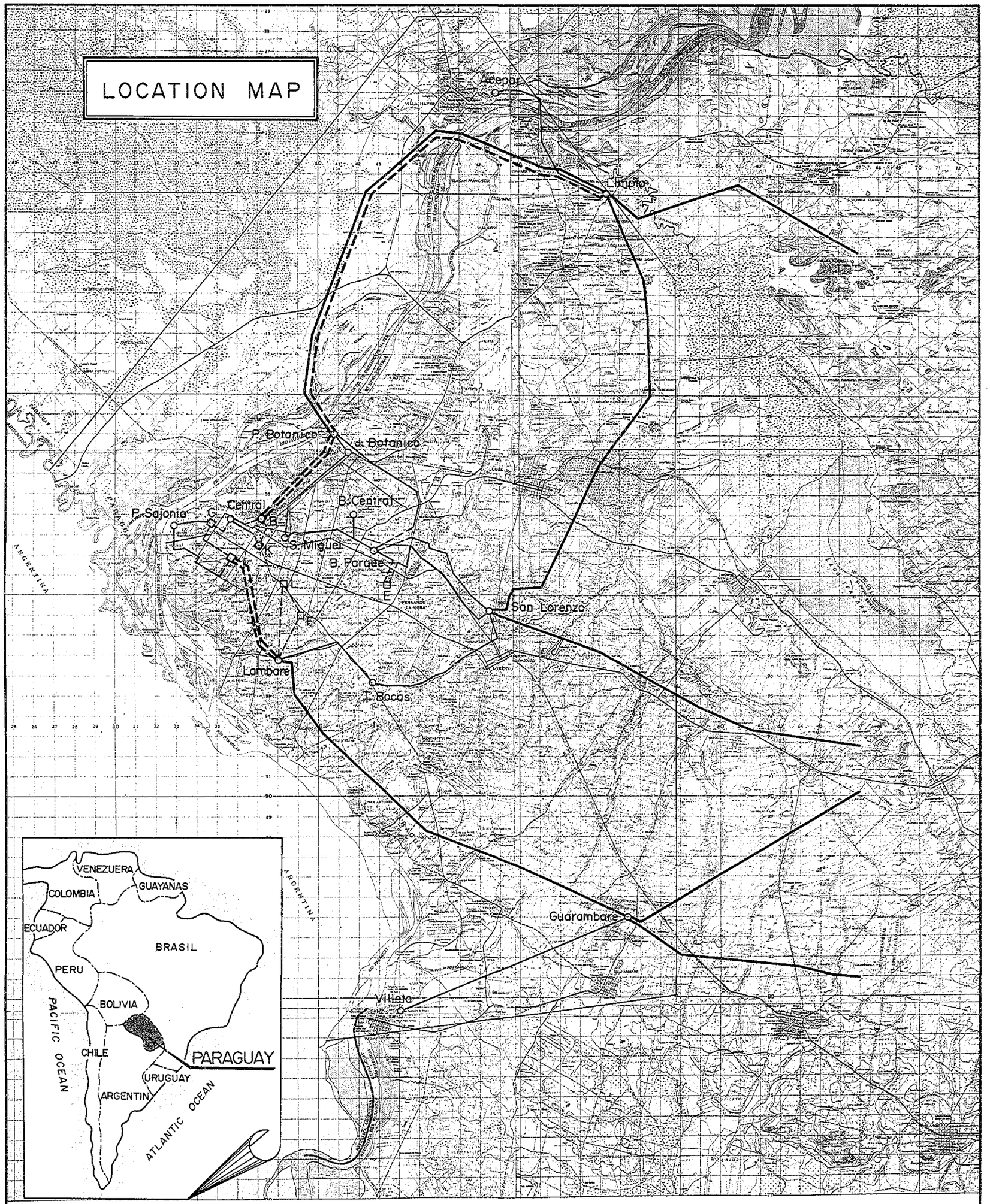
I hope that this report will contribute to the development of the project and to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Paraguay for their close cooperation extended to the team.

May, 1990

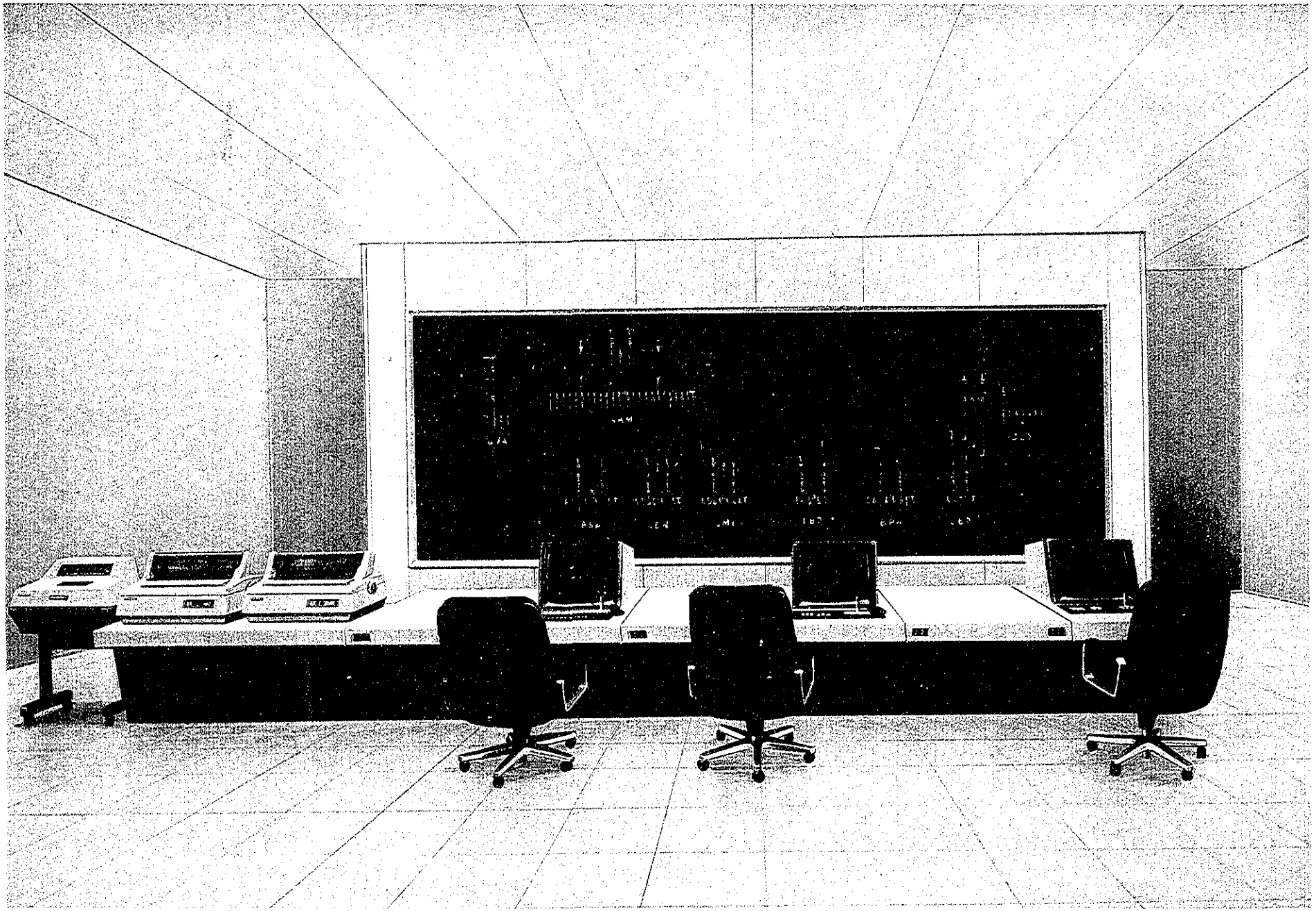
Kensuke Yanagiya
President
Japan International Cooperation Agency

# LOCATION MAP



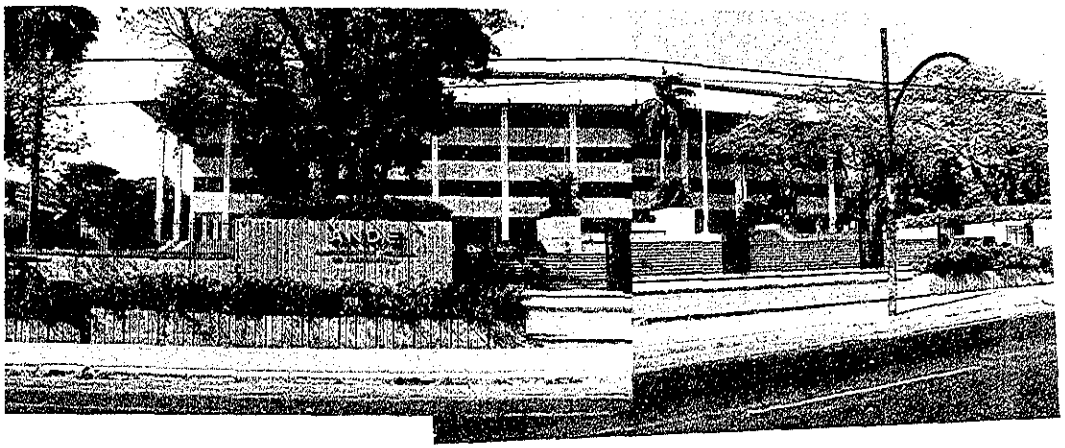

## LEGEND

- ——— : 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

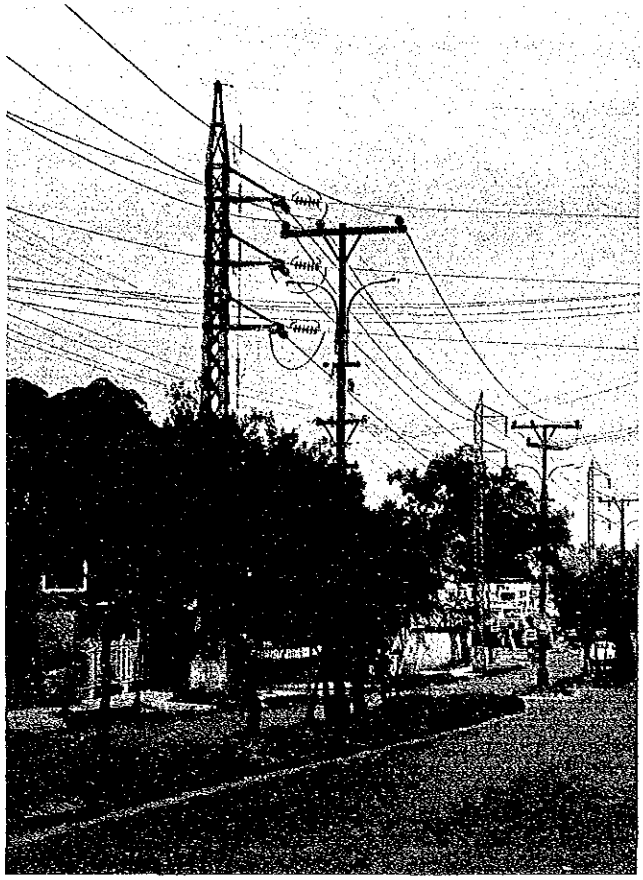


NEW DISTRIBUTION CONTROL CENTER

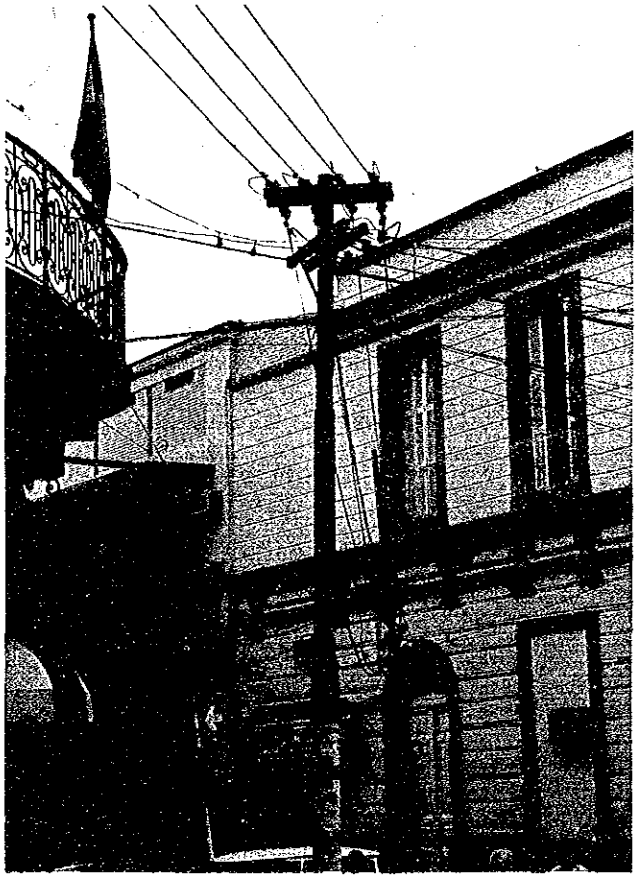
Asuncion City



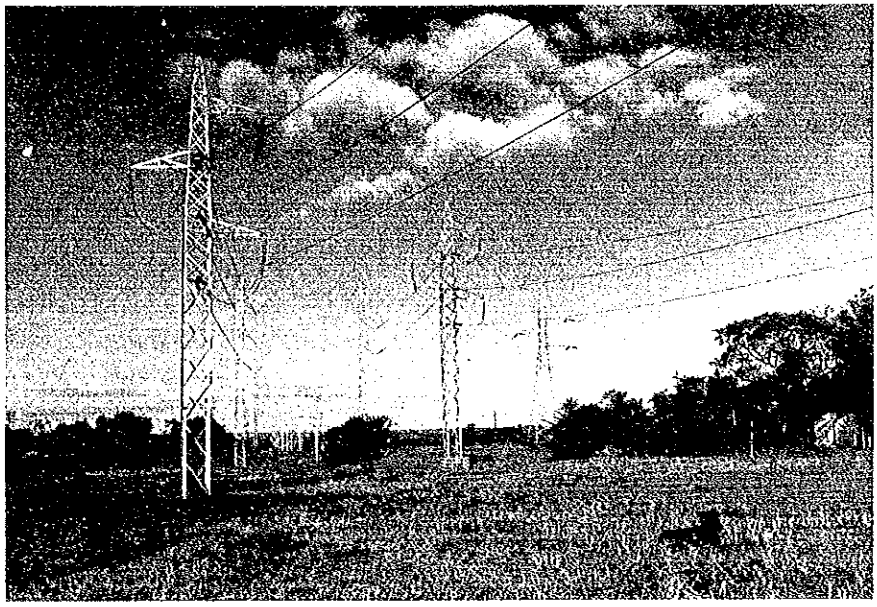

Head Office of ANDE



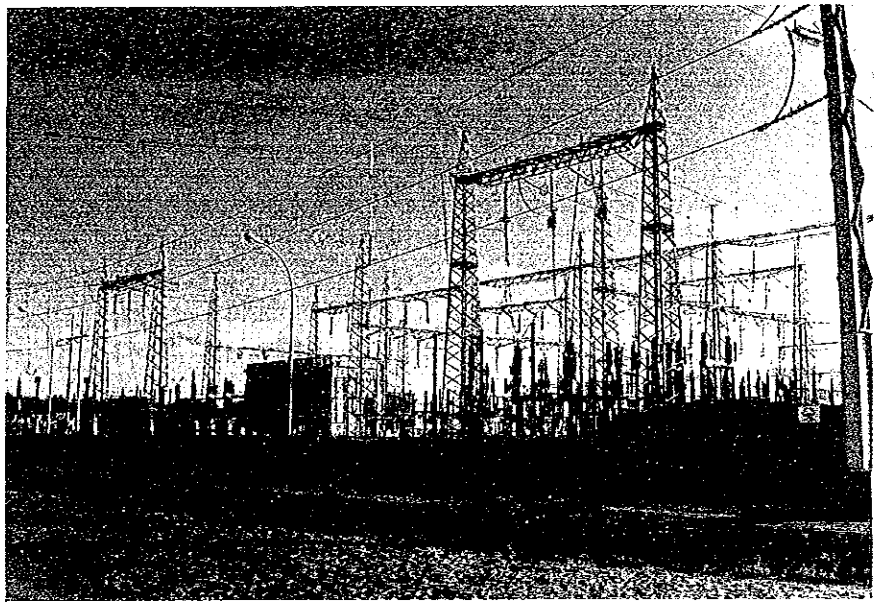
66 kV Transmission Line and
23 kV Distribution Line



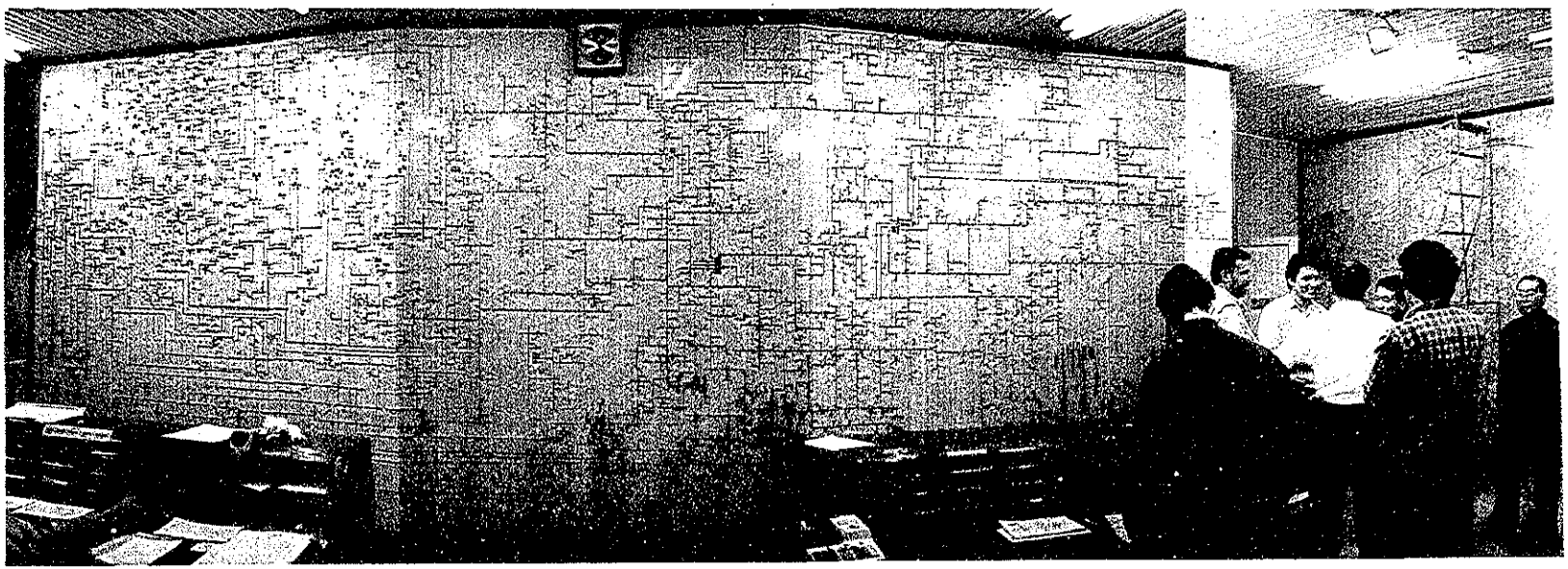
Low Voltage Distribution Line



220 kV Transmission Line



San Lorenzo Substation



Distribution Dispatching Center

The Location of New Distribution Dispatching Center

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# UNITS AND GLOSSARIES

## (1) Units

| | | |
|---|---|---|
| mm | : | Millimeter |
| cm | : | Centimeter |
| m | : | Meter |
| km | : | Kilometer |
| $cm^2$ | : | Square centimeter |
| $m^2$ | : | Square meter |
| $km^2$ | : | Square kilometer |
| kg | : | Kilogram |
| t | : | Metric ton |
| kW | : | Kilowatt |
| kWh | : | Kilowatt hour |
| MW | : | Megawatt (1,000 kW) |
| GWh | : | Gigawatt hour (1,000,000 kWh) |
| kV | : | Kilovolt |
| kVA | : | Kilovolt-Ampere |
| MVA | : | Megavolt-Ampere |
| MVAR | : | Megavar |
| MCM | : | Thousands of circular mils (for transmission line) |
| rpm | : | Revolutions per minute |
| Hz | : | Hertz (cycles per second) |
| El. | : | Elevation |
| °C | : | Degree in centigrade |
| % | : | Percentage |
| p.a | : | Per annum |

(2) Glossaries

(i) Terms

| | | |
|---|---|---|
| US$ | : | U.S. dollar |
| ₲ | : | Guarani |
| yr | : | Year |
| Max. | : | Maximum |
| Min. | : | Minimum |
| cct | : | Circuit |
| ACSR | : | Aluminum Conductor Steel Reinforced |
| GDP | : | Gross Domestic Product |
| IRR | : | Internal Rate of Return |
| UHF | : | Ultra High Frequency |
| VHF | : | Very High Frequency |
| IKL | : | Iso Keraunic Level |

(ii) Agencies

| | | |
|---|---|---|
| ANDE | : | Administracion Nacional de Electricidad |
| EPDC | : | Electric Power Development Co., Ltd. |
| JICA | : | Japan International Cooperation Agency |

(iii) Abbreviation of Substations

| | | |
|---|---|---|
| SLO | : | San Lorenzo |
| LAM | : | Lambare |
| GUA | : | Guarambare |
| PSA | : | Puerto Sajonia |
| SMI | : | San Miguel |
| BPA | : | Barrio Parque |
| ACY | : | Acaray |
| JBO | : | Jardin Botanico |
| PBT | : | Puerto Botanico |
| TBO | : | Tres Bocas |
| CEN | : | Centro |
| VTA | : | Villeta |
| LIM | : | Limpio |
| ACE | : | Acepar |

# CONCLUSION AND RECOMMENDATION

# 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 econo-

mically 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 11-1, 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.

# CHAPTER 1

# INTRODUCTION

# CHAPTER 1 INTRODUCTION

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# CHAPTER 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 years 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 improvement plan has been implemented so far. Today, many supply failures occur in these systems by facility failures. These power supply failures bring shut downs with some long time because communication systems depend 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 for power supply in the 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 there-

fore placed a request for technical assistance on implementation of this project on the Government of Japan as of January, 1988.

In response to the 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 power distribution system improvement project in March, 1989. The 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.

Based on this study, the Government of Japan decided to conduct a feasibility study on the Power Distribution System Improvement Project in the Metropolitan Area of the Republic of Paraguay (to be termed "the Project" hereafter), and assigned the task to JICA.

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

### 1.2.1 Objective of Study

The objective of the study is to conduct on-site surveys and domestic works on the Project 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.

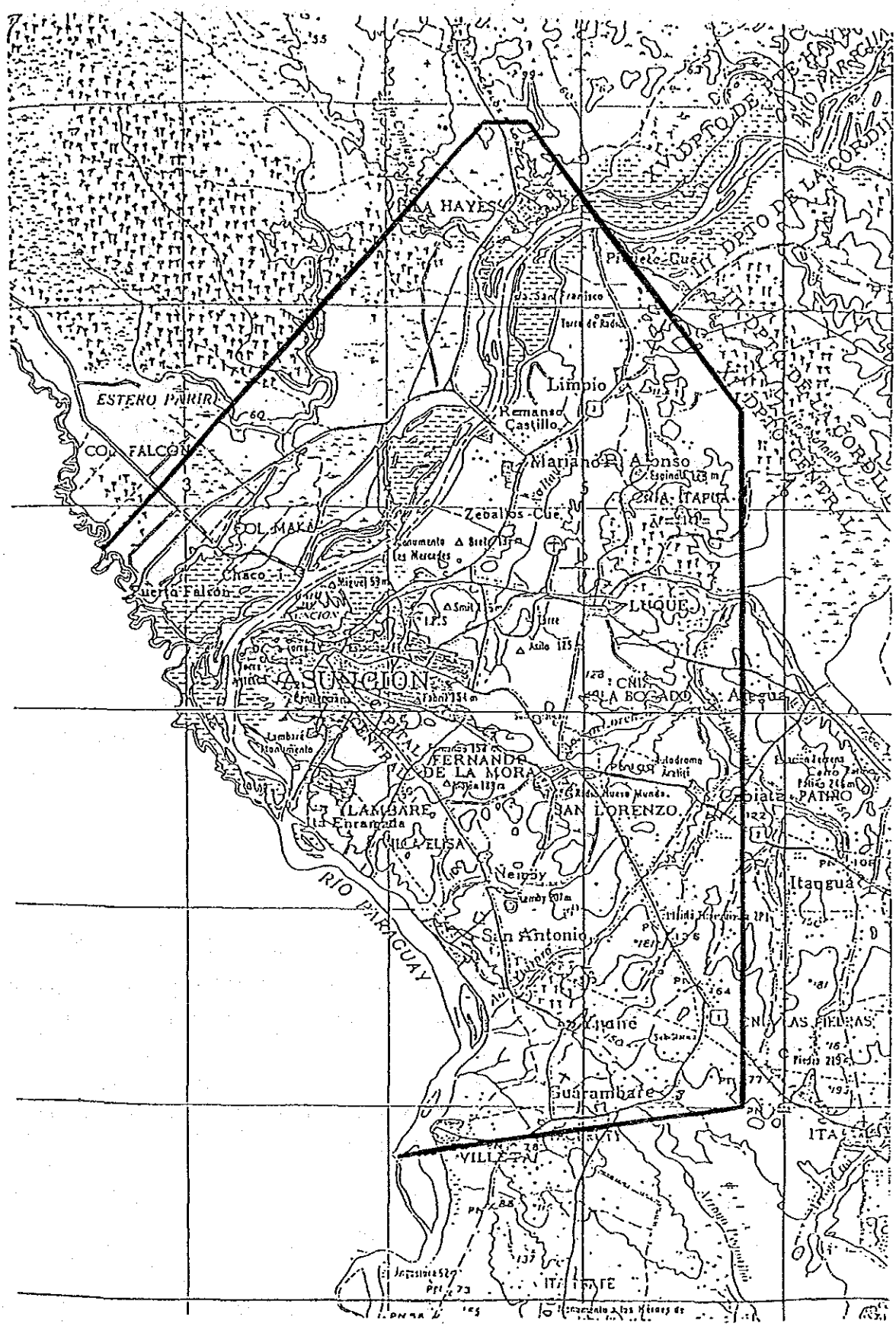
At the same time, it is planned to transfer the related technologies to the Paraguayan counterparts through the processes of the study.

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

### 1.2.2 Areas Covered by the Study

Concerning the areas to be covered by the 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.

Fig. 1-1 PROJECT AREA



The cities, towns and villages included in the Project Area, and the populations in 1972 and 1982 (as given in the Statistical Year Book 1985/86 by the United Nations), are as presented below.

| City/Town/Village | Population (1972) | Population (1982) |
|---|---|---|
| Asuncion | 388,958 | 454,981 |
| Fdo. de la Mora | 36,892 | 66,597 |
| Lambare | 31,732 | 67,168 |
| Limpio | 12,767 | 16,036 |
| Luque | 40,677 | 64,289 |
| M.R. Alonso | 7,388 | 14,636 |
| Nemby | 6,899 | 8,293 |
| San Antonio | 7,321 | 8,924 |
| San Lorenzo | 36,811 | 74,468 |
| Villa Elisa | 4,774 | 12,038 |
| Villa Hayes | 7,195 | 19,875 |
| Total | 581,769 | 807,305 |
| (National Total) | (2,357,955) | (3,029,830) |

In the Project Area, Itaugua, Caacupe, Paraguari, Quiindy and Caapucu, which belong to the Metropolitan Area as defined in the material of ANDE, are not included. Therefore, the Project Area is a little narrower than the Metropolitan Area defined by ANDE.

### 1.2.3 Scope of Study

The Scope of the Study has been defined by the "Scope of Work" that has been agreed upon by JICA Pre-study Mission and ANDE, as given in Appendix 1. The major items in the Scope of Study are presented below.

(1) Collection of existing materials, studied reports and various information related to the Project

(2) On-site surveys

(3) Analysis and evaluation of collected materials, information and data

(4) Study on distribution network reinforcement plan

(5) Study on distribution supervisory control system

(6) Economic Evaluation and Financial Analysis of the 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 Project has been conducted for 45 days, starting from July 5 in 1989 and ending in August 18.

The Study Mission (to be termed "The JICA Study Team" hereafter) 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 |

The JICA 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 studies.

Engineers of ANDE, who are experts in respective fields, and led by Ing. Guillermo Krauch (Manager of Business Department, Business

Bureau) of ANDE took the work of accompanying the JICA Study Team through on-site survey tours, and the coordination required for the survey have been performed by these engineers.

### 1.3.2 Domestic Works

The JICA Study Team, after returning from its 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 as trainees invited by JICA on October 12, 1989 to take part in surveys and studies for development of the Report, and stayed in Japan for one month.

The 5 members of the JICA 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 Team including the Leader again visited ANDE, to report the progress and hold discussions on the content of the Report.

# CHAPTER 2

# GENERAL DESCRIPTION OF PARAGUAY

# CHAPTER 2 GENERAL DESCRIPTION OF PARAGUAY

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# CHAPTER 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 at 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 km2, which is roughly divided into two parts by Paraguay River that runs from the north to the south through the country.

The eastern part of the country accounts for approximately 40% of the national land area, where hilly lands (with maximum elevation of 700 m) covered by rich forests are intermingled with flat lands (with minimum elevation of 60 m) to present a complex geographical features.

The western part of the country accounts for approximately 60% of the land area. This place is called "Chaco", a Spanish word representing a great plain. The land here is flat, and covered mostly by grasses and bushes.

The routes by which Paraguayans can reach the ocean from their inland nation are La Plata River, which is a downstream of Paraguay River and Parana River, a canal reaching Buenos Aires of Argentina, and the land route leading to Paranagua and other cities in Brazil. Although the land transportation is becoming more important in recent years, 75% of international transportation of cargoes still depend on water channels.

### 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 temperature and precipitation records of the Metropolitan Area are quoted below.

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precipitation (mm) | 154 | 145 | 140 | 166 | 99 | 73 | 49 | 64 | 86 | 124 | 163 | 142 | 117 |
| Maximum Temperature (°C) | 42.0 | 40.8 | 40.0 | 36.7 | 33.5 | 32.9 | 34.0 | 38.7 | 39.1 | 40.3 | 40.2 | 41.9 | 38.0 |
| Minimum Temperature (°C) | 12.0 | 14.0 | 10.0 | 6.4 | 2.6 | 1.4 | 0.6 | 0.0 | 3.6 | 7.0 | 8.8 | 10.8 | 6.9 |
| Average Temperature (°C) | 27.5 | 27.1 | 25.9 | 22.5 | 19.6 | 17.9 | 18.2 | 18.4 | 20.6 | 23.0 | 24.4 | 26.4 | 22.6 |
| Humidity (%) | 68 | 70 | 72 | 71 | 76 | 75 | 70 | 71 | 66 | 67 | 67 | 68 | 70 |

Note: Average records from 1965 to 1985

### 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 estimated 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 lower 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 has 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 is 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 is 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 consists 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 national industry.

Although Paraguay is well known as a nation having plenty of cattle, the contribution of stock farming to GDP is relatively small, being

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

8%. This is probably due to the underdeveloped meat processing industry.

### 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 Payments

To describe the import and export status of Paraguay in 1988, while the agricultural, stock farming 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 payments has been constantly in deficit.

The deficit in 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 balance of international payments is presented in Table 2-4.

Table 2-2 Exports (FOB)

(1,000 US$: %)

| Items \ Year | 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

The Central Bank of Paraguay 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 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 consumer price indices are presented in Table 2-5.

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 in Paraguay 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.

The major causes of inflation include governmental expenditures not supported by appropriate income, speculation in markets where goods are in shortage, and devaluation of exchange rate.

### 2.2.5 New Economic Development Plan

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

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

The following targets are stipulated in the Plan.

(1) Continuation of Development Plan

(2) Stabilization of commodity prices

Table 2-5 Consumer Price Index

(100 in 1980)

| Year | General Index | Increasing Rates (%) |
|---|---|---|
| 1983 | 138.1 | 13.5 |
| 1984 | 166.1 | 20.3 |
| 1985 | 208.0 | 12.5 |
| 1986 | 274.0 | 31.7 |
| 1987 | 333.8 | 21.8 |
| 1988 | 410.6 | 23.0 |

Source: Departamento de Informatica

(3) Abolition of plural exchange rate and adoption of floating exchange rate

Note: Three different exchange rates were used as of November, 1988. (Value of 1 US$ in guarani.)

(i) 400 guarani:

External debt services by public organizations including the power corporation, and import by government and public organizations.

Import by national merchant fleet, and import of petroleum and other fuels.

(ii) 550 guarani:

Export, and import of agricultural products.

(iii) Free exchange rate, 950 guarani:

Import of products other than the agricultural, and transfer of civil sector capitals.

(4) Prevention of inflation

(5) Public investment policy with more consideration on cost/benefit

(6) Expansion of export based on agricultural industries

(7) Expansion of technical cooperation with foreign nations

(8) Development of domestic agricultural sector

(9) Forest conservancy

The economic growth expected by the Long Term Economic Plan for the period from 1989 to 2005 is presented in Table 2-6.

In this plan, three cases of economic growth, the high, medium, and low cases, are projected. In the "medium case", the annual averaged growth rate of GDP from 1990 to 1995 is 5.3%, and that from 1995 to 2005 is 5.0%.

Table 2-6 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 the 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 11.4% per annum and the latter 8.2%.

This estimation of energy consumption growth (in terms of thousand tons oil equivalent) is eqoted 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 |

As there are some oil resources in Chaco District of Bolivia, it has been expected that there might also be oil in Chaco District of Paraguay. Oil explorations have been done several times since 1940 by American corporations, but none of these attempts was successful so far. The hydroelectric resources are the largest energy asset owned by Paraguay. The Government of Paraguay has been promoting the development of hydroelectric resources since 1960 based on its aggressive policy of making full use of this precious asset.

The development of hydroelectric power is in progress. Acaray Power Plant has been completed, and Itaipu Power Plant, which is the world's largest hydroelectric project being developed under cooperation with Brazil, and Yacyreta Power Plant, a joint development with Argentina, are under construction. The portion of Itaipu Power Plant owned by Paraguay is already completed. The development of

Yacyreta Power Plant had been suspended due to the political instability and financial predicament on the part of Argentina, but the construction was resumed in 1986.

# CHAPTER 3

# CURRENT STATUS OF ELECTRIC UTILITY INDUSTRY

# CHAPTER 3 CURRENT STATUS OF ELECTRIC UTILITY INDUSTRY

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# CHAPTER 3 CURRENT STATUS OF ELECTRIC UTILITY INDUSTRY

## 3.1 Electric Power Supply Structures

The electric utility industry of Paraguay is being operated by the National Administration of Electricity (ANDE) and the Itaipu Binational Entity responsible for the construction and operation of the undertaking.

ANDE operates the whole power supply systems including power generation and power distribution, and the Itaipu Binational divide the energy produced at the Itaipu Power Plant equally between Paraguay and Brasil, each retaining the right to preferential purchase of any of the other's unused electric power.

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

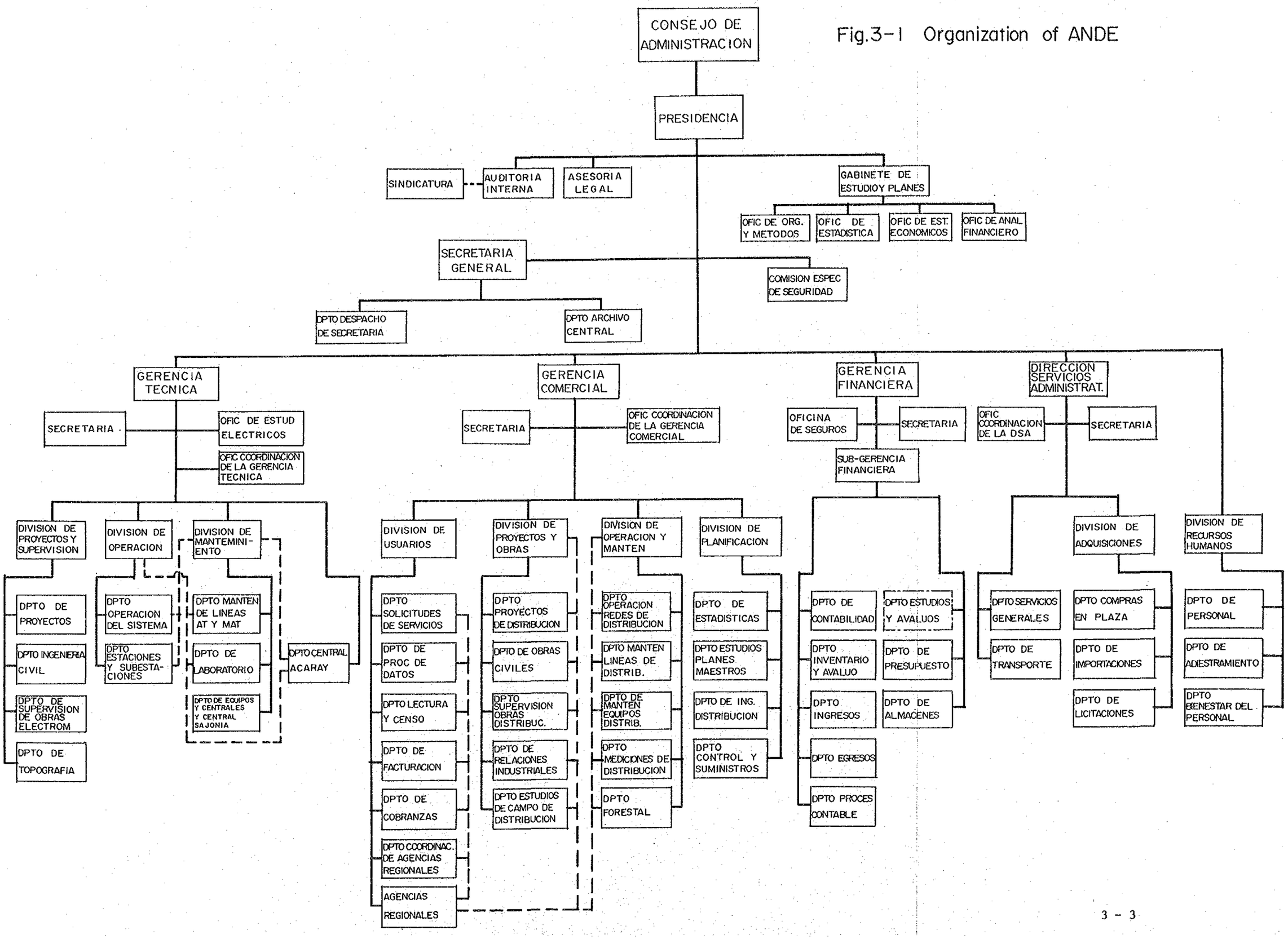
The organizational chart of ANDE is given in Figure 3-1.

The 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 ¢ and ANDE employs 2,509 persons, as the end of 1988.

The Itaipu Binational Entity has been established in May 1974 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.

Fig.3-1 Organization of ANDE



## 3.2 Electric Power Demand and Supply

### 3.2.1 The Past Trend of Electric Power Consumption

The past trend of electric power consumption in Paraguay is illustrated in Table 3-1.

Since Itaipu Power Plant started operation in 1985, the capacity of supply in this country has been drastically increased. As of 1988, the domestic power demand (in whole System of ANDE, Sistema Interconectado Nacional, to be termed "SIN") was 357 MW while there was supply capability as much as 6,574 MW. Thus, most of power was exported to Brazil.

ANDE purchases most of its power from the Itaipu Binational and supply this to domestic customers adding its own generated energy. At the same time, the surplus power is exported to Brazil and Argentina, and also used as construction power for Itaipu and Yacyreta Project.

The domestic generated energy of ANDE in 1988 was 1,766 GWh. The consumed energy in the 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 80.3% of the total, is consumed in the Metropolitan Area.

The energy consumption of each load category within Paraguay is presented in Table 3-2.

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 is 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 collecting equipment of products in eastern agricultural villages.

Rate of electrification in the country is 49.4% as of 1988. There are 62 customers with load of 1,000 kW or more and among them 7 have load of 3,000 kW or more.

Table 3-1 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

Table 3-2 Energy by Category (ANDE)

(1) Consumed Energy

(GWh)

| Catgegory \ Year | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | Annual Increase Rate (1988/1983) (%) |
|---|---|---|---|---|---|---|---|
| Household | 492.2 | 540.7 | 399.5 | 461.2 | 504.9 | 566.6 | ] 10.2 |
| Commercial | | | 166.2 | 176.3 | 197.0 | 232.4 | |
| Industrial | 260.5 | 286.5 | 204.7 | 221.8 | 287.1 | 392.9 | ] 18.2 |
| Others | | | 143.7 | 158.6 | 184.0 | 209.1 | |
| Municipal | 32.6 | 33.1 | 34.9 | 36.6 | 42.8 | 45.3 | ] 7.8 |
| Public Lighting | 41.9 | 47.0 | 50.9 | 55.5 | 60.1 | 63.3 | |
| Total | 827.2 | 907.3 | 999.9 | 1,110.0 | 1,275.9 | 1,509.6 | 12.8 |

(2) Number of Customers

| Catgegory \ Year | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | Annual Increase Rate (1988/1983) (%) |
|---|---|---|---|---|---|---|---|
| Household | 242,507 | 259,373 | 223,978 | 244,888 | 256,489 | 270,455 | ] 5.7 |
| Commercial | | | 35,415 | 37,986 | 43,505 | 49,008 | |
| Industrial | 1,580 | 1,620 | 3,330 | 3,493 | 3,862 | 4,335 | |
| Others | | | 15,300 | 16,394 | 18,984 | 21,514 | |
| Municipal | 1,100 | 1,148 | 1,214 | 1,303 | 1,399 | 1,494 | 8.0 |
| Public Lighting | | | | | | | |
| Total | 245,187 | 262,141 | 279,237 | 304,064 | 324,239 | 346,806 | 7.2 |

Source: ANDE

### 3.2.2 Load Characteristics

The peak power demand in the Metropolitan Area was 282 MW in 1988, which is approximately 80% the nations total power demand of 357 MW.

An example of load curve in the Project Area is presented in Figure 3-2. The daily load curve has the typical pattern of "lighting peak in the evening", because the household cooking is usually done by propane gas in the Metropolitan Area and there are few factories with large electric load in the area. The duration of the evening peak is relatively short, being from 2 to 3 hours.

### 3.2.3 Power System Operation

The Central Load Dispatching Center is located in the Head Office Building of ANDE, where the operation of power plants, 220 kV transmission lines, 66 kV transmission lines, and substations down to the 66 kV level are dispatched.

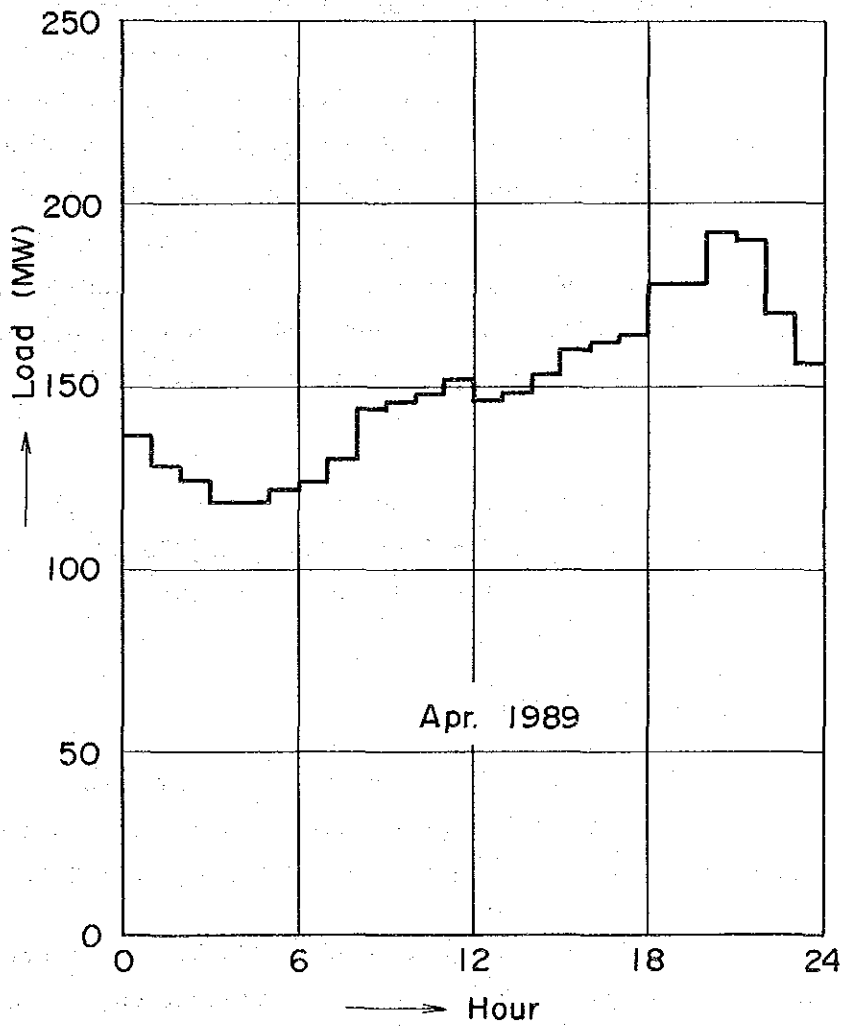
The command of the Central Load Dispatching Center is transmitted to each power facility by UHF telephone channels. The remote control function or telemeter system has not been introduced, and the power system operation is conducted mainly on the mimic power system board.

ANDE is now testing a prototype system with an attempt to change the current operation system to a remote monitoring/control system employing computer system.

The Distribution Dispatching Center is located at Don Basco near Centro, and the office is engaged in the monitoring, operation and maintenance of distribution lines below 23 kV, and deals with complaints placed by customers.

ANDE plans to move the Distribution Dispatching Center to the premise of its warehouse located at Boggiani in eastern Centro.

Fig. 3-2 Daily Load Curve
(Project Area)



## 3.3 Power Facilities

### 3.3.1 Power Generation Facilities

The current status of power generation facilities in Paraguay is presented in Table 3-3. Those under construction and being planned for construction are presented in Table 3-4.

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 Power 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.

### 3.3.2 Power Transmission Facilities

The power system diagram of ANDE's power systems is presented in Figure 3-3. The current status of transmission facilities and those under construction are presented in Table 3-5 and Table 3-6.

The standard transmission voltage is either 220 kV and 66 kV. The 220 kV transmission system have a radial configuration, 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 designed towers) is under construction with the scheduled commissioning date of 1990. Local trunk systems have sufficient

Table 3-3 Generating Capacity

| Owner | Type | Name | Installed Capacity (MW) | Year of Commissioning | Generated Energy | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| La Entidad Binacional ITAIPU | Hydro | Itaipu | 700 | 1985 | | | | | | |
| | | | 700 | " | | | | | | |
| | | | 700 | " | | | | | | |
| | | | 700 | 1986 | | | | | | |
| | | | 700 | 1987 | | | | | | |
| | | | 700 | " | | | | | | |
| | | | 700 | 1988 | | | | | | |
| | | | 700 | " | | | (for ANDE only) | | | |
| | | | 700 | " | | | | | | |
| | | Total | 6,300 | | - | 161.6 | 391.2 | 837.8 | 1,114.6 | 1,414.8 |
| ANDE | Hydro | Acaray | 47.5 | 1968 | | | | | | |
| | | | 47.5 | " | | | | | | |
| | | | 47.5 | 1975 | | | | | | |
| | | | 47.5 | " | | | | | | |
| | | Total | 190 | | 782.1 | 885.5 | 864.4 | 800.9 | 617.7 | 676.9 |
| | Diesel | Total | 84 | | 10.9 | 8.9 | 3.6 | 3.9 | 3.7 | 3.7 |
| | Total | | 274 | | 793.0 | 894.4 | 868.0 | 804.8 | 621.4 | 680.6 |
| Total | Hydro | | 6,490 | | 782.1 | 1,047.1 | 1,255.6 | 1,638.7 | 1,732.3 | 2,091.7 |
| | Diesel | | 84 | | 10.9 | 8.9 | 3.6 | 3.9 | 3.7 | 3.7 |
| | Total | | 6,574 | | 793.0 | 1,056. | 1,259.2 | 1,642.6 | 1,736.0 | 2,095.4 |

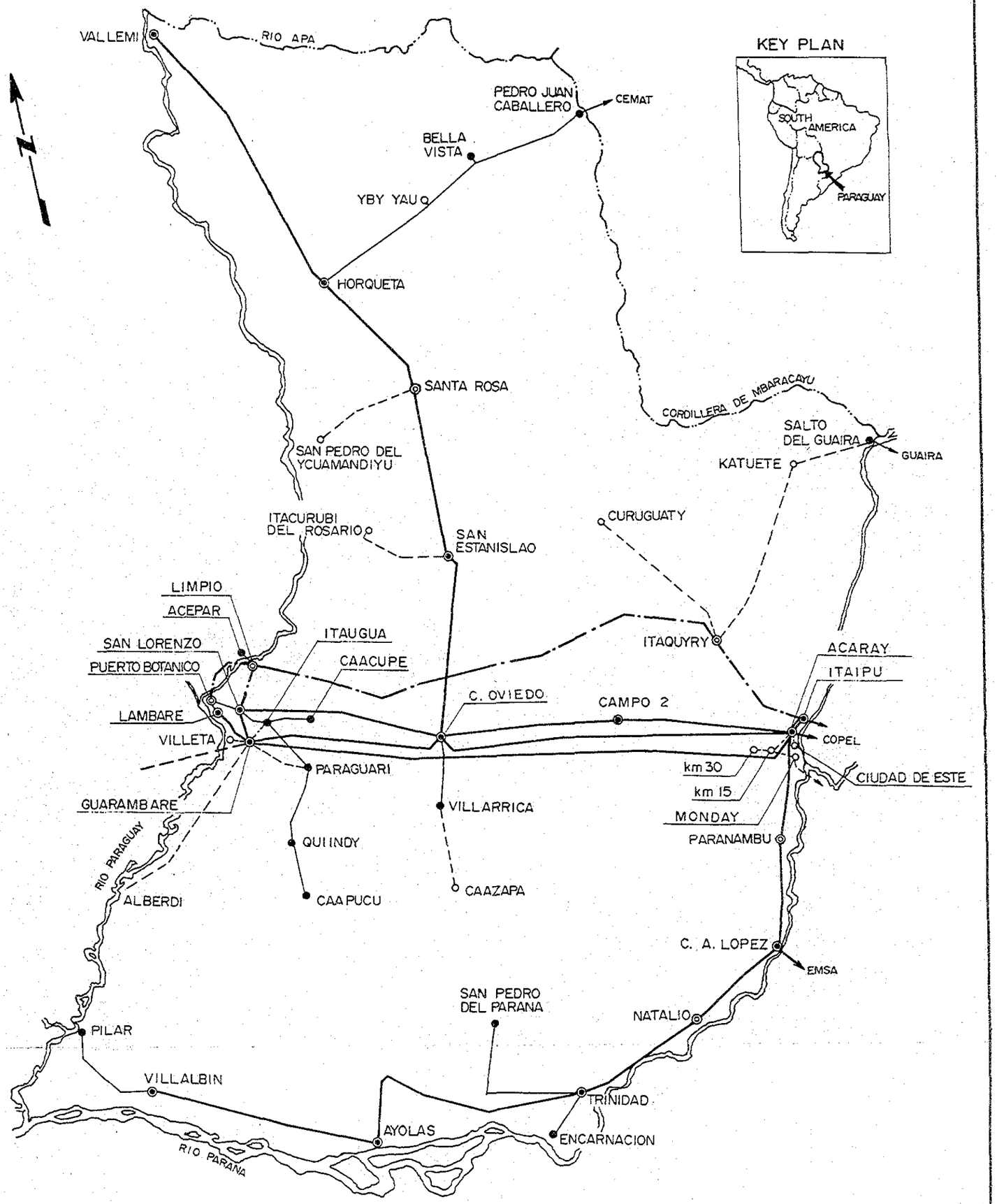
Source: ANDE

Table 3-4 Hydro-Power Stations under Construction

| | ITAIPU | YACYRETA | CORPUS |
|---|---|---|---|
| Partner | Brasil | Argentina | Argentina |
| Location of the Dam | 14 km upstream of Stroessner City | 120 km down stream of Encarnacion City | 14 km upstream of Encarnacion City |
| Installed Capacity | 12,600 MW<br>(6,300 MW) | 1st Stage 2nd Stage<br>2,700 MW 4,050 MW<br>(1,350 MW) (2,025 MW) | 4,020 MW<br>(2,010 MW) |
| Annual Energy | 70 x $10^9$ kWh | 27 x $10^9$ kWh | 18.9 x $10^9$ kWh |
| Construction Period | 1974 - 1991 | 1980 - 1994 (1st Stage) | Under Planning |

Source: ANDE

Note: ( ) is power for Paraguay.




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. 3 – 3

Table 3-5 Transmission Lines (1)

| Voltage | System | Section | No. of Circuit | Circuit Length (km) | Size | Type of Support | Year of Commission |
|---|---|---|---|---|---|---|---|
| 220 kV | Trunk Lines to Metropolitan Area | Acaray - Campo Dos - C.Oviedo - San Lorenzo | 1 | 302.2 | ACSR 395.6 mm$^2$ | Iron Tower | 1968 |
| | | Acaray - C.Oviedo - Guarambare - San Lorenzo | 1 | 309.4 | ACSR 374.7 mm$^2$ | " | 1980 |
| | | Acaray - Guarambare | 1 | 291.3 | " | " | 1981 |
| | | Guarambare - Lambare | 1 | 23.4 | ACSR 481.3 mm$^2$ | " | 1981 |
| | Interconnect Line | Itaipu - Acaray | 2 | 10.0 | | " | 1984 |
| | Southern Trunk Lines | Acaray - Carlos A. Lopez | 1 | 113.3 | AAAC 402.8 mm$^2$ | " | 1982 |
| | | Carlos A. Lopez - Trinidad | 1 | 124.8 | ACSR 374.7 mm$^2$ | " | 1982 |
| | | Trinidad - Ayolas | 1 | 159.3 | " | " | 1985 |
| | | Ayolas - Villalbin | 1 | 120.9 | ACSR 481.8 mm$^2$ | " | 1987 |
| | Northern Trunk Lines | C. Oviedo - Horqueta | 1 | 265.1 | ACSR 374.7 mm$^2$ | " | 1984 |
| | | Horqueta - Vallemi | 1 | 178.0 | " | " | 1988 |
| | 220 kV Total Circuit Length | | | 1,897.7 | | | |

Source: ANDE

Table 3-5 Transmission Lines (2)

| Voltage | System | | Section | No. of Circuit | Circuit Length (km) | Size | Type of Support | Year of Commission |
|---|---|---|---|---|---|---|---|---|
| 66 kV | Metro-politan Area | Project Area | San Lorenzo - Barrio Parque | 1 | 8.5 | ACSR 176.7 mm$^2$ | Iron Tower | 1968 |
| | | | Barrio Parque - San Miguel | 1 | 5.1 | ACSR 176.7 mm$^2$ XLPE 150 mm$^2$ | Iron Tower Underground Cable | " |
| | | | San Miguel - Jardin Botanico | 1 | 5.9 | ACSR 176.7 mm$^2$ XLPE 150 mm$^2$ | Iron Tower Underground Cable | " |
| | | | Puerto Sajonia - Lambare | 1 | 9.2 | ACSR 176.7 mm$^2$ | Iron Tower | " |
| | | | San Lorenzo - Jardin Botanico | 1 | 11.9 | " | Pipe Tower | 1976 |
| | | | San Lorenzo - Tres Bocas | 1 | 8.6 | " | Iron Tower | 1968 |
| | | | Lambare - Tres Bocas | 1 | 6.0 | " | " | " |
| | | | San Miguel - Centro | 1 | 3.5 | XLPE 150 mm$^2$ | Underground Cable | " |
| | | | Centro - Puerto Sajonia | 1 | 3.5 | ACSR 176.7 mm$^2$ XLPE 150 mm$^2$ | Iron Tower Underground Cable | " |
| | | | Lambare - Centro | 1 | 8.0 | ACSR 176.7 mm$^2$ XLPE 300 mm$^2$ | Iron Tower Underground Cable | 1987 |
| | | Rural Area | San Lorenzo - Itaugua | 1 | 22.1 | ACSR 142.5 mm$^2$ | Pipe Tower | 1973 |
| | | | Itaugua - Caacupe | 1 | 18.6 | " | " | " |
| | | | Itaugua - Paraguari | 1 | 28.9 | " | " | " |
| | | | Paraguari - Quiindy - Caapucu | 1 | 75.3 | " | " | " |
| | Central System | | Coronel Oviedo - Villarrica | 1 | 38.8 | " | " | " |
| | Southern System | | Trinidad - Encarnacion | 1 | 27.2 | ACSR 176.7 mm$^2$ | Concrete Tower | 1982 |
| | | | Trinidad - San Pedro Del Parana | 1 | 90.4 | " | " | 1984 |
| | | | Villalbin - Pilar | 1 | 54.4 | " | " | 1987 |
| | Northern System | | Horqueta - Pedro Juan Caballero | 1 | 164.9 | " | " | 1984 |
| | 66 kV Total Circuit Length | | | | 590.5 | | | |

Table 3-6 Transmission Lines under Construction

| System | Section | Voltage (kV) | No. of Circuit | Circuit Length (km) | Size | Year of Commission |
|---|---|---|---|---|---|---|
| Trunk Lines to Metropolitan Area | Itaipu - Limpio | 220 | 1 | 321 | ACSR 374.7 $mm^2$ | 1990 |
| | Limpio - Jardin Botanico | 220 | 1 | 28 | " | " |
| | Limpio - San Lorenzo | 220 | 1 | 24.4 | " | 220 kV design Operated at 66 kV |
| Metropolitan System | Guarambare - Itaugua | 66 | 1 | 17.3 | ACSR 176.7 $mm^2$ | 1989 |
| | Guarambare - Villeta | 66 | 1 | 12.5 | " | |

Source: ANDE

capacity, but they have radial configuration despite the fact that they transmit power for long distances.

The aggregate length of these transmission lines amounts to 1,890 km, and all of which are overhead lines. The 66 kV systems can be divided into the Metropolitan Area system, the central system, the southern system and the northern system. These systems started transmission in 1968, 1973, 1982 and 1984 respectively, and the current configurations have been created after a series of expansion programs. The Metropolitan Area system has a loop configuration, but its transmission capacity falls short when a single circuit fails, leading to supply failure. The local systems have capacity margins, but they are radial, single circuit lines. The aggregate line length as of the end of 1988 was 623 km, comprising of 611 km overhead lines and 12 km underground cables.

### 3.3.3 Substation Facilities

The data of substations operated by ANDE are presented in Table 3-7, and those under construction and planned for construction are presented in Table 3-8.

As of the end of 1988, there are 29 substations. They consist of 9, 220 kV primary system substations, and 20 secondary substations for distribution (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, with the aggregate installed capacity of 1,080 MVA. The total supply capacity is 708 MVA on the 66 kV side, and 638 MVA on the 23 kV side.

The unit capacity of transformer banks is standardized into 5 types from 25 MVA to 120 MVA for the 220 kV primary system transformers, and into 10 types from 5 MVA to 60 MVA for the distribution transformers. A substantial number of phase compensation capacitors are installed in substations of the Metropolitan Area, but their capacity is small. Few capacitors are provided in substations in local areas.

Table 3-7 Substation (1)

| System | | Substation | | Transformer | | | Capability (MVA) | | 23 kV Feeder | Year of Commission |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Voltage (kV) | Capacity and Number (MVA) | Phase x Unit | 66 kV | 23 kV | | |
| Metro-politan Area | Project Area | San Lorenzo | SLO | 220/66<br>220/23 | 60 x 2<br>40 x 1 | 1 x 3 x 2<br>3 x 1 | 120<br>40 | 40 | 8 | 1968 |
| | | Lambare | LAM | 220/66/23 | 120/60/60 x 2 | 1 x 3 x 2 | 240 | 120 | 9 | " |
| | | Guarambare | GUA | 220/66<br>66/23 | 37.5 x 1<br>20 x 1 | 1 x 3 x 2<br>3 x 1 | 37.5 | 20 | 4 | 1981 |
| | | Puerto Sajonia | PSA | 66/23 | 20 x 2 | 3 x 2 | | 40 | 5 | 1968 |
| | | San Miguel | SMI | 66/23 | 20 x 2 | 3 x 2 | | 40 | 5 | " |
| | | Barrio Parque | BPA | 66/23 | 20 x 2 | 3 x 2 | | 40 | 7 | " |
| | | Jardin Botanico | JBO | 66/23 | 12 x 2 | 3 x 2 | | 24 | 5 | " |
| | | Tres Bocas | TBO | 66/23 | 10 x 2 | 3 x 2 | | 20 | 4 | 1979 |
| | | Centro | CEN | 66/23 | 20 x 2 | 3 x 2 | | 40 | 4 | 1987 |
| | Rural Area | Itaugua | ITG | 66/23 | 20 x 1 | 3 x 1 | | 20 | | 1973 |
| | | Caacupe | CAE | 66/23 | 12 x 1 | 3 x 1 | | 12 | | " |
| | | Paraguari | PAR | 66/23 | 9 x 1 | 3 x 1 | | 9 | | " |
| | | Caapucu | CAU | 66/23 | 5 x 1 | 3 x 1 | | 5 | | " |
| | | Quiindy | QUI | 66/23 | 5 x 1 | 3 x 1 | | 5 | | 1987 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Metropolitan Area | Project Area | | | 661.5 | | - | 384 | 51 | |
| | Rural Area | | | 51.0 | | - | 51 | | |
| | Total | | | 712.5 | | 437.5 | 435 | | |

Source: ANDE

Table 3-7 Substation (2)

| System | Substation | | Transformer | | | Capability (MVA) | | Year of Commission |
|---|---|---|---|---|---|---|---|---|
| | | | Voltage (kV) | Capacity x Unit (MVA) | Phase x Unit | 220 kV | 23 kV | |
| Central System | Coronel Oviedo | COV | 220/66<br>66/23 | 37.5 x 1<br>12 x 1 | 1 x 3 x 1<br>3 x 1 | 37.5 | 12 | 1973 |
| | Villarrica | VIL | 66/23 | 10.7 x 1 | 3 x 1 | | 10.7 | " |
| | Campo Dos | CDO | 220/23 | 10 x 1 | 3 x 1 | 10 | 10 | 1981 |
| Southern System | Trinidad | TRI | 220/66<br>66/23 | 37.5 x 1<br>10 x 1 | 1 x 3 x 1<br>3 x 1 | 37.5 | 10 | 1982 |
| | Encarnacion | ENC | 66/23 | 20 x 1 | 3 x 1 | | 20 | " |
| | San Pedro Del Parana | SPP | 66/23 | 3 x 1 | 3 x 1 | | 3 | 1984 |
| | Carlos A. Lopez | CAL | 220/23 | 12.5 x 1 | 3 x 1 | 12.5 | 12.5 | 1985 |
| | Ayolas | AYO | 220/23 | 20 x 1 | 3 x 1 | 20 | 20 | " |
| | Villalbin | VIN | 220/66/23 | 30/25/10 x 1 | 3 x 1 | 30 | 10 | 1987 |
| | Pilar | PIL | 66/23 | 15 x 1 | 3 x 1 | | 15 | " |
| Northern System | Horqueta | HOR | 220/66<br>66/23 | 37.5 x 1<br>20 x 1 | 1 x 3 x 1<br>3 x 1 | 37.5 | 20 | 1984 |
| | Pedro Juan Caballero | PJC | 66/23 | 10 x 1 | 3 x 1 | | 10 | " |
| | Cruce Bella Vista | CBV | 66/23 | 5 x 1 | 3 x 1 | | 5 | 1987 |
| | San Estanislao | SES | 220/66/23 | 25/15/15 x 1 | 3 x 1 | 25 | 15 | " |
| Eastern System | Acaray | ACY | 220/66/23 | 30/20/15 x 2 | 3 x 3 | 60 | 30 | 1970 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SIN | Metropolitan System | | | 712.5 | | 437.5 | 435 | |
| | Others | | | 375.7 | | 270 | 203.2 | |
| | Total | | | 1,088.2 | | 707.5 | 638.2 | |

Table 3-8 Substation under Construction

| System | Substation | Transformer | | Capability (MVA) | | Year of Commission |
|---|---|---|---|---|---|---|
| | | Voltage (kV) | Capacity x Unit (MVA) | 220 kV | 23 kV | |
| Metropolitan Area | Limpio | 220/66<br>66/23 | 37.5 x 1<br>20 x 1 | 37.5 | 20 | 1990 |
| Southern System | Puerto Botanico | 220/66/23 | 120/60/60 x 1 | 120 | 60 | " |
| | Paranambu | 220/23 | 10 x 1 | 10 | 10 | " |
| | Natario | 220/23 | 10 x 1 | 10 | 10 | " |
| Eastern System | Itaquyry | 220/66/23 | 25/15/15 x 1 | 25 | 15 | " |

As for the construction of substations, Limpio Substation and Puerto Botanico Substation are being constructed in the Metropolitan Area in pace with construction of new 220 kV transmission line. Paranambu Substation and Natario Substation are being constructed in the southern system, and Itaquyry Substation in the eastern system.

### 3.3.4 Distribution Facilities

The current status of power distribution facilities being operated by ANDE is presented in Table 3-9.

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.

Concerning construction of new facilities, the Local City Electrification Project (IDB, 20 million dollars) is in progress in the northern district of the country. At the same time, specific rural electrification projects are being implemented under ANDE's own financing according to its own electrification plan and in response to customers' requests.

### 3.3.5 Telecommunication Facilities

The telecommunication systems being operated by ANDE consist of power line carrier systems and radio systems. The power line carrier systems are used for communication between major substations, protective relays, telex services and telemeters by using 220 kV and 66 kV lines. The radio systems are UHF (400 MHz band) and VHF (150 MHz band) systems, which are mainly used for telephone services.

Table 3-9 Distribution Lines

| | | | Unit | A N D E S I N | | | | | | Metropolitan Area | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
| Length of Lines | Medium Voltage | Overhead | km | 2,917.4 | 3,429.7 | 3,933.9 | 4,376.8 | 4,890.9 | 5,451.3 | 622.2 | 651.8 | 675.1 | 698.8 | 735.1 | 776.5 |
| | | Under-ground | km | 250.8 | 260.1 | 270.1 | 274.9 | 306.7 | 322.7 | 250.8 | 260.1 | 270.1 | 274.7 | 305.6 | 318.5 |
| | | Sub-Total | km | 3,168.2 | 3,689.8 | 4,204.0 | 4,651.7 | 5,197.6 | 5,774.0 | 873.0 | 911.9 | 945.2 | 973.5 | 1,040.7 | 1,095.0 |
| | Low Voltage | Overhead | km | 4,520.0 | 4,966.5 | 5,325.0 | 5,774.2 | 6,181.5 | 6,630.8 | 2,075.9 | 2,173.8 | 2,231.2 | 2,279.5 | 2,342.3 | 2,409.1 |
| | | Under-ground | km | - | - | 2.2 | 5.0 | 7.0 | 8.3 | - | - | 2.2 | 4.0 | 5.7 | 6.0 |
| | | Sub-Total | km | 4,520.0 | 4,966.5 | 5,327.2 | 5,779.2 | 6,188.5 | 6,639.1 | 2,075.9 | 2,173.8 | 2,233.4 | 2,383.5 | 2,348.0 | 2,415.1 |
| 23 kV Feeders | | | | | | | | 89 | - | | | | | 51 | 56 |
| Transformer | | Number | | 4,172 | 4,740 | 5,549 | 6,333 | 7,299 | 8,768 | 2,329 | 2,562 | 2,802 | 3,052 | 3,422 | 3,863 |
| | | Capacity | MVA | 498.8 | 548.9 | 618.9 | 679.6 | 763.8 | 888.0 | 312.9 | 338.2 | 369.7 | 397.9 | 436.7 | 484.9 |

## 3.4 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 old and new systems are compared below in terms of average revenue per kWh in 1988 vs. after revision.

| | 1988 | 1989 (after revision) |
|---|---|---|
| Residential | 26.16 Gs/kWh | 49.86 Gs/kWh |
| Commercial | 34.25 | 65.15 |
| Industrial | 19.26 | 41.00 |
| Others | 22.26 | 44.76 |
| Farming Villages | 23.58 | 46.64 |
| Street Light | 28.66 | 33.26 |
| Average | 24.79 | 47.13 |

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

# CHAPTER 4

# POWER DEMAND PROJECTION

# CHAPTER 4 POWER DEMAND PROJECTION

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# CHAPTER 4 POWER DEMAND PROJECTION

## 4.1 Current Status and Trend of Power Demand

### 4.1.1 Current Status and Trend of Power Demand in Paraguay

(1) The trend of electric power consumption and the sending end maximum power in Paraguay in the past few years are presented in Table 4-1. The trends in each region of the country are presented in Table 4-2.

Speaking of the power demand in 1988, the total electric energy consumption of the nation was 1,509.7 GWh, of which the residential and commercial consumptions account for 53% of the total, the industrial 26%, and the public use including street lighting 21%. The feature of the composition of electric demand is that the proportion of residential and commercial loads is large, and the industrial loads are relatively small. When we look at the growth of demand in the period from 1985 to 1988, we find that the growth rate of the total national demand is 14.7% per annum in the average, while the growth rate of industrial loads is 24.3%. That is, the industrial loads grew more rapidly.

(2) To analyze the regional distribution of electric energy consumption, we find that the consumption in the Metropolitan Area accounts for approximately 74% of nation's total consumption (in 1988).

However, the growth rates of energy consumption in local areas are higher than the national average, and we notice that the electricity demands in local areas are growing rapidly.

### 4.1.2 Demand in the Project Area

(1) The past electricity demands in the Project Area are presented in Table 4-3. The demands in the Project Area account for approximately 90% of the total demand in the Metropolitan Area.

Table 4-1 Historical Data of Power and Energy Demand in Paraguay

| Year | | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
|---|---|---|---|---|---|---|---|---|
| Energy Consumption (GWH) | Residential | 468.9 | 492.2 | 540.7 | 399.5 | 461.2 | 504.9 | 566.7 |
| | Commercial | | | | 166.2 | 176.3 | 197.0 | 232.5 |
| | Industrial | 241.7 | 260.5 | 286.5 | 204.7 | 221.8 | 287.1 | 393.0 |
| | Others | | | | 143.7 | 158.6 | 184.0 | 207.8 |
| | Public | 28.6 | 32.6 | 33.1 | 34.9 | 36.6 | 42.8 | 46.4 |
| | Street Lighting | 37.5 | 41.9 | 47.0 | 50.9 | 55.5 | 60.1 | 63.3 |
| | Total | 776.7 | 827.2 | 907.3 | 999.9 | 1,110.0 | 1,275.9 | 1,509.7 |
| Energy at Sending End (GWH) | | 895.4 | 970.7 | 1,065.3 | 1,206.6 | 1,326.3 | 1,483.6 | 1,766.3 |
| Maximum Demand (MW) | | 190.6 | 202.0 | 217.5 | 242.0 | 271.5 | 303.6 | 357.5 |
| Load Factor (%) | | 53.6 | 54.9 | 55.9 | 56.9 | 55.8 | 55.8 | 56.4 |

Table 4-2 Historical Data of Energy Demand of Each Area

(GWH)

| Area | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | Average Annual Increase (%) (1982 - 1988) |
|---|---|---|---|---|---|---|---|---|
| Metropolitan | 700.4 | 761.0 | 831.6 | 915.5 | 985.4 | 1,094.9 | 1,238.5 | 10.0 |
| Eastern | 66.3 | 70.2 | 75.7 | 87.4 | 106.1 | 113.1 | 152.7 | 14.9 |
| Central | 48.2 | 50.6 | 58.2 | 67.6 | 73.9 | 84.3 | 109.4 | 14.6 |
| Southern | 25.7 | 29.5 | 35.7 | 43.4 | 55.9 | 78.2 | 119.0 | 29.1 |
| Northern | - | - | 3.4 | 27.2 | 30.3 | 36.3 | 57.7 | 60.3 |
| Total | 840.6 | 911.3 | 1,004.6 | 1,141.1 | 1,251.6 | 1,406.8 | 1,677.3 | 12.2 |
| Transmission Losses | 54.8 | 59.4 | 60.7 | 65.5 | 74.7 | 76.8 | 89.0 | 8.4 |
| Energy at Sending End | 895.4 | 970.7 | 1,065.3 | 1,206.6 | 1,326.3 | 1,483.6 | 1.766.3 | 12.0 |

Table 4-3 Breakdown of Energy Demand (GWH) at Ultimate Consumer's Level of the Project Area (1981 - 1988)

(GWH)

| Category | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | Average Annual Increase (%) |
|---|---|---|---|---|---|---|---|---|---|
| Residential | 305.7 | 353.8 | 376.5 | 397.7 | 299.7 | 346.2 | 369.1 | 407.8 | |
| Commercial | | | | | 114.7 | 122.6 | 137.4 | 154.7 | |
| Industrial | 139.7 | 145.8 | 166.8 | 180.3 | 133.6 | 144.6 | 176.1 | 192.3 | |
| Street Lighting | 20.7 | 21.8 | 23.1 | 24.5 | 25.1 | 26.4 | 27.7 | 28.6 | |
| Others | 19.7 | 24.4 | 25.6 | 28.9 | 132.8 | 144.3 | 172.0 | 177.1 | |
| Total | 485.9 | 545.8 | 591.9 | 631.4 | 705.7 | 784.3 | 882.3 | 960.6 | 10.2 |
| Increase Rate (%) | - | 12.3 | 8.4 | 6.7 | 11.8 | 11.1 | 12.5 | 8.9 | - |

Of these demands, the residential and commercial loads account for approximately 60% of the total, and the industrial loads amounts to only approximately 20% of the total. The remaining 20% consists of miscellaneous loads which can not be clearly classified into residential, commercial or industrial loads, and the street lighting power. The average annual growth of total demand in this area was 10.2% in the period from 1981 to 1988.

(2) The record of actual demands on substations in the Project Area is given in Table 4-4.

It is noted that the demands on substations in the periphery or suburbs of the Asuncion City, such as Lambare, Jardin Botanico, San Lorenzo, Tres Bocas and Guarambare grew much faster than those on the substations at the central area of the city.

4.1.3 Daily Load Curve of Project Area and Trend of Annual Demand

(1) The actual daily load curves of the commercial load area (Centro Substation) and the residential (lighting) load area (Barrio Parque Substation) are presented in Figure 4-1 and Figure 4-2 respectively.

The daily load change of the whole project area, expressed in terms of percentage, is presented in Figure 4-3. This load curve has been obtained by combining the loads of San Lorenzo Substation and Lambare Substation, which are the key power supply centers to the capital city Area, on a same day in 1988, and this load curve can be regarded as the typical daily load curve of the whole Project Area.

(2) The feature of the power demand in the Project Area is that, the proportion of residential load is large, while the industrial load is small (approximately 20% of the total load), and the daily peak of the whole Project Area appears in the evening from 7 to 8 o'clock. It is expected that the industrial load in this area will increase in future, since there are factories of steel, cement, vegetable oil, cotton,

Table 4-4 Energy Demand (GWH) at the Substations of the Project Area

(GWH)

| Substation | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | Average Annual Increase (%) |
|---|---|---|---|---|---|---|---|---|---|
| Puerto Sajonia | 127.9 | 127.6 | 112.1 | 115.0 | 119.8 | 133.3 | 125.5 | 122.6 | |
| San Miguel | 127.2 | 129.9 | 135.9 | 136.4 | 141.1 | 145.6 | 136.7 | 139.4 | |
| Centro | - | - | - | - | - | - | 24.5 | 40.8 | 4.5 |
| Barrio Parque | 88.6 | 97.5 | 119.4 | 124.1 | 140.0 | 142.6 | 155.8 | 165.8 | |
| Lambare | 54.8 | 86.9 | 111.0 | 125.0 | 138.2 | 147.4 | 165.6 | 205.1 | |
| Jardin Botanico | 61.7 | 61.8 | 62.9 | 75.3 | 82.8 | 91.7 | 104.7 | 114.0 | 15.5 |
| San Lorenzo | 72.2 | 89.3 | 100.0 | 121.1 | 128.1 | 128.8 | 134.2 | 146.4 | |
| Tres Bocas | 44.3 | 46.8 | 53.8 | 57.6 | 61.8 | 66.2 | 75.0 | 88.3 | 14.3 |
| Guarambare | - | - | - | - | 14.9 | 32.6 | 43.2 | 62.4 | |
| Acepar | - | - | - | - | - | 5.7 | 28.8 | 33.7 | |
| Total | 576.7 | 639.8 | 695.1 | 754.5 | 826.7 | 893.9 | 994.0 | 1,118.5 | 9.9 |

Fig. 4-1 Actual Daily Load Curve at Centro Substation

(Commercial Load Area)

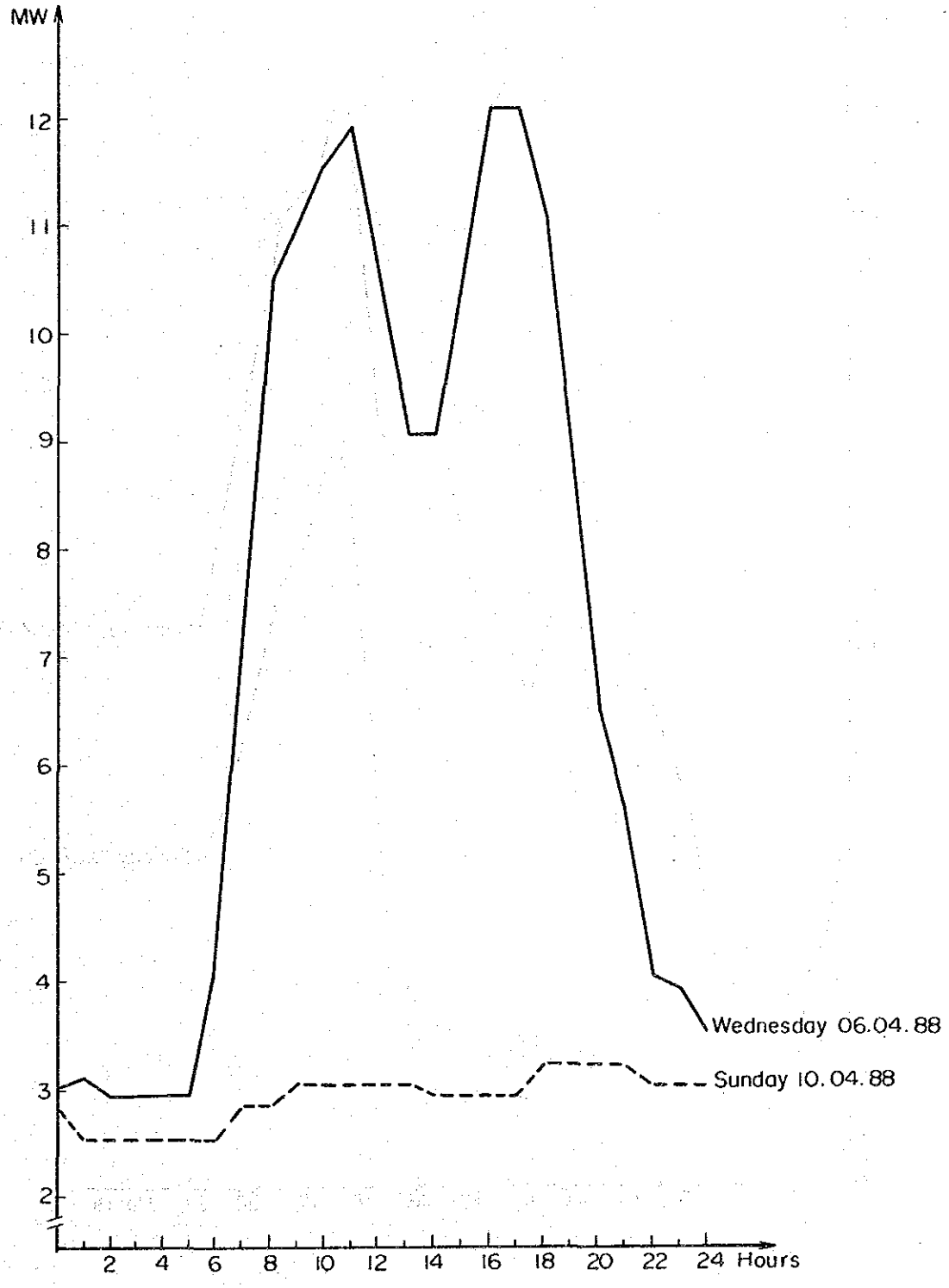


Fig.4-2 Actual Daily Load Curve at Barrio Parque Substation

(Lighting Load Area)

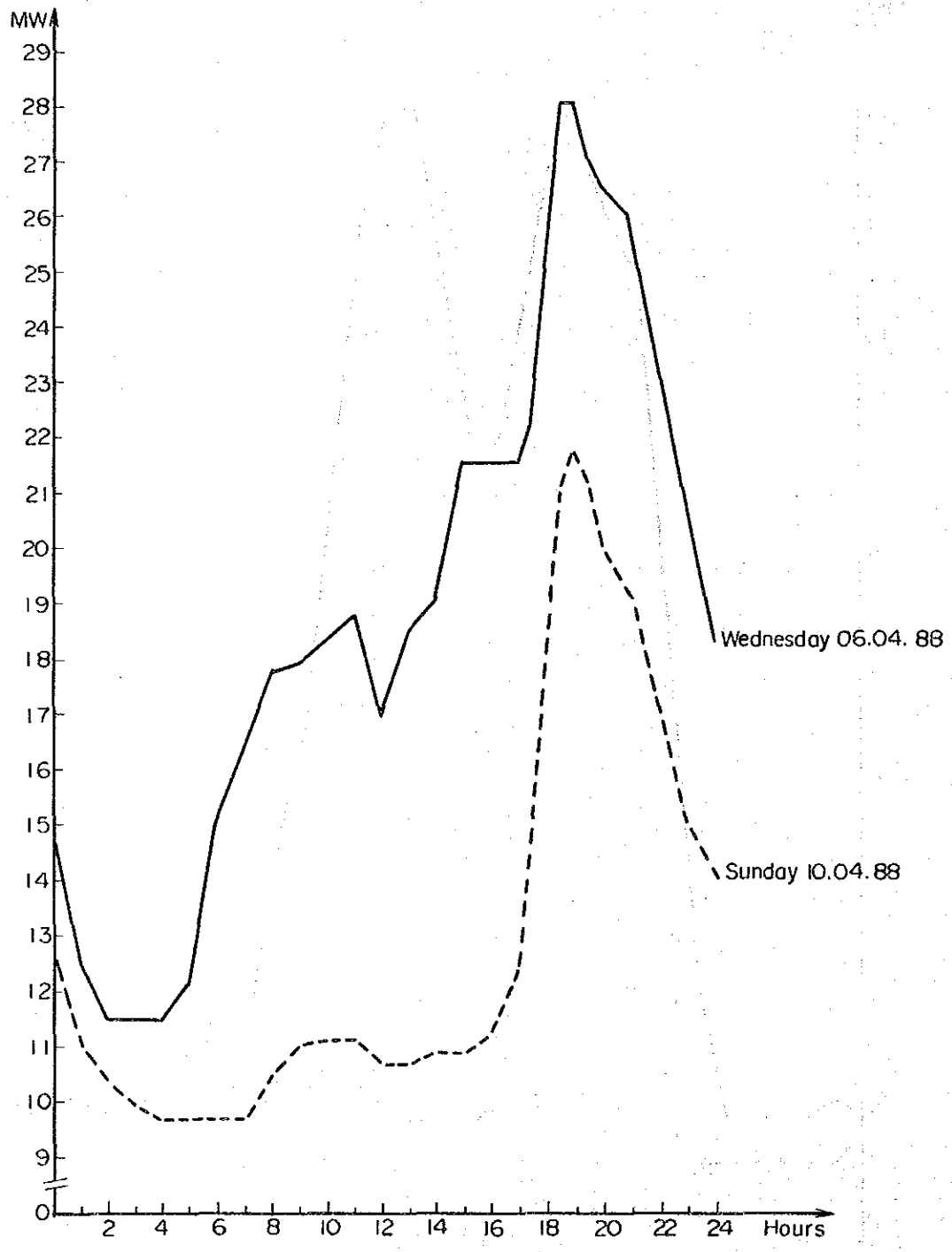
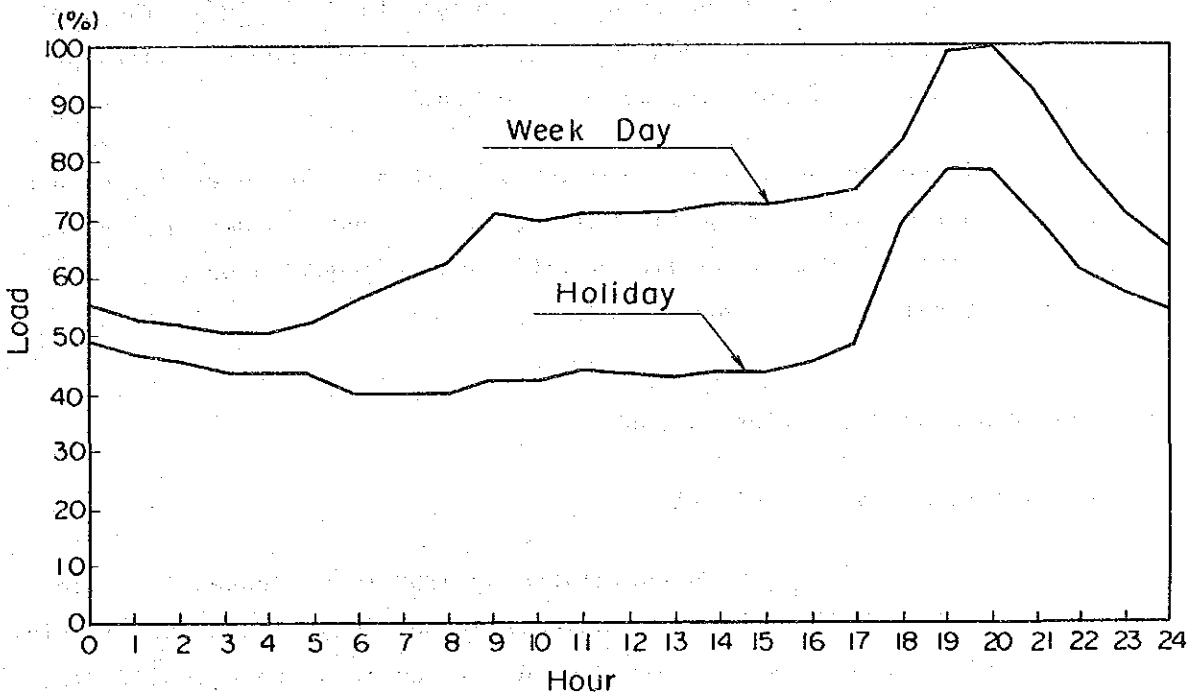


Fig. 4-3 Typical Daily Load Curve in the Project Area



etc., and Villeta Industrial Park is planned to be developed in the southern side of this area. However, the proportion of industrial loads is expected to remain small even when these new industrial loads are taken into account, and consequently, the daily peak demand will appear in the evening for some time to come.

(3) The monthly maximum power demand on each substation in the Project Area during 1988 is presented in Table 4-5. The composite sum of maximum power demands on each substation is presented in Figure 4-4 for each month.

It can be seen that the monthly maximum demand does not change appreciably throughout a year, but it tends to decline in the winter season from May to July, and the peak is observed in December in the summer season.

## 4.2 Power Demand Projection by ANDE

### 4.2.1 Long Term Demand Projection

(1) A demand projection formulated by ANDE is presented in Table 4-6. The data of this table is graphically illustrated in Fig. 4-5 and Fig. 4-6. This demand forecast was prepared in 1975, and it seems to be still consistent today, as the JICA Study Team compare this forecast to the actual development of demand up to today.

(2) In this projection, the demand growth of the whole power system of ANDE is predicted for three cases, Alternatives A, B and C. In Alternative A, where the largest demand growth was projected, the consumer end energy consumption in the year 2000 is predicted to be 4,930 GWh, and the corresponding peak demand 1,150 MW. In Alternative C, which is the most modest case, the load end energy consumption is assumed to be 3,787 GWh, and the peak demand 880 MW, in year 2000. In both cases, it is predicted that the industrial loads will grow more quickly than residential and commercial loads.

## Table 4-5 Monthly Substation Peaks in the Project Area (1988)

(MW)

| MONTH | SLO | PSA | JBO | SMI | DEN | BPA | TBO | LAM | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| Jan | 28 | 23.8 | 22.4 | 31.6 | 15.4 | 31.4 | 18.3 | 39 | 209.9 |
| Feb | 28 | 23.2 | 19.8 | 28.8 | 14 | 30 | 17.3 | 40.5 | 201.6 |
| Mar | 33 | 27.1 | 20 | 32.4 | 16.2 | 31.2 | 18.2 | 40 | 218.1 |
| Apr | 32 | 26.3 | 19.9 | 29.7 | 14 | 30.9 | 22.2 | 41.5 | 216.5 |
| May | 30 | 20.6 | 22.3 | 25.4 | 9 | 31.2 | 22 | 40 | 200.5 |
| Jun | 30 | 21.1 | 21.3 | 27.3 | 7.5 | 30.8 | 18.4 | 40.5 | 196.9 |
| Jul | 31 | 21.5 | 19.7 | 29.4 | 8 | 31.2 | 19 | 40.5 | 200.3 |
| Aug | 33.5 | 22.3 | 19.5 | 28.1 | 9.2 | 30.7 | 19.6 | 39 | 201.9 |
| Sep | 28.7 | 24 | 20.8 | 31 | 11.5 | 34.7 | 20.3 | 41 | 212 |
| Oct | 27.8 | 20.8 | 19.5 | 26.2 | 11.7 | 31 | 21.7 | 40 | 198.7 |
| Nov | 28.3 | 22.8 | 19.7 | 32.9 | 20.3 | 32.7 | 19.8 | 40 | 216.5 |
| Dec | 31.9 | 31 | 21.1 | 28.7 | 24.3 | 32.1 | 20.7 | 42 | 231.8 |

Fig.4-4 Transition of Total of Monthly Substation Peaks in the Project Area (1988)

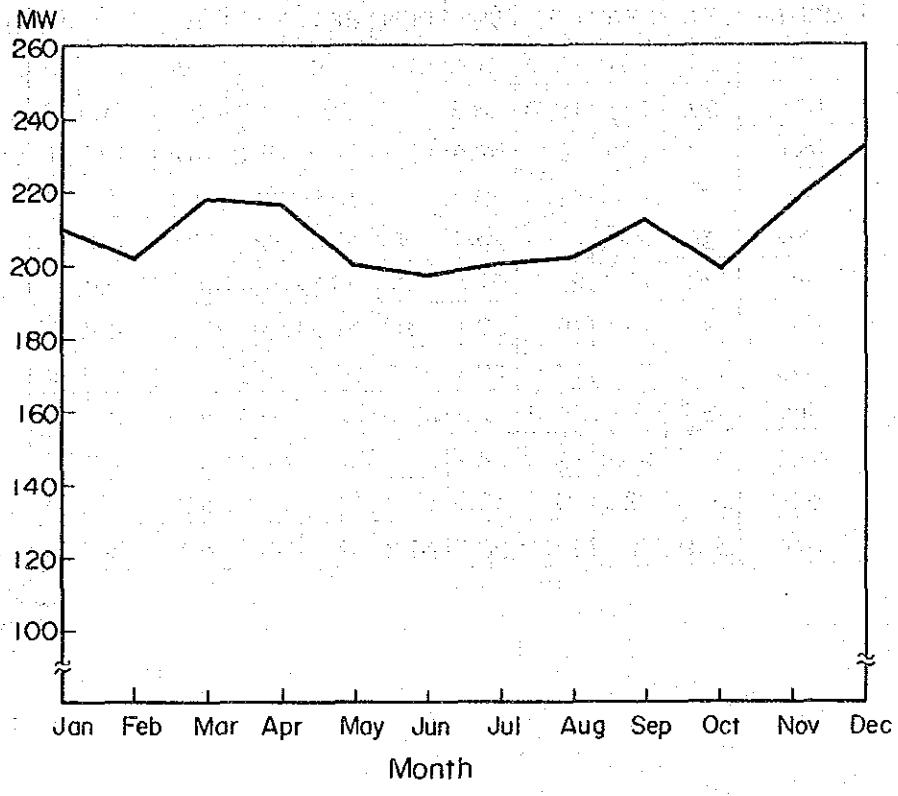


Table 4-6 Demand Forecast for Integrated Power System (ANDE)

a) Alternative A

| Year | | 1976 | 1980 | 1985 | 1990 | 2000 | 1990/2000 Average Annual Increase (%) |
|---|---|---|---|---|---|---|---|
| Energy Demand at Consumer's Level (GWH) | Residential | 226 | 380 | 651 | 992 | 2,142 | 8.0 |
| | Industrial | 115 | 359 | 745 | 1,156 | 2,788 | 9.2 |
| | Total | 341 | 739 | 1,396 | 2,148 | 4,930 | 8.7 |
| Energy Demand at Generation Level (GWH) | | 382 | 828 | 1,564 | 2,406 | 5,522 | 8.7 |
| Peak Demand (MW) | | 79.3 | 171.9 | 324.6 | 499.4 | 1,146.1 | 8.7 |
| Load Factor (%) | | 55 | 55 | 55 | 55 | 55 | - |

b) Alternative B

| Year | | 1976 | 1980 | 1985 | 1990 | 2000 | 1990/2000 Average Annual Increase (%) |
|---|---|---|---|---|---|---|---|
| Energy Demand at Consumer's Level (GWH) | Residential | 224 | 373 | 633 | 951 | 1,999 | 7.7 |
| | Industrial | 113 | 348 | 719 | 1,106 | 2,620 | 9.0 |
| | Total | 337 | 721 | 1,352 | 2,057 | 4,619 | 8.4 |
| Energy Demand at Generation Level (GWH) | | 377 | 808 | 1,514 | 2,304 | 5,173 | 8.4 |
| Peak Demand (MW) | | 78.3 | 167.6 | 314.3 | 478.2 | 1,073.7 | 8.4 |
| Load Factor (%) | | 55 | 55 | 55 | 55 | 55 | - |

c) Alternative C

| Year | | 1976 | 1980 | 1985 | 1990 | 2000 | 1990/2000 Average Annual Increase (%) |
|---|---|---|---|---|---|---|---|
| Energy Demand at Consumer's Level (GWH) | Residential | 221 | 358 | 556 | 815 | 1,632 | 7.2 |
| | Industrial | 110 | 313 | 642 | 962 | 2,155 | 8.4 |
| | Total | 331 | 671 | 1,198 | 1,777 | 3,787 | 7.9 |
| Energy Demand at Generation Level (GWH) | | 371 | 752 | 1,342 | 1,990 | 4,241 | 7.9 |
| Peak Demand (MW) | | 77.0 | 156.1 | 278.5 | 413.0 | 880.2 | 7.9 |
| Load Factor (%) | | 55 | 55 | 55 | 55 | 55 | - |

Fig.4-5 Demand Forecast for Integrated Power System (ANDE)

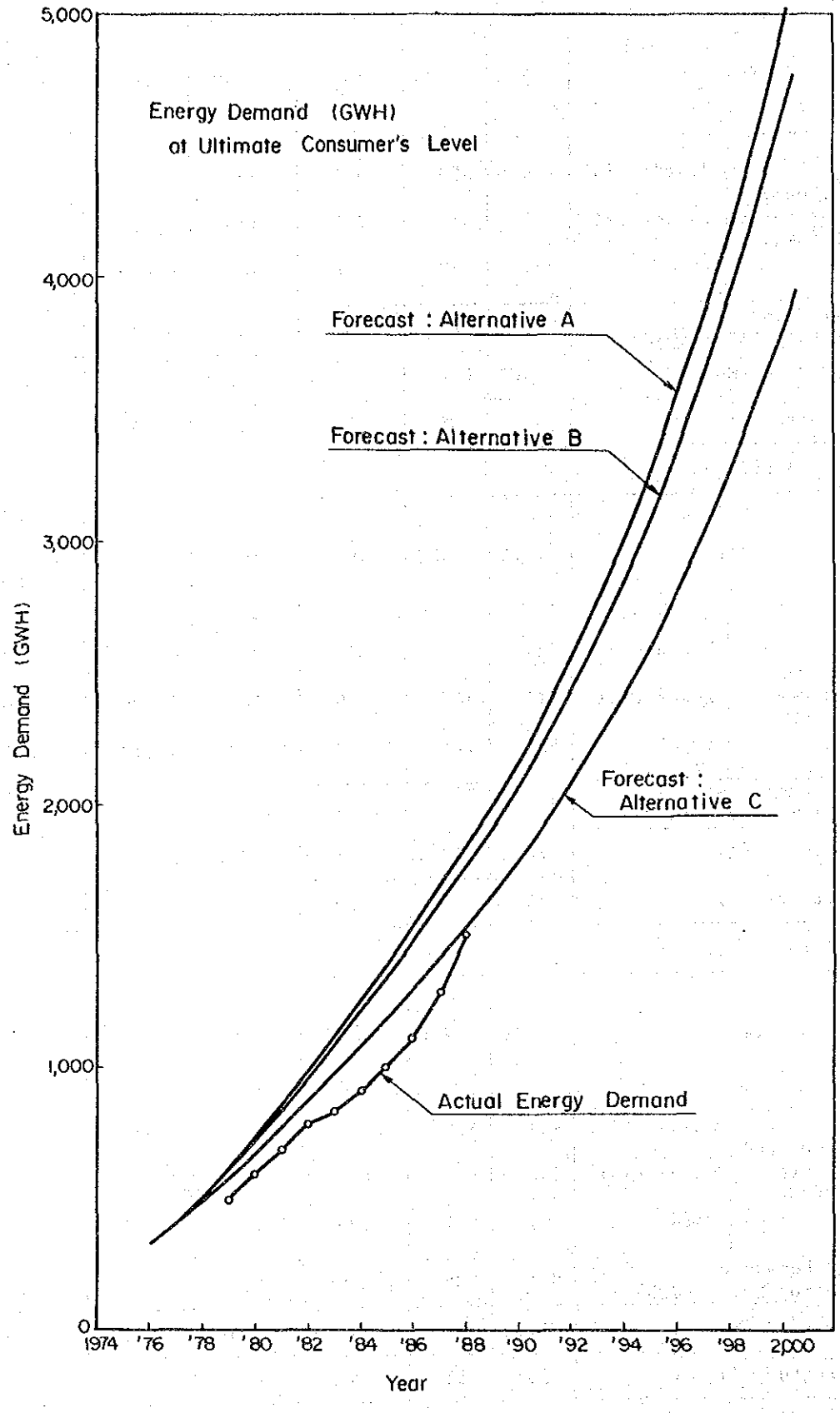
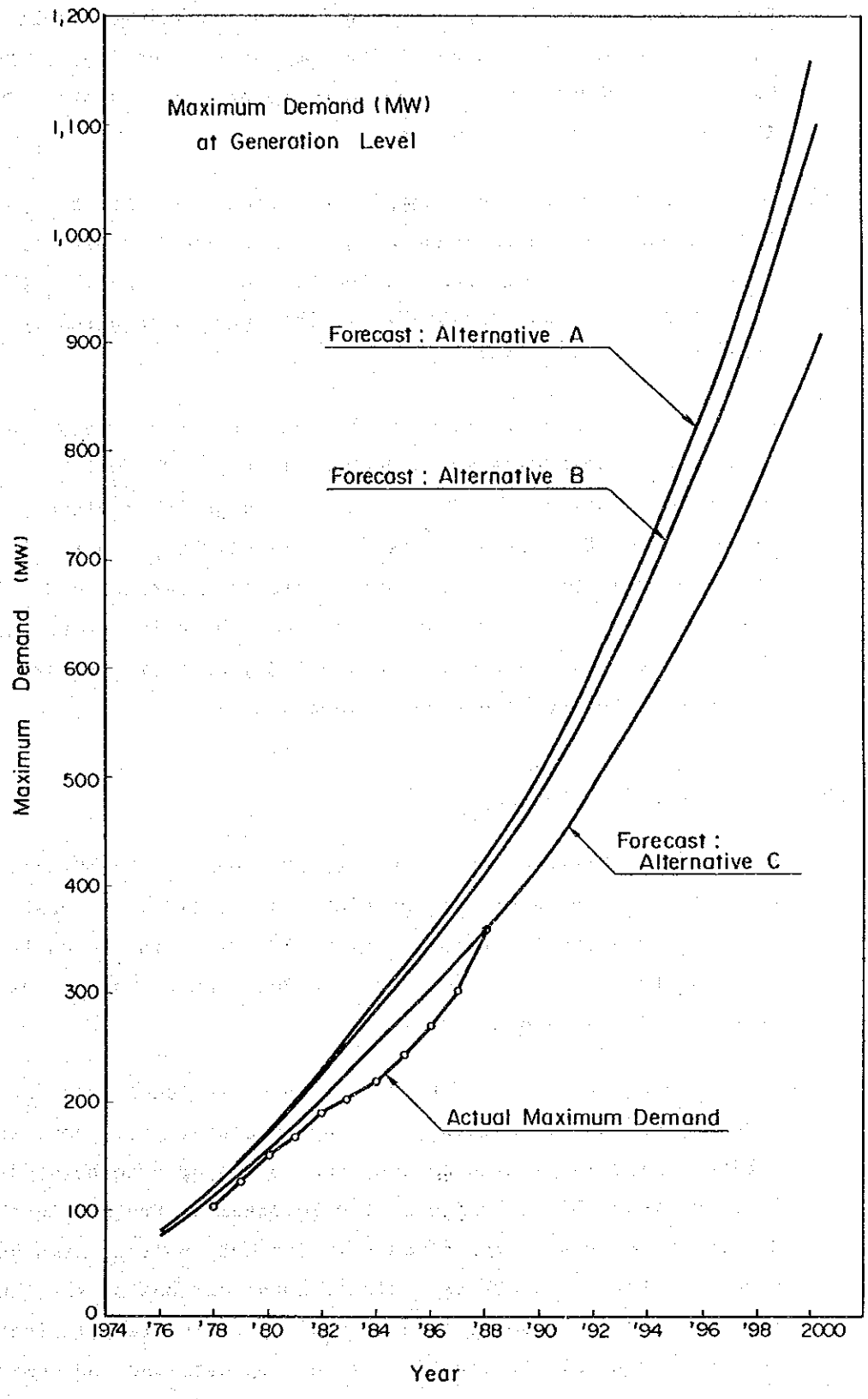


Fig. 4-6 Demand Forecast for Integrated Power System (ANDE)



(3) In Figs. 4-5 and 4-6, the actual growth of demand from 1979 to 1988 is illustrated together with projected values. So far, the growth in both energy consumption and peak demand fell below the projection values in the modest Alternative C. But the actual growth tends to approach the projections of Alternative C in recent years.

(4) Next, let us examine the demand projection (only for the peak power demand) which has been adopted in the master plan of "Development of Power Transmission System of Paraguay". This projection is shown in Table 4-7. The data is graphically illustrated in Fig. 4-7.

In this projection, it is assumed that the maximum power output in the whole power system in 2000 will be 945 MW, which corresponds to 15% of 6,300 MW of the Itaipu Power Plant (allocated to Paraguay). This value is slightly (65 MW) larger than the projection in the above-mentioned Alternative C. The demand in 2000 in the Metropolitan Area (which is larger than the Project Area) is estimated at 554 MW, which is approximately 60% of the total national power demand.

4.2.2 Short Term Demand Projection

(1) According to "Sistema Interconectado Nacional (SIN), Historico y Prevision de Potencial y Energia" made by ANDE, the past records and a short term projection of demands in the whole power system and in the Metropolitan Power System are given as presented in Table 4-8 and Fig. 4-8.

Here, the demand of the Metropolitan Area includes those at Itaugua, Caacupe, Paraguari, Quiindy, Caapucu, etc., covering a substantially large area as compared to the area to be studied by this "Power Distribution System Improvement Project in the Metropolitan Area". The demands in the Metropolitan Area have accounted for 70 to 80% of nation's total demands so far, but this proportion is decreasing gradually. This trend indicates that the rural electrification is in progress, and the demands in local areas are growing faster than in the Metropolitan Area.

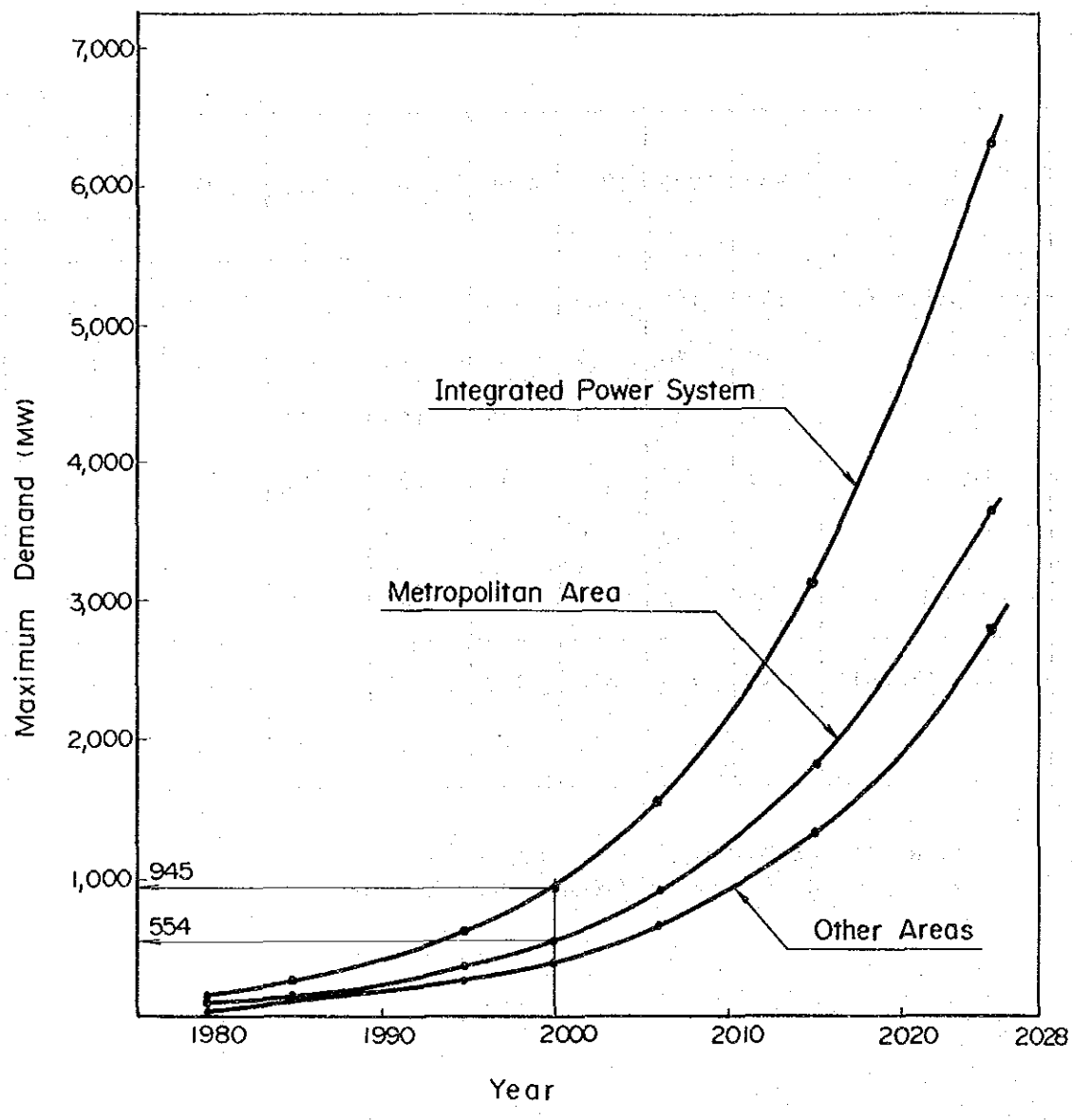
Table 4-7 Estimated Maximum Demand for ANDE Power System

(MW)

| Area | 1980 | 1985 | 1995 | 2000 | 2006 | 2015 | 2025 | 1985/2000 Average Annual Increase (%) |
|---|---|---|---|---|---|---|---|---|
| Metropolitana | 108 | 155 | 369 | 554 | 921 | 1,825 | 3,582 | 8.9 |
| Central | 18 | 30 | 67 | 101 | 169 | 355 | 697 | 8.4 |
| Parana | 11 | 30 | 58 | 78 | 130 | 248 | 505 | 6.6 |
| Norte | 3 | 20 | 60 | 91 | 150 | 303 | 593 | 10.6 |
| Sur | 4 | 30 | 60 | 90 | 150 | 303 | 595 | 7.6 |
| Perdidas | 1 | 5 | 16 | 31 | 55 | 116 | 328 | 12.9 |
| System (Total) | 145 | 270 | 630 | 945 | 1,575 | 3,150 | 6,300 | 8.7 |
| % | - | - | 10 | 15 | 25 | 50 | 100 | - |

As per: PLAN MAESTRO DE DESARROLLO DEL SISTEMA NACIONAL DE TRANSPORTE DE ENERGIA ELECTRICA DE PARAGUAY

Fig. 4-7 Maximum Demand Forecast (ANDE)



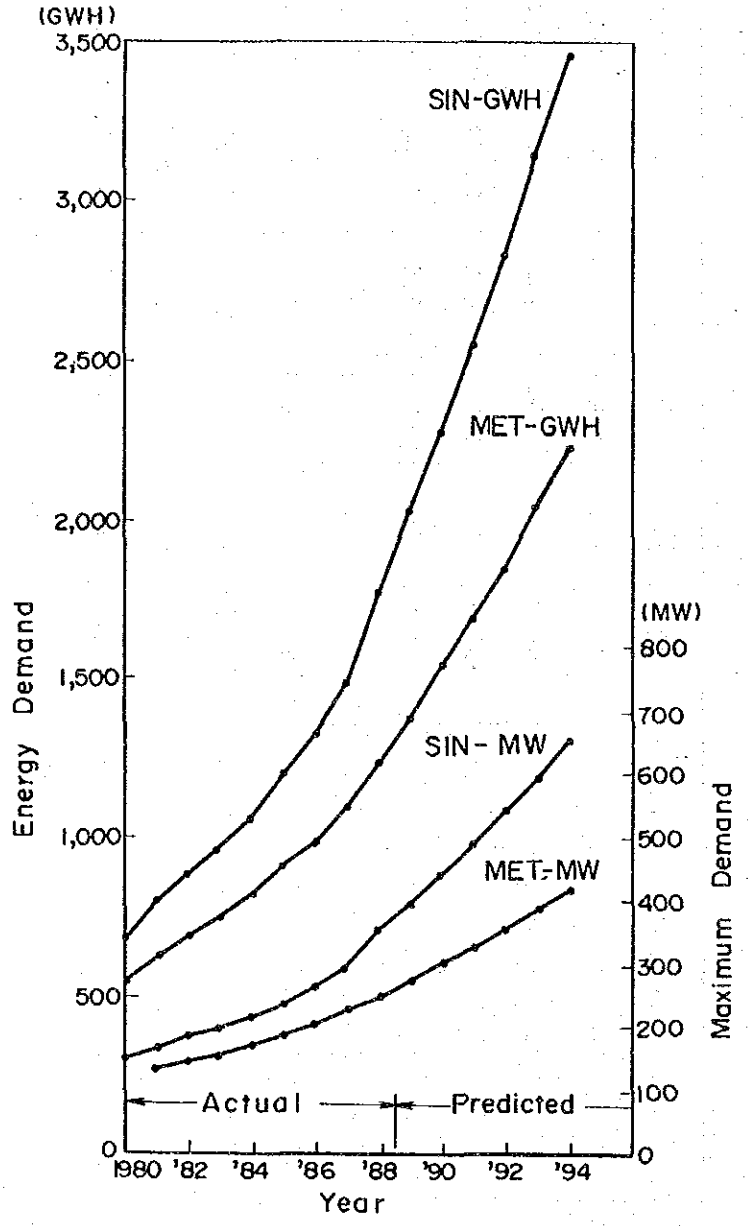

As per. PLAN MAESTRO DE DESARROLLO DEL SISTEMA NACIONAL DE TRANSPORTE DE ENERGIA ELECTRICA DE PARAGUAY

Table 4-8 Short-term Load Forecast by ANDE

| Year | Integrated Power System | | | | | Metropolitan Power System | | | | | Rate (2)/(1) (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Energy Demand (1) | | Maximum Demand | | Load Factor | Energy Demand (2) | | Maximum Demand | | Load Factor | |
| | GWH | % Increase | MW | % Increase | | GWH | % Increase | MW | % Increase | | |
| 1981 | 806.2 | 17.4 | 167.7 | 12.1 | 0.549 | 632.8 | 17.0 | 137.3 | - | - | 78.5 |
| 1982 | 895.4 | 11.1 | 190.6 | 13.7 | 0.536 | 700.4 | 10.7 | 146.4 | 6.6 | 0.546 | 78.2 |
| 1983 | 970.7 | 8.4 | 202.0 | 6.0 | 0.549 | 761.0 | 8.7 | 160.8 | 9.8 | 0.540 | 78.4 |
| 1984 | 1,065.3 | 9.7 | 217.5 | 7.7 | 0.559 | 831.6 | 9.3 | 175.1 | 8.9 | 0.542 | 78.1 |
| 1985 | 1,206.6 | 13.3 | 242.0 | 11.3 | 0.569 | 915.5 | 10.1 | 190.6 | 8.9 | 0.548 | 75.9 |
| 1986 | 1,326.3 | 9.9 | 271.5 | 12.2 | 0.558 | 985.4 | 7.6 | 206.5 | 8.3 | 0.545 | 74.3 |
| 1987 | 1,483.6 | 11.9 | 303.6 | 11.8 | 0.558 | 1,094.9 | 11.1 | 229.5 | 11.1 | 0.545 | 73.8 |
| 1988 | 1,766.3 | 19.1 | 357.5 | 17.8 | 0.564 | 1,238.5 | 13.1 | 252.7 | 10.1 | 0.560 | 70.3 |
| 1989 | 2,025.0 | 14.6 | 400.0 | 11.9 | 0.578 | 1,380.3 | 11.4 | 278.0 | 10.0 | 0.567 | 67.7 |
| 1990 | 2,276.0 | 12.4 | 443.0 | 10.8 | 0.586 | 1,536.5 | 11.3 | 305.0 | 9.7 | 0.575 | 67.5 |
| 1991 | 2,543.0 | 11.7 | 491.0 | 10.8 | 0.591 | 1,687.6 | 9.8 | 331.8 | 8.8 | 0.581 | 66.4 |
| 1992 | 2,831.0 | 11.3 | 541.0 | 10.2 | 0.597 | 1,853.1 | 9.8 | 358.8 | 8.1 | 0.589 | 65.5 |
| 1993 | 3,150.0 | 11.3 | 596.0 | 10.2 | 0.603 | 2,035.4 | 9.8 | 388.0 | 8.1 | 0.599 | 64.6 |
| 1994 | 3,458.0 | 9.8 | 654.0 | 9.7 | 0.604 | 2,224.8 | 9.3 | 419.0 | 8.0 | 0.606 | 64.3 |

Note: 1981 - 88 Historical
1989 - 94 Predicted

Fig.4-8 Short-term Power Demand Forecast by ANDE Foresighted on 01, June, 1989




Note ; SIN-GWH Energy Demand of Integrated Power System

SIN-MW Maximum Demand of Integrated Power System

MET-GWH Energy Demand of Metropolitan Power System

MET-MW Maximum Demand of Metropolitan Power System