REPORT ON THE JUQUIA RIVER BASIN WATER RESOURCES DEVELOPMENT PLAN IN THE FEDERATIVE REPUBLIC OF BRAZIL

August, 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request of the Government of the Federative Republic of Brazil, the Government of Japan decided to dispatch experts for the Juquia River basin water resources development plan.

This plan is one of the most important projects by DAEE (Department of Water and Electrical Energy of São Paulo State), and has three main purposes ———

——— water supply to the São Paulo Metropolitan Region

——— peak load power generation through pumped storage station

——— Juquia River basin flood control

The experts ——Terumi Ushijima (from Oct. 12, 1981 to Aug. 11, 1982) and Kooji Kojima (from May 14 to Aug. 11, 1982) ——— conducted a pre-feasibility study and had discussions with their counterparts of DAEE. Based on the findings of the study they completed this report.

I hope this report will contribute to implementation of the plan, thus dedicating to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned in the Brazil for their close cooperation extended to the experts.

September 1982

Kazuto Nakazawa

Kazuto NAKAZAWA

Executive Director
Japan International Cooperation
Agency

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INTRODUCTION

INTRODUCTION

The oil crisis of 1973 and 1978 have caused great change in the energy policies of the countries in the world and, while with the various estimates of natural resources, the situation regarding the energy problem is still quite unstable. The securing energy is an indispensable factor in promotion of economic growth through industrializing the economic structure so that the development of domestic energy resources to decrease or at least to conserve imported energy has been taken up as an urgent problem, and these energy resources, particularly hydroelectric power, have been vigorously developed.

On the other hand, the Metropolitan Region of São Paulo is continuously developing in accordance with the impact of intensive economical activities. Although the last census confirmed the decreasing trend in the population, its growth rate is still high and even for the long future, the population of the Great São Paulo will continue to grow, perhaps with gradually decreasing rate. So, drinking water for the incremental population, and for other uses such as industrial and commercial, has to be provided, and long terms plan is quite necessary.

Since the major water resources around São Paulo City are almost powerfully developed, and considering that other resources available for water supply have restraints in the future utilization related to insatisfactory quality of water, interference with irrigation, and interferences with other municipalities supply, such as Paraiba, Atibaia and Jaguari Rivers, the developments of water resources in the São Paulo Region is pointed out as the urgent problem in the near future.

According to the electric power demand and supply plans of the South-Southeast-Midwest Region in this country, the shortage of supply capacity, especially for the peaking power demand, is anticipated after 1995, and the water demand in the Metropolitan Region is also presupposed to exceed the suppliable capacity after 1995. This year, however, has a great probability to be too late looking at a water supply side because Cantareira System, actual major system, has to release much more water to its downstream, in order to mitigate the pollution and the water requirements of Piracicaba River Basin. Also, some water resources presently planned to be developed up to 1995, have limitation with regards to the high cost and interferences with irrigation, and in some cases, there are doubts if they are fully developable or not.

With such situation as the backgrounds, GOVERNO DO ESTADO DE SÃO PAULO - SECRETARIA DE OBRAS E DO MEIO AMBIENTE - DEPARTAMENTO DE AGUAS E ENERGIA ELETRICA (DAEE) have searched all the river basins around the São Paulo, and concluded by the preliminary studies, that the Juquia - São Lourenço River System is economically and quantitatively the most developable project to supply not only the necessary water for long periods, but also to generate the peak electric power.

As this system involves the complicated water supply system and furthermore the high head reversible power stations, the Government of the Federal Republic of Brazil requested the Government of Japan in 1981 to make the technical cooperations for the feasibility study, especially for the reversible power stations, in order to expedite the Juquia - São Lourenço Project. In response to this request, the Government of Japan commissioned the Japan International Cooperation Agency (JICA) to carry out the technical cooperations for the Project.

JICA sent the two engineers listed below for the Project.

TERUMI USHIJIMA	Civil Engineer	EPDC	12 Oct. 1981 - 11 Aug. 1982
KOOJI KOJIMA	Electri-Mechanic Engineer	EPDC	14 May 1982 - 11 Aug. 1982

During the period of technical cooperations a large number of engineers of Departamento de Aguas e Energia Eletrica (DAEE), Eletricidade de São Paulo S.A. (ELETROPAULO), and many engineers concerned with the Project have cooperated in studying this Project.

This Report, though the studies being in progress, is prepared, as the summary or our activities, in order to make contribute for the completion of feasibility report as soon as possible.

On the occasion of submitting the Report, we wish to express our sincere gratitudes to all persons concerned for their kind and generous technical cooperations in performing the study and sincerely expect the promotion of friendly and cooperative relations between the Federal Republic of Brazil and Japan.

7th, August, 1982.

TERUMI USHIJIMA

KOOJI KOJIMA

PART I

CONCLUSION AND RECOMMENDATION

CHAPTER 1

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CHAPTER 1. CONCLUSION

This project is planned to develop Juquia River for the water and electric power supply by means of the series of reservoir system so that the feasibility study of all the system was judged to be difficult to be completed in a short period because of very complicated system.

Accordingly, the technical cooperation has been mainly concentrated on the demand and supply planning, studies of the water supply and electric power and the designings of the two reversible power stations named Sao Lourenço and Cubatão which can be called as the key projects of this system.

As for the studies of the above mentioned two power stations, each one alternative was only selected such as 9 units case for the former and 8 units case for the latter and has been studied aiming at the improvement of counterparts' technical abilities so that the determinations on optimum development scales of them are not obtained yet.

The present suppliable water to the Metropolitan Region of São Paulo including underconstruction facilities is 53.7 m^3/sec which is enough to cover the water demand until 1987.

The water demand is forecast to be 89 m^3/sec in 2000 and 177 m^3/sec in 2040 respectively of which amounts are estimated based on the increasing forecasts on the population and water consumption per capita in the Metropolitan Region. Though many water resources have been studied to cover the above mentioned water demand, this water supply system is finally selected because other planned systems are judged to be unreasonable because of their systems involving many kinds of difficulties such as small resources to meet the water demand necessiations of high frequent construction, industrial water utilization, diffusion of sewage and irrigation, and water diversion from the Coastal Region, water pollution, and so on. According to the development plan of this Project, the water is, at first, supplied from the upper basin of this Project in accordance with the water demand until 1995 and São Lourenço Reversible Power Station is to be commenced operation in 1996 to pump-up the water of the lower basin and finally the first stage of Juquia - São Lourenço System has to be completed until 2007.

The utilized water in the Metropolitan Region is to be diverted to Billings Reservoir through the canals of Tiete and Pinheiros Rivers and by means of the two pump stations to utilize for generation at the series of Cubatão Power Stations.

In the relation to electric power circumstances, the electric power demand in the present years is steadily increasing and the average increasing rate of the electric power demand from 1981 to 2000 is forecast as 8.0% Considering that the increasing rate of electric power demand from 1991 to 2000 is supposed to be the stable increasing rate of more than 6%, the electric power demand in 1995 is anticipated as 67×10^3 MW and 352×10^6 MWH respectively of which amounts are corresponding to 3.4 and 2.9 times each comparing to those in 1981.

The large scales of hydroelectric power station including Itaipu Power Station and so on are being developed at the present to cope with the above mentioned electric power demand. Further, the electric power supply plans of 75×10^3 MW in 1996 and 78×10^3 MW in 2000 according to the published data at the present are shown to be a little shortage of reserve power and apparent shortage in comparisons with the electric power demand plans of 71×10^3 MW in 1996 and 92×10^3 MW in 2000 respectively. To meet the shortage of the electric power supply capacity, the development of reversible power stations cooperated with the above mentioned water supply system is considered to be very effective measures as contributing to the electric power supply by means of sharing in some part of the electric power supply capacity.

Furthermore, as for the supplying measures of electric peaking power to the power demand districts, the development of hydroelectric power stations with long distance of transmission line is also considered. But, in case of this development method, the distance of transmission line is too long so that the installation of reversible power stations as mentioned above which are located near the power demand is considered to be apparently more profitable than that of the power station with the long distance transmission line.

Judging from study results of the electric power demand and supply balance, in case the power demand and supply are shifted in accordance with the plan, these reversible power stations will be needed to be put into commercial operation sequentially from 1996 as shown with following table.

TABLE I-1.1. OPERATION COMMENCEMENT YEAR FOR SÃO LOURENÇO AND CUBATÃO POWER STATIONS

Year	São Lourenco P/S			Cubatão P/S			Total MW
	Unit	MW	Total MW	Unit	MW	Total MW	
1996	1	315	315				315
1997	2	630	945				945
1998	3	945	1,890	1	300	300	2,190
1999	3	945	2,835	3	900	1,200	4,035
2000				4	1,200	2,400	5,235

CHAPTER 2

RECOMMENDATION

CHAPTER 2. RECOMMENDATION

As described in Introduction, the technical cooperation during stay in Brazil has been performed concentrating on the improvement of each counter-parts' technical capabilities by means of giving the fundamental subjects to design the necessary structures for the feasibility study and requiring to solve those matters, so that the basic considerations such as damsite selection, its economical evaluation and so on have not been payed so much because of having had intentions to give as much subjects as possible for making the feasibility report by themselves.

Accordingly, some fundamental matters are described as recommendation hereinunder of which considerations are important to continue the studies of this Project.

(1) Ecological Survey

This project is consisted of many reservoir systems which are generally planned to be developed as large scales of reservoir area and dead water capacity comparing with inflow discharge and the project area is covered especially with jungle on the upper basin and with banana plantation on the lower basin so that the natural conditions may be ecologically altered after completion of the series of reservoir system.

Accordingly, the preliminary survey on the ecological view points by those kinds of expert is recommendable.

(2) Water Quality

Many reservoir systems are planned, almost of the upper basin is consisted of the jungle with marshy place, on the other hand, the series of reservoir area of the downstream excepting the reservoir of LH-2A are almost covered with the banana plantation and the organic materials of 2 - 3 m are deposited on the reservoir areas according to the field investigations and furthermore lots of houses are dotted and or concentrated especially on the downstream basin of which sewages are directly flowed down to the rivers at the present. Accordingly, the following investigations and anticipating surveys are considered to be the important matters because of this project being the most essential purpose to supply the water to the Great Sao Paulo, and the basic considerations and or the effective measures for the present reservoir systems may be necessiated if the results of the above mentioned investigations and surveys are found out to be unreasonable.

(1) Periodical water quality investigations.

(2) Analysis of the organic materials.

(3) Anticipating surveys of reservoir water qualities in case that the vegetation and the organic materials are not removed and or only the latter nor done so.

Anyway, the vegetation and its root are considered to be at least removed from the reservoir areas.

(3) Hydrology

Though the natural inflow estimations are considered to be reasonable, the flood hydrograph to design the spillway and diversion which is adopted as 1,000 and 25 years return period flood is necessary to be reconsidered especially about the intensity distributions of regional storm rainfall.

According to the inflow to Billings and Pedras Reservoirs including the pumping up discharge, the authorized data have to be prepared for the further studies of Cubatão Compounded Resersible Power Station.

The flood control capacity of Cubatão River Canal and the necessary release discharge for the downstream of Cubatão River are expected to be determined because these items greatly give the affects to the operation rules of the existing power stations and to the studies of Cubatão Compounded Reversible Power Station.

The periodical measurements of the relation between the suspended material quantity and the natural flow are recommendable to be performed especially on both of the upper basin and the downstream of lower basin because that quantity is supposed not to be little accroding to the field investigations.

Evaporation from each reservoir is to be more carefully studied because the amount is considered not to be negligible as the reservoir area is generally big in comparison with the drainage area.

(4) Selection of Damsites

As for São Lourenço Reversible Power Station, the selection studies for upper and lower reservoirs are expected to be performed again taking into considerations of the above mentioned ecological and water quality matters, the connection procedures of water supply system, the economical evaluation including the reservoir cleaning costs, the necessary reservoir capacities, the relation of water-way concerned and other necessary items.

On the other hand, other good damsite is judged not to be existing for the lower reservoir of Cubatão Compounded Reversible Power Station by means of the field investigations.

(5) Further Studies of Alternatives

Each one alternative of São Lourenço and Cubatão Reversible Power Stations have been only studied during stay in Brazil as described in this report so that other alternatives are earnestly recommended to be studied from now on to solve the most reasonable development scales of the both power stations.

As almost of all studying procedures have been shown, the same and or applied procedures are utilizable for these performances.

Also, the pipe line system at the upper basin is considered to be one other alternative so that this system is expected to be further studied.

(6) Geological and Construction Material Investigations

The geological investigations have been performed and some useful geological informations are obtained, but the further investigations are quite recommendable in accordance with the final selection of damsites, reservoir types and power structures, and referring the results of the field geological reconaissances.

Accordingly, the further necessary geological investigation items as the feasibility stage are already submitted by the letter on the conditions that the layouts of each structure on São Lourenço and Cubatão Reversible Power Stations are assumed to be final. Furthermore, some traces of land sliding are observed around the lower reservoirs of Dam LH-2A and Cubatão so that their distributions and scales are necessary to be geo-technically studied by the field investigations and the phenomena by the water level being up and down after completions of their reservoirs are to be anticipated.

As for the dam embankment materials, the borrow areas for each dam have to be selected considering qualities, quantity distributions, transportation conditions and so on, and the necessary field and laboratory investigations at the feasibility stage are to be executed for impervious core, filter and rock embankment materials.

According to the concrete aggregate for this Project, any special investigation is considered not to be necessary at the feasibility stage because the rock qualities around the project area are generally supposed to be sufficient to produce the aggregate.

(7) Fundamental Designing Procedures

The above mentioned items have been submitted and been studied during the technical cooperation and some further considerations and informations are submitted by the letter so that studies on this Project are quite recommendable to be progressed using and or applying the above procedures and other ones.

(8) Operation Rules

As the electric power system of Juquia - São Lourenço Project is considered to be reasonable to be planned as the same system, the weekly operation is better for Sao Lourenço Reversible Power Station to make as longer generation hours a day as possible during the economical lives, though the necessary reservoir capacities for the generation are increased.

On the other hand, the series of pump station are not operated during the generating times, and further, the designed pumping up capacities have to be determined considering the actual generation hours a year and the periodical repairment and accident rates, but in the case of the latter, the full pumping up operations will be necessary.

According to Cubatão Compounded Reversible Power Station, the reservoir capacity of Pedras is limited so that the daily operation is considered to be reasonable.

(9) Firm Discharge

The firm discharge is now considered as the regulated minimum discharge in the reservoir during the driest period, but it is considered to be one other procedure that the average dischage of the first and second driest periods is adopted keeping the necessary reservoir capacity for the driest period, because this kind of the driest period will not occur so often in future, and it will be possible to require to the consumers to save the water consumption during such driest period.

(10) Compensation Costs

The compensation costs such as land, land right and so on are recommendable to prepare the figures showing relation between the elevation of reservoir and the total compensation costs.

The compensation costs by the decreased hydroelectric energy at CBA's Power Stations for the development of upper basin is to be estimated and negotiated with the organization.

(11) As for the Reversible Power Station, it is quite important to study the basic plan of the daily and or weekly operation rules in accordance with the peaking power demand considering the forecast demand duration curves.

(12) The electric power systems in south, southeast and midwest regions of Brazil are composed of those of some electric power companies. The both Reversible Power Stations are designed to be connected with the electric power systems of other electric power companies by reason of distance from reversible power station to substation, voltage of transmission line and so on.

Generally, in case of the installation of large capacity power station at the base of complicated power systems, the enough grasp of conditions in power systems is necessary.

Especially, as for the installation of these two large capacity reversible power stations, analysis of power system about output and input of power is executed and then the stability such as static and transient of the power system is necessary to be studied in detail.

(13) In case of the plan of reversible power station, the necessity of cynchronous condenser operation is recommendable to be studied from the view of voltage regulation on power system.

(14) The improvement and or extension of the existing substation being connected with reversible power station have to be studied in accordance with the capacity of reversible power station.

(15) As for the development study of Cubatão Compounded Reversible Power Station, detailed study of revolving speed of pump-turbine and voltage of generator-motor is further necessary including stability and economy of machine.

(16) The reasonable type such as Francis or Diagonal types and the unit capacity of each pump station have to be carefully selected after studying in detail not only effective head and pumping discharge but also efficiencies, economies, methods of operation and maintenance and so on.

PART II

GENERAL STIUATION IN BRAZIL

CHAPTER 1

GENERAL SITUATION

PART II

GENERAL SITUATION IN BRAZIL

CHAPTER 1 GENERAL SITUATION

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Chapter 1. General Situation

1.1. Physical Features.

Covering an area of 8.5 x $10^6 km^2$ (inland waters 55,000 km^2) - 47% of the South American Continent, Brazil ranks among the five largest countries in the world.

Extreme points are defined by parallels 5°16' 19" N and 33°45' 09" S and meridians 39°45' 54" and 73°59' 32" WGr.; the major part of the territory is located between the Equator and the Tropic of Capricorn. The predominant portion of Brazilian boundaries is the eastern sea-coast of the Atlantic Ocean with extension of 7,400 km and all other South American Countries excepting Chile and Equador have frontiers in common with Brazil.

Brazilian territory consists of 41% of lowlands, 58.5% of highlands with heights up to 1,200 m and only 0.5% of lands with altitudes over 1,200 m. The hydrographic basin is divided into nine and the Amazon Basin occupies 47% of country, followed in order by the Parana, Northeast, Tocantins-Araguaia, São Francisco, East Paraguai, Southeast and Uruguai Basins.

As to hydraulic potential, the Parana Basin (46,000 MW) and the São Francisco Basin (15,000 MW) have leading positions while other river basins are under 8,000 MW.

Brazil is divided into five regions which in turn are subdivided into 27 political units comprising 22 States, 4 Federal Territories and the Federal District, seat of the government, where Brasilia City is located.

Five main climatic zones are typical in the country; hot and humid climate in the Amazon Rainforest, with an average temperature 24-26°C the year round and rainfall 1,700-3,000 mm, hot and humid climate in the Tropical Forest with rainfall 1,000 - 1,700 mm; hot and semi-humid in the Cerrado with 1,500 - 2,000 mm; moderately warm and humid climate in the middle latitudes with annual rainfall 1,500 mm and temperature ranging between 20°C and 14°C.

In the last zone, temperatures reaches minimum of - 8°C from the coast to the upland and maximum over 40°C in the low inland areas.

1.2. Population.

The last census (1980) resulted for Brazil's total population 119,100,000 inhabitants constituted by 67% and 33% for the urban and rural population respectively.

The geometric mean rate of annual growth per 100 persons observed for the last decade was 2.48 and the population density 14.08 inhabitants/km^2. The Table II-1.1 shows the general distribution of the population in the country for each great regions.

Table II-1.1 - Distribution of Population for each Great Regions.

Region	Population (inhabitants)	Geometric mean of rate of annual growth (per 100 persons) 70/80	Population density (inhab/km^2)
North	5,890,000	5.05	1.66
Northest	34,860,000	2.16	22.60
Southeast	51,750,000	2.64	56.32
South	19,040,000	1.43	33.87
Center-West	7,560,000	4.05	4.02
Brazil	119,100,000	2.48	14.08

The heavy concentration of the population and social-economic activities that have occurred in a number of urban nucleus have resulted in population growth beyond the boundaries of the main cities increasing in excess of the population of metropolitan areas. The Table II-1.2 presents the evolution of 9 (nine) metropolitan areas in which 34.5 million inhabitants almost 30% of total population of the Country are concentrated.

Table II.1.2 Evolution of Population in the Metropolitan Areas of Brazil.

Metropolitan Areas	Population (inhab.)		Geometric mean of annual Growth. rate (per 100 persons) 70/80	Area (km^2)	Population density ($inhab/km^2$)
	1970	1980			
São Paulo	8,137,401	12,588,439	4.46	7,951	1,583
Rio de Janeiro	7,082,404	9,018,637	2.45	6,464	1,395
Belo Horizonte	1,605,663	2,541,788	4.70	3,670	693
Recife	1,792,688	2,348,362	2.74	2,201	1,067
Porto Alegre	1,531,168	2,232,370	3.84	5,806	384
Salvador	1,148,828	1,772,018	4.43	2,183	801
Fortaleza	1,038,041	1,581,588	4.30	3,483	454
Curitiba	820,766	1,441,743	5.80	8,763	165
Belém	656,351	1,000,349	4.30	1,221	819

The economically active population is distributed by activities in agriculture 32%, industry 24%, commerce 10%, services 15%, transport and communications 4% and others 15%.

About the religion, 95% are Christian, and the people is constituted mainly by Portuguese, Italian, Spanish, German and Japanese descendants.

1.3. National Economy.

The energy crisis which intensified world inflation and unemployment has also had effects on the Brazilian economy.

The general price index (according to criteria on internal available assets) which by definition reflected the country's degres of inflation, increased to 95.2% during 1981. The increase in 1980 was 110.2%. The balance of payments showed US$ 1,207 x 10^6 surplus in 1981 after registering US$ 2,928 x 10^6 deficit in the preceding year.

The growth rate of Brazilian economy decreased from 7.9% in 1980 to -3.5% in 1981.

Examined by sectors, the 1981 product growth rate shows the following values: agriculture 6.8%; industry -8.4%; commerce -6.0%; transportation and communication 0.8%. In 1980 the increased were 6.3%; 7.9% 8.0% and 10.8% respectively.

The increase of inflation during 1981 can be partially explained by the readjustments that were in respect to petroleum products and their associated cumulative effects.

In reference to the financial performance of the country, there were surpluses of US$ 38 x 10^6 and US$ 33 x 10^6 in 1980 and 1981 respectively. Improved efficiency of tax collection procedures, the normal increase of population subjected to taxation, the acceleration in the rate of inflation as well as the favorable performance of the country's economic sectors of activity resulted in an increase of federal receipts from US$ 23,131 x 10^6 in 1980 to US$ 24,319 x 10^6 in 1981. On the other hand, expenditures during the years were US$ 23,101 x 10^6 and US$ 24,286 x 10^6 respectively.

Several subsequent mini-devaluation of exchange rate were realized between Brazilian money (cruzeiro) in relation to US dollar with the worsening of the world economic crisis and the increase of domestic prices we well as other factors and a total accumulative percentage was 95.3% in relation to US dollar in 1981. The following table shows the main data about Brazilian economical situation during the last four years.

Table II-1.3 Brazilian Economical Activity.

ITEM	Unit	1978	1979	1980	1981
Gross National Product	10^9US$	201.85	226.15	240.99	273.33
Gross Domestic Product	10^9US$	206.49	232.21	248.66	284.26
Net Income sent Abroad	10^9US$	4.64	6.06	7.67	10.93
Growth Rate	%	4.8	6.7	7.9	-3.5
Income per Capita	US$	1,821	1,998	2,088	2,334
Net Domestic Product (IInternal Revenue)	10^9US$	173.34	198.06	210.72	241.81
Internal Revenue by Branch					
Agriculture	%	13.5	13.3	13.0	12.1
Industry	%	33.4	32.4	34.0	31.9
Services	%	53.1	54.3	53.0	56.0
Balance of Payments					
Exports	10^6US$	12,659	12,244	20,132	23,293
Imports	10^6US$	13,683	17,961	22,960	22,086
Surplus or Deficit	10^6US$	1,024	-2,717	-2,828	+1,207
Public Federal Finances					
Receipts	10^6US$	19,333	18,974	23,139	24,318
Expenditures	10^6US$	19,064	18,889	23,101	24,286
Surplus of Deficit	10^6US$	+269	+85	+38	+32
General Price Index (inflation Rate)	%		77.2	110.2	95.2

1.4. Energy Resources.

Electric energy especially hydraulic and alcohol energies are at present actively being developed aiming at industrialization of Brazil. The present energy resources consumption, as indicated in Table II-1.4, shows that 39.1% of total consumption is of petroleum.

Table II-1.4 Balance of Primary Energy in PEt (1980)

Primary Energy	Production	Importation	Exportation	Total Consumption	Rate of Energy
Petroleum	9,083	43,485	60	54,319	39.1
Natural Gas	2,022	-	-	1,112	0.8
Steam Coal	1,495	-	-	1,430	1.0
Metallurgic Coal	980	3,334	-	4,043	2.9
Hydraulic Energy	37,086	-	-	37,086	26.7
Firewood	28,319	-	-	28,319	20.3
Sugar Cane	12,471	-	-	12,471	9.0
Other Resources	267	-	-	267	0.2
Total	91,723	46,819	60	139,047	100.0

The electric power supply facilities in 1980 are totaled as 31,735 MW (120,720 GWh) with the ratio of composition between hydraulic and thermal being 85.9%: 14.1% and the electric energy consumption per capita was 1006 kwh.

It is forecast that power demand will grow at an annual rate of 8% untill 2,000. Hydraulic potential possible to be developed is estimated as 213,000 MW as shown in Table II-1.5 with only 15% presently developed, and this means that Brazil has a lot of hydraulic energy.

Table II-1.5 Hydraulic Potential in Brazil.

Name of Region	Hydraulic Potential (MW)		
	Total	Operation	Under Construction (80 to 85)
North	97,800	705	2,640
Northeast	15,500	4,091	3,301
Southeast	56,200	21,497	4,050
South	43,500	4,470	11,756
Center-West	(*)	589	(*)
Total	213,000	31,735	21,747

(*) included in the North or Southeast Regions.

The Brazilian's programme of alcohol foresees the production of 10.7 million m^3 in 1985 of ethilic acohol, utilizing as the raw matherial basically the sugar cane with the following purposes:

6.1 million m^3 of hydrous alcohol to supply alcohol motor vehicles.

3.1 million m^3 of anydrous alchol to add till 20% in the gasolin.

1.5 million m^3 for the chemical industries consumption.

With regard to petroleum, 84% of the total processed of 63.2 million m^3 is presently being imported, so that intensive expolitations in sedimentary areas and along the continental shelves are being executed and the most prominent fields are along the continental shelves of the State of Bahia, Rio de Janeiro, Sergipe, Espirito Santo and Rio Grande do Norte.

Promising petroleum and natural gas deposits by means of initial well drillings and sismographic, aero-magnetometric and photogrammetric surveys of geology are prospected as 213×10^6 m^3 and $52.5 \times 10^9 m^3$ respectively.

In respect to the pyrobetuminous schist, Brazil has several prospected reserves such as in the Parana and Rio Grande do Sul States totalizing $672 \times 10^6 m^3$. Mineral coal such as lignite is deposited in the South Region especially in the States of Rio Grande do Sul and Santa Catarina, where the deposits are estimated to be 22.6×10^9 ton.

The deposits of uranium ore are also prospected to be 236×10^3 ton and nuclear power stations with total installed capacity 10,500 MW in 2,000 are being developed and planned as well as mining and enriching of uranium.

In any event, Brazil was severely hit by the energy crisis because of petroleum importing country. For this reason, developments of natural abundant energy resources are expected to be the most important matters to stimulate and develop economic activities in the country.

CHAPTER 2

PRESENT STATE OF ELECTRIC ENTERPRISES

PART II

GENERAL SITUATION IN BRAZIL

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CHAPTER 2. PRESENT STATE OF ELECTRIC ENTERPRISES.

2.1 Electric Power Situation in Brazil.

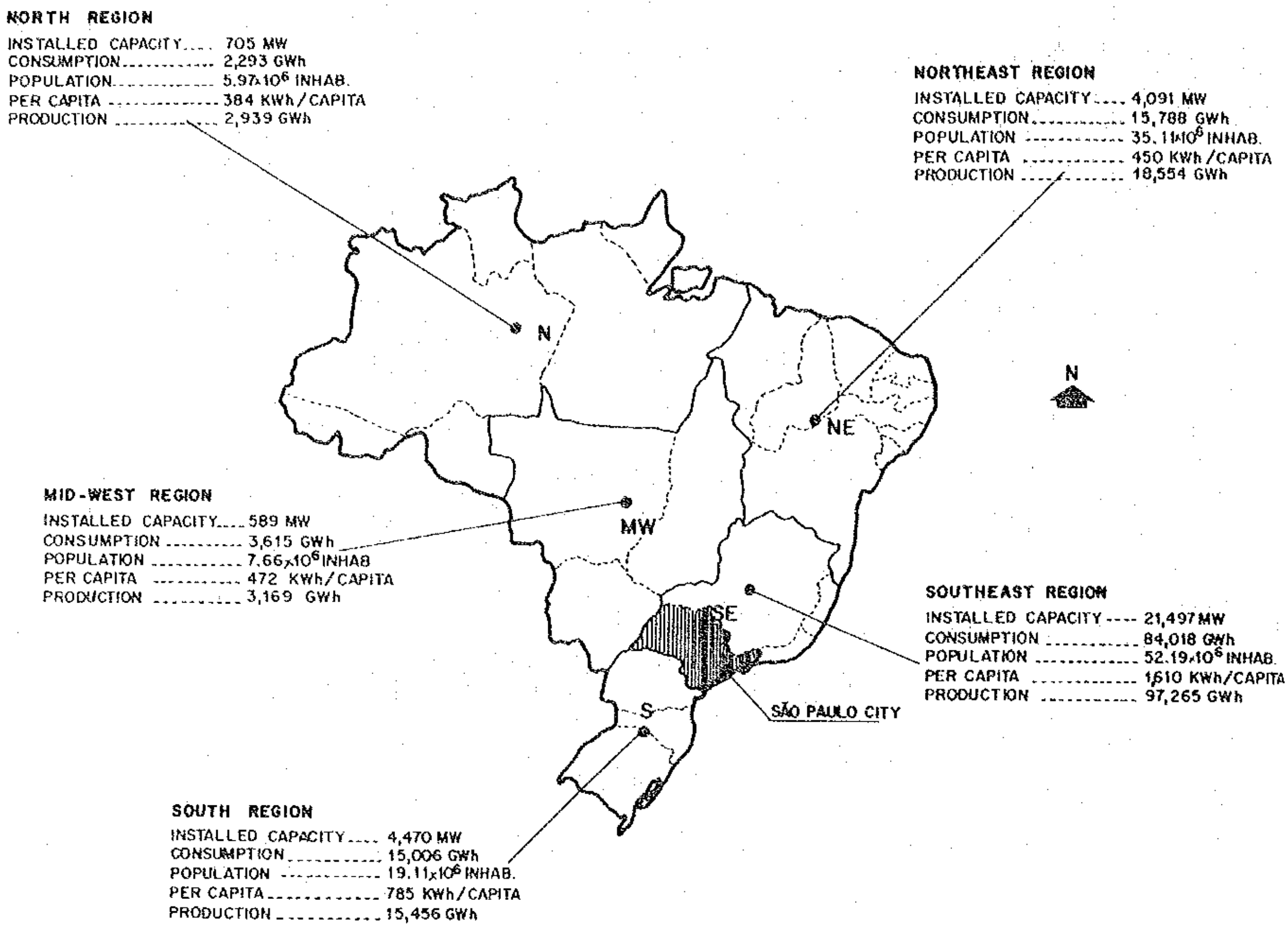
According to existing energy sources and to energy market conditions, Brazil is usually divided into 5 groups of states with integrated electrical systems, either existing or planned, forming regional power systems of great extension in area with similar economic features.
These regions are:

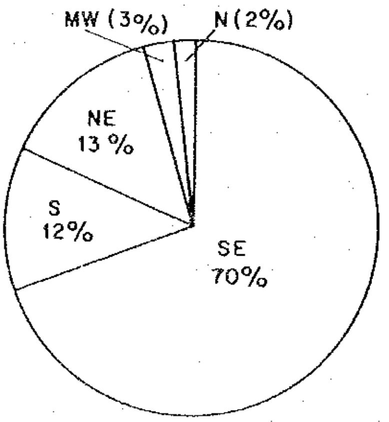
- North Region: States of Para, Amazonas, Acre, Amapa and Rondonia.
- Northeast Region: State of Bahia, Alagoas, Sergipe, Pernambuco, Paraiba, Rio Grande do Norte, Ceara, Piaui and Maranhao.
- Southeast Region: States of Espirito Santo, Rio de Janeiro, Minas Gerais and São Paulo.
- Midwest Region: States of Mato Grosso, Mato Grosso do Sul, Goias and Distrito Federal.
- South Region: States of Parana, Santa Catarina and Rio Grande do Sul.

For the energy market studies, the South-Southeast and Midwest Regions (to be indicated in this report by S/SE/MW simbols), have to be analysed all together because there are too much interdependency among them, through the interconnection of transmission lines and energy transferences. The importance of the S/SE/MW Regions is so that 65% of total population and 85% of energy consumption are concentrated in this region, as indicated in Figure II-2.1.

General informations about the Brazil and the main enterprises are mentioned in next items, with special emphasis for this region.

The trends in installed capacity and gross generated energy in Brazil are indicated in Table II-2.1 and II-2.2 and Figure II-2.2. The installed capacity in 1980 was a total of 31,735 MW with 85% of the facilities consisting of hydraulic and 15% of thermal. The total gross annual electric energy production is 137.38 TWh of which 92% is due to hydroelectric power generation. The per capita energy production are variables from 384 kWh in North Region to 1610 kWh in Southeast Region with an average value of 1006 kWh, as indicated in Figure II-2.1.





ENERGY CONSUMPTION
BY REGIONS
(100 = BRAZIL)

BRAZIL
- INSTALLED CAPACITY ---- 31,735 MW
- CONSUMPTION .... 120,720 GWh
- POPULATION .... 120.03x10⁶ INHAB.
- PER CAPITA .... 1,006 KWh/CAPITA
- PRODUCTION .... 137,383 GWh

FIGURE II-2.1 REGIONAL CHARACTERISTICS OF BRAZIL IN 1980

Obs: (a) Energy production and consumption data are preliminaries

(b) Selfproducers energy are included.

The per capita consumption level is not on the high side but growth rate in energy production is high, with 1970-1980 average exceeding 11% a year. It is surmised that such a trend is partially due to the first and second National Development Plan started in the beginning of years 70, and although restraints in the petroleum utilization have been forced since 1974, the policies to substitute fuel by electricity and the stimulus for the industries with intensive utilization of electricity, have been responsible for the continuity of such a high growth rate.

However, the year 1981, although based on preliminary data, shows that it was a typical year with 3.4% negative growth rate in the Gross domestic Product as a result mainly of inflation control policy. Although this growth rate is supposed to return gradually to its general tendency, up to about 4% in the year of 2000, its effect has taken into account for the demand forecast, as explained in Chapter 1 of Part III. According to this forecast, Brazil, for example, is aiming at the generated energy to be increased to 5.5 times of the present capacity until 2000.

TABLE II-2.1 EVOLUTION OF POWER STATIONS INSTALLED CAPACITY IN BRAZIL.

Year	Hydraulic		Thermal		Total	Annual growth	
	MW	%	MW	%	MW	MW	%
1963	4,479	70.5	1,876	29.5	6,355	626	10.9
1964	4,894	71.5	1,946	28.5	6,840	485	7.6
1965	5,391	72.7	2,020	27.3	7,411	571	8.3
1966	5,524	73.0	2,042	27.0	7,566	155	2.0
1967	5,787	72.0	2,255	28.0	8,042	476	6.3
1968	6,183	72.2	2,372	27.8	8,555	513	6.4
1969	7,857	76.6	2,405	23.4	10,262	1,707	20.0
1970	8,828	78.6	2,405	21.4	11,233	971	9.5
1971	10,244	80.9	2,426	19.1	12,670	1,437	13.0
1972	10,756	81.4	2,450	18.6	13,206	536	4.2
1973	12,500	81.0	2,936	19.0	15,436	2,230	16.9
1974	13,757	81.3	3,162	18.7	16,919	1,483	9.6
1975	16,184	82.7	3,385	17.3	19,569	2,650	15.7
1976	17,675	83.9	3,385	16.1	21,060	1,491	7.6
1977	19,038	84.1	3,599	15.9	22,637	1,577	7.5
1978	21,575	85.5	3,654	14.5	25,229	2,592	11.5
1979	24,137	85.0	4,249	15.0	28,386	3,157	12.5
1980	27,267	85.9	4,468	14.1	31,735	3,349	11.8

TABLE II-2.2 GROSS GENERATED ENERGY IN BRAZIL.

Year	Hydraulic		Thermal		Total	Annual growth	
	TWh	%	TWh	%	TWh	TWh	%
1963	20.73	74.4	7.14	25.6	27.87	-	-
64	22.10	76.0	7.00	24.0	29.09	1.22	4.4
65	25.52	84.7	4.61	15.3	30.13	1.04	3.6
66	27.91	85.5	4.75	14.5	32.65	2.52	8.4
67	29.19	85.3	5.05	14.7	34.24	1.59	4.9
68	30.55	80.0	7.63	20.0	38.18	3.94	11.5
69	32.69	78.5	8.96	21.5	41.65	3.47	9.1
1970	39.80	87.9	5.49	12.1	45.29	3.64	8.7
71	43.28	85.6	7.30	14.4	50.58	5.29	11.7
72	50.66	89.5	5.96	10.5	56.62	6.04	11.9
73	57.89	89.4	6.84	10.6	64.73	8.11	14.3
74	65.68	91.6	6.02	8.4	71.70	6.97	10.8
75	72.29	91.6	6.65	8.4	78.94	7.24	10.1
76	82.91	92.1	7.12	7.9	90.03	11.09	14.0
77	93.48	92.7	7.34	7.3	100.82	10.79	12.0
78	102.75	91.3	9.83	8.7	112.58	11.76	11.7
79	115.11	92.3	9.56	7.7	124.67	12.09	10.7
1980(*)	126.93	92.4	10.45	7.6	137.38	12.71	10.2

(*) Estimated value

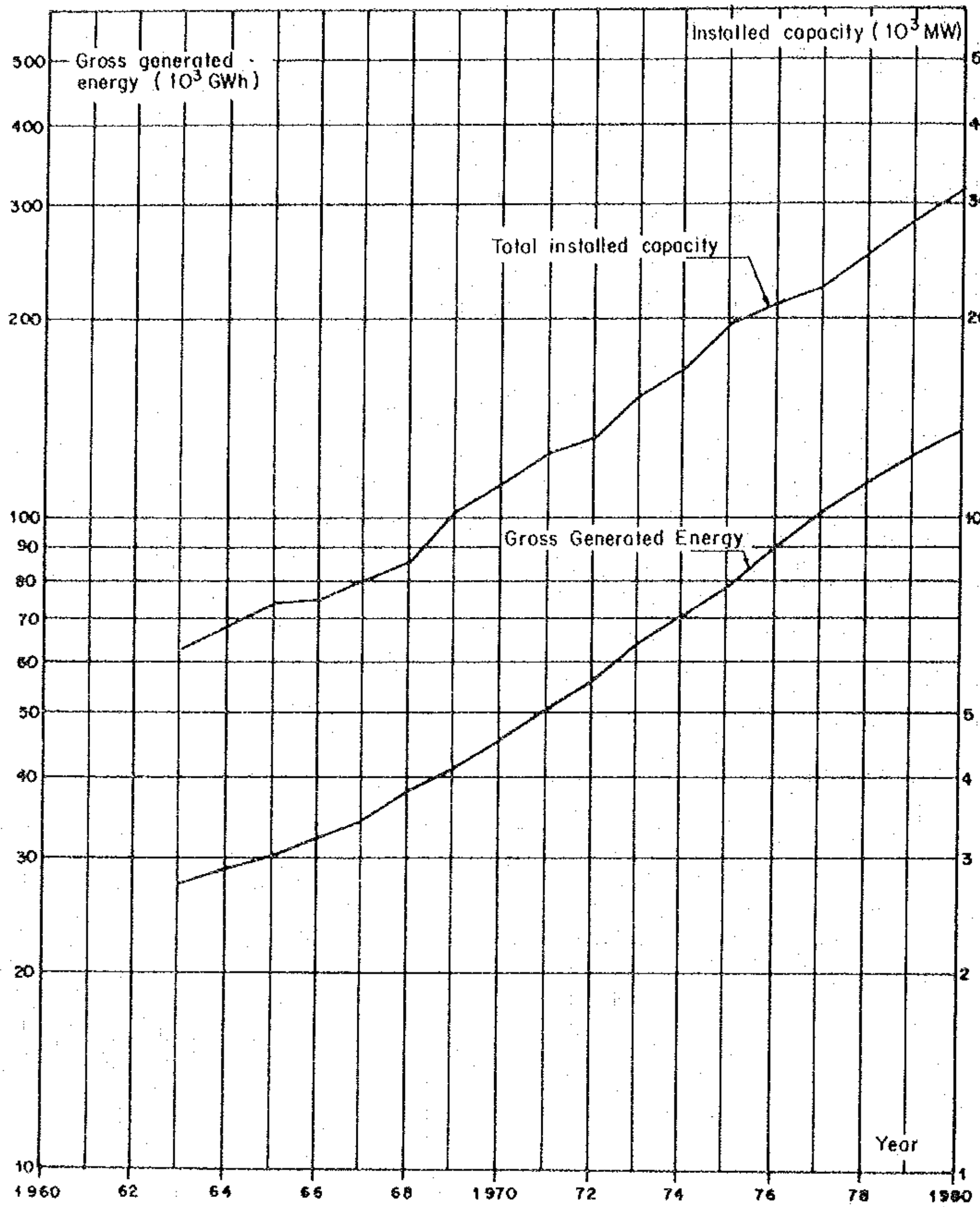


FIGURE II-2.2 INSTALLED CAPACITY AND GENERATED ENERGY IN BRAZIL

Particularly for the South/Southeast Midwest Region, this will be increased to 4.7 times of the present production and large scale hydro-power stations are scheduled to be commissioned such as Foz do Area (2,460 MW), Segredo (2,100 MW), Salto Santiago (1,998 MW), Ilha Grande (2,000 MW Itaipu (12,600 MW) and others up to 1995. Also in 1982, the first nuclear power station (626 MW) is planned to go into operation, and 8 additional nuclear power stations are planned to complete with 10,586 MW up to 2000. However, during the period 1995-2000, the electric power development plans are not complete and so that electric energy has to be increased by means of development of other new power stations, probably from North or South Region depending on future cost analysis. Also for the maximum demand supply of the S/SE/MW Region, pumped storage power stations are judged to be necessary so that, São Lourenco (2835 MW) and Cubatão III (2400 MW) MW) Power Stations are planned to be commissioned in 1996 and 1998 respectively.

The ratio of energy consumptions by consumers category, in 1980, were 58% for industrial use, 19% for general household and 11% for commercial as indicated in Table II-2.3. These ratios have not changed so much curing the past 10 years.

TABLE II-2.3 ENERGY CONSUMPTION BY CATEGORIES IN BRAZIL

	Industrial		Household		Commercial		Others		Total
	GWh	%	GWh	%	GWh	%	GWh	%	GWh
1970	19,905	52.2	8,365	21.9	5,158	13.5	4,724	12.4	38,152
71	22,702	52.9	9,178	21.4	5,646	13.2	5,361	12.5	42,887
72	25,733	53.6	9,885	20.6	6,369	13.3	5,992	12.5	47,979
73	30,056	54.7	10,943	19.9	7,237	13.2	6,692	12.5	54,928
74	34,067	55.3	12,020	19.5	8,117	13.2	7,426	12.0	61,630
75	37,583	55.1	13,210	19.4	8,987	13.2	8,400	12.3	68,180
76	43,589	56.2	14,877	19.2	9,911	12.8	9,195	11.8	77,572
77	49,155	56.5	17,133	19.7	10,534	12.1	10,163	11.7	86,985
78	55,663	57.3	18,946	19.5	11,389	11.7	11,118	11.5	97,186
79	63,088	57.9	21,020	19.3	12,560	11.5	12,260	11.3	108,928
1980*	69,781	57.8	23,310	19.3	13,806	11.4	13,823	11.5	120,720

(*) Preliminary data.

TABLE II-2.4 MAJOR HYDROELECTRIC POWER STATIONS IN OPERATION AND UNDER CONSTRUCTION (DEC.81)

River Basin	Name	Stage	Ownership	Firm energy (MW year)	Installed Capacity (MW)
Iguaçu	Foz do Areia	OP	COPEL	603	2,502
	Salto Osorio	OP	ELETROSUL	645	1,050
	Salto Santiago	C	ELETROSUL	876	1,998
Paranapanema	Xavantes	OP	CESP	180	414
	Capivara	OP	CESP	334	641
Tiete	Cubatao	OP	ELETROPAULO	420	870
	Promissao	OP	CESP	75	264
	Tres Irmaos	C	CESP	160	640
Parana	Jupia	OP	CESP	796	1,411
	Ilha Solteira	OP	CESP	1,404	3,230
	Porto Primavera	C	CESP	772	1,800
	Itaipu	C	BINACIONAL	7,500	12,600
Paranaiba	Emborcacao	C	CEMIG	465	1,000
	Itumbiara	C	FURNAS	822	2,081
	Sao Simao	C	CEMIG	1,110	2,688
	Cachoeira Dourada	OP	CEMIG	354	416
Grande	Furnas	OP	FURNAS	500	1,216
	Estreito	OP	FURNAS	421	1,049
	Jaguara	OP	CEMIG	295	639
	Marimbondo	OP	FURNAS	601	1,444
	Agua Vermelha	OP	CESP	562	1,380
São Francisco	Sobradinho	OP	CHESF	435	1,050
	Itaparica	C	CHEST	875	2,500
	Moxoto + Paulo Afornso	OP	CHESF	1,878	4,424
Tocantins	Tucurui	C	ELETRONORTE	2,100	3,990

C: Under construction OP: in operation

The major hydro-power stations in Brazil in operation and under construction are indicated in Table II-2.4.

In the North Region, there are several small municipalities or villages supplied by diesel units. A plan to substitute diesel oil by alcohol, vegetal coal, or firewood, is on course, and in some cases, the small hydroelectric power stations are also under planning stage.

The major transmission network is composed of 500 KV (6,785 km) and 440 kV (4,624 km) transmission lines in 1980. Voltages of 345 kV (6,677 km) and 230 kV (19,868 km) are also commonly adopted and 138 kV, 88 kV, 69 kV are adopted for local transmission. The introduction of 500 kV system to the major network has been going on since 1974 and at present, there are under construction of the 750 kV-AC and ± 600 kV-DC from Itaipu Power Station (12,600 MW) to the São Paulo Metropolitan Region.

Table II-2.5 indicates the annual trends in lengths of transmission lines and Table II-2.6 indicates the main characteristics of the transmission lines from Itaipu to São Paulo (Sao Roque and Tijuco Preto Substations).

TABLE II-2.5 MAIN TRANSMISSION LINES IN BRAZIL (in Kms)

Year	VOLTAGES (kV)			
	230	345	440	500
1972	11,493	3,456	1,096	-
1973	12,005	4,081	2,329	-
1974	12,725	4,431	2,708	360
1975	13,409	4,962	2,982	360
1976	14,714	5,301	3,225	1,693
1977	16,234	6,204	3,225	3,089
1978	17,221	6,444	3,909	3,660
1979	18,748	6,748	3,909	5,267
1980*	19,868	6,777	4,624	6,785

(*) Estimated.

TABLE II-2.6. TRANSMISSION LINES FROM ITAIPU TO SÃO PAULO

Name	Voltage(KV)	Length(Km)	Conductor (MCM)
Itaipu-Ivaipora	750-AC	322	4 x 1113 (2 circuits)
Ivaipora-Itabera	750-AC	265	4 x 1113 (3 circuits)
Itabera-Tijuco Preto	750-AC	304	4 x 1113 (3 circuits)
Itaipu-Ilha Grande-Ivaipora	750-AC	440	4 x 1113 (1 circuit)
Itaipu-São Roque (South)		792	4 x 1272 (1 circuit)
Itaipu-São Roque (North)	± 600-DC	816	4 x 1272 (1 circuit)

The electricity tariffs in Brazil, as of June/1981, were based on a double term monthly tariff system as follows:

TABLE II-2.7. MONTHLY TARIFF SYSTEM IN BRAZIL AS OF JUNE-1981

Categories	US$/kW	US$/kWh
More than 230 kV	8.02/kW	0.0118/kWh
88 kV - 138 kV	8.44/kW	0.0126/kWh
20 kV - 69 kV	9.37/kW	0.0167/kWh
2.3kV - 13.8 kV	9.63/kW	0.0215/kWh
residential (*)	-	0.1097/kWh

(*) Discount rate for small consumers:

0 to 30 kWh/month 70.9%
31 to 200 kWh/month 43.7%
201 to 500 kWh/month 23.6%
More than 500 kWh/month 0

Note: June 1981 : 1 US$ = Cr$ 88.90

2.2. Electric Enterprises.

The electrical industry of Brazil is almost entirely operated in the form of Governmental ownership with electric power administration and the jurisdiction of the Ministery of Mining and Energy (MME) through the Water and Electrical Energy National Department (DNAEE). However, the organization of the companies is complex and it may be separated into two main groups as below:

ELETROBRAS (CENTRAIS ELETRICAS BRASILEIRAS S.A.) GROUP:

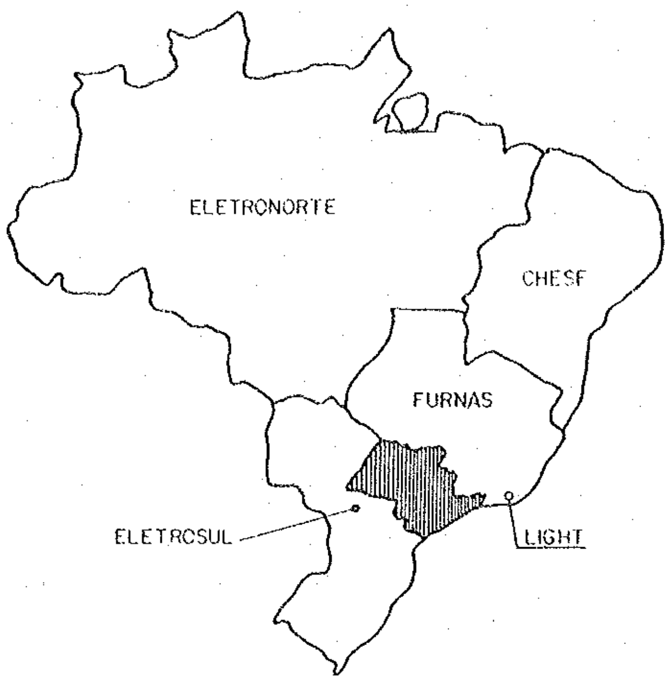
FURNAS: Furnas Centrais Electricas S.A.
CHESF - Companhia Hidroeletrica do Sao Francisco
ELETROSUL - Centrais Eletricas do Sul do Brasil S.A.
ELETRONORTE - Centrais Eletricas do Norte do Brasil S.A.
LIGHT - Light Servicos de Eletricidade S.A.

OTHER GROUP: The main companies are:

CESP - Companhia Energetica de Sao Paulo S.A.
CEMIG - Centrais Eletricas de Minas Gerais S.A.
COPEL - Companhia Paranaense de Energia Eletrica.
CEEE - Companhia Estadual de Energia Eletrica do Rio Grande do Sul.
CPFL - Companhia Paulista de Forca e Luz.
ELETROPAULO - Eletricidade de Sao Paulo S.A.

The first group is the federal ownership and the areas directly handled by them are indicated in Figure II-2.3. Although all the country is covered by federal ownership, there are some cases in which the state companies have control of their respective state area, that is the second group mentioned above, such as CESP, ELETROPAULO and CPFL for São Paulo State, and CEMIG for Minas Gerais State.

ELETROBRAS is a holding company established in 1962, with the purpose of planning and financing the electrical energy program of the country and also the co-ordination of accomplishment. At present ELETROBRAS has about 2,100 employees and the main activities are the control of the electrical companies, co-ordination of interconnected systems and the general planning.



obs: Shaded area indicates São Paulo State.

FIGURE II-2.3 MAIN ELECTRICAL COMPANIES CONTROLED BY ELETROBRAS

In the South-Southeast-Midwest, there are a high concentration of the population and industries which are responsible for 82% of total energy consumption in Brazil. In this region, São Paulo state is mainly supplied by CESP and ELETROPAULO, and CEMIG and FURNAS supply mainly to Rio de Janeiro and Minas Gerais State.

Figure II-2.4 indicates the contribution of the major companies in the total energy production when compared with the total gross energy produced in Brazil, Southeast Region and São Paulo State in 1980.

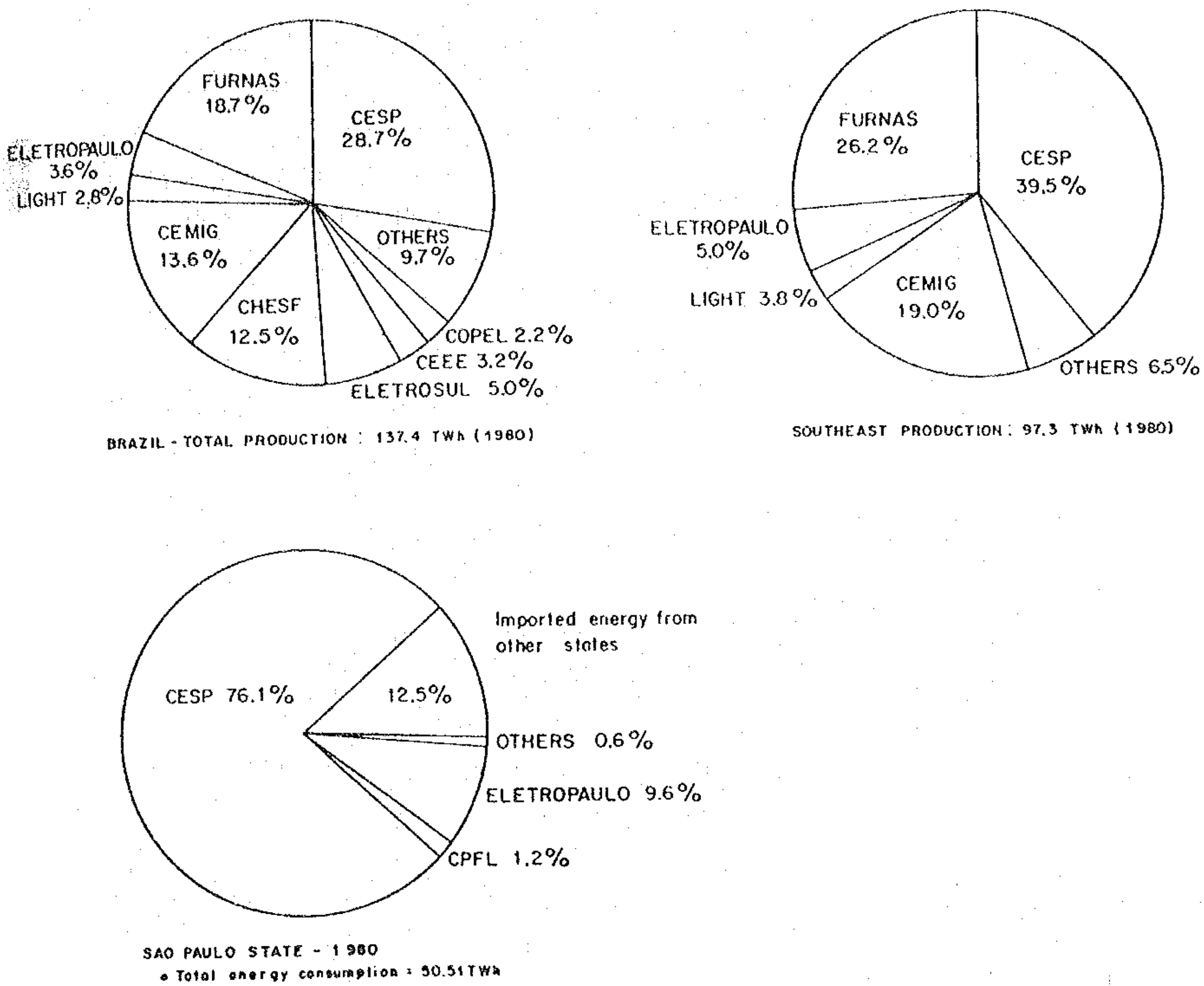


FIG. II-2.4 GROSS ENERGY GENERATED IN BRAZIL AND THE ENERGY GENERATION IN THE MAJOR COMPANIES - 1980.

So, almost 53% of energy generated in South Region, or 37% of Brazilian production, is consumed in São Paulo State which has 22% of population of all the country.

It is important to observe that although ELETROPAULO production is only 9.7% of total consumption of São Paulo State, its distribution area requires 64% of the energy consumed in Sao Paulo State. This is because the São Paulo Metropolitan Region with its 12,500,000 inhabitants and the industrial area of Paraiba river valley along the São Paulo-Rio de Janeiro roadway are included in the distribution area of ELETROPAULO, as indicated in Figure II-2.5.

Three main companies are responsible for the energy generation and distribution in São Paulo State, that is CESP, CPFL and ELETROPAULO. At present CPFL is a subsidiary company of CESP, and also there are other regional or municipal organizations supplying the energy, but its generation capacity is almost negligible compared with these 3 companies.

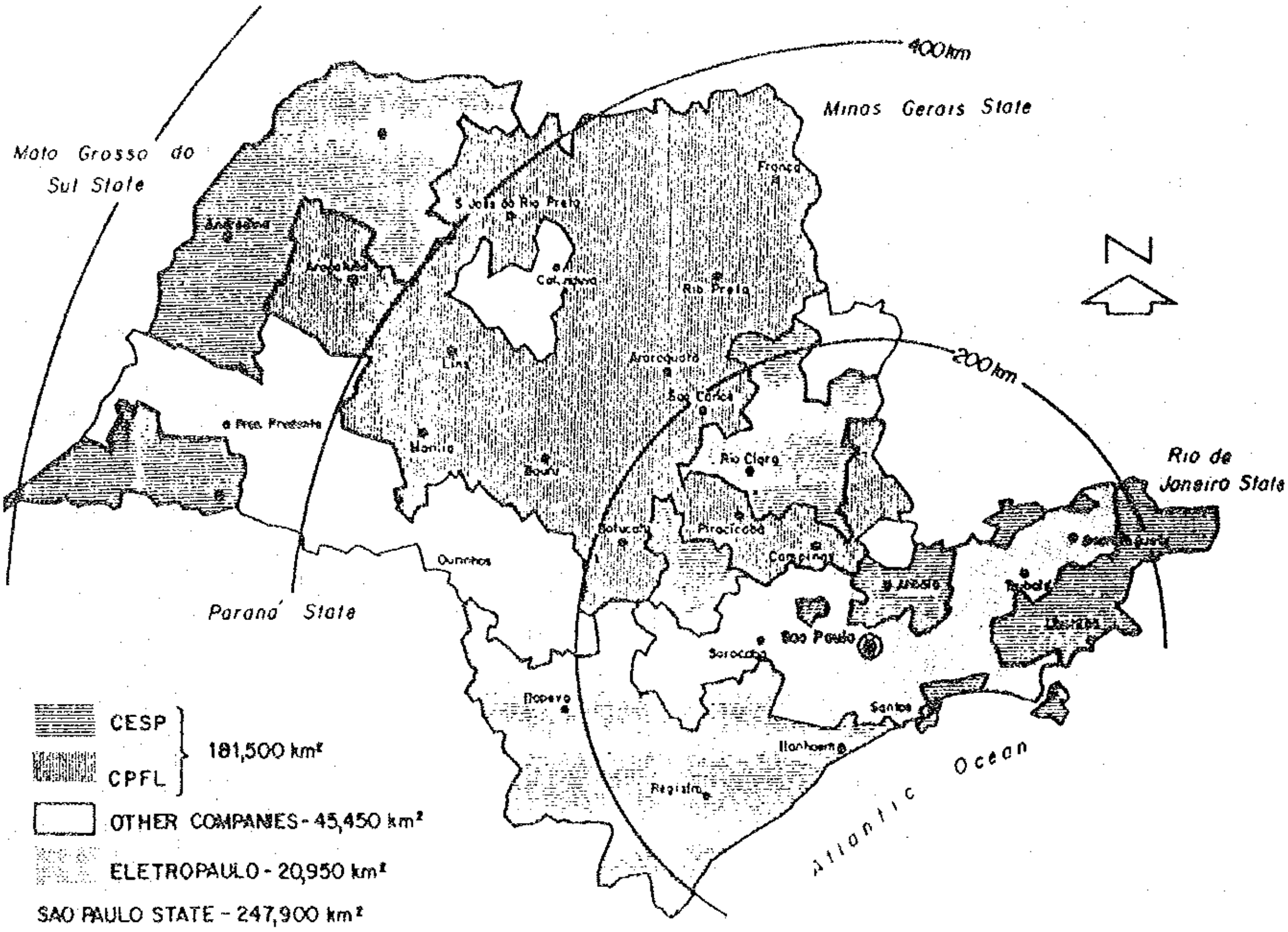
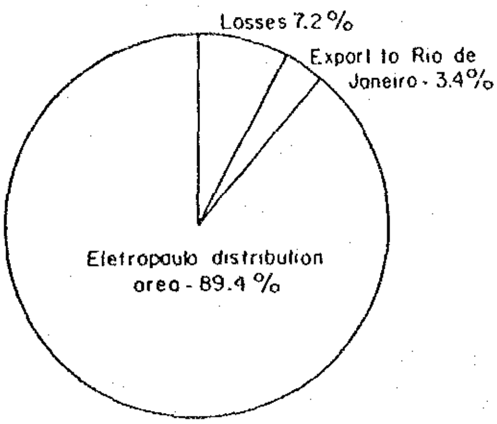


FIGURE II-2.5 POWER DISTRIBUTION IN SÃO PAULO STATE

CESP is a State enterprise established in 1966 with 25,000 employees, and it is connected with the Secretary of Public Works and Environment, through the Department of Water and Electric Energy (DAEE) that is the representative of São Paulo State Government. In 1975, CESP took control of the CPFL Company.

ELETROPAULO is also a state enterprise established in 1981, and formerly known as a LIGHT-Electricity Co., which was one of the oldest energy enterprise in Brazil supplying the two main metropolis, Rio de Janeiro and Sao Paulo. At present ELETROPAULO is connected with the São Paulo State Government through the Department of Water and Electric Energy-DAEE, and the remaining LIGHT is under the ELECTROBRAS control, s supplying Rio de Janeiro, and is known as LIGHT-Rio.

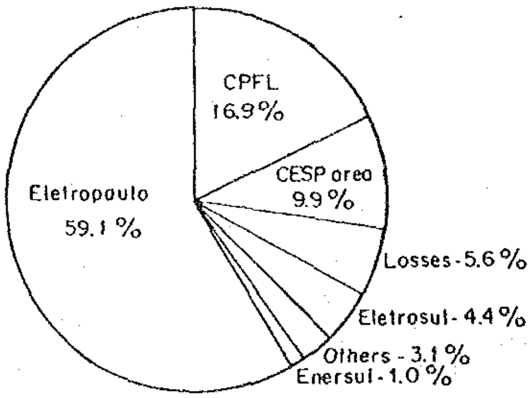
The energy generation and distribution among these companies and the percentual contribution of each one is indicated in the Figure II-2.6.



Energy distribution of ELETROPAULO system

(100=Eletropoulo generation + import = 36,311 GWh)

CESP	68.0%
FURNAS	18.3%
ELETROPAULO	13.4%
OTHERS	0.3%



Energy distribution of CESP SYSTEM

(100=CESP generation + import = 41,767 GWh)

CESP	92.0%
FURNAS	0.7%
CEMIG	7.3%

FIGURE II-2.6. ENERGY DISTRIBUTION OF CESP AND ELETROPAULO SYSTEM IN 1980.

2.3. Present State of demand and supply of electric power in São Paulo State.

As mentioned before, CESP and ELETROPAULO electric system is one of the most representative of Southeast region, as they control more than 85% of this region.

The weight of São Paulo State is indicated in Figure II-2.7 which shows that it represent 50% of total energy consumed in S/SE/MW Region, and 42% of total energy used in Brazil.

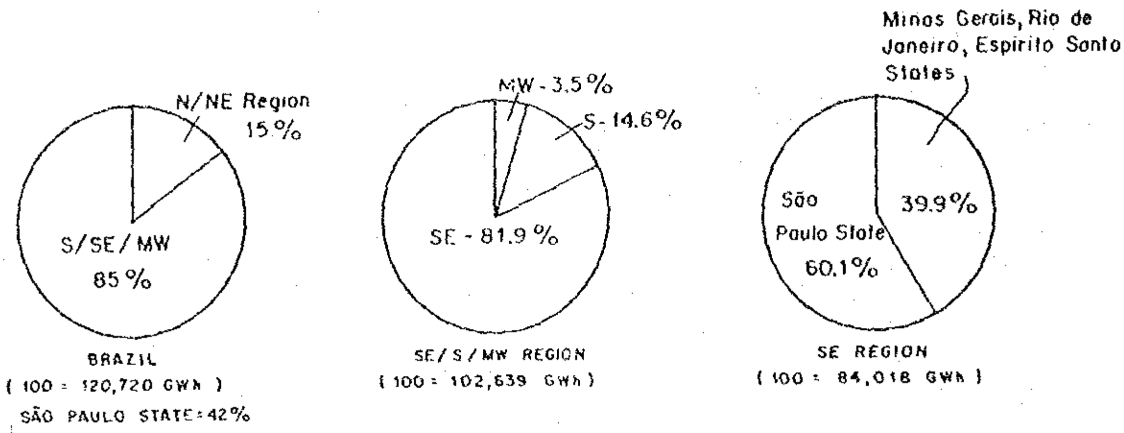


FIGURE II-2.7 ENERGY DISTRIBUTION IN SÃO PAULO STATE, SOUTHEAST REGION, AND S/SE/MW REGIONS-1980

With regard to the São Paulo State, the trend in energy generated is indicated in Table II-2.8. The average growth rate of energy generated in the past 10 years, was 13.1% and the amount of energy generated, 3.4 times of 10 years ago.

Usually the period from August to December is the maximum demand period for South-Southeast-Midwest Region and it depends on each distribution area. Rio de Janeiro city for exmple has the maximum demand on December, meanwhile Sao Paulo city is on August. Figure II-2.8 indicates the monthly percentage of peak with regard to the yearly maximum demand. As indicated, there is not very much difference between the smallest maximum demand, with the range of 77 % to 86%.

TABLE II-2.8 ENERGY BALANCE IN SÃO PAULO STATE

(unit:TWh)

Year	Generations of energy by					(2) Exportations (**)	Energy consumptions (1) - (2)
	CESP	Eletro-paulo	Others	Importations(*)	Total (1)		
1970	6.06	5.88	1.00	6.82	19.76	0.45	19.31
1971	9.17	5.84	0.95	7.23	23.19	1.51	21.68
1972	10.02	4.70	1.00	8.50	24.23	0.43	23.80
1973	11.96	5.79	0.91	8.83	27.49	0.36	27.13
1974	15.98	5.15	0.84	8.74	30.70	0.84	29.86
1975	20.58	4.08	0.83	8.23	33.72	1.80	31.92
1976	23.80	4.39	1.00	8.61	37.80	2.37	35.44
1977	26.32	3.79	0.91	9.10	40.12	1.38	38.74
1978	30.81	4.19	0.87	10.05	45.92	3.82	42.09
1979	35.46	4.45	0.84	10.93	51.68	5.16	46.52
1980	38.41	4.87	0.91	13.29	57.49	6.98	50.51

Notes: (*) Energy is imported from States of Rio de Janeiro, minas Gerais and Parana.

(**) Energy is exported to States of Rio de Janeiro, Minas Gerais, Parana and Mato Grosso do Sul.

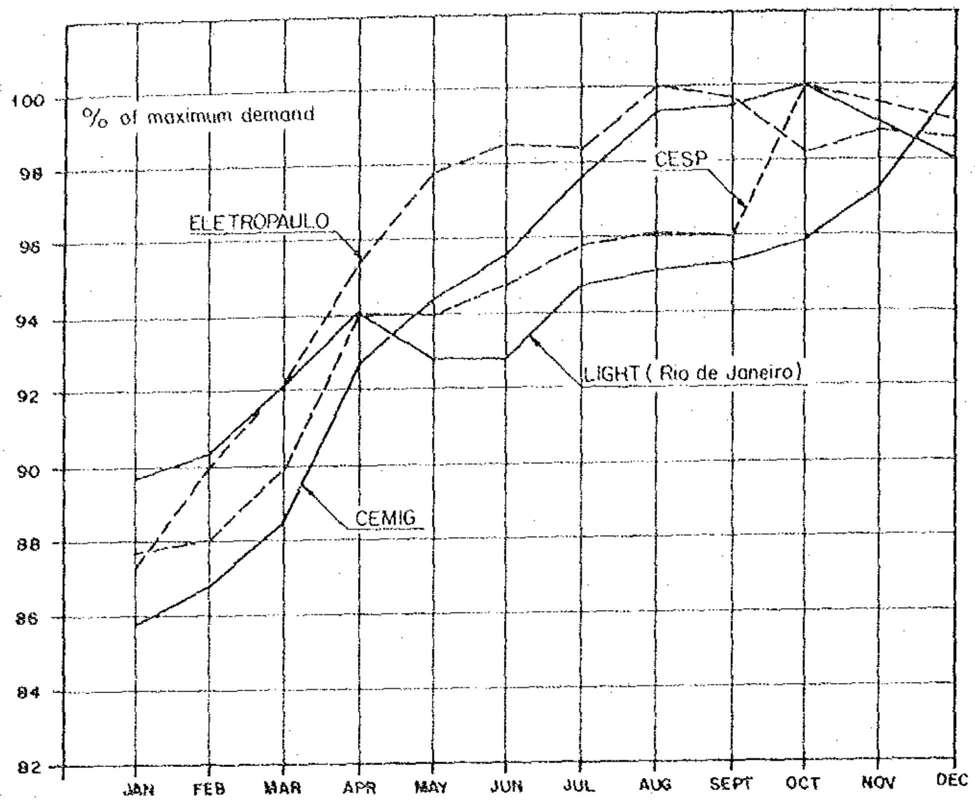


FIGURE II-2.8 MONTHLY VARIATION OF MAXIMUM DEMAND

With regard to the daily demand curve it is indicated in Figure II-2.9 and Table II-2.9 some typical curves for CESP and ELETROPAULO systems in September, 1980. The demand curve for the São Paulo State Southeast Region, and South-Southeast-Midwest Region is indicated in Table II-2.10, that was obtained indirectly considering the ELECTRO-PAULO and CESP demand curve, and also the relationship between their generated energies with regard to these regions.

As the CESP system is the most representative for São Paulo State, Table II-2.11 indicates the trends in annual demand and supply balances of the power system of CESP.

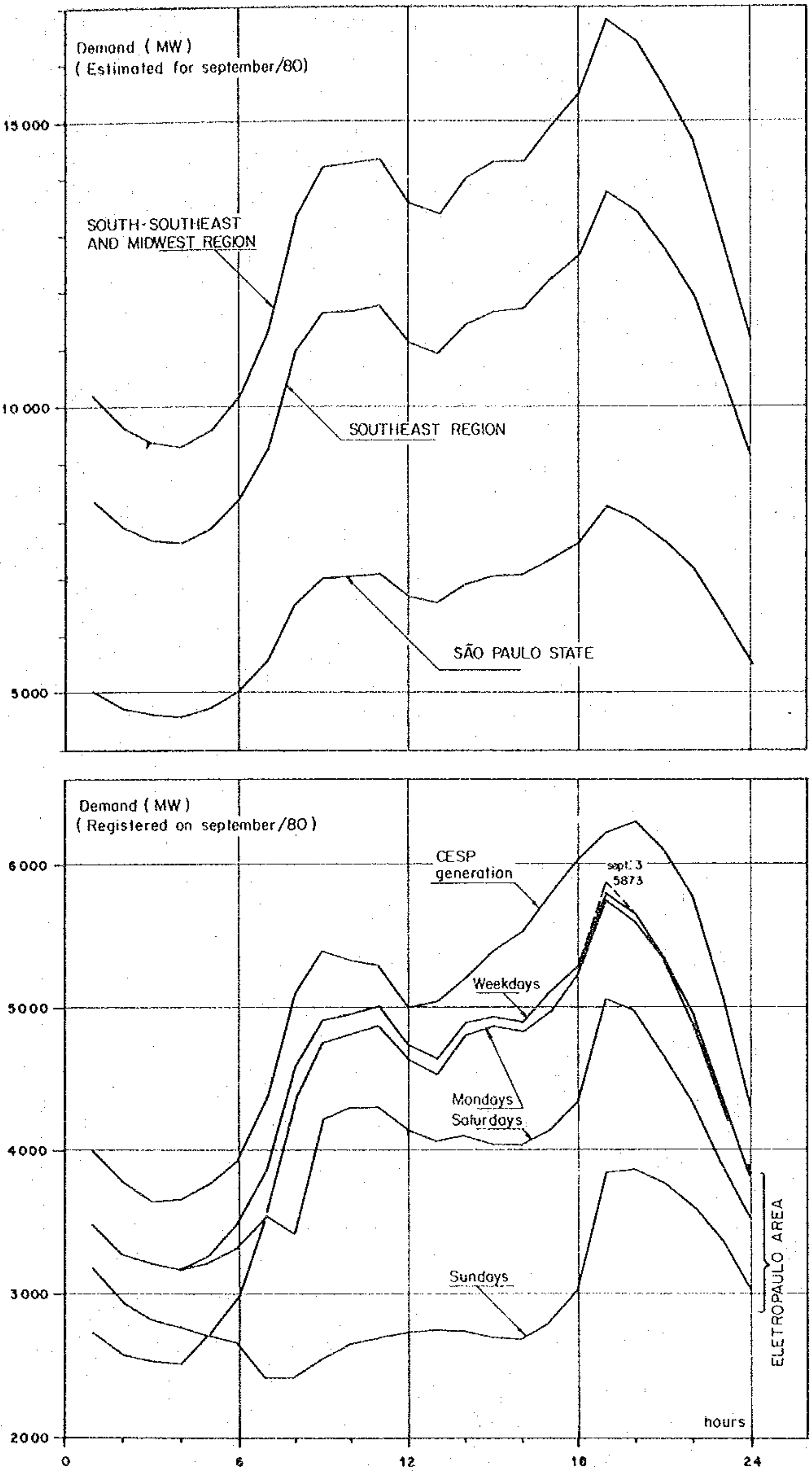


FIGURE II-2.9 TYPICAL DEMAND CURVE (SEPTEMBER 1980)

TABLE II-2.9 TYPICAL DEMAND CURVE
SEPTEMBER 1980 (unit: MWH/h)

hour	CESP systems (1)	ELETROPAULO systems week-days (2)	saturdays (3)	sundays (4)	mondays (5)
01	4,010	3,480	3,530	3,190	2,730
02	3,800	3,280	3,350	2,950	2,580
03	3,640	3,220	3,200	2,810	2,540
04	3,660	3,180	3,180	2,780	2,530
05	3,770	3,260	3,210	2,700	2,660
06	3,940	3,480	3,330	2,660	2,980
07	4,380	3,860	3,550	2,420	3,580
08	5,100	4,600	3,410	2,420	4,370
09	5,400	4,910	4,230	2,580	4,740
10	5,330	4,970	4,300	2,670	4,810
11	5,300	5,030	4,300	2,700	4,880
12	5,000	4,760	4,150	2,730	4,640
13	5,040	4,650	4,080	2,760	4,530
14	5,200	4,900	4,100	2,760	4,800
15	5,400	4,950	4,050	2,720	4,870
16	5,530	4,910	4,050	2,710	4,830
17	5,800	5,120	4,150	2,790	4,980
18	6,050	5,290	4,340	3,040	5,240
19	6,220	5,870	4,080	3,850	5,770
20	6,300	5,650	5,000	3,880	5,600
21	6,100	5,330	4,670	3,790	5,330
22	5,780	4,950	4,350	3,630	4,860
23	5,100	4,360	3,910	3,400	4,300
24	4,320	3,850	3,550	3,050	3,830

Obs: (1) Data obtained from one typical week

(2) Average values for week-days, excluding mondays.

(3) Average values for saturdays.

(4) Average values for sundays and hollidays.

(5) Average values for mondays.

TABLE II-2.10. ESTIMATED DEMAND CURVE
SEPTEMBER 1980

hour	ESTIMATED DATA		
	São Paulo State	Southeast Region	S/SE/ Region
01	5,020	8,350	10,200
02	4,740	7,890	9,640
03	4,620	7,690	9,390
04	4,590	7,630	9,320
05	4,710	7,840	9,570
06	5,000	8,320	10,160
07	5,550	9,230	11,270
08	6,560	10,920	13,340
09	6,990	11,630	14,200
10	7,020	11,680	14,270
11	7,070	11,760	14,370
12	6,680	11,110	13,570
13	6,590	10,960	13,390
14	6,900	11,480	14,020
15	7,030	11,690	14,290
16	7,040	11,710	14,300
17	7,350	12,230	14,940
18	7,620	12,680	15,480
19	8,260	13,740	16,790
20	8,080	13,440	16,420
21	7,680	12,770	15,610
22	7,200	11,980	14,630
23	6,320	10,510	12,840
24	5,510	9,160	11,200

TABLE II-2.11. ENERGY BALANCE OF CESP

(unit: TWh)

A. Energy requirements						
. Gross generated by CESP	20.58	23.80	26.32	30.81	35.46	38.41
. Purdhased power	0.25	0.45	0.48	0.84	5.43	7.09
. Total A	20.83	24.25	26.80	31.65	40.89	45.50
B. Destination of energy						
. ELETROPAULO	13.71	15.77	18.50	19.65	22.46	24.90
. CPFL	1.08	1.28	1.57	2.07	6.71	7.35
. ELETROSUL/COPEL	2.15	2.47	2.77	3.15	3.49	4.12
. CESP area	0.06	0.06	0.06	0.07	0.08	0.08
. Others	0.77	0.23	0.50	2.82	2.57	2.23
. Own consumption	1.59	2.75	1.62	1.82	2.93	4.49
. Total B	19.36	22.56	25.02	29.58	38.24	43.17
C. Losses						
. Losses	1.47	1.69	1.78	2.07	2.65	2.33
. Relative losses (C/A)	7.1	7.0	6.6	6.5	6.5	5.1

Source: CESP annual report.

CHAPTER 3

PRESENT STATE OF WATER ENTERPRISES

PART II

GENERAL SITUATION IN BRAZIL

CHAPTER 3 PRESENT STATE OF WATER ENTERPRISES

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Chapter 3. Present State of Water Enterprises

3.1. Water Supply Situation

3.1.1. General Considerations

The Metropolitan Region of São Paulo is constituted with 37 municipalities covering an area of 7,951 km^2 and its total population is 12,500,000 inhabitants according to the last 1980 Census. Almost of this population is concentrated in the Upper Tiete Besin (upstream from the Pirapora Dam) with 5,720 km^2 of Drainage area corresponding to 75% of total area of Metropolitan Region of São Paulo.

The social - economical importance of the Metropolitan Region compared with the Brazil is presented in the Table II-3.1.

TABLE II-3.1 SOCIAL - ECONOMICAL PARTICIPATION OF THE METROPOLITAN REGION IN RELATION TO THE SÃO PAULO STATE AND BRAZIL.

Discrimination	Relation to	
	São Paulo State	Brazil
Population	50%	10%
Industry Activities	62%	27%
Personal occupied in the Industries	71%	36%
Industrial Transformation value	72%	40%

With regard to the water supply system of Metropolitan Region of São Paulo, it is divided into the two modalities of attendances named "Integrated System" and "Isolated System".

The "Integrated System" is constituted with production systems interconnected with a complex adducer system named "Metropolitan Adducer System". This System is operated by SABESP and attends 28 municipalities. The remaining 9 municipalities of Metropolitan Region are supplied by individual system or "Isolated System". The total nominal capacity of the production system is nowadays 31 m^3/s and the "Metropolitan

TABLE II-3.2 WATER SUPPLY SYSTEM SITUATION OF METROPOLITAN REGION OF SÃO PAULO ATTENDED BY SABESP (SEPTEMBER/ 1979).

Manicipalities	Urban Population (Inhabitants)		Supplied rate (%)
	Total	Supplied	
1. Direct Distribution			
Arujá	18,000	8,850	49
Barueri	68,500	37,150	54
Caieiras	14,900	14,750	99
Diadema	147,000	120,700	82
Embú	45,000	40,700	90
Embú-Guacu	12,000	5,900	45
Farraz de Vasconcelos	46,700	23,650	51
Francisco Morato	21,200	-	-
Franco da Rocha	28,300	16,500	58
Guararema (*)	5,000	4,700	94
Itapecerica da Serra	33,700	7,750	23
Itapevi	48,100	19,400	40
Itaquaquecetuba	55,900	36,350	65
Jandira	26,600	18,650	70
Juquitiba (*)	3,400	2,550	75
Mairipora (*)	11,300	6,900	61
Mauá	166,000	134,000	81
Poa	52,000]	36,250	70
Ribeirao Pires	36,900	19,000	51
Rio Grande de Serra	14,400	10,250	71
Salesópolis (*)	5,750	4,850	84
São Paulo	8,662,000	7,951,350	92
Suzano	73,000	43,400	59
Taboao da Serra	81,900	64,000	78
Sub-Total	9,677,550	8,507,000	88
2. Wholesale			
Carapicuiba	135,500	104,900	77
Cotia	58,000	27,000	47
Guarulhos	380,000	305,300	80
Mogi das Cruzes	184,000	136,600	74
Osasco	510,000	417,300	82
Santo Andre	556,000	547,900	98
São Bernardo	352,000	345,600	98
São Caetano	160,800	158,700	97
Sub-Total	2,336,300	2,043,300	87
TOTAL	12,013,850	10,550,300	88

(*) Isolated Systems

TABLE II-3.3 DISTRIBUTED WATER VOLUME BY SABESP IN SEPTEMBER 1979.

Municipalities	Distributed Volume (l/s)
1. Integrated System	
Arujá	12
Barueri	102
Caieiras	(30)
Carapicuiba	197
Cotia	84
Diadema	207
Embú	91
Embú-Guacu	23
Ferraz Vasconcelos	54
Francisco Morato	-
Franco da Rocha	(30)
Guarulhos	768
Itapecerica da Serra	(15)
Itapevi	48
Itaquaqueoetuba	54
Jandira	23
Mauá	527
Mogi das Cruzes	80+(200)
Osasco	989
Poá	89
Ribeirão Pires	59
Rio Grande da Serra	16
1. Integrated System (cont.)	
Santo André	1,472
São Bernardo	1,237
São Caetano	715
São Paul0	23,689
Suzano	111
Taboao da Serra	152
Sub-Total	30,873
2. Isolated System	
Guararema	11
Juquitiba	5
Mairiporã	13
Salesópolis	7
Sub-Total	36
TOTAL	30,909

( ) Temporarily Isolated System

Adducer System" is constituted with 1000 km of adducer and 1,400,000 m^3 of reservation capacity. In the municipalities supplied by SABESP the total length of water system is 14,000 km and 1,400,000 domiciliary connections to supply 8,500,000 inhabitants (September 1979).

The Tables II-3.2 and II-3.3 presentes the situation of each municipality supplied by SABESP (September/79)

3.1.2. Existing Water Supply Plans

The São Paulo State Government, through Departmento de Aguas e Energia Eletrica - DAEE, in 1968 developed the "Plano Director de Obras para Desenvolvimento Global dos Recursos Hidricos das Bacias do Alto Tiete e Cubatao", known by "HIBRACE PLAN".

The HIBRACE PLAN foresees the water utilization of upper Tiete and neighbourhood basins to supply the prospected demand of Metropolitan Region of São Paulo with 72 m^3/s up to 2000.

The following facilities showed in the Table II-3.4 were planned in this Plan and the prospected water demand is presented in the Table II-3.5.

TABLE II-3.4 HIBRAGE PLAN FACILITIES (1968 Plan)

Planned System	Supply Capacity (m^3/s)
Alto Tiete	19.6
Guarapiranga	38.0
Cantareira	30.0
Billings	10.0
Cotia	3.0
Baixada Santista	5.8(*)
Total	101.4

(*) To Supply Coastal Region

TABLE II-3.5 PROSPECTED WATER DEMAND FOR THE METROPOLITAN REGION OF SÃO PAULO (HIBRACE PLAN - 1968)

YEAR	Total Population (Inhab.)	Supplying Population (Inhab.)	Average Demand (m^3/s)	Average Per Capita Consumption (l/Inhab day)
1970	6,901,000	5,998,000	30.9	445
1980	10,269,000	8,459,000	43.9	447
1990	14,384,000	11,382,000	60.3	457
2000	19,247,000	13,623,000	72.4	459

In 1976, The "Companhia de Saneamento Basico do Estado de São Paulo"-SABESP", based on new data developed the "Plano Director de Suprimento de Agua Potavel da Regiao Metropolitana de São Paulo". The results of this study are presented in the Table II-3.6.

TABLE II-3.6 PROSPECTED WATER DEMAND FOR THE METROPOLITAN REGION OF SÃO PAULO (SABESP PLAN - 1976)

YEAR	Total Population (Inhab.)	Supplying Population (Inhab.)	Average Demand (m^3/s)	Average Per Capita Consumption (l/Inhab day)
1980	12,461,000	11,201,000	37	282
1990	17,876,000	16,429,000	65	341
2000	23,626,000	22,435,000	104	400

3.2. Water Supply Enterprises

The water supply enterprise of the Metropolitan Region of São Paulo (SABESP) is entirely operated in the form of state ownership. It is under the jurisdiction of the Secretary of Public Works.

In the past, all the municipalities had its particular water wupply enterprises, but in attention to a governmental policy, SABESP incorporated almost all the municipal water supply enterprises of Sao Paulo State.

SABESP is an organ established in 1973 and has the main purpose of construction and operation of facilities for water supply and sewerage treatment. SABESP has several regional departments throughout the state and a total numbers of 16,800 employees.

3.3. Water Supply Facilities

Nowadays, the water supply system of Metropolitan Region of Sao Paulo serves 85% of the total population, by the use of superficial resources as shown in the Table II-3.7.

TABLE II-3.7 WATER SUPPLY SYSTEMS DEVELOPED BY SABESP

Name	Firm Discharge(m^3/s)
Guarapiranga	10.5
Cantareira (1st stage)	11.0
Rio Grande (BILLINGS)	4.1
Others	2.1
TOTAL	31.7

Presently, SABESP is concluding the final stage of Cantareira System that will add 22 m^3/s to the supply system. Then, the total available discharge for the Metropolitan Region will be 53.7 m^3/s, which is enough to cover the demand until 1987, according to the prospected water demand by SABESP PLAN in 1976.

3.4. Supply and Demand Situation of Water

After 1987, SABESP foresees the utilization of new recources for the supply of Metropolitan Region. According to the plan developed in 1976, these new resources are described in Table II-3.8

TABLE II-3.8 NEW RESOURCES FOR WATER SUPPLY AFTER 1987

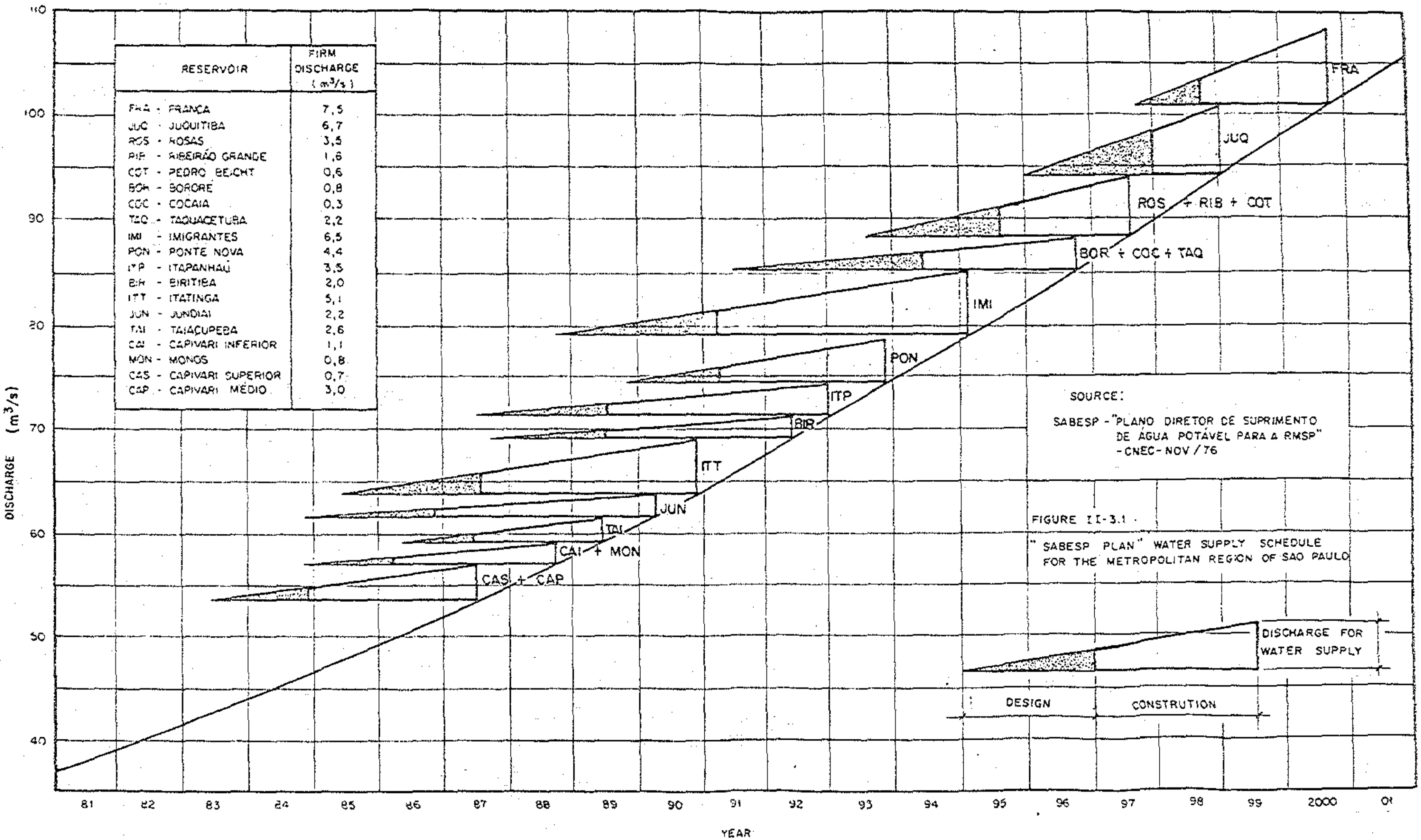
NAME		DISCHARGE (m^3/s)	
		FIRM	FOR WATER SUPPLY
CAPIVARI-MONOS:	Capivari Superior	0.7	0.7
	Capivari Medio	3.0	3.0
	Capivari Inferior	1.1	1.1
	Monos	0.8	0.8
			5.6
ALTO TIETE:	Taiacupeba	3.9	2.6
	Jundiai	2.2	2.2
	Itatinga	5.1	5.1
	Biritiba	2.0	2.0
	Itapanhau	3.5	3.5
	Ponte Nova	8.4	4.4 (1)
			19.8
BILLINGS:	Imigrantes (Rio Grande)	10.0	6.5 (2)
	Borore	0.8	0.8
	Cocaia	0.3	0.3
	Taquacetuba	2.2	2.2
			9.8
ALTO JUQUIA:	Rosas	3.5	3.5
	Riveirao Grande	1.6	1.6
	Juquitiba	6.7	6.7
	Franca	7.5	7.5
			19.3
AUTO COTIA:	Pedro Beicht	1.4	0.6 (3)
TOTAL		64.7	55.1

(1) Excluding 4 m^3/s, already in exploitation

(2) Excluding 3.5 m^3/s, already in exploitation

(3) Excluding 0.8 m^3/s, already in exploitation

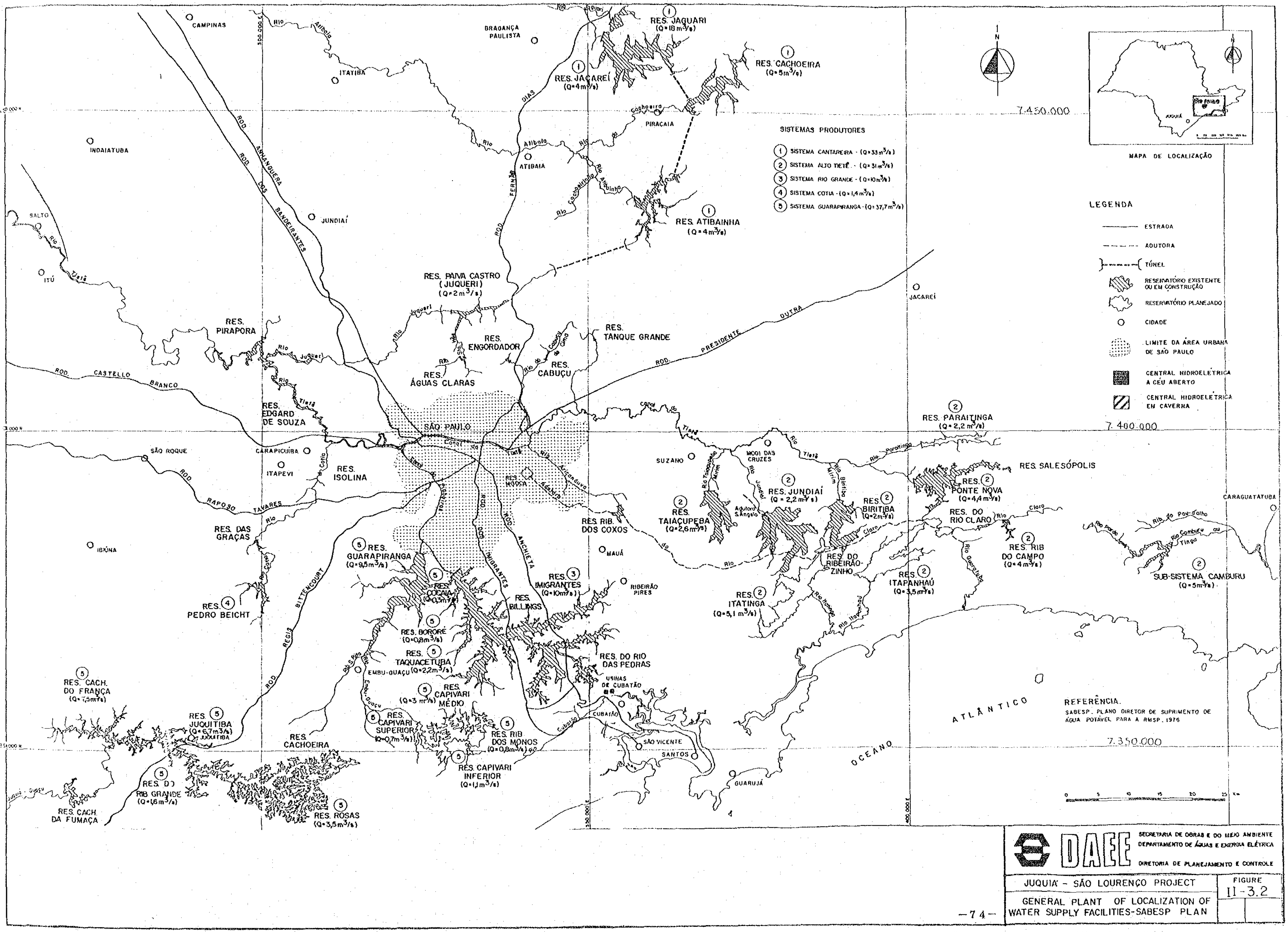
The Figure II-3.1 shows the prospected water demand curve for the Metropolitan Region and the sequence of works planned in 1976 by SABESP to cover the demand up to 2000, and in the Figure II-3.2 is shown the general plant of localization of those facilities.



RESERVOIR	FIRM DISCHARGE (m^3/s)
FRA - FRANÇA	7,5
JUQ - JUQUITIBA	6,7
ROS - ROSAS	3,5
RIB - RIBEIRÃO GRANDE	1,6
COT - PEDRO BEICHT	0,6
BOR - BORORÉ	0,8
COC - COCAIA	0,3
TAQ - TAQUACETUBA	2,2
IMI - IMIGRANTES	6,5
PON - PONTE NOVA	4,4
ITP - ITAPANHAÚ	3,5
BIR - BIRITIBA	2,0
ITT - ITATINGA	5,1
JUN - JUNDIAÍ	2,2
TAI - TAIAÇUPEBA	2,6
CAI - CAPIVARI INFERIOR	1,1
MON - MONOS	0,8
CAS - CAPIVARI SUPERIOR	0,7
CAP - CAPIVARI MÉDIO	3,0

FIGURE II-3.1

"SABESP PLAN" WATER SUPPLY SCHEDULE FOR THE METROPOLITAN REGION OF SAO PAULO



SECRETARIA DE OBRAS E DO MEIO AMBIENTE
DEPARTAMENTO DE ÁGUAS E ENERGIA ELÉTRICA
DIRETORIA DE PLANEJAMENTO E CONTROLE

JUQUIÁ - SÃO LOURENÇO PROJECT

GENERAL PLANT OF LOCALIZATION OF WATER SUPPLY FACILITIES-SABESP PLAN

FIGURE II-3.2

PART III

DEVELOPMENT PLAN

CHAPTER 1

DEMAND AND SUPPLY FORECAST OF ELECTRIC POWER

PART III

DEVELOPMENT PLAN

CHAPTER 1 DEMAND AND SUPPLY FORECAST OF ELECTRIC POWER

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Chapter 1. Demand and Supply Forecast of Electric Power

1.1. Demand Forecast.

As presented in the Chapter-2, water demand forecast and supply analysis made for the São Paulo Metropolitan Region, indicates that, water from São Lourenco River will be required in 1996, and it is necessary to construct the large scale pumping station (525 m effective head) to make possible the supply of drinking water to São Paulo Area, which is situated more than 700 m above sea level.

Especially for this pumping station, the present plan is recommended as a reversible power station, named São Lourenco, which has an advantage to be useful for the water supply side as a pumping station, and for the electric power side, mainly as a power station for the peak power generation. On the other hand, once this water of São Lourenco River is utilized, it will return to the natural drainage system of São Paulo Area, which is mainly based on Tiete, Tamanduatei and Pinheiros Rivers. These rivers are closely related to the ELETROPAULO Hydroelectric System, which has a diversion works to the seaside region through hydroelectric power stations of Cubatao I and II (700 m head) in full operation since 1950 (first unit in 1926) and 1961 respectively. In the future, through the gradual development of São Lourenco River to supply the water to São Paulo, much more utilized water will be available, and another reversible power station named Cubatao III is planned to make the effective utilization of this incremental water and to get advantage of the peaking power generation for power demand districts, of which power station is to contribute for the energy recovery of the electric power system from the view point of energy balancing.

The purpose of this chapter is to analyse the electric power demand and supply balance for the future, and to indicate the year of operation commencement of these power stations.

Electric power demand forecasts are roughly divided into long-range or short-range forecasts depending on the number of years considered. For the construction of the structures such as São Lourenco and Cubatão Reversible Power Stations, mainly considering that this kind of power stations is the first in Brazil, it is supposed that a minimum of 10 years hence will be required including the preparatory period. For the water supply side, a demand forecast up to 2040 is considered, and even for electric power side, a demand forecast beyond 2000 is desirable, but this kind of study is considered to be very complex and difficult, mainly because the trends of international energy situation, and the evolution of the world and domestic economies are very difficult to forecast. Consequently, in this report, for the electric power side, a demand forecast up to 2000 is made, and from the view point of demand and supply balance, it is judged that the operation commencement years of São Lourenco and Cubatão Reversible Power Stations will be necessary before 2000.

The water supply side is taken into account of only the São Paulo Metropolitan Region to analyse the demand and supply of drinking water. However, the electric power side has to be considered all the South Southeast and Midwest Region of Brazil, even for the planning of the peak power generation, because these regions are interconnected or will be interconnected by transmission lines in order to compose an integrated electrical system.

The contents of this Chapter consist of four items, that are the outline of the demand forecast made by ELETROBRAS in 1981, named PLAN 2000, the forecast made by applying an equation over the energy basic data, the longrange forecast made by a macro-method and, finally, the results of present study.

1.1.1. Demand Forecast by ELETROBRAS

This paragraph is a summary of the report "Plan to supply the electric energy requirements until 2000", or simply "PLAN 2000", published in March 1982 by ELETROBRAS- Centrais Eletricas Brasileiras S.A., following the guidelines of the Ministry of Mines and Energy.

Historically, the behavior of the electric energy market in Brazil may be characterized by the high annual average rates of growth of the consumptions above 10% verified in the last 10 years period. Until 1974, the evolution of the requirements of overall energy and electric energy followed up to growth of GDP (Gross Domestic Product). Since then, due to the restraint of the use of petroleum products, alternations of the industrial production structures with increase of electric energy utilization to substitute fuel energy at the lower degree were promoted and the growth of the requirements of overall energy decreased following the evolution of GDP. While, until 1980, the growth of the consumption electric energy was maintained at the level of the beginning of the previous ten years as shown in Figure III-1.1.

The plan of Plan 2000 is maintained near to and below the previous plan named Plan 90, such as the demand for the 1981-1984 period being quite typical in comparison with previous trends.

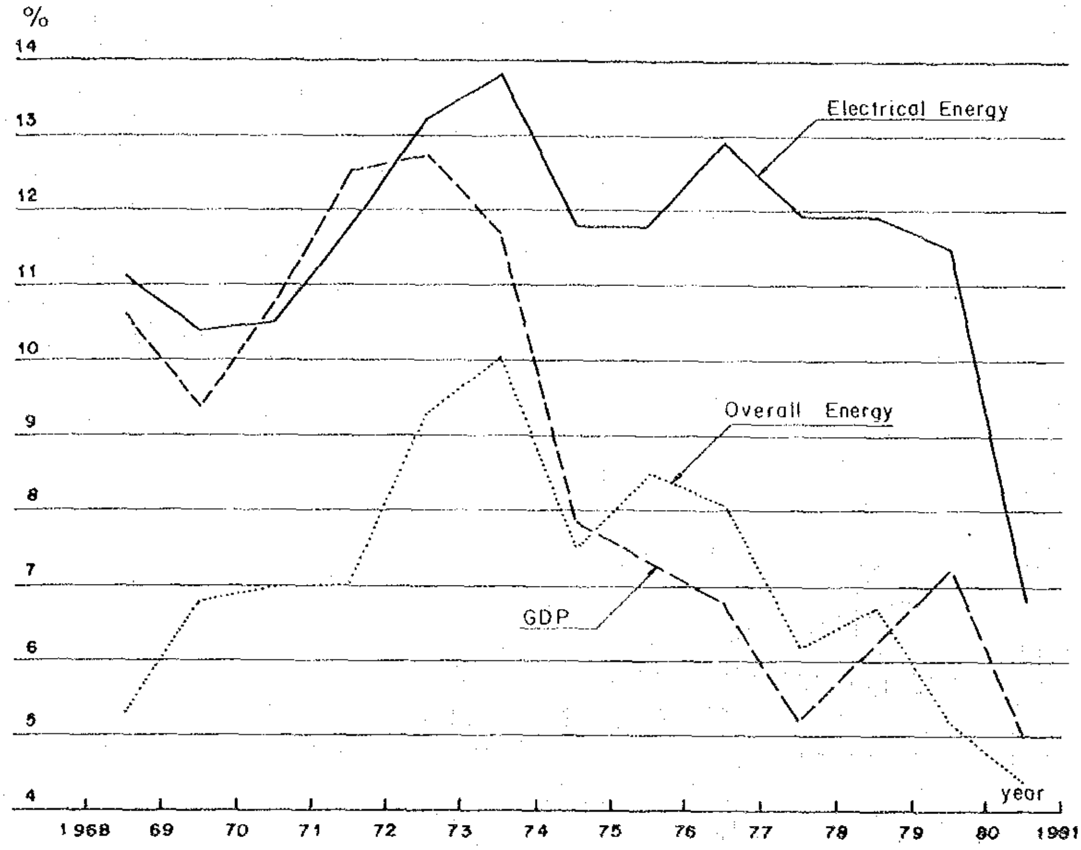

FIGURE III-1.1 EVOLUTION OF THE GROWTH RATES OF THE GDP, OVERALL AND ELECTRIC ENERGY

Notes: (a) Growth rates considering biannual movable average values.

(b) Overall energy includes electrical energy, and other energy sources such as petroleum, coal, gas and etc.

(c) GDP - Gross Domestic Product, or PIB-Produto Interno Bruto, is close to the values of GNP - Gross National Product in the case of Brazil.

(d) Source: PLAN 2000 - ELECTROBRAS.

Table III-1.1 summarizes the evolution foreseen in the period 1980/2000, of the total electric energy required in Brazil and in the regions that are considered for planning purposes, according the estimations made by ELETROBRAS.

TABLE III-1.1 BRAZIL AND REGIONS - AVERAGE FORECASTS FOR THE ENERGY REQUIREMENTS, MADE BY ELETROBRAS

(unit: GW year)

Planning Regions	1980	1984	1990	1995	2000
North plus Maranhão	0.3	0.6	2.8	3.9	5.2
Northeast minus Maranhão	1.7	2.4	4.9	6.9	9.2
Southeast plus Mid-west minus Mato Grosso do Sul	10.3	13.3	21.4	29.8	40.4
South plus Mato Grosso do Sul	1.9	2.8	5.7	8.3	11.4
Brazil	14.2	19.1	34.8	48.9	66.2

(GW year = 8760 GWh)

Especially for the South, Southeast and Midwest Region, which includes the São Paulo Metropolitan Region, the results of the PLAN 2000, considering a load factor between 63.9% and 65.4%, and a reserve of about 15%, can be summarized as follows:

TABLE III-1.2. RESULTS OF DEMAND FORECAST MADE BY ELECTROBRAS FOR THE S/SE/MW REGION OF BRAZIL.

Year	Gross energy required		Maximum Demand
	(GWh)	(MWyear)	(MW)
1980	106,950	12,200	21,960
81	114,570	13,070	23,520
82	122,810	14,010	25,210
83	131,670	15,020	27,030
84	141,130	16,100	28,970
85	154,280	17,600	31,670
86	168,310	19,200	34,550
87	183,210	20,900	37,610
88	199,860	22,800	41,030
89	217,400	24,800	44,630
1990	237,560	27,100	47,720
91	254,210	29,000	51,720
92	272,620	31,100	54,770
93	291,030	33,200	58,470
94	312,070	35,600	62,700
95	333,950	38,100	67,100
96	365,020	40,500	71,320
97	377,810	43,100	75,900
98	401,480	45,800	80,660
99	426,900	48,700	85,760
2000	454,080	51,800	91,080

Obs.: Maximum Demand (including reserve) and the yearly values are calculated from data available in PLAN 2000 - ELETROBRAS.

1.1.2. Demand forecast by analysis of trends.

A method using gross energy consumption obtained from the past trends is also applied in estimation for the period 1981-2000. In this method, an equation is derived from data on gross energy consumption for the period 1961 - 1980, and the most suitable equation for these data is the Gompertz equation and the results can be summarized as follows:

TABLE III-1.3 AVERAGE FORECASTS FOR THE ENERGY REQUIREMENTS BY GOMPERTZ'S EQUATION

Year	Gross Energy required 10^3GWh	Gross Energy required (MWyear)
1979	91.7	10,460
1982	123.2	14,050
1895	160.5	18,310
1988	203.9	23,260
1991	253.2	28,880
1994	307.4	35,070
1997	366.4	41,800
2000	430.2	49,080

(MWyear = 8760. MWH)

1.1.3. Demand forecast by Macro-Method.

Although the ELETROBRAS-PLAN 2000 is based on Macro-Method, a forecast by this technique is again attempted considering the period 1965-1981. The main purpose is to find out what kind of difference in trend is produced between the above mentioned forecast results and those macroscopic technic reviews.

a) Consideration about the demand forecast based on GDP:

It is established statistically that there is a correlation between the energy demand and the national economy of the country. Particularly, it is clarified that a fairly regular correlation exists between GNP (Gross National Product) and the kWh Generated,

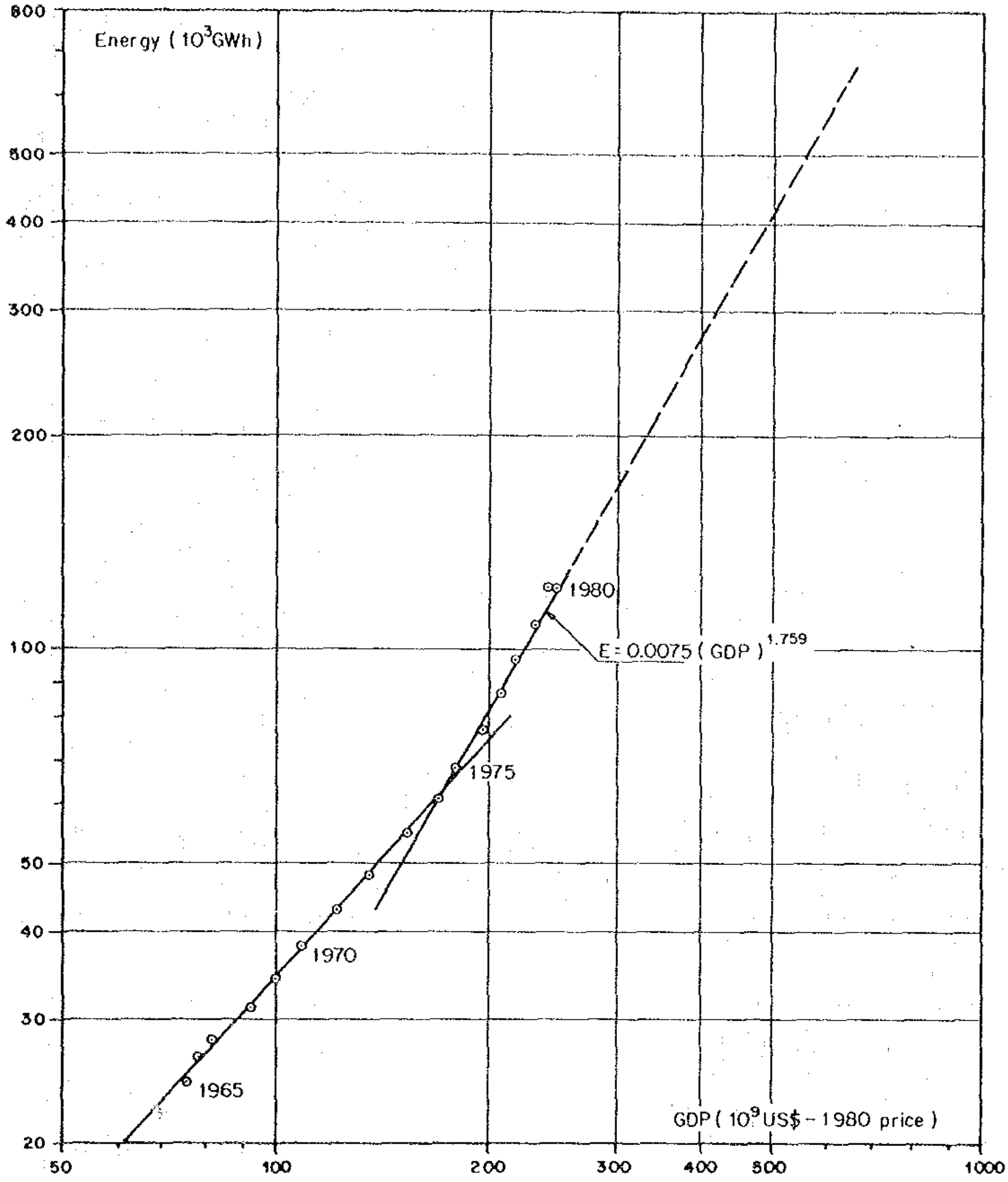

FIGURE III-1.2 CORRELATION BETWEEN GDP AND CONSUMED ENERGY IN BRAZIL

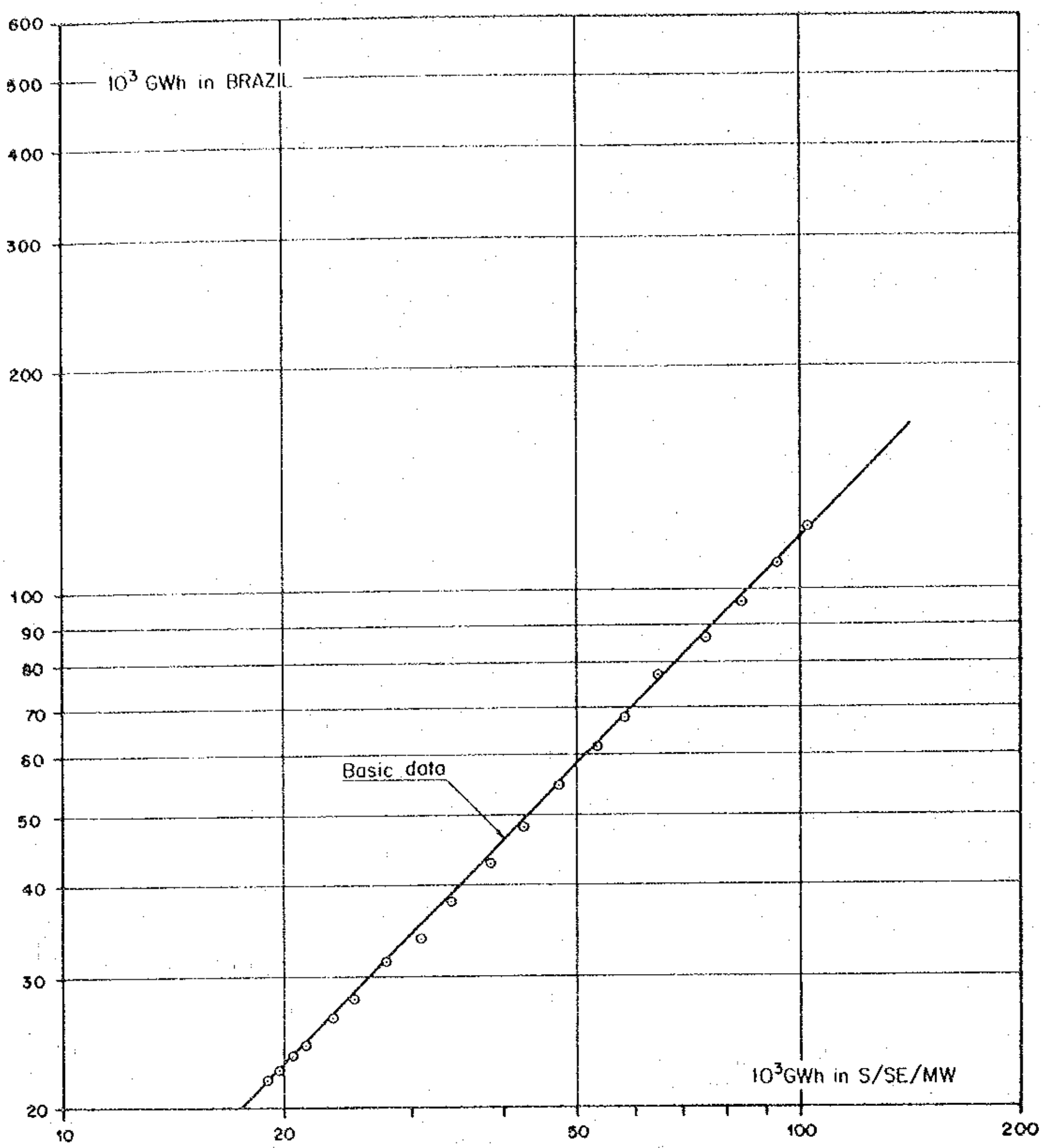

FIGURE III-1.3 RELATIONSHIP BETWEEN CONSUMED ENERGY IN BRAZIL AND ITS S/SE/MW REGION

and many cases of demand forecasts are made by macroscopic method based on GNP. For the case of Brazil, the GDP (Gross Domestic Product or PIB - Produto Interno Bruto) is considered instead of GNP, because this is nearly same value as GNP, and the GDP is much more representative of the economical activity in Brazil.

At first, the study is made for all of the Brazil, and after then, a correlation showing the relationship between Brazil and south-Southeast-Midwest - Region is utilized in order to establish the GDP corresponding only for these regions. On the next items these procedures are explained step by step.

b) Basic data for demand forecast and the relationship with Brazil and South-Southeast-Midwest Region:

The basic data available for forecast are indicated in Table III-1.4, and they are published by "Fyndacao Getulio Vargas" and "Fundacao Instituto Brasileiro de Geografia e Estatistica", the main organizations in Brazil, which deals this kind of data. For the population of Brazil, there are only the results of Census which is provided once a decade.
Grompertz's equation is utilized to determine the intermediate values.

Figure III-1.2 indicates the correlation between GDP and the consumed energy in Brazil, showing 2 trends with one tendency before 1974 and another after 1974. For the purpose of this study it is considered that the equation established for the period 1974-1981 will remain until 2000, and by means of this equation, the energy required is forecast considering the evolution of the national economy as indicated in next step.

However, the use of this method to forecast the necessary energy in S/SE/MW Region has one trouble that there is no data about the GDP in this region. As the importance of this region on the economy of Brazil is high, it is assumed that there are relationships between consumed energies, and in fact, Figure III-1.3 indicates a good correlation that can be used to estimate the gross product equivalent to the S/SE/MW Region.

So, the GDP for this region is estimated by means of yearly relationship with the generated energy between Brazil and S/SE/MW Region, and the Table III-1.5 indicates the results of this procedure.

For the population forecast, Gompertz's equation is adopted as adopted for the Brazil case.

The correlation between equivalent GDP for S/SE/MW Region and its consumed energy is indicated in Figure III-1.4 and equation considering the period 1974 - 1981 is utilized to establish the energy requirements until 2000 according to the evolution of the economy of this Region, as indicated in next step.

TABLE III-1.4. BASIC DATA FOR DEMAND FORECAST - BRAZIL

Year	GDP-Gross Domestic Product (Constant Price in 1980)		Energy Generated		Population	GDP per capita		Energy per capita	
	10^6 US$	Growth rate (%)	GWh	Growth rate (%)	(thousand)	US$	Growth rate (%)	KWh	Growth rate (%)
1961			19,630	-	72,193			272	-
62			21,857	11.3	74,276			294	8.1
63			22,618	3.5	76,419			296	0.7
64			23,521	4.0	78,624			299	1.0
65	75,073	-	24,268	3.2	81,006	927	-	300	0.3
1966	77,883	3.7	26,494	9.2	83,343	935	0.9	318	6.0
67	81,686	4.9	27,988	5.6	85,748	953	1.9	326	2.5
68	90,814	11.2	31,399	12.2	88,222	1,029	8.0	354	8.6
69	99,841	9.9	34,049	8.4	90,768	1,100	6.9	375	5.9
70	108,643	8.8	38,152	12.0	93,139	1,167	6.1	410	9.3
1971	121,672	12.0	42,887	12.4	95,457	1,275	9.3	449	9.5
72	135,250	11.2	47,979	11.9	97,833	1,382	8.4	490	9.1
73	154,148	14.0	54,928	14.5	100,269	1,537	11.2	548	11.8
74	168,820	9.5	61,630	12.2	102,764	1,643	6.9	600	9.5
75	178,270	5.6	68,180	10.6	105,322	1,693	3.0	647	7.8
1976	195,527	9.7	77,572	13.8	107,944	1,811	7.0	718	11.0
77	206,196	5.4	86,985	12.1	110,631	1,864	2.9	786	9.5
78	216,067	4.8	97,186	11.7	113,384	1,906	2.2	857	9.0
79	230,515	6.7	108,928	12.1	116,207	1,984	4.1	937	9.3
80	248,668	7.9	121,364	11.4	119,099	1,088	5.2	1,019	8.8
(*)1981	240,263	-3.4	124,293	2.4	121,673	1,975	-5.4	1,022	0.3

(*) Preliminary data.

TABLE III-1.5. BASIC DATA FOR DEMAND FORECAST - SOUTH-SOUTHEAST-MIDWEST REGION OF BRAZIL

Year	GDP-Gross Domestic Product (**) (Constant Price in 1980)		Energy Generated		Population	GDP per capita		Energy per capita	
	10^6 US$	Growth rate (%)	GWh	Growth rate (%)	(thousand)	US$	Growth rate (%)	KWh	Growth rate (%)
1961			16,881	-	46,951			360	-
62			18,725	10.9	48,510			386	7.2
63			19,838	5.9	50,085			396	2.6
64			20,463	3.2	51,675			396	0.0
65	66,476	-	21,489	5.0	53,279	1,248	-	403	1.8
1966	68,979	3.8	23,465	9.2	54,895	1,257	0.7	428	6.2
67	72,440	5.0	24,820	5.8	56,523	1,282	2.0	439	2.6
68	80,049	10.5	27,677	11.5	58,162	1,376	7.3	476	8.4
69	90,191	12.7	30,758	11.1	59,810	1,508	9.6	514	8.0
70	96,429	6.9	33,863	10.1	61,423	1,570	4.1	551	7.2
1971	108,250	12.3	38,156	12.7	63,133	1,715	9.2	604	9.6
72	119,664	10.5	42,450	11.3	64,805	1,847	7.7	655	8.4
73	133,089	11.2	47,424	11.7	66,483	2,002	8.4	713	8.8
74	141,948	6.7	51,820	9.3	68,166	2,082	4.0	760	6.6
75	151,739	6.9	58,033	12.0	69,853	2,172	4.3	831	9.3
1976	169,590	11.8	67,282	15.9	71,543	2,371	9.2	940	13.1
77	178,829	5.4	75,440	12.1	73,236	2,442	3.0	1,030	9.6
78	185,484	3.7	83,430	10.6	74,929	2,476	1.4	1,114	8.2
79	197,553	6.5	93,352	11.9	76,624	2,578	4.1	1,218	9.3
80	207,999	6.7	102,914	10.2	78,315	2,656	3.0	1,314	7.9
(*)1981	201,549	-3.2	104,015	1.1	80,011	2,519	-5.1	1,300	-1.1

Note: (*) Preliminary data
(**) GDP data obtained by computations considering yearly relationship between consumed energy in Brazil and S/SE/MW Region.

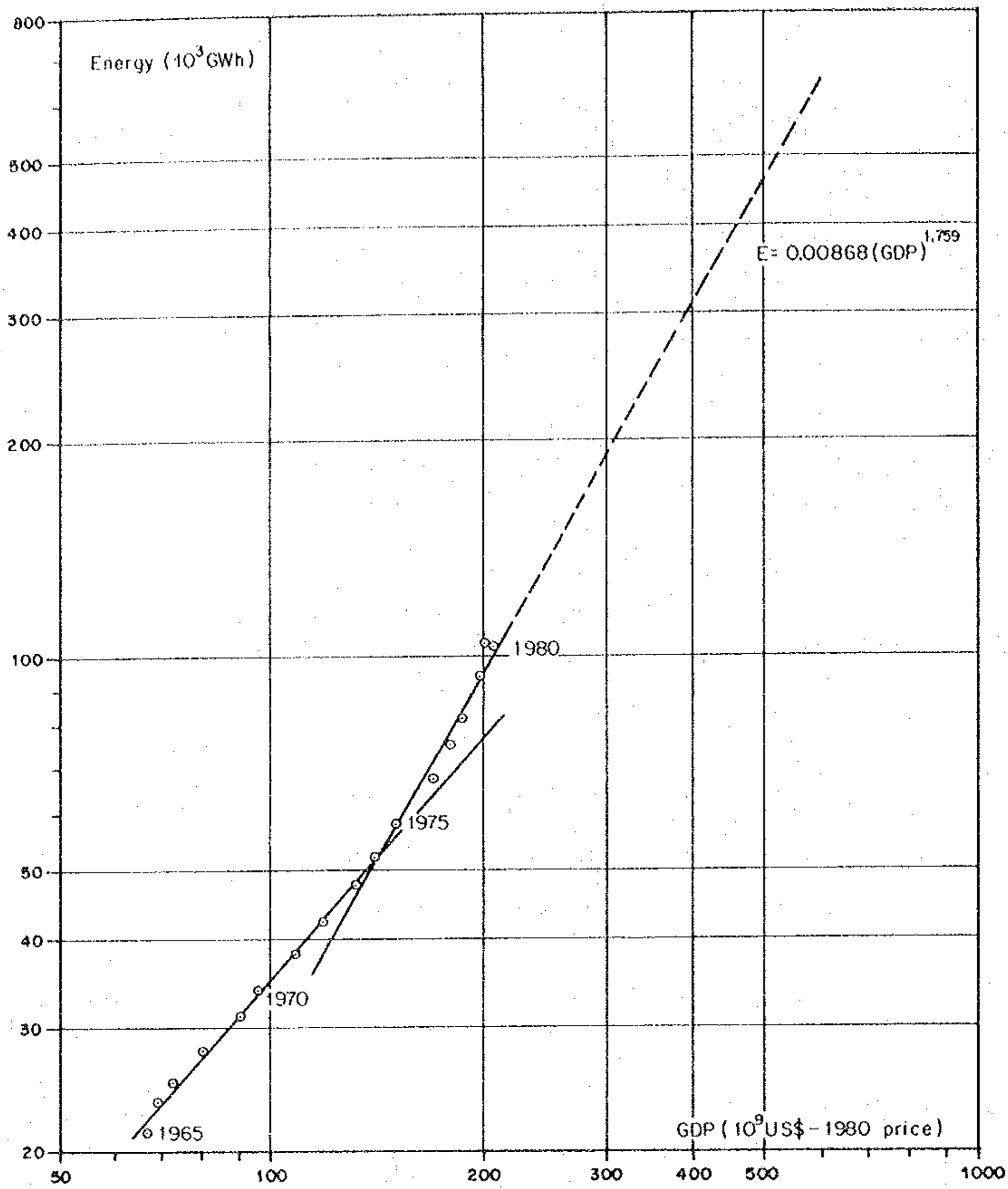

FIGURE III-1.4 CORRELATION BETWEEN GDP AND ENERGY FOR S/SE/MW REGION OF BRAZIL

c) Annual growth rate of GDP and consumed energy, and results of demand forecast by Macro-Method:

The annual growth rate of GDP and consumed energy is indicated in Figure III-1.5 for Brazil and Figure III-1.6 for its S/SE/MW region. A general trend of GDP considering triannual movable average rate is also indicated in these figures and the equations are developed.

So, for the prediction of annual growth rate of GDP, assumptions are made in order to follow the general trend according these equations as indicated in Figures III-1.5 and III-1.6, and in Tables III-1.6 and III-1.7. These tables also present the results of the demand forecast for Brazil and its S/SE/MW Region.

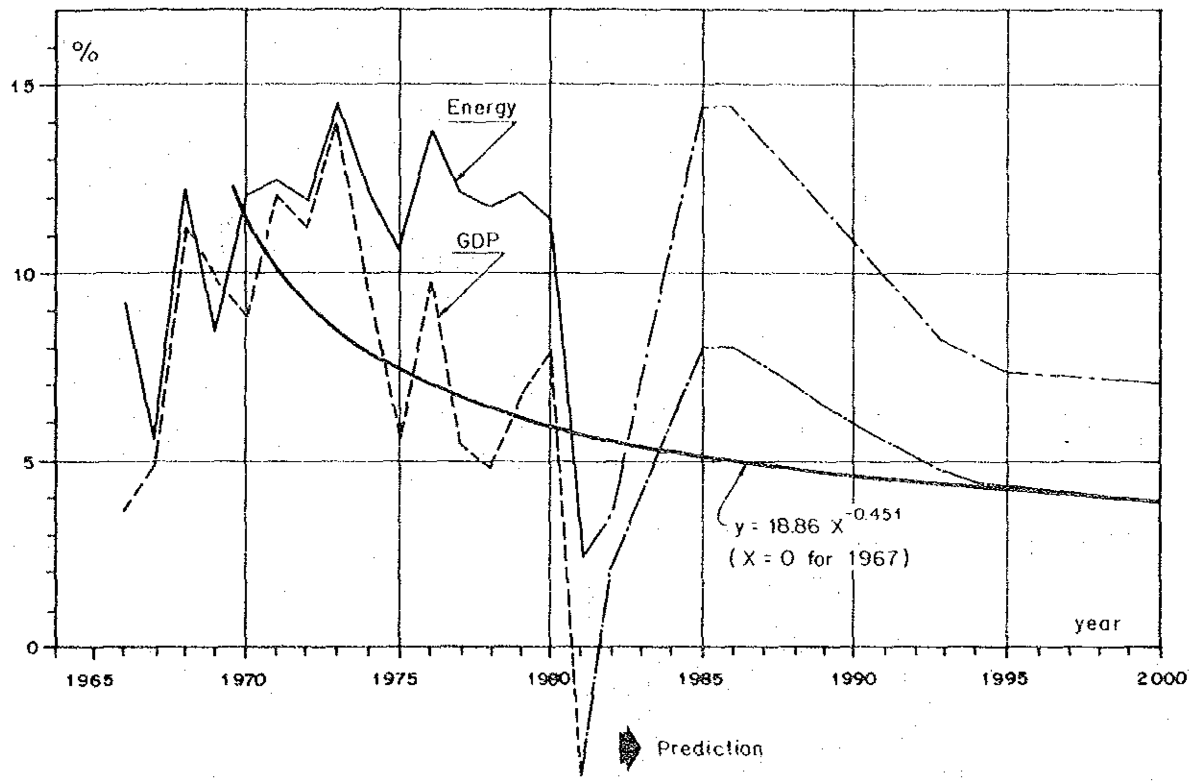

FIGURE III-1.5 ANNUAL GROWTH RATE OF GDP AND CONSUMED ENERGY IN BRAZIL

TABLE III-1.6. DEMAND FORECAST FOR BRAZIL

Year	GDP-Gross Domestic Product (Constant Price in 1980)		Energy Generated		Population	GDP-per capita		Energy per capita	
	10^6 US$	Growth rate (%)	GWh	Growth rate (%)	(thousand)	US$	Growth rate (%)	KWh	Growth rate (%)
1981	240,259	-	115,525(*)	-	121,814	1,972	-	948	-
82	245,064	2.0	119,620	3.5	124,566	1,967	-0.3	960	0.1
83	254,867	4.0	128,164	7.1	127,339	2,001	1.7	1,006	4.8
84	270,159	6.0	141,997	10.8	130,132	2,076	3.7	1,091	8.4
85	291,771	8.0	162,581	14.5	132,945	2,195	5.7	1,223	12.1
1986	315,113	8.0	186,150	14.5	135,776	2,321	5.7	1,371	12.1
87	338,747	7.5	211,404	13.6	138,625	2,444	5.3	1,525	11.2
88	362,459	7.0	238,121	12.6	141,492	2,562	4.8	1,683	10.4
89	386,019	6.5	266,015	11.7	144,374	2,674	4.4	1,843	9.5
90	409,180	6.0	294,726	10.8	147,273	2,778	3.9	2,001	8.6
1991	431,685	5.5	323,832	9.9	150,186	2,874	3.5	2,156	7.7
92	453,701	5.1	353,443	9.1	153,113	2,963	3.1	2,308	7.1
93	475,025	4.7	383,182	8.4	156,054	3,044	2.7	2,455	6.4
94	495,926	4.4	413,332	7.9	159,007	3,119	2.5	2,599	5.9
95	516,755	4.2	444,354	7.5	161,973	3,190	2.3	2,743	5.5
1996	538,458	4.2	477,702	7.5	164,949	3,264	2.3	2,896	5.6
97	560,535	4.1	512,688	7.3	167,936	3,338	2.3	3,053	5.4
98	583,517	4.1	550,236	7.3	170,932	3,414	2.3	3,219	5.4
99	606,858	4.0	589,538	7.1	173,937	3,489	2.2	3,389	5.3
2000	631,132	4.0	631,644	7.1	176,950	3,567	2.2	3,570	5.3

(*) Calculated data. Note: Energy values calculated by GWh= 0,0075 (GDP) where GDP = 10^9 US$

TABLE III-1.7. DEMAND FORECAST FOR SOUTH-SOUTHEAST-MIDWEST REGION OF BRAZIL

Year	GDP-Gross Domestic Product (Constant Price in 1980)		Energy Generated		Population	GDP per capita		Energy per capita	
	10^6 US$	Growth rate (%)	GWh	Growth rate (%)	(thousand)	US$	Growth rate (%)	KWh	Growth rate (%)
1981	201,549	-	95,810(*)	-	80,011	2,519	-	1,197	-
82	205,177	1.8	98,860	3.2	81,706	2,511	-0.3	1,210	1.1
83	212,563	3.6	105,180	6.4	83,398	2,549	1.5	1,261	4.2
84	224,042	5.4	115,340	9.7	85,087	2,633	3.3	1,356	7.5
85	240,173	7.2	130,300	13.0	86,771	2,768	5.1	1,502	10.8
1986	257,465	7.2	147,200	13.0	88,450	2,911	5.2	1,664	10.8
87	274,973	6.8	165,210	12.2	90,124	3,051	4.8	1,833	10.2
88	292,296	6.3	183,900	11.3	91,791	3,184	4.4	2,003	9.3
89	309,542	5.9	203,350	10.6	93,451	3,132	4.0	2,176	8.6
90	326,257	5.4	223,000	9.7	95,103	3,431	3.6	2,345	7.8
1991	342,570	5.0	242,920	8.9	96,747	3,541	3.2	2,511	7.1
92	358,328	4.6	262,860	8.2	98,382	3,642	2.9	2,672	6.4
93	373,378	4.2	282,530	7.5	100,008	3,733	2.5	2,825	5.7
94	388,313	4.0	302,650	7.1	101,623	3,821	2.4	2,973	5.2
95	403,846	4.0	324,210	7.1	103,228	3,912	2.4	3,141	5.7
1996	419,595	3.9	346,710	6.9	104,822	4,003	2.3	3,308	5.3
97	435,540	3.8	370,150	6.8	106,405	4,093	2.2	3,479	5.2
98	451,655	3.7	394,500	6.6	107,976	4,183	2.2	3,654	5.0
99	467,915	3.6	419,750	6.4	109,534	4,272	2.1	3,832	4.9
2000	484,290	3.5	445,860	6.2	111,079	4,360	2.0	4,014	4.7

(*) Calculated data.

Note: Energy values calculated by $GWh = 0,0087\ (GD)^{1,754}$
where $GDP = 10^9$ US$

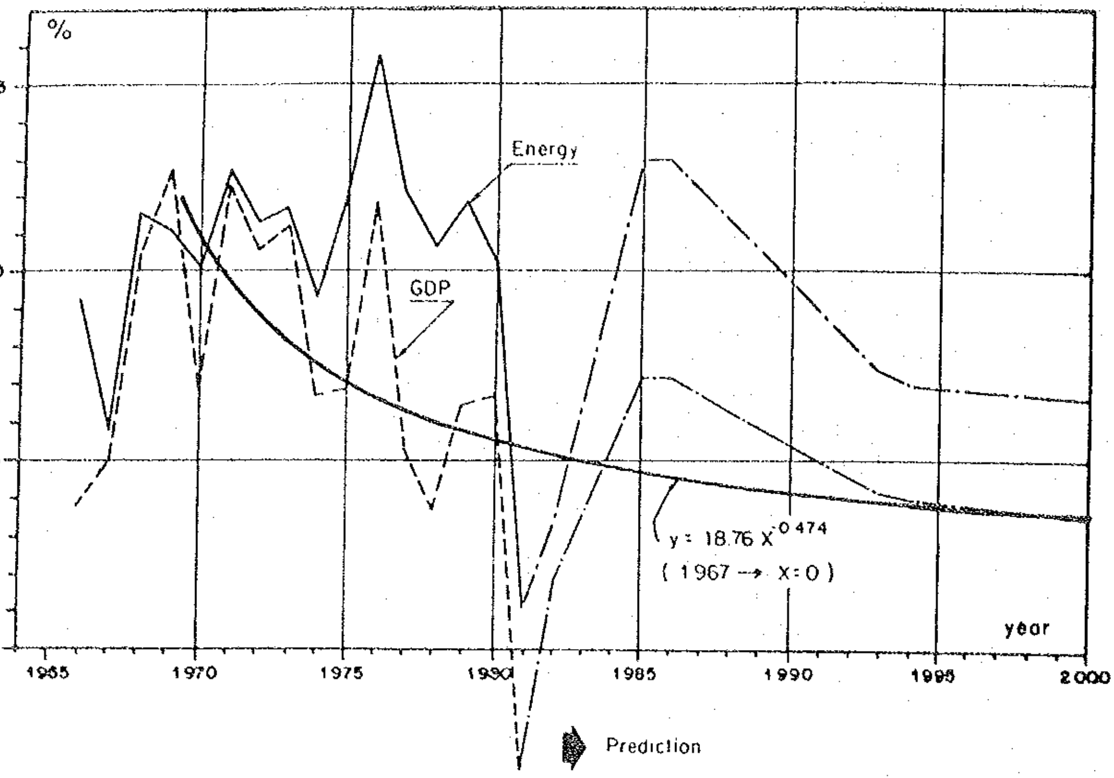

FIGURE III-1.6 ANNUAL GROWTH RATE OF GDP AND CONSUMED ENERGY IN S/SE/MW REGION OF BRAZIL

Obs: For the S/SE/MW Region, the values of GDP are calculated by means of correlation shown in Figure III-1.2.

d) Results of the study:

A comparison of the results of forecasts are given in Table III-1.8 and Figure III-1.7.

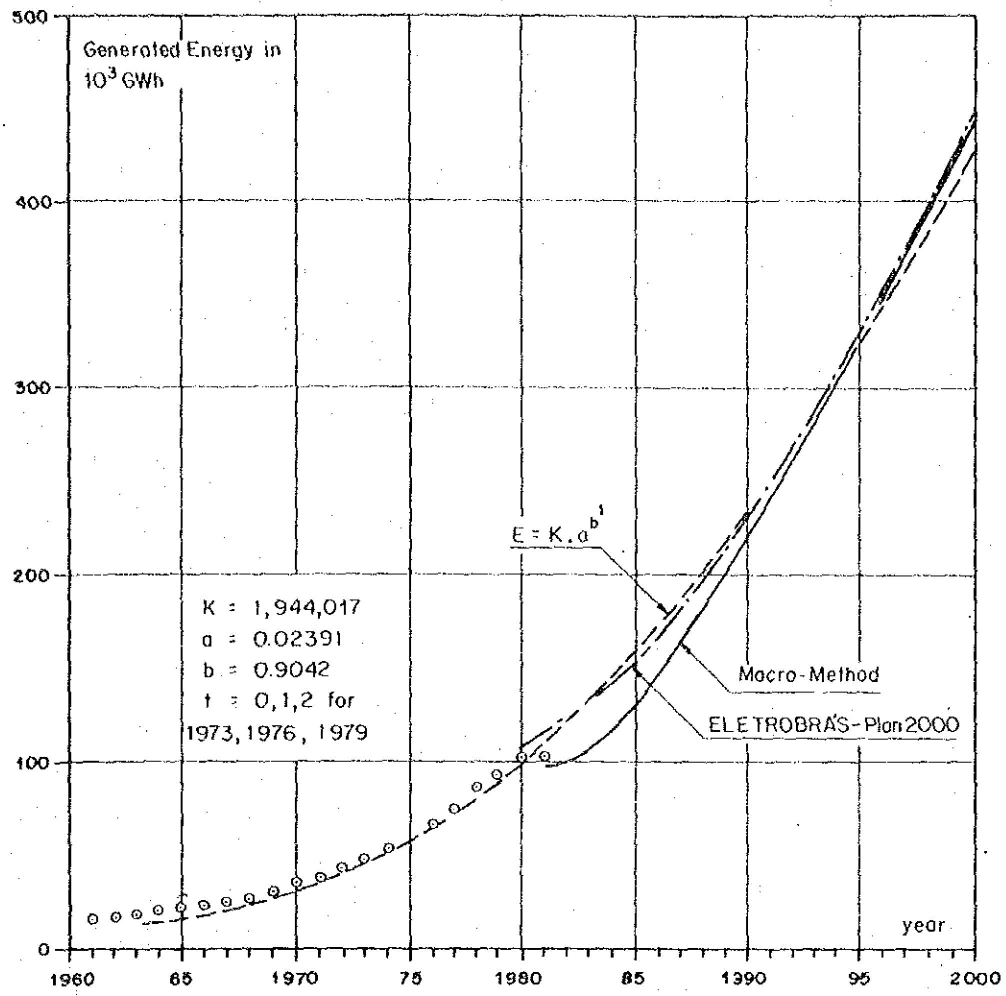

FIGURE III-1.7 COMPARISON OF ENERGY DEMAND FORECASTS FOR S/SE/MW REGION OF BRAZIL

TABLE III-1.8. COMPARISON OF ENERGY DEMAND FORECASTS FOR S/SE/MW REGION

Year	Plan 2000 Electrobras(a)	Gompertz's equation(b)	Macro-Method (c)	$\frac{(a) - (c)}{(c)}$ %	$\frac{(b) - (c)}{(c)}$ %
1985	154.3	160.5	130.3	18.4	23.2
1990	237.6	235.7	223.0	6.5	5.7
1995	334.0	326.5	324.2	3.0	0.7
2000	454.1	430.0	445.9	1.8	-0.5

(unit: 10^3 GWh)

As it is clear in the Table and Figure, the annual gross energy by the Macro-Method is usually lower than the other results and for the period 1981-1990, the difference in percentage is high.

This is because Macro-Method considers the negative value of GDP in 1981 and after then, the trend is gradually recovered meanwhile the other methods do not take into account of this typical year.
However for the period 1990-2000, those forecast methods do not show much difference and this period is most important for this study so that they are judged to be quite same in regard to the growth rates.

Therefore, the results estimated by Macro-Method are adopted as the demand forecast. The load factor is forecast to be 63.5% from the past performances and a reserve factor of 15% is considered as the maximum demand considering the factor utilized by ELETROBRAS in its plan.

Accordingly, the results of demand forecast can be summarize as follows;

TABLE III-1.9. RESULTS OF DEMAND FORECAST FOR S/SE/MW REGION OF BRAZIL

Year	Gross energy required		Power	Maximum demand
	GWh	MW year	MW	MW
1981	95,810	10,930	17,210	19,795
82	98,860	11,280	17,760	20,430
83	105,180	12,000	18,900	21,730
84	115,340	13,160	20,725	23,835
85	130,300	14,860	23,400	26,910
86	147,200	16,790	26,440	30,410
87	165,210	18,850	29,685	34,140
88	183,900	20,980	33,040	37,995
89	203,350	23,200	36,535	42,015
1990	223,000	25,440	40,060	46,070
91	242,920	27,710	43,640	50,185
92	262,860	29,990	47,230	54,310
93	282,530	32,230	50,755	58,370
94	302,650	34,530	54,380	62,535
95	324,210	36,980	58,235	66,970
96	346,710	39,550	62,285	71,625
97	370,150	42,230	66,505	76,480
98	394,500	45,000	70,865	81,495
99	419,750	47,880	75,400	86,710
2000	445,860	50,860	80,095	92,110

1.2. Demand and Supply Balance

1.2.1. Planning for supply

The total potential of hydroelectric power resources in Brazil is said to be 106,500 MW year of which 49,800 MW year is in S/SE/MW Region, as indicated in Figure III-1.8 and Table III-1.10. The annual totals of the hydraulic energies available in S/SE/MW Region are indicates in Table III-1.11.

TABLE III-1.10. HYDROELECTRIC POTENTIAL OF BRAZIL AND REGIONS

Region	Firm energy in 10^3 MW year			Installed capacity (dec/79)-10^3 MW		
	In operation or under construction	Planned site or estimated	Total	In operation or construction	Planned site or estimated	Total
N/MW	2.1	47.3	49.4	4.1	93.7	97.8
NE	3.3	4.0	7.3	8.3	7.2	15.5
SE/MW	11.9	14.7	26.6	24.8	31.4	56.2
S	6.8	16.4	23.2	13.3	30.2	43.5
Total	24.1	82.4	106.5	50.5	162.5	213.0

Note: N: North, NE: Northeast, SE: Southeast; MW: Midwest; S: South.

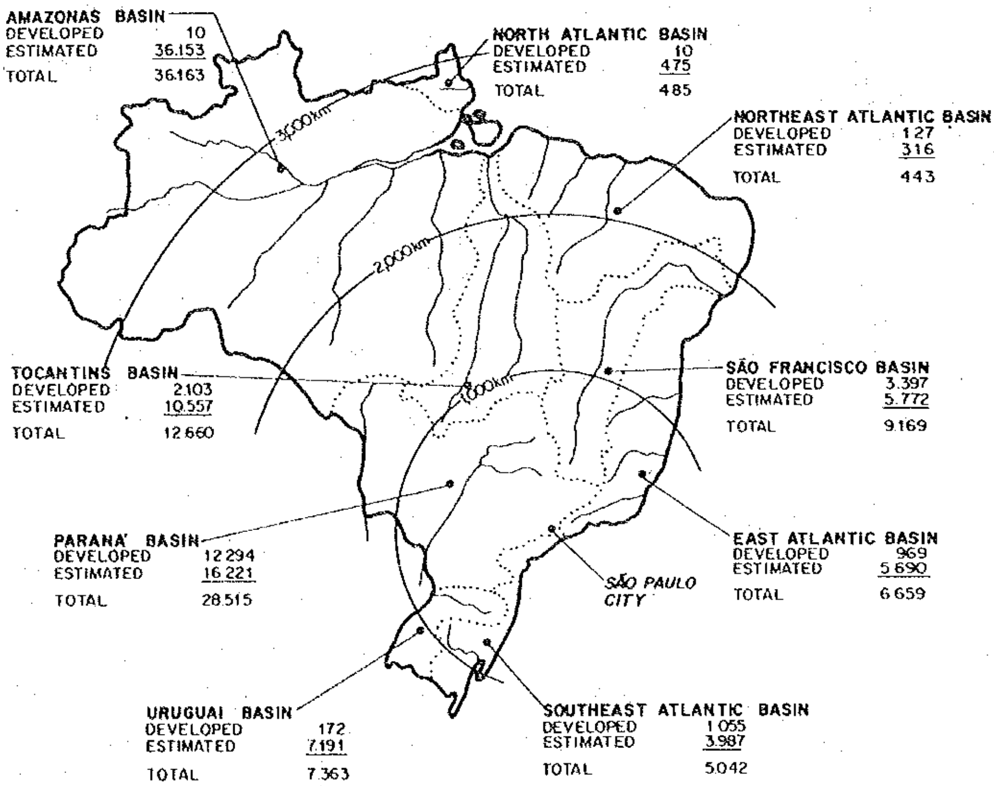

FIGURE III-1.8 HIDROELECTRIC POTENTIAL OF MAIN BRAZILIAN RIVER BASINS IN MW YEAR

TABLE III-1.11. TOTAL OF POWER STATIONS PROJECTS IN S/SE/MW REGION OF BRAZIL (dec. 81)

State of project	Number of projects	Firm energy (MW year)			Installed capacity (MW)		
		Hydro	Thermal (*)	Total	Hydro	Thermal (*)	Total
In operation	59	12,563	1,258	13,821	25,377	2,241	27,618
Under construction	12	9,799	1,525	11,324	17,923	2,191	20,114
Planning or Design stage	53	9,713	8,872	18,585	18,100	12,836	30,936
Total	124	32,075	11,655	43,730	61,400	17,268	78,668

(*) Including 9 nuclear power stations.

The electric power development plans from 1982 to 2000, according to the PLAN 2000 - ELECTROBRAS, are indicated in Tables III-1.12 and III-1.13. However, after 1996 this PLAN is not complete about the construction schedule of power stations, and the result is that there are more than 7,000 MW year deficiency in the firm energy and 13,500 MW deficiency in the maximum demand up to the year 2000. However, the PLAN 2000 - ELECTROBRAS mentions that, during the period from 1996 to 2000, the energy requirements of the S/SE/MW Region may be supplied of 3150 MW year from the North Region specially from the Tocantis/Araguaia and Xingu River Basins, through electric interconnections between these basins and the main load centers of the Southeast Region. ELECTROBRAS considers that the hydroelectric potentials of the Southeast and South Regions, which are sufficient to supply the market of these Regions, shall have their uses from 1997 to 2000 by means of a more accurated economic comparison with the supply from the North Region of Brazil.

Anyway, for the purpose of this study, it is enough to consider simply that new additional power stations have to be completed during 1996-2000, besides those mentioned in the PLAN 2000. These new power stations shall be either the thermal power stations or the hydroelectric power stations at a long distance, something like more than 1000 km (North Region) and, in this case, they are considered as a base load power stations with about 70% of load factor. This assumption, even for the hydroelectric power stations, is quite reasonable because of too costly transmission lines for long distances.

The construction and production schedules of these new additional power stations are indicated in Table III-1.14. They are simply computed in this table, only to satisfy the energy dificiency during the period 1996-2000, and it is considered that the detailed planning of these new additional power stations is out of the present study.

However, it is enough to observe that, even taking into account of the addition of the new power stations, the installed capacity will not be sufficient for the maximum demand. Accordingly, São Lourenço (2835 MW) and Cubatão (2400 MW) Reversible Power Stations are planned especially for the peak-load supply during period 1996-2000.

Therefore, according to the present plan, the total installed capacity in 2000 is to be expanded 3.5 times of the present with total output 96,500 MW. The plan also calls for the annual firm energy to be increased to 460,500 GWh with 3.8 times of the present. With regard to expansion of hydroelectric facilities, it is planned to be an installed capacity of 79,200 MW in 2000, approximately 3 times of the present considering that the new power stations after 1996 are hydroelectric power stations. As a result, up to 2000, hydroelec power stations will represent 80% of total installed capacity of S/SE/MW Region as indicated in Figure III-1.9 although at present it represents 90%, and this is because of gradual introduction of nuclear and coal thermal power plants. The major hydroelectric power stations presently being constructed are listed in Table III-1.15.

TABLE III-1.12. PRODUCTION SCHEDULE OF ENERGY IN S/SE/MW REGION

Year	by thermal (1)	by hydraulic (firm) (2)	Total Firm Energy (1) + (2)	
			MW year	GWh
Existing	1,258	12,563	13,821	121,155
82	1,696	13,394	15,090	132,279
83	1,804	15,438	17,242	151,143
84	1,911	17,313	19,224	168,518
85	1,911	19,188	21,099	184,954
86	1,911	21,063	22,974	201,390
87	2,783	21,520	24,303	213,040
88	3,233	23,085	26,318	230,704
89	4,398	23,828	28,226	247,429
1990	4,623	25,347	29,970	262,717
91	5,720	26,638	32,358	283,650
92	6,817	27,723	34,540	302,778
93	6,817	28,507	35,324	309,650
94	7,042	30,367	37,409	327,927
95	8,139	32,051	40,190	352,306
96	9,236	32,075	41,311	362,132
97	9,236	32,075	41,311	362,132
98	10,333	32,075	42,408	371,749
99	11,430	32,075	43,505	381,365
2000	11,655	32,075	43,730	383,337

Obs.: This table considers the informations available in PLAN 2000-ELECTROBRAS. Values of firm energy for each hydro-electric power stations take into account of the most driest period 1952-56, and these data are available in Plan 90, Plan 92 and Plan 95 of ELECTROBRAS, and in the reports of other companies. For the period 1995-2000, see also Table III-1.14.

TABLE III-1.13. CONSTRUCTION SCHEDULE OF POWER STATIONS IN S/SE/MW REGION OF BRAZIL

Year	Installed capacity - MW				Total
	Thermal		Hydraulic		
	New plant	Total (1)	New plant	Total (2)	(1) + (2)
Existing	-	2,241	-	25,377	27,618
82	626	2,867	1,933	27,310	30,177
83	160	3,027	2,550	29,860	32,887
84	160	3,187	2,100	31,960	35,147
85	-	3,187	2,100	34,060	37,247
86	-	3,187	2,100	36,160	39,347
87	1,245	4,432	2,840	39,000	43,432
88	670	5,102	4,283	43,283	48,385
89	1,681	6,783	2,140	45,423	52,206
1990	335	7,118	2,970	48,393	55,511
91	1,580	8,698	3,206	51,599	60,297
92	1,580	10,278	2,453	54,052	64,330
93	-	10,278	1,886	55,938	66,216
94	335	10,613	2,821	58,759	69,372
95	1,580	12,193	2,491	61,250	73,443
96	1,580	13,773	150	61,400	75,173
97	-	13,773	-	61,400	75,173
98	1,580	15,353	-	61,400	76,753
99	1,580	16,933	-	61,400	78,333
2000	335	17,268	-	61,400	78,668

Obs.: This table considers only the informations available in the PLAN 2000 - ELECTROBRAS. For the period 1995 - 2000, see also Table III-1.14.

- New thermal power plants considered up to 2000:
  - 9 nuclear plants with total capacity of 10,586 MW.
  - 14 coal power plants with total capacity of 4,441 MW.

TABLE III-1.14. SUPPLEMENTARY SCHEDULE FOR THE PERIOD 1995-2000 IN S/SE/MW REGION OF BRAZIL

Year	Energy generated (MW year)			Installed capacity (MW)			
	from Plan 2000 (Table - III-1.12)	New Power Stations	Total	from Plan 2000 (Table - III-1.13)	New Power Station	S. Lourenço and Cubatão	Total
1995	40,190	-	40,190	73,443	-	-	73,443
96	41,311	-	41,311	75,173	-	315	75,488
97	41,311	1,800	43,111	75,173	2,570	945	78,688
98	42,408	3,800	46,208	76,753	5,430	2,190	84,373
99	43,505	5,400	48,905	78,333	7,715	4,035	90,083
2000	43,730	8,800	52,530	78,668	12,570	5,235	96,473

Obs.: New power stations are indicated only to complete the energly deficiency in the Plan 2000, during the period 1996-2000, because there is no definite planning for this period. They are considered to be thermal or long distance hydroelectric power stations, both in the base load operation.

- Cubatao III and São Lourenço Power Stations are reversbile power stations so that the energy in MW year is neglected.

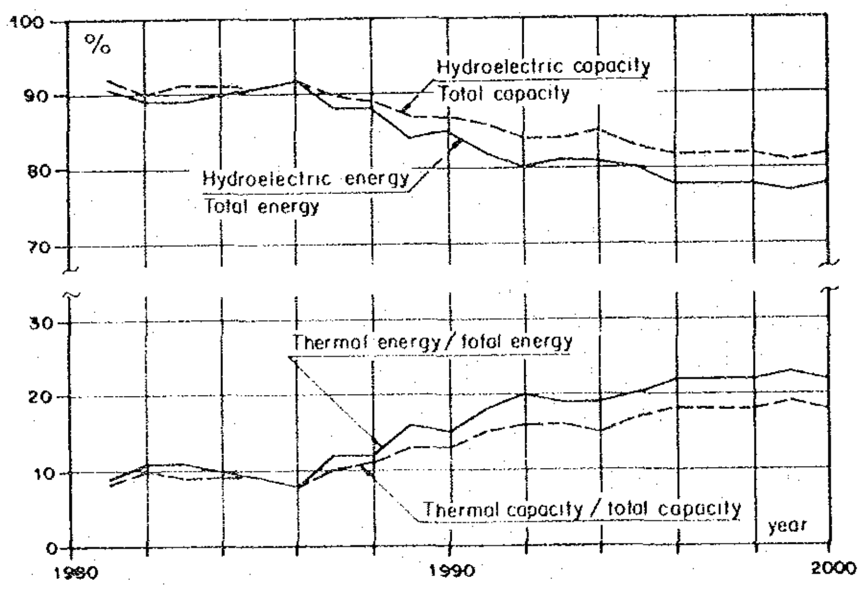

FIGURE III-1.9 RATIO OF HYDRAULIC AND THERMAL POWER STATIONS IN TOTAL INSTALLED CAPACITY (S/SE/MW REGION BRAZIL)

TABLE III-1.15. MAJOR HYDRAULIC POWER STATIONS UNDER CONSTRUCTION IN SOUTH-SOUTHEAST-MIDWEST REGION

Name of Station	Installed capacity (MW)	Firm energy (MW year)	Year of commissioning
Itaipu	12,600	500	1983 - 1988
Porto Primavera	800	772	1987 - 1990
Emborcaçao	1,000	465	1982 - 1983
Salto Santiago	1,998	876	1982
Taquaruçu	500	213	1987 - 1988

1.2.2. Demand and Supply Balance

From the forecast results according to the Macro-Method, and the supply plan described in 1.2.1 the balance sheet predicted for electric energy and maximum demand up to 2000 is indicated in Tables III-1.16 and III-1.17. The general trends of demand and supply balance are graphically indicated in Figure III-1.10.

As it is clearly seen in the Table III-1.17 and in the Figure III-1.10 according to the ELETROBRAS - PLAN 2000, there are surplus energy and installed capacity up to 1995, and probably some of power stations may have a little more later year of commissioning. However, after 1995, new power stations will be necessary in order to supply the energy for the S/SE/MW Region, and besides that, other power stations will be required especially to supply the maximum demand.

TABLE III-1.16. ESTIMATED ENERGY BALANCE

Year	Estimated energy demand (GWh) (1)	Available firm energy (GWh) (2)	Allowance	
			GWh(3) (3) = (2) - (1)	% (3) / (1)
1981	95,810	121,155	25,345	26
82	98,860	132,279	33,419	34
83	105,180	151,143	45,963	44
84	115,340	168,518	53,178	46
85	130,300	184,954	54,654	42
86	147,200	201,390	54,190	37
87	165,210	213,040	47,830	29
88	183,900	230,704	46,804	25
89	203,350	247,429	44,079	22
1990	223,000	262,717	39,717	18
91	242,920	283,650	40,730	17
92	262,860	302,778	39,918	15
93	282,530	309,650	27,120	9.5
94	302,650	327,927	25,277	8.4
95	324,210	352,306	28,096	8.7
96	346,710	362,132	15,422	4.4
97	370,150	377,911	7,761	2.1
98	394,500	405,059	10,559	2.7
99	419,750	428,701	8,951	2.1
2000	445,860	460,478	14,618	3.3

TABLE III-1.17. ESTIMATED MAXIMUM DEMAND BALANCE

Year	Estimated Maximum Demand (MW) (1)	Construction Schedule (2)	Allowance	
			MW (3) = (2) - (1)	% (3) / (1)
1981	19,795	27,618	7,823	39
82	20,430	30,177	9,747	48
83	21,730	32,887	11,157	51
84	23,835	35,147	11,312	47
85	26,910	37,247	10,337	38
86	30,410	39,347	8,937	29
87	34,140	43,432	9,292	27
88	37,995	48,385	10,390	27
89	42,015	52,206	10,191	24
1990	46,070	55,511	9,441	20
91	50,185	60,297	10,112	20
92	54,310	64,330	10,020	18
93	58,370	66,216	7,860	13
94	62,535	69,372	6,837	11
95	66,970	73,443	6,473	10
96	71,625	75,488	3,863	5.4
97	76,480	78,688	2,208	2.9
98	81,495	84,373	2,878	3.5
99	86,710	90,083	3,370	3.9
2000	92,110	96,473	4,363	4.7

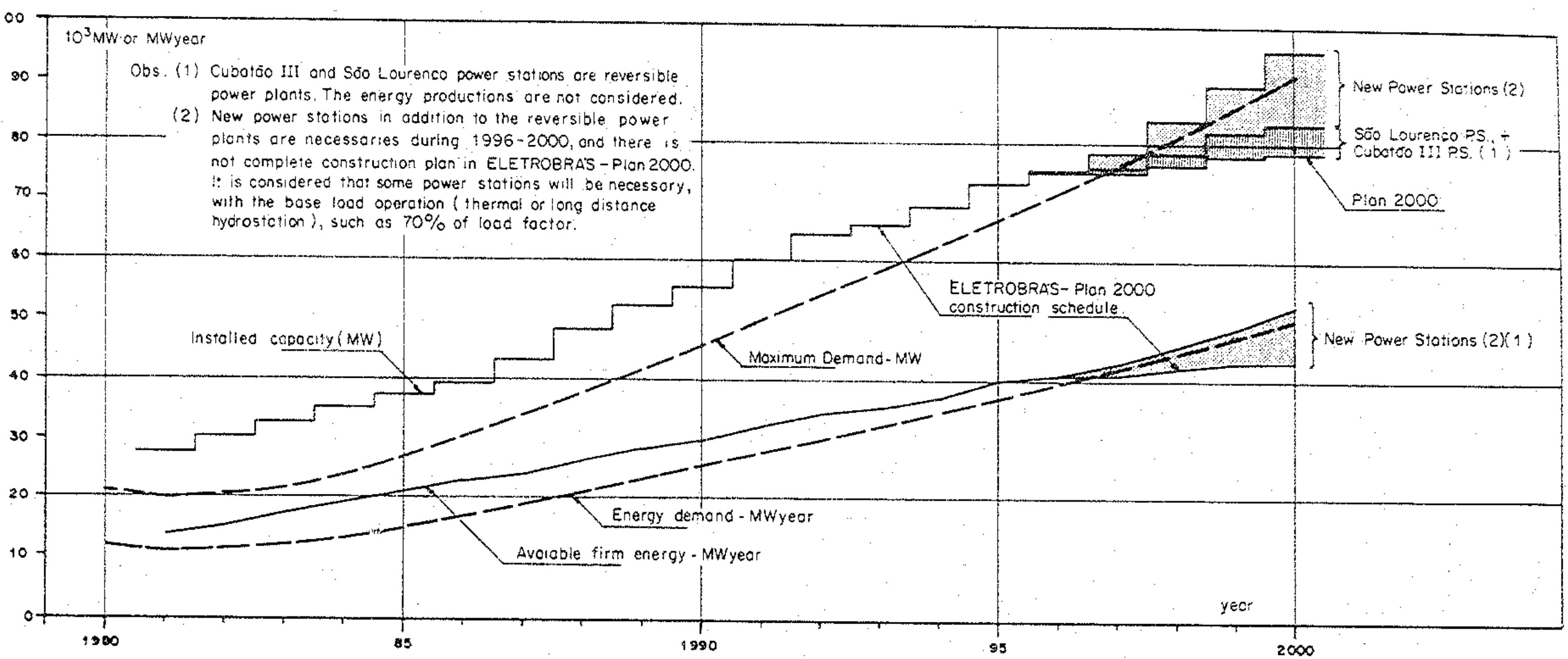

FIGURE III-1.10 DEMAND FORECAST FOR SOUTH-SOUTHEAST-MIDWEST REGIONS OF BRAZIL-ENERGY AND POWER

For this purpose, DAEE forecasts the year of commissioning of São Lourenço and Cubatão Reversible Power Stations during the period 1996-2000, according to the Table III-1.18. It is judged appropriate to start these projects at that time, considering not only for energy balance but also the water supply and demand balance for the energy balance but also the water supply and demand balance for the São Paulo Metropolitan Region, which will also require the operation of the São Lourenço Reversible Station in 1996 as shown in the Chapter 2 - Part III.

In addition, it is necessary to mention that the new power stations required after 1996 will probably be hydroelectric power stations from North Region more than 1,000 km from the Southeast load center. In this case, it is supposed that those power stations have to operate in the base-load generation, because the transmission line costs and loss costs are supposed to be very high, and in this case the reversible power stations close to the load center, will be probably much more advantageous. In the case of São Lourenço Power Station, its convenience is also closely related to the necessity to supply clean water to São Paulo Metropolitan Region.

Also, the Cubatão III Power Station is planned for this period with year of commissioning in 1998, because of the gradual availability of the water supplied to Sao Paulo, which will return to the existing - ELETROPAULO Hydroelectric Power System in the Tiete-Pinheiros and Billings System.

The construction schedule of São Lourenço and Cubatão Reversible Power Stations are indicated Table III-1.18.

Finally it is important to mention that, although electric power side is indicated that São Lourenço Power Station has to Start operation in 1996, it is necessary to consider the existing restraints about some water supply systems, as presented in Part III-Chapter 2.

TABLE III-1.18. CONSTRUCTION SCHEDULE OF SÃO LOURENÇO AND CUBATÃO III REVERSIBLE POWER STATIONS

Year	São Lourenço Power Station			Cubatão III Power Station		
	Units	MW	Total MW	Units	MW	Total MW
1996	1	315	315	-	-	-
1997	2	630	945	-	-	-
1998	3	945	1,890	1	300	300
1999	3	945	2,835	3	900	1,200
2000	-	-	-	4	200	2,400

Obs.: The operation year takes into account of only the energy balance. Considering the water supply balance, the operation year of São Lourenço Power Station has probability to have to be situated during 1992 - 1996.

Considering, for example, that Alto Tiete and Cantareira Systems have to release 12 m^3/s of water for the downstream users, the sewage dillution and the irrigation, the conclusion is that São Lourenço Reversible Power Station has to start the operation by 1996, at least with one unit. Especially for the São Lourenço Power Station, the operation years have to be analysed closely to the water supply side schedule.

CHAPTER 2

DEMAND AND SUPPLY FORECAST OF WATER

PART III

DEVELOPMENT PLAN

CHAPTER 2 DEMAND AND SUPPLY FORECAST OF WATER

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CHAPTER 2. DEMAND AND SUPPLY FORECAST OF WATER

2.1. Demand Forecast

According to the existing water supply plans, already presented in the Chapter 3 of Part II, "HIBRACE PLAN" and "SABESP PLAN" for water supply have to provide enough water until the year of 2000. The population forecast and water demand in the Metropolitan Region of São Paulo according to existing studies are presented in the Figures III-2.1 and III-2.2.

For the present report, the water demand forecast for the Metropolitan Region of São Paulo, is made by means of more recent data of population (results of 1980 Census) and is provided up to the year of 2040. The considerations about the water demand forecast are presented in the next items.

2.1.1. Forecast of Population

The forecast of urban population of Metropolitan Region of São Paulo is based on the Gompertz equation as follows:

$$p = k\, a^{b^t}$$

where: p = population in the time t

k = maximum population

a and b = coefficients.

In applying the decimal log for the above function and using the results of last census (1960, 1970 and 1980), the values of coefficients k, a and b are determined and the results are:

$k = 45{,}462{,}600$

$a = 0.999$

The evolution of the total population of Metropolitan Region of São Paulo for the same period is estimated by means of the urbanization rate using the same estimation method.

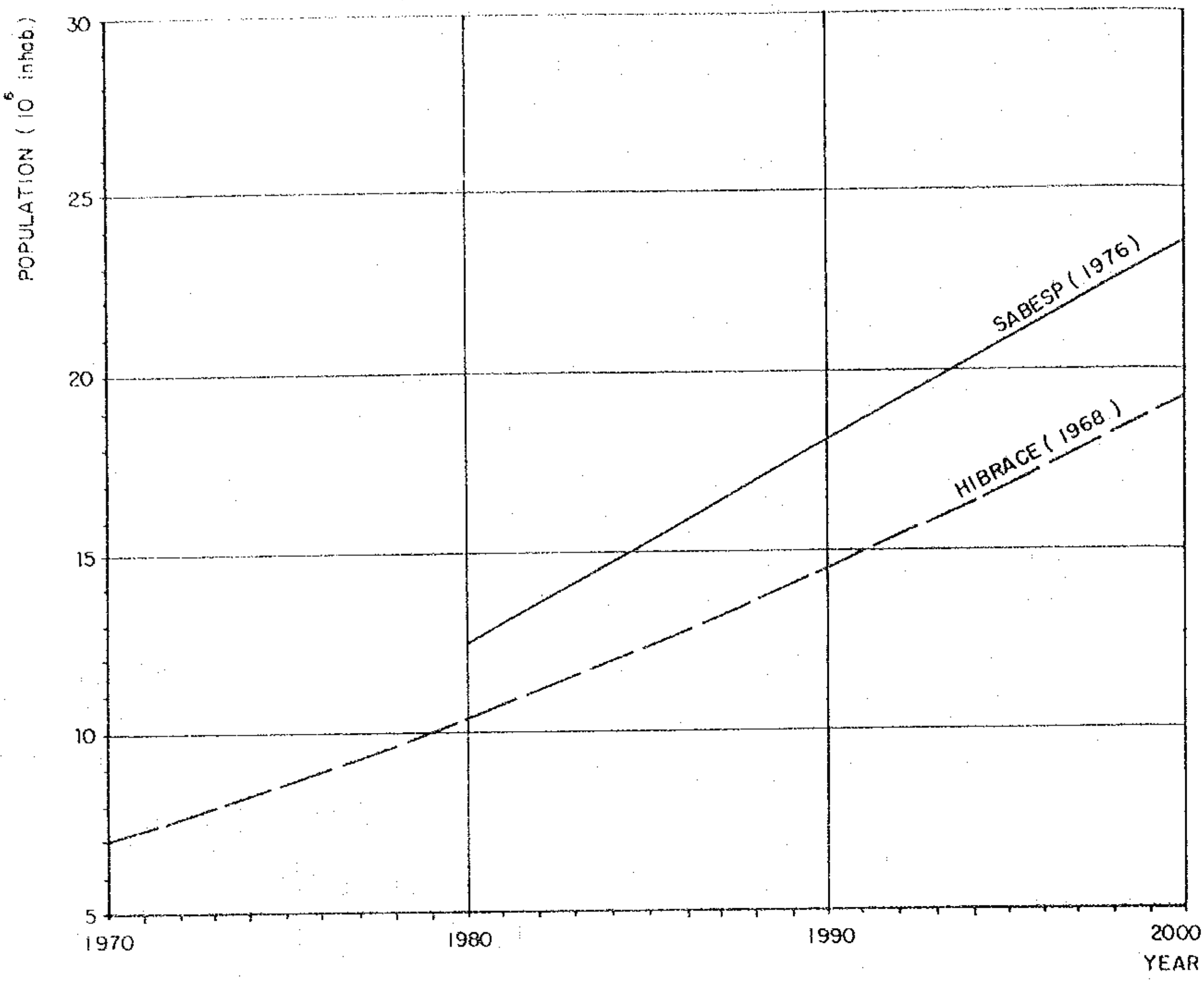

FIGURE III-2.1 FORECAST OF THE POPULATION FOR THE METROPOLITAN REGION OF SÃO PAULO (SABESP AND HIBRACE PLANS)

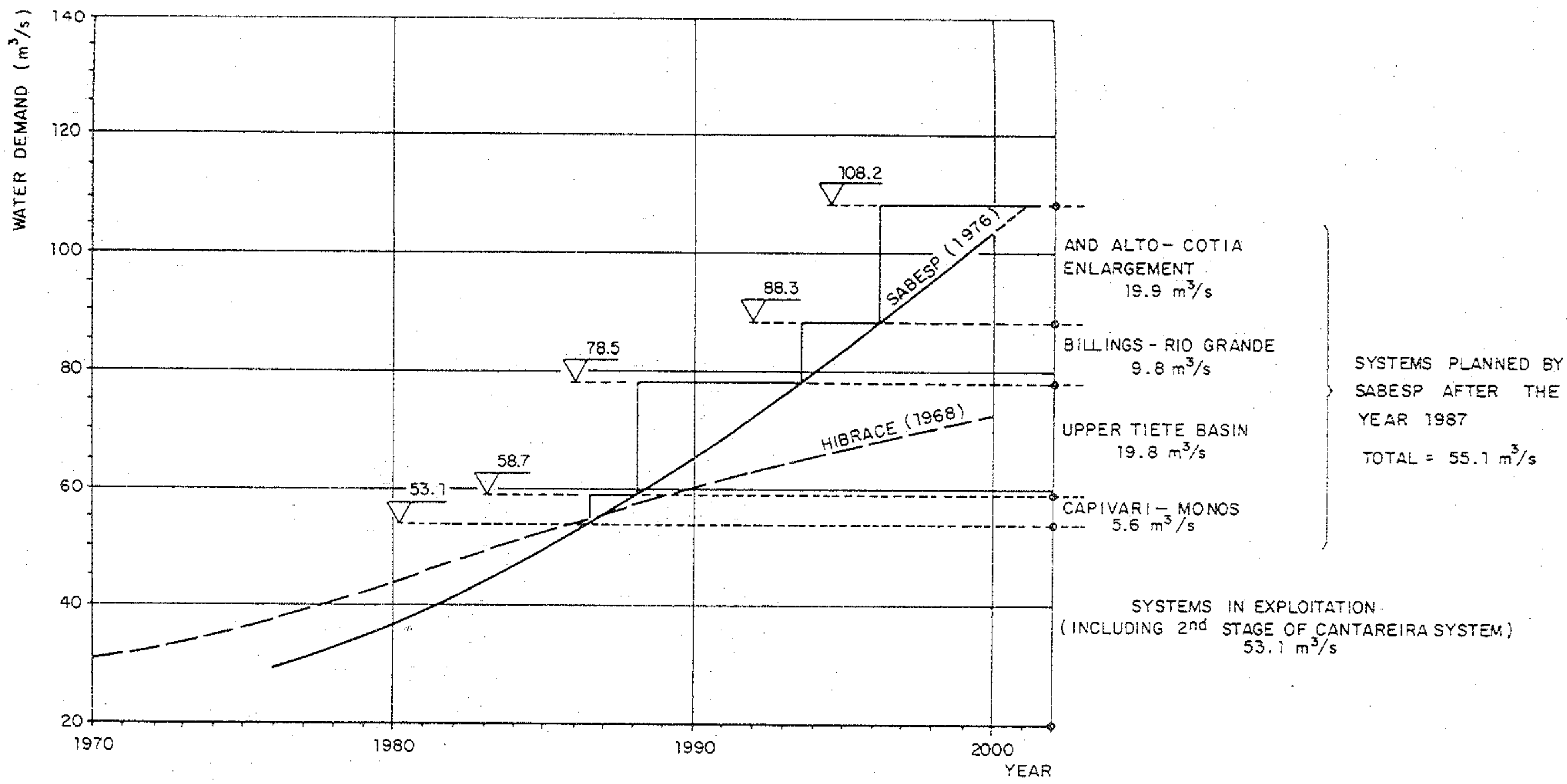

FIGURE III-2.2 WATER DEMAND FORECAST FOR THE METROPOLITAN REGION OF SÃO PAULO (SABESP AND HIBRACE PLANS)

The Table III-2.1 is presented summary of estimated results including results obtained in census until 1980. The Figure III-2.3 is presented evolution curve of population in the Metropolitan Region São Paulo.

TABLE III-2.1. RESULTS OF CENSUS AND ESTIMATION OF POPULATION

Year	Population (inhab)		Urbanization rate (%)	Geometric Annual Growth rate (%)	
	Urban	Total		Urban	Total
1940(*)	1,375,300	1,549,000	88.9	5.6	5.6
50(*)	2,374,500	2,659,300	89.3	6.6	6.1
60(*)	4,488,800	4,791,200	93.7	5.9	5.5
70(*)	7,931,100	8,206,109	96.7	4.4	4.4
80(*)	12,183,100	12,588,439	96.8	3.3	3.3
90	16,840,500	17,378,300	96.9	2.5	2.5
2000	21,497,400	22,156,400	97.0	1.9	1.8
10	25,843,400	26,604,100	97.1	1.4	1.4
20	29,693,100	30,532,100	97.3	1.1	1.0
30	32,971,000	33,866,000	97.4	0.8	0.8
40	35,681,000	36,610,000	97.5		

(*) Results of Census

2.1.2. Water Demand Forecast

The estimation of water demand for the Metropolitan Region of São Paulo is made considering that the present (1980) average "per capita" consumption of 282 l/inhab. day in the year of 2040, as observed in the main developed cities of the world.

The Figure III-2.4 is presented the curve of evolution of the prospected average "per capita" consumption assumed in this study.

As regard to the rate of water supply population, it is assumed that as verified to be 90% in the decade 80, the rate will increase to 92% in the decade 90, and from year 2000 to year 2040, the rate will be stable in 95%.

The Table III-2.2 shows the result of the water demand forecast, and the Figure III-2.5 indicates the evolution of water demand until the year of 2040.

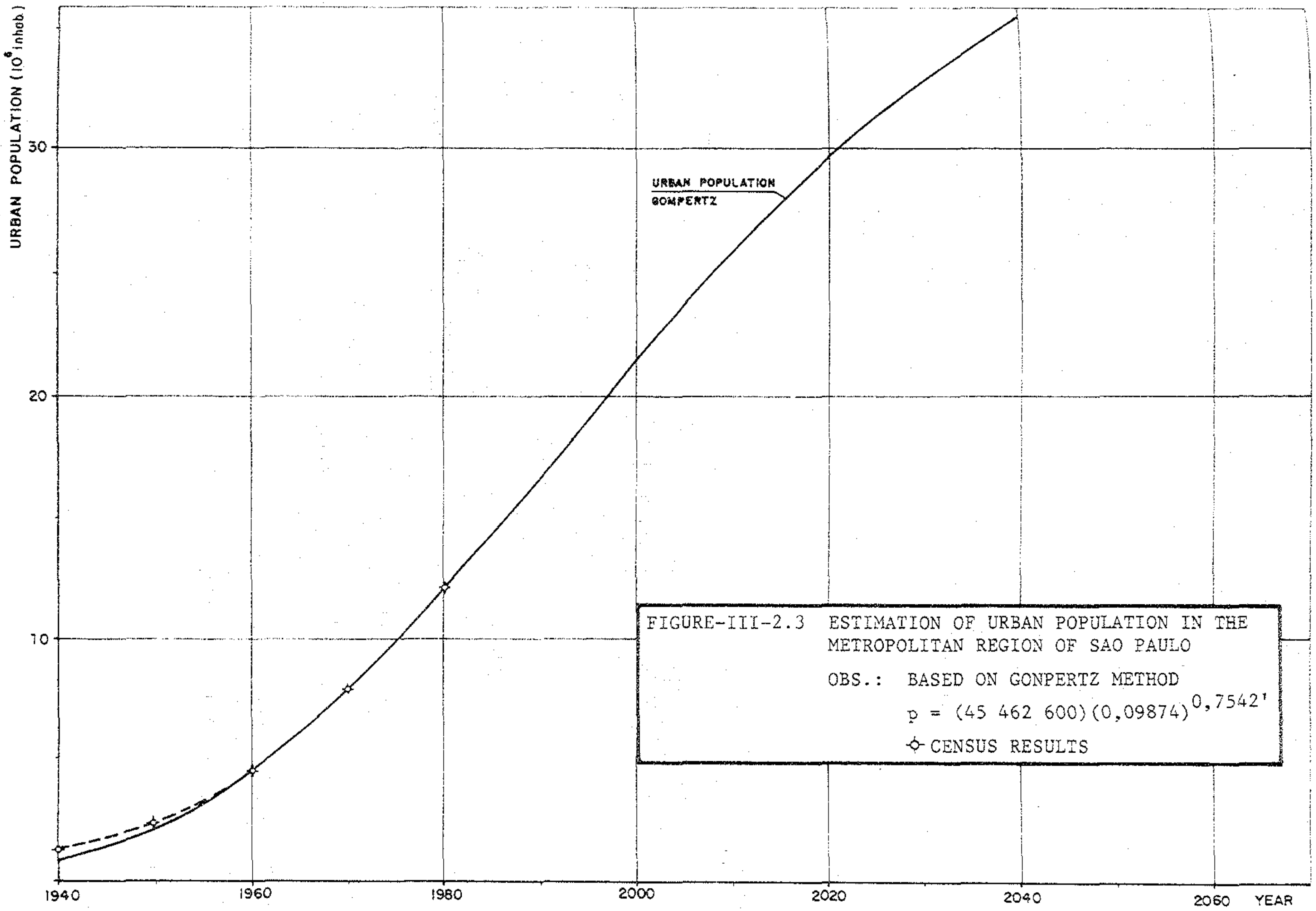

FIGURE-III-2.3 ESTIMATION OF URBAN POPULATION IN THE METROPOLITAN REGION OF SAO PAULO

OBS.: BASED ON GONPERTZ METHOD

$p = (45\ 462\ 600)(0{,}09874)^{0{,}7542'}$

-◇- CENSUS RESULTS

TABLE III-2.2. POPULATION FORECAST AND WATER DEMAND FOR THE METROPOLITAN REGION OF SÃO PAULO

Year	Urban Population (inhab)	Rate of Supplied Population (%)	q (l/inhab./day)	Q (m^3/s)
1980	12,183,139	90	282	36
1990	16,840,500	92	334	60
2000	21,497,400	95	377	89
2010	25,843,400	95	408	116
2020	29,693,100	95	430	140
2030	32,971,000	95	444	161
2040	35,681,000	95	450	177

q = average "per capita" consumption.

Q = average of water demand.

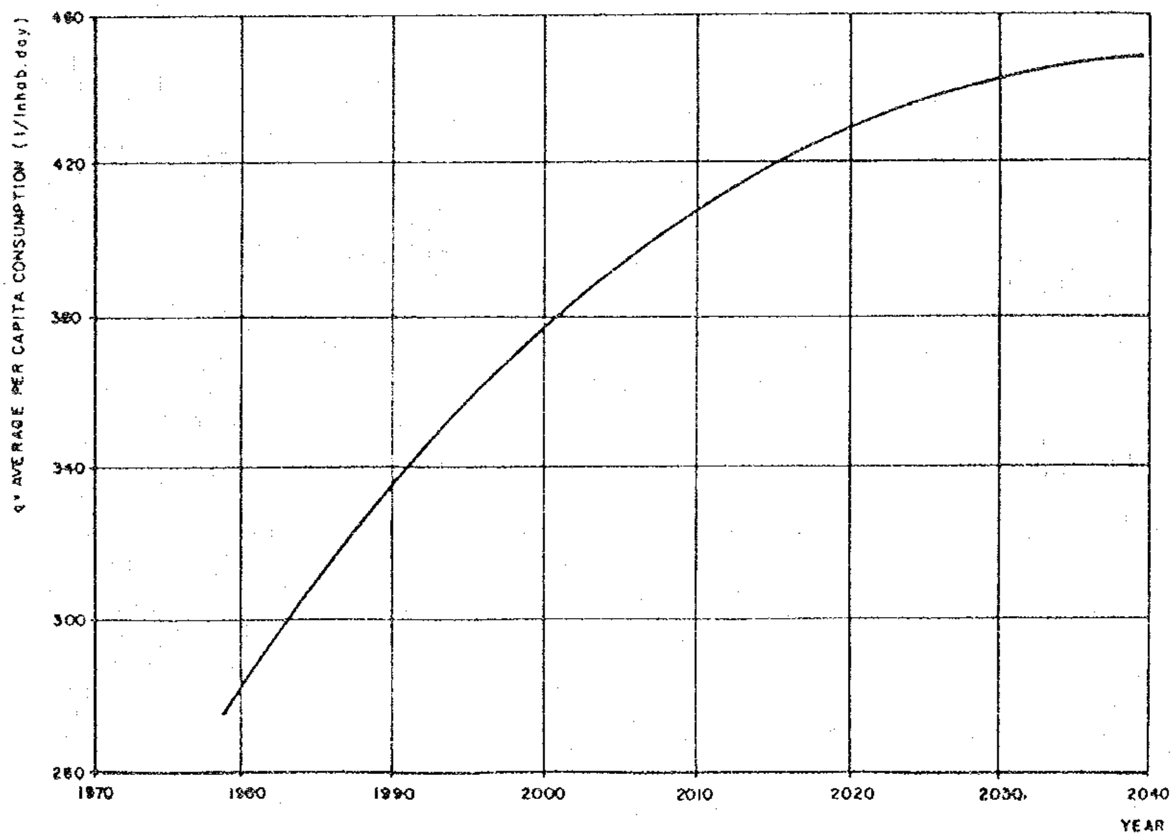

FIGURE III-2.4 EVOLUTION OF AVERAGE PER CAPITA CONSUMPTION IN THE METROPOLITAN REGION OF SÃO PAULO

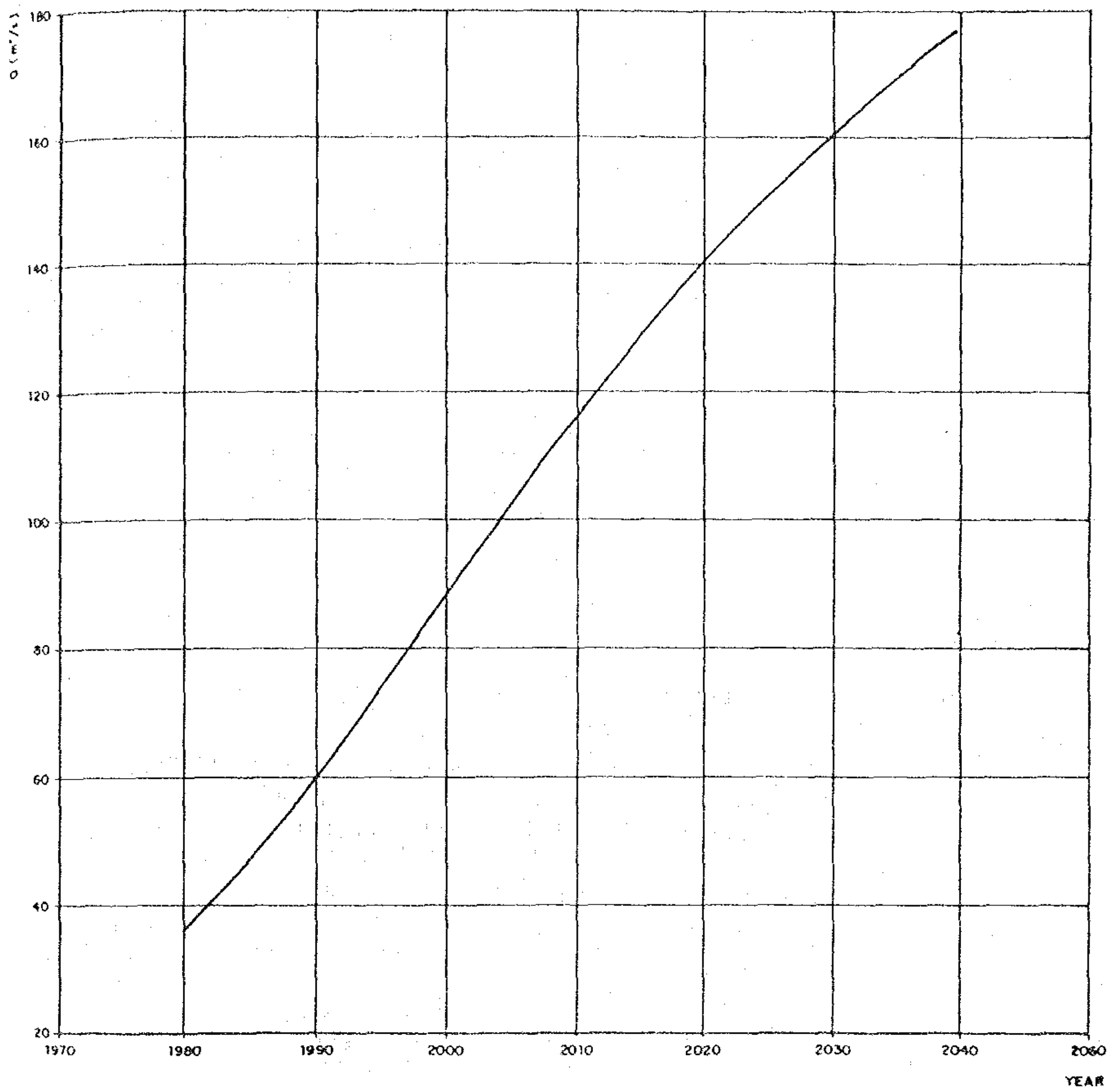

FIGURE III-2.5 EVOLUTION OF WATER DEMAND IN THE METROPOLITAN REGION OF SÃO PAULO