REPUBLIC OF ECUADOR

REPORT
ON
LONG-RANGE ELECTRIC POWER DEVELOPMENT
PROGRAM

OCTOBER, 1973

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

The Government of Japan, in response to the request of the Government of the Republic of Ecuador, undertook to make a survey regarding a long-range electric power development program in Ecuador for the period from 1975 to 1984 and entrusted the work to the Japan International Cooperation Agency.

Cognizant of the importance of the long-range electric power development program in Ecuador and of the economic and social impact of the electric power industry, the Japan International Cooperation Agency organized a survey mission composed of six members headed by Mr. Kokichi Yoshizawa of Electric Power Development Co., Ltd. and carried out field survey in Ecuador for a period of sixty days from January 20 to March 20, 1975.

This Report is the optimum plan of the Long-Range Electric Power Development Program for the Ten-year Period (1975 - 1984) which was formulated on examination from an overall viewpoint of the 1972 Long-Range Electric Power Development Program prepared by INECEL and the 1974 revision thereof.

It shall be extremely grateful if this Report will be effectively utilized in the Republic of Ecuador and also serve for further promotion of economic relationship and friendship between Ecuador and Japan.

In closing, I wish to take this opportunity to express my heartfelt gratitude to the Government of the Republic of Ecuador and other authorities concerned for their kind cooperation and assistance extended to the survey team.

October, 1975

Shinsaku Hogen
President
Japan International Cooperation Agency

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Mr. Shinsaku Hogen, President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir:

Presented herewith is a report on a long-range electric power development program (1975 - 1984) for the Republic of Ecuador. This report has been prepared for formulation of an optimum plan for future power expansion based on reviewing the existing programs prepared by INECEL, taking into account in detail the present local conditions of projected sites.

The Survey Mission, in order to formulate this program, stayed for field surveys in the Republic of Ecuador for a period of sixty days from January 20 to March 20, 1975. On return to Japan, the Survey Mission carried out detailed analyses of data collected in the field and results of at-site investigations, and the product has been compiled into this Report which is herewith presented.

The economic activities in the Republic of Ecuador have become prominent with full-scale production of petroleum since 1972 and the economy is showing a remarkable growth which is expected to be further expanded in the future. In order to give strong support to this economic development, it is indispensable for the Republic of Ecuador that her electric power sector be expanded and enlarged, and especially, that large-scale hydro.electric power projects be developed, nation-wide interconnected transmission line network be formed, and rural electrification be accelerated in order to supply low-cost energy stably and extensively to the country. It is strongly hoped that the Long-Range Electric Power Development Program will be implemened based on this Report.

In closing, may I take this opportunity to express my sincere gratitude to the officials of the agencies concerned of the Republic of Ecuador, above all of INECEL, and the concerned persons of the Japanese Embassy in Ecuador, the relevant authorities of the Japanese Government and the Japan International Cooperation Agency for their support and cooperation extended to us in carrying out the study.

October 1975

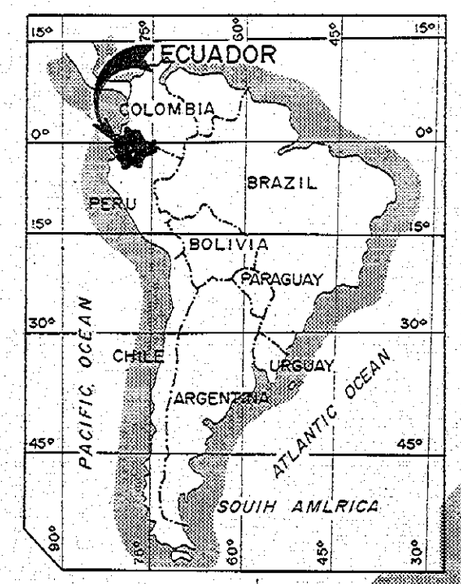
K. Yoshizawa

Kokichi Yoshizawa, Chief
Ecuador Long-Range Electric
Power Development Program
Survey Mission

NATIONAL INTERCONNECTED SYSTEM

Key and Location map

1 : 2,000.000



COLOMBIA

PASTO

Pto. San Lorenzo

ESMERALDAS

MUISNE

Río Esmeraldas

Río Cayapas

Río Santiago

Río Mira

TULCAN

IBARRA

Río Blayllabamba

Río Quinindé

Río Blanco

R. Yambi

Quito

STO DOMINGO DE LOS COLORADOS

Río Coca

Central Norte
30MW

BAEZA

BAHIA DE CARAQUEZ

CHONE

Río Daule

Río Peripa

Río Quinsaloo

Río Toachi

LATACUNGA

TENA

Río Napo

PORTOVIEJO

QUEVEDO

AMBATO

Pisayambo
Central Pucara
69.2 MW

JIPIJAPA

Río Zapotal

BAÑOS

Río Pastaza

PUYO

GUARANDA

RIOBAMBA

Río Daule

BABAHOYO

Río Palora

DAULE

Río Babahoyo

GUAYAQUIL

Río Chimbo

AGRO

SALINAS

STA. ELENA

MACAS

Río Pastaza

Paute
Central Molino
1ª – Etada
500 MW

NARANJAL

AZOGUES

PAUTE

CUENCA

Central Guayaquil
146MW

ISLA PUNÁ

PLAYA

GUAYAQUIL GULF

MACHALA

Río Jubones

Río Zamora

GUALAQUIZA

Río Santiago

Río Morona

TUMBEZ

LOJA

ZAMORA

Río Nambija

Río Cenepa

Río Catamayo

MACARA

Río Quiróz

AMALUZA

ZUMBA

PERU

Río Marañón

OCEAN PACIFIC

LEGEND

- International boundary
- Railway
- Main road
- River
- City, Town
- Hydro power plants
- Thermal power plants
- Transmisson Line (230kV)
- Transmisson Line (138kV)
- Substation

Abbreviations of the principal authorities concerned and units used in this report are as follows :

INECEL :	Instituto Ecuatoriano de Electrificacion
CEPE :	Corporacion Estatal Petrolera Ecuatoriana
EEQ :	Empresa Electrica Quito S. A.
EMELEC :	Empresa Electrica del Ecuador S. A.
kW :	kilowatt = 10^3 watt
MW :	10^3 kilowatt
kWh :	kilowatt hour
MWh :	10^3 kilowatt hour
GWh :	10^6 kilowatt hour
kV :	kilovolt
kVA :	kilovolt-ampere
MVA :	10^3 kilovolt-ampere
Hz :	Hertz (Cycles)
MVar :	10^3 kilovar
kcal/kg :	10^3 calorie per 10^3 gram
m :	meter
m^3 :	Cubic-meter
m^3/s :	Cubic-meter per second
km :	kilometer
km^2 :	square kilometer
S/. :	Sucre
mills/kWh :	10^{-3} US $ per kWh

1 barrel = 42 gallon = 159

1 US $ = 300 Yen = 25 Sucres

1 Sucre = 12 Yen

CONTENTS

CHAPTER 1

INTRODUCTION

CHAPTER 1. INTRODUCTION

1-1 Objective of Study

This study was made based on the request from the Government of the Republic of Ecuador to review the long-range electric power deveopment program of 1972 prepared by INECEL and the 1974 revision thereof taking into account the present situation, and to formulate from technical and economic standpoints an optimum plan for expansion over a ten-year period from 1975 through 1984 of power generating, transmitting and transforming facilities which will constitute the framework of electric power development of Ecuador.

1-2 Antecedents

The Government of Ecuador places emphasis on electric power development as the foundation for social and economic development, and has been materializing the projects in line with the long-range electric power development program established in the past, for development of large-scale power sources, construction of nation-wide interconnecting transmission lines, and expedition of regional electrification. However, due to some delay in implementation of those projects and to increasing necessity for review of electric power load forecast, the Government of the Republic of Ecuador requested the Government of Japan for technical cooperation regarding a study for revision of the existing long-range power development plan to match the present situation.

In response to this request, the Government of Japan had conferred with the authorities concerned on the Ecuadorian side in regard to concrete method of proceeding with such technical cooperation, and the Government of Japan dispatched a Survey Mission consiting of six experts for a period of sixty days from January 20 to March 20, 1975 to carry out field surveys.

1-3 Contents of Study

The contents of the study made by the Survey Mission are as follows:

i) Field investigations of expected power development projects and of principal locations of the nation-wide interconnecting transmission and transforming projects covering the entire territory of Ecuador, surveys of the projects presently under construction, and examinations of present progress in the existing long-range program.

ii) Long-range electric power load forecast based on information available at present.

iii) Review of the programs in the sectors of power generation, transmission and transforming from the viewpoint of possibility to meet the demand forecast at the present time, and examination of an optimum plan modifying the existing long-range program.

iv) Preliminary study on hydroelectric power generation projects considering the latter half of the 1980s.

1-4 Preconditions for Preparation of Report

This Report was prepared based on the preconditions described below.

i) Since some of the power generation projects are already under construction or in the process of bidding based on the long-range electric power development program prepared in 1972 and revised in 1974, the original program of corresponding part is respected in this report, leaving unchaged. However, examinations are made of the completion times of the power generation projects based on the load forecasts to be made in the present study.

ii) A part of the nation-wide interconnecting power transmission and transforming program, is also under way and the original program of corresponding part is also respected as stated in i) above. The times of interconnections between the various regional power systems are to be studied and the economically advantageous times of interconnections of the regional systems with the National Interconnected System are studied and examined.

iii) The original plan is to be checked by carrying out a power system analysis on the National Interconnected System based on the power demand forecast in the present study.

iv) Regarding power demand and supply balance, examinations are made severally and independently in units of regional systems before nation-wide interconnection, while after nation-wide interconnection, examinations are made on the basis of the National Interconnected System.

1-5 Members of Survey Mission

The Mission comprises the following six members:

Chief	Overall management	Kokichi Yoshizawa	Electric Power Development Co., Ltd.	Foreign Activities Dept.
Member	Demand and supply, system planning	Shunichi Hiraoka	"	Power Sales Dept.
"	General planning	Naoya Kubo	"	Planning & Design Office
"	Power transmission and transforming planning	Tadao Sato	"	Operation & Maintenance Dept.
"	Hydroelectric power planning	Toshihiko Mitsuta	"	Foreign Activities Dept.
"	Economic analysis	Hiroyoshi Inoue	Japan International Cooperation Agency	

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2. CONCLUSIONS AND RECOMMENDATIONS

2-1 Conclusions

The conclusions reached after the present study are as described below.

2-1-1 Present Electric Power Situation

Electric power in Ecuador is being supplied by power stations owned by electric power companies, electrification cooperatives and local municipalities scattered in various regions of the country, and the greater part of the generating facilities are owned by the two largest electric power companies of EEQ and EMELEC.

The present state of electric power in Ecuador in terms of such items as power generating facilities and energy production is described below.

Generating facilities

Hydro	133.7 MW	(30%)
	(6.5)	
Thermal	318.6 MW	(70%)
	(69.7)	
Total	452.3 MW	
	(76.2)	

Figures in parenthesis indicate facilities for private use

Annual energy production (estimated)	1,420	GWh
Generating capacity per capita	69.6	W
Annual energy consumption per capita	218.5	kWh
Electric power-consuming population (estimated)	2,100,000	persons
Electrification pervasion rate (estimated)	33	%
Power transmission, transforming and distribution loss (estimated)	16.5	%
Transmission line length of 13.8 kV and higher (estimated)	1,850	km

2-1-2 Load Forecast

Load forecasts were made up to 1984 by the analytical method utilizing and studying data of INECEL, past records of demand, and other relevant information. As indicated in Table 2-1, the results of the study show that maximum demand of 299.76 MW in 1974 is forecast to grow at an annual average rate of 13% in the future to reach 1,018.70 MW ten years later or in 1984.

Table 2-1 Load Forecast for Entire Ecuador at Generating End

Year	Max. Demand (MW) *	Energy (GWH)	Increase (%) MW	Increase (%) GWH
1974	299.76	1,247.64	—	—
1975	342.78	1,435.07	14.4	15.0
1976	395.10	1,659.02	15.3	15.6
1977	466.07	1,995.67	18.0	20.3
1978	537.10	2,314.25	15.2	16.0
1979	604.95	2,597.25	12.6	12.2
1980	682.91	2,933.87	12.9	13.0
1981	754.63	3,237.73	10.5	10.4
1982	834.44	3,576.95	10.6	10.5
1983	922.11	3,950.41	10.5	10.4
1984	1,018.70	4,366.36	10.5	10.5
		10 years average	13.0	13.3

* Figures from 1974 to 1980 indicate total demand summed up by each regional system in consideration of incompletion of the National Interconnected System.

Meanwhile, energy demand of 1,247.64 GWh in 1974 is forecast to show an annual average growth rate of 13.3% to become 4,366.36 GWh in 1984.

2-1-3 Demand and Supply Balance

(1) Demand and Supply Balance of Independent Regional Systems

As a result of examination of the balance between power demand and supply capacity of power generating facilities existing, under construction, and being projected within each of nine independent regional systems, shortages of supply

capacity will be produced before interconnection with the National System in the three regional systems described below, the deficits being as indicated in Table 2-2.

Table 2-2 Deficit of Power in Independent Power System (MW)

System	1975	1976	1977	1978	1979	1980	1981
Centro-Norte	3.40	6.95					
Latacunga	1.49	2.17					
Ambato	0.64	1.73					
Riobamba	1.17	2.86					
Puyo	0.10	0.19					
Sur					2.21	4.39	
Guayas-Los Rios		3.94	15.04	0.64			
Guayaquil, Duran			3.27				
Milagro		3.94	11.77				
Santa Elena				0.64			

Accordingly, it will be necessary to supplement the shortages in electric power in these three regional systems. In carrying out supplementation, transfer of diesel power plants presently possessed in the regional systems was first adopted in this report, with new diesel facilities to be installed where such transfer cannot be made.

1) Centro-Norte System

It is necessary for the following to be carried out as soon as practicable :

For Latacunga District, transfer of one 2.18 MW diesel generator

For Riobamba District, transfer of two 0.3 MW diesel generators

For Puyo District, transfer of one 0.3 MW diesel generator

It was adopted that the above 2.18 MW unit would come from among the five units of 2.18 MW diesel generator presently owned by EEQ.

2) Sur System

For the Sur System, it will be necessary to add one new unit of 5.0 MW diesel generator by the end of 1978.

3) Guayas-Los Rios System

In this power system it will be necessary to add one new 21.5 MW gas turbine for the Guayaquil-Duran and Milagro Districts by the end of 1976. For the Santa Elena District, there is a necessity for one 2.18 MW diesel generator to be transferred also by the end of 1976 from the EEQ-owned 2.18 MW units mentioned in 1) above.

(2) Demand and Supply Balance of National Interconnected System

The various regional systems will become interconnected successively from 1977 and after in accordance with the National Interconnecting Power Transmission and Transforming Program, but rapid increase in demand will still necessitate development of new power sources which are described in the following paragraph 2-1-4.

2-1-4 Projects Constituting Long-Range Electric Power Development Program

(1) Power Generation Projects for National Interconnected System

It will be necessary to complete new power development projects amounting to a total of 745.2 MW by the end of 1984, in order to meet with increases in power demand, and the salient features and commissioning dates of those projects are as indicated in Table 2-3. The difference between the INECEL Plan revised in 1974 and this plan is described below.

Table 2-3 Power Projects to be Developed in Interconnected National System up to 1983

Projects	Revised plan by the Mission		INECEL's plan in 1974	
	Capacity (MW)	Date of comissioning	Capacity (MW)	Date of comissioning
Hydro				
Pisayambo	* 69.2	Dec, 1977	69.2	Aug, 1976
Paute in 1st stage				
No. 1, 2 units	* 200	Jan, 1981	200	Jan, 1979
No. 3 unit	100	Aug, 1982	200	Jan, 1981
No. 4 unit	100	Aug, 1983		
No. 5 unit	100	Aug, 1984		
Thermal				
North thermal	* 30	Mar, 1977	30	Aug, 1975
Guayaquil (1st stage)	* 73	Apr, 1978	50	Jan, 1977
Guayaquil (2nd stage)	73	Apr, 1979	50	Jan, 1978
Total	745.2		599.2	

Note : * Under construction or bidding.

First, in the INECEL Plan revised in 1974, the period covered by the plan is 1974 through 1983 and the No. 5 unit of the Paute Hydro Project in the first stage is excluded, commisioning of which is scheduled in 1984. Meanwhile the present plan covers the period from 1975 through 1984 and the above unit is included accordingly. Secondly, the installed capacity of the First and Second Stages of Guayaquil Thermal Power Project is modified in this plan from 50 MW x 2 units proposed in INECEL plan to 73 MW x 2 units actually being invited for bid.

Thirdly, the dates of commissioning of the project in the INECEL plan were reviewed based on the progress of construction work and the results of our load forecast.

(2) National Interconnecting Power Transmission and Transforming Program

The national interconnecting transmission lines are projected for transmission of electric power generated from large-scale power sources such as Pisayambo Hydro, Paute Hydro and Guayaquil Thermal Power Projects to the nine regional systems scattered around the country, and will comprise 230 kV transmission lines of 685 km long and 138 kV transmission line of 1,015 km long with the respective appurtenant substation facilities.

The particulars of the project and required completion date thereof are as given in Table 2-4.

Table 2-4 Interconnecting Transmission Line

Systems	Volt (kV) x circuits	Length (km)	Date of commissioning
Quito-Pascuales	230 x 2	330	June, 1978
Pascuales-Paute	230 x 2	200	Dec, 1979
Milagro-Paute	230 x 1	155	June, 1983
Norte	138 x 1	90	Dec. 1976
Centro-Norte	138 x 1	144	Dec, 1976
Centro-Sur	138 x 1	40	Dec, 1979
Sur	138 x 1	150	Dec, 1980
Esmeraldas	138 x 1	170	Dec, 1980
Manabi	138 x 1	120	Dec, 1978
El Oro	138 x 1	125	Dec, 1980
Pascuales-Guayaquil	138 x 2	16	Dec, 1976
Pascuales-Sta Elena	138 x 1	120	Dec, 1978
Milagro-Babahoyo	138 x 1	40	Dec, 1979

(3) Regional Electrification Program

This program consists of development of power generating, transmitting and transforming facilities, and power distribution facilities which must be expanded inside the regional systems in the coming ten years by electric power companies or electrification cooperatives.

As stated in the results of the present study of demand and supply balances, development of the power generating facilities totaling 208.12 MW in capacity, is required in the regional systems before interconnection with National Power System. Of this amount, 181.62 MW are already under construction or are being prepared for construction, and it will be necessary to additionally develop the remaining 26.5 MW.

(4) Installed Capacity in 1984

When the power generation projects described in (1), (2) and (3) above are developed in the coming ten years, the generating facilities in 1984 will reach a total of 1,309.59 MW in capacity. The breakdown is as shown in Table 2-5.

Table 2-5 Installed Capacity of Generating Facilities in 1984

(Unit-MW)

	Hydro	Thermal	Total
Existing facilities at the end of 1974	133.71	318.59	452.30
Facilities to be retired			
Facilities owned by autonomies	-6.45	-69.65	-76.10
Old facilities	-5.16	-14.77	-19.93
Facilities to be remained(A)	122.10	234.17	356.27
Facilities to be developed			
INECEL	569.20	176.00	745.20
Private companies	15.10	193.02	208.12
Sub total (B)	584.30	369.02	953.32
Total (A + B)	706.40	603.19	1,309.59

2-1-5 Investment Required

The investment costs required for materialization of this long-range electric power development program which comprises power generation projects including Paute hydro electric power development project and the National Interconnecting Power Transmission and Transforming Program, are as indicated in Table 2-6.

Table 2-6 Investment Cost for National Interconnected System

Items	F. C. (10^6 US$)	L. C. (10^6 US$)	Total (10^6 US$)
Generating projects	341.15	141.95	483.10
National interconnection facilities	139.23	36.17	175.40
Project to be developed in and after 1985	38.58	54.70	93.28
Sub total	518.96	232.82	751.78
Regional system electrification program	51.52	22.08	73.60
Investigation and others	14.39	42.61	57.00
Total	584.87	297.51	882.38

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

As shown in the above table, of the construction cost of 751,780 thousand dollars not including the required funds for the regional electrification program, the amount which INECEL must procure from outside is 426.3 million dollars, and excepting the loans already committed, the funds to be newly financed amount to 305.1 million dollars.

2-1-6 Income and Expenditure Balance of Project

On determining the energy cost for the service lives of the nation-wide interconnecting power transmission and transforming facilities and the power generation projects to be constructed during the ten years period from 1975 through 1984, it will be 30.5 mills/kWh at terminal substation outlets of 138 kV systems.

Calculating the income and expenditure balance of the entire project by applying this energy cost to sales price of power, the cumulative deficit up to 1984 will reach 64,390 thousand dollars. In order to make this deficit for the ten years to be zero, the above sales price would become 36.1 mills/kWh.

Consequently, in case of application of 30.5 mills/kWh, it is desirable to secure more long-term and low-interest construction funds for some reduction of the deficit.

2-1-7 Evaluation of Long-Range Electric Power Development Program

The result of a review of the Long-Range Electric Power Development Program, reveals that construction of Paute Project and nation-wide interconnecting transmission and substation facilities are of greatest importance, judged from the aspect of long-range balance of demand and supply. Also, from the economical standpoint, compared with a case of constructing heavy oil-burning thermal power plants at Santo Doming in the north and Guayaquil in the south to supply power individually to the respective service area, implementation of the former projects is superior, and in the next twenty-five years approximately 150 million dollars will be saved.

2-1-8 System Analysis

The results of system analyses by digital computer of the power generation facilities and the National Interconnecting Transmission and Transforming Program of the long-range electric power development program are as described below.

i) The voltage step-up transformers for Paute Hydroelectric Power Station are to be of two-stage step-up type in the plans of INECEL, but since the greater part of electric power generated from Paute Power Station will be supplied to 230 kV systems, direct step-up to 230 kV would be appropriate. This direct step-up is advantageous also from the aspect of transient stability of the power system.

ii) Regarding the 230 kV transmission line between Paute and Milagro, it will be necessary to extend another circuit from the standpoint of transient stability in 1983 when the output of Paute Power Station will become 400 MW.

iii) The capacity of Pascuales Substation of 450 MVA is excessive judging from the aspects of demand and supply balance and system stability, and it is judged that one half of that originally planned by INECEL, or 225 MVA, will be adequate.

2-1-9 Projects in and after 1985

As a result of priority studies of power generation projects after completion of Paute Project in the period from 1985 to 1990, the power sources should be sought in the northern part of the National Interconnected System in consideration of the distribution of power demand. The projects and their order of development are as follows:

1. Santo Domingo Thermal Power Project (300 MW)

2. Toachi Hydroelectric Power Project (First Stage, 225 MW)

3. Guayllabamba No.1 Hydroelectric Power Project (First Stage, 210 MW)

2-2 Recommendations

In implementation by INECEL of the Long-Range Electric Power Development Program for the ten year period from 1975 through 1984, it is recommended that due attention will be paid to the matters described below.

i) It is necessary for the major projects of the Long-Range Electric Power Development Program described herein which are Pisayambo Project, Paute Project, and the First and Second Stages of Guayaquil Thermal Project to be completed without fail by the dates of commissioning indicated in Table 2-3.

In particular, power shortages will occur in the regional systems, should the start-up of Paute Project be delayed.

ii) In consideration of period required for procurement procedure, manufacture, and installation works, the additional power generation facilities for coping with the shortage in supply capacity which may occur in 1976 and 1977 in the Milagro District of the Guayas-Los Rios System should be arranged as soon as practicable.

For the shortage in supply capacity in the Centro-Norte System, transferable generating equipment in systems having surplus of generating capacity should be transferred at an early date. This will result in effective utilization of facilities available in the country, and to realize this, the mutual cooperation of the various electric power companies under the guidance of INECEL will be required.

iii) The National Interconnecting Transmission Lines should be constructed as indicated in Table 2-4 for tie-up with the respective regional systems.

In particular, the extension of one circuit of 230 kV between Paute and Milagro is absolutely necessary from the stadpoints of system stability and reliability. If this extension were not realized, there would be a danger which will lead to complete stoppage of power when a fault should occur in the transmission line between Paute and Guayaquil, the function as a trunk transmission line would be lost, and the intent of this Program to improve reliability and economy of the power system and to aim at efficient system operation would be frustrated.

In addition step-up transformers to be installed at Paute Hydroelectric Power Station, should be modified for direct step-up to 230 kV, while the capacity of tie transformers at Pascuales Substation should be reduced to 225 MVA in consideration of the troublesome work of raising funds.

iv) The greatest factor governing successful implementation of the Long-Range Electric Power Development Program is procurement of construction funds. Particulary, regarding portion of funds which are expected to be raised from the proceed of foreign loans, explanations should be made to the domestic agencies concerned,

while surveys and preparations necessary for introduction of funds from the outside should be actively carried out in step with timing of development.

v) INECEL will be required to develop 745.2 MW of hydroelectric and thermal power generation projects and construct as much as nation-wide interconnecting power transmission and transforming facilities of 1,700 km and 1,185 MVA in a ten-year period from 1975, and simultaneously it must bear the responsibility of operating, maintaining and administrating these facilities. For this purpose, INECEL should secure operating and maintainance personnel for the facilities including administration personnel, whose training should be intensified so that they may be fully capable of economical operation of the National Interconnected System.

vi) Forecasting of electric power demand in general, is the basis for formulation of electric power development plans and power transmission and transforming plans and in order to at improve qualitative and quantitative accuracy of the forecast, data should be collected and sorted taking the following points into consideration:

a) For residential demand, the state of spread of electric home appliances by type should be investigated along with the state of use of these appliances.

b) For commercial demand, concrete details of electric power-consuming equipment peculiar to commercial sector should be investigated.

c) For industrial demand, besides carrying out investigations of the actual states of energy consumption per product in order that the consumption trend and production quantity can be correlated by category of industry, the aspect of increasing efficiencies of production facilities, namely, factors for lowering energy consumption per product should be investigated and grasped.

d) Regarding location, scale and production plans of new industries, thorough studies should be made of projects which would be related to electric power demand, irrespective of whether the projects are drawn up or planned by the government or private firms through direct surveys by questionnaires. In particular, thorough surveys and studies should be made of the possibilities for development in the highly power-consuming industrial sectors, including petrochemical industry.

e) Investigation and survey should be made for collection of basic data on various economic indices which are related to electric power demand.

f) In sorting and studying of the above data, efforts should also be made regarding concrete measures for reduction in loss rates and improvement of equipment plant factor from the standpoint of efficient operation of electric power facilities.

g) INECEL should proceed with studies on Santo Domingo Thermal Project (300 MW), Toachi Project (First Stage, 225 MW) and Guayllabamba

No. 1 Project (First Stage, 210 MW) as power generation projects to be materialized in and after 1985. Furthermore, besides these large-scale projects, it is recommended that studies also be made for medium-scale hydro projects (50 to 100 MW) in consideration of construction periods and financial requirements.

CHAPTER 3

GENERAL PRESENT SITUATION IN ECUADOR

CHAPTER 3. GENERAL PRESENT SITUATION IN ECUADOR

3-1 Socio-Economic Environment

3-1-1 Geographical Conditions and Population

Ecuador is situated in the northwestern part of the South American continent, on the equator, bounded by Colombia on the north and by Peru on the east and south and faces the Pacific Ocean on the west. The area is 270, 670 km^2.

By her geographical features, Ecuador may be divided into three zones. These are i) the plain area (Costa) bordering the Pacific Ocean, ii) the plateau area (Sierra) belonging to the Andes Mountain Range running north-south through the central part of the country, and iii) the Amazon River Basin area (Oriente) in the eastern part of the country.

i) Costa

This is a plain facing the Pacific Ocean and is covered with tropical forests and pampas. The Guayas Plain is the largest in this zone and it comprises marshy land. On the other hand, the vicinities of Manta and Salinas along the coastline are dry areas. There are 3,090,000 people (48.8% of the total population) living in this zone where there are the cities of Guayaquil, Manta, Machala, Portoviejo, Esmeraldas and so forth, and the roads connecting these cities have sufficient width, paved in the greater part.

ii) Sierra (Central Andean Plateau)

The Andes Mountain Range which runs north-south through the middle part of Ecuador comprises two parallel cordilleras on the east and west between which there lie basin-like plateaus of elevation of 2,500m to 2,800m. These plateaus are a habitable region of temperate or subtropical climate where cities such as Ibarra, Quito, Ambato, Riobamba, Cuenca and Loja have developed and the population of the region is 3,200,000 (47.5% of the total population). The Andean cordilleras have high peaks of 5,000 m to 6,000 m class with perpetual snow such as Mt. Cotopaxi and Mt. Chimborazo.

iii) Oriente (Eastern Amazonian Region)

The Oriente consists of the skirts widely extending to the east of the Andes Mountain Range, is made up of hilly or plain areas comprising sources of the Amazon River, and occupies approximately one third of the area of Ecuador. The entire area of this region is thickly covered with tropical forests and has until recently been left undeveloped.

However, the region has attracted attention due to the discovery of petroleum in recent years, and the construction of roads accompanying the exploitation of petroleum, has progressed, with the expectations of the regional development.

The inhabitants of this region are almost all indigenous people and the population is only 200,000.

According to the results of a national census taken in June 1974 the total population of Ecuador is approximately 6,500,000. The population growth rate is 3.4%, the density is 24 per km^2 (but 37 per km^2 excluding the sparsely populated Amazonian region).

The distributions of population by province and by principal cities are as indicated in Table 3-1 and Table 3-2.

Table 3-1 Population by Province

Unit : Person

	Provinces	Masculine	Feminine	Total
I.	SIERRA			
	Carchi	59,994	60,269	120,263
	Imbabura	107,741	110,072	217,813
	Pichincha	484,212	496,841	931,053
	Cotopaxi	116,195	119,420	235,615
	Tungurahua	135,248	140,866	276,114
	Bolivar	72,348	74,074	146,424
	Chimborazo	149,471	156,667	306,138
	Cañar	71,291	76,172	147,463
	Azuay	171,060	194,597	365,657
	Loja	172,864	170,289	343,153
II.	COSTA			
	Esmeraldas	105,803	97,603	203,406
	Manabi	409,807	398,808	808,615
	Los Rios	203,943	180,170	384,113
	Guayas	752,466	760,372	1,512,838
	El Oro	136,751	123,467	260,218
III.	ORIENTE			
	Napo	33,247	26,504	59,751
	Pastaza	12,449	10,609	23,058
	Morona Santiago	26,677	23,729	50,406
	Zamora Chinchipe	18,834	15,811	34,645
IV.	Galapagos	2,363	1,695	4,058
	Sub total	3,242,764	3,238,037	6,480,801
V.	Others	–	–	20,044
	Total	3,242,764	3,238,037	6,500,845

Source : Census in 1974

Table 3-2 Population in Principal Cities

Order	Name of cities	Population (Persons)	Region	Province
1	Guayaquil	814,060	COSTA	Guayas
2	Quito	597,130	SIERRA	Pichincha
3	Cuenca	104,670	"	Azuay
4	Ambato	77,050	"	Tungurahua
5	Machala	68,380	COSTA	El Oro
6	Manta	63,520	"	Manabi
7	Esmeraldas	60,130	"	Esmeraldas
8	Portoviejo	59,400	"	Manabi
9	Riobamba	58,030	"	Chimborazo
10	Milagro	53,060	"	Guayas
11	Quevedo	43,130	"	Los Rios
12	Ibarra	41,060	SIERRA	Imbabura
13	Sto. Domingo	30,140	COSTA	Pichincha

Source : Census in 1974

The population distribution by region is 48.8% in the Costa, 47.5% in the Sierra, 3.0% in the Oriente and 0.7% in other parts. The population of the Costa 100 years ago was only 20.0% of the whole, but an increase in population has been recently conspicuous in this region, and judging from the distribution of cities, the Costa has nine out of thirteen cities with population of more than 30,000. Of these cities, increases in population have been prominent in Machala, Manta and Esmeraldas indicating the recent progress in regional development in the Costa.

In comparison with this, the increase in urban population in the Sierra has been slight indicating that economic development has come to a standstill.

The urban population is 2,680,000 (41% of total population) and concentration of the population in urban areas has been especially noticeable in recent years. Of the urban population, the number of people in the two major cities of Guayaquil and Quito is 1,410,000, which comprises 21.7% of the entire population of the country.

3-1-2 Outline of Economy

Ecuador in the 1960s relied heavily on agriculture and was a nation of small economic scale, lagging in industrialization. However, with completion of a petroleum pipeline in 1972, petroleum production and its export were commenced in earnest, with industrialization being started in such fields as the relevant industries.

The trend in gross national product (GNP) are as shown in Table 3-3 with the nominal figures of 2,500 million dollars in 1973 and estimated 2,870 million

dollars in 1974, ranking the country on a medium level among the countries of Latin America. The GNP per capita as of 1974 is estimated to have been around 430 dollars. The growth rates in GNP against preceding years were 10.4% for 1972, 12% for 1973 and an estimated 13% for 1974 indicating a high pace of growth among the developing nations.

The gross domestic product (GDP) was approximately 2,330 million dollars in 1973 as shown in Table 3-4, and per capita, this amounted to 360 dollars. The composition of GDP by sector is given in Table 3-5. In 1973, this was 22% agriculture, 17.4% manufacturing, 16.5% services, 13% commerce and hotels, 7.7% mining mainly composed of petroleum, and 23.4% others. All sectors have been indicating favorable gains yearly, and in and after 1972, the growth in the petroleum industry sector and the construction sector have been particularly outstanding.

The trends in foreign trade of Ecuador are as given in Table 3-6 and Table 3-7 indicating favorable increases in recent years. In export, the amount in 1970 was approximately 200 million dollars, but this became approximately 500 million dollars in 1973 and in 1974 it reached an estimated 1,000 million dollars. In view of export item, petroleum is main and occupies 60% of the whole. Besides this, there are agricultural products such as banana, cacao, coffee and sugar.

On the other hand, imports which were 250 million dollars in 1970 increased to an estimated 850 million dollars in 1974. This growth is due to sharp increases in imports of equipment and construction materials accompanying expansion of economic activity and progress in development works. The balance of export and import was in the red up to 1972, but was evened in 1973, and in 1974 exports far exceeded imports.

Regarding the international balance of payments, this is as shown in Table 3-8. During the 1960s, a pattern was followed with the deficit in the current account being covered by the surplus in the capital account coming from foreign loans and investments, but since export of petroleum was started in 1972, the foreign trade balance has been greatly improved and surpluses have come to be shown in the total balance.

Meanwhile, foreign exchange reserves, which were 128 million dollars in 1972, reached a record high of 382 million dollars in May 1974, but due to a decline in petroleum exports during the latter half of the year, the reserves were decreased to 328 million dollars in December 1974.

As described above, the active turn in the economy of Ecuador can be clearly seen from statistical data, and has been caused by the expansion in public investments and the income from petroleum. The amount of public investments (See Table 3-9), reached 71.5 million dollars in 1970 while they had increased to 148 million dollars in 1973. The principal sectors in which investments have been made are education, housing and hospital facilities, while roads, urbanization, electrification, irrigation, and ports and harbors have also been invested. The records of annual revenues and expenditures of the central government of Ecuador are as indicated in Table 3-10.

Table 3-3
Gross National Product (G. N. P)

Year	GNP (10^6 US$)	GNP per capita (US $)
1960	841	195
1965	1, 210	235
1970	1, 670	274
1971	1, 600	254
1972	1, 878	289
1973	2, 536	377

Table 3-4
Gross Domestic Product (G. D. P)

Year	GDP (10^6 US$)	GDP per capita (US $)
1960	857	-
1965	1, 114	216. 3
1970	1, 534	255. 7
1971	1, 488	236. 3
1972	1, 731	266. 3
1973	2, 334	359. 0

Table 3-5 Gross Domestic Products by Sector

Sector \ Year	1970		1971		1972		1973	
	10^6 US$	%	10^6 US$	%	10^6 US$	%	10^6 US$	%
Primary	437		407		484		701	
Agriculture	412	26.9	388	26.0	431	24.9	521	22.0
Mining	25	1.7	19	1.3	53	3.0	180	7.7
(Petroleum)	4		3		35		158	
Secondary	624		627		725		942	
Manufacturing	263	17.0	263	17.7	310	17.9	406	17.4
Construction	96	6.3	93	6.3	96	5.5	128	5.5
Transportation	97	6.3	95	6.4	115	6.6	149	6.4
Others	168		176		204		259	
Tertiary	473		454		522		691	
Commerce & Hotel	200	13.0	202	13.6	230	13.3	305	13.0
Services	273	17.8	252	16.9	292	16.9	386	16.5
Gross domestic product	1,534	100	1,488	100	1,731	100	2,334	100

Table 3-6 Amount of Exports at FOB Price

Unit : 10^6 US$

Sector \ Year	1970	1971	1972	1973	1974 (estimated)
Petroleum	0.7	1.0	60.1	248.6	597.6
Banana	94.3	101.2	109.0	105.1	107.5
Cacao	22.3	25.4	23.3	26.7	98.8
Coffee	9.4	13.5	17.1	12.1	32.3
Sugar	50.5	36.5	42.6	66.8	61.9
Marine product	6.8	14.6	16.7	24.4	26.7
Others	17.5	24.8	32.7	59.7	73.0
Total	201.5	217.0	301.5	543.4	997.8

Table 3-7 Amount of Import at CIF Price

Unit : 10^6 US$

Sector \ Year	1971	1972	1973	1974
Durable goods	11.7	8.9	14.9	–
Non-durable goods	26.2	29.4	40.0	–
Fuel oil	26.6	21.3	9.2	–
Materials for agriculture	6.0	4.0	10.1	–
Materials for industrial	92.6	93.3	146.7	–
Materials & machines for construction	10.9	9.6	13.8	–
Materials & machines for manufacturing	41.3	45.0	60.6	–
Materials & machines for agriculture		4.3	6.3	–
Machine & equipments for transportation	36.2	32.9	44.1	–
Total	256.6	248.7	345.7	617.6 (estimated)

Table 3-8 Balance of Payments

Unit : 10^6 US $

Sector \ Year	1971	1972	1973
(1) Trade balance			
Export of goods	242.9	323.2	575.1
Import of goods	- 360.7	- 366.6	- 492.9
Surplus or Deficit	- 117.8	- 43.8	82.2
(2) Service			
Transportation	- 49.1	- 54.9	- 67.9
Investment & insurance	- 35.7	- 32.0	- 37.0
Others	- 23.0	- 21.8	- 28.7
Deficit	- 107.8	- 108.7	- 133.6
(3) Balance of transfer account	15.7	15.8	38.3
Balance of current account (1) + (2) + (3)	- 209.9	- 136.3	- 13.1
(4) Long-term capital			
Direct investment	162.1	150.0	54.3
Debt	47.9	111.9	60.2
Disversement	- 28.7	- 28.7	- 33.8
Others	—	- 5.7	- 0.5
Surplus	182.3	227.8	80.2
(5) Basic balance of payments (1) + (2) + (3) + (4)	- 27.6	91.5	67.1
(6) Special drawing rights allotment	3.5	3.5	—
Short-term capital			
(7) Non-financial accounts	- 5.8	4.4	35.1
(8) Financial accounts	29.9	- 99.4	- 102.2
(9) (7) + (8) Surplus or Deficit	24.1	- 95.0	- 67.1
Total balance (5) + (6) + (7)	- 29.9	99.4	102.2
Foreign currency reserves	25.0	128	226

Table 3-9 Public Investments by the Government

Unit : 10^6 Sucres

Sector \ Year	1970	1971	1972	1973
Public utilities	349	457	469	516
Education	127	153	201	149
Hospital	33	60	54	30
Housing	59	147	81	182
Others	130	97	133	155
Construction, others	1,144	1,771	1,423	2,467
Load	604	810	673	968
Air-port & harbour	53	63	85	103
Portable water, Drainage & irrigation	123	231	241	376
Electrification	76	277	143	698
Urbanization	131	225	152	171
Others	157	165	129	151
Machine & equipments	294	351	424	717
Total	1,787	2,579	2,316	3,700

Table 3-10 Annual Revenue and Expenditure of the Government

Unit : 10^6 US $

Sector \ Year	1970	1971	1972	1973
Annual revenue	148	177	221	327
Annual expenditure	210	246	256	336
Balance	- 61	- 69	- 35	- 9

The economic indicators in Table 3-3 to Table 3-10 are according to the annual report "Memoria del Gerente General" published by the Banco Central.

3-1-3 Industry

Manufacturing

Manufacturing in Ecuador during the 1960s was mainly composed of production of consumer goods such as foodstuffs processing, beverages, leather and textiles, but on entering 1970s, a prominent trend of development was beginning to appear in such sectors as the manufacturing of plastic household goods and construction materials, the processing of rubber products, plywood, cement, reinforcing bars, structural steel and pipes, the assembly of electrical household appliances, automobiles and timepieces, and the foodstuffs processing.

Especially, in the foodstuffs processing sector, domestic demands for edible oil, dairy products, sugar, canned fish, beer, carbonated beverages and tobacco are filled by domestic production with parts having grown to the extent of being exported.

Manufacturing in the past had been concentrated in the two major cities of Guayaquil and Quito, but the Government, along with providing a transportation network, has been promoting industrialization of provincial cities, and the cities of Ibarra, Otavalo, Ambato, Riobamba, Cuenca, Machala, Esmeraldas and Manta are successively becoming industrialized.

There are high expectations for the petrochemical sector in the future and CEPE is aiming at implementation of plans.

Agriculture

The agriculture of Ecuador, because of topography, climate and population distribution, is concentrated in the plains of the Costa and the plateau of the Sierra. The Costa plain area has fertile soil and the climate is suitable so that productivities of tropical and subtropical crops are extremely high, and in recent years, as a result of promotion of agricultural development under the guidance of the Government, this region is becoming the principal agricultural area of Ecuador. The main agricultural products are banana, coffee, cacao and abaca, with the greater part exported to play a major role along with petroleum in gaining foreign exchange. The plateau area of the Sierra has long been farmland where primitive methods of cultivation had been used, but in recent years improvement and modernization of cultivation methods have been promoted under the guidance of the Government, the effects of which are now beginning to appear.

Stockfarming

Stockfarming is on a scale to meet domestic demand and as a result of efforts made by the Government to nurture this industry through a subsidizing policy, there has been a trend of gradual development in recent years. The mainstream of stockfarming is raising of beef cattle which is concentrated in the Sierra. Sheep, hogs and so on, are also raised for the private uses of the indigenous people.

Forestry

The forestry resources of Ecuador are extremely abundant in the Oriente and the northern part of the Costa, but development has retarded because of the inadequacy of transportation facilities such as roads. However, with increasing demand as a building material, timber from the vicinity of the Rio San Lorenzo has been hauled out, processed and brought to market. Of lumber being exported, balsa is very well-known.

Fisheries

The coastal waters off Ecuador, influenced by ocean currents, are a treasure house of fishes and the marine products occupy the sixth place among the export items. The fishing has increased to approximately quadruple in the last five years. Increases in fishing are expected to continue in the future and the Government is making efforts to enlarge and equip fishing ports. The principal fishing ports are Esmeraldas, Bahia de Caraques, Manta, Salinas and Machala.

Mining

The geological distribution of the Andes Mountain Range suggests that there are aboundant deposits of mineral resources. However, because of cover by thick volcanic ash and forests, mineral exploration is extremely difficult and development has not progressed except for petroleum.

3-1-4 Energy Resources

Ecuador is a country favored with various energy resources, but only a part of them is being utilized. The energy resources owned are water power, petroleum, natural gas and charcoal.

(1) Water Power Resources

The Andes Mountain Range which runs north-south through the central part of Ecuador has a great amount of precipitation and there is a large number of rivers and streams which are rapid flows forming V-shaped valley. This topographical conditions are adequate to develope hydroelectric power sources, and the hydroelectric potential in Ecuador is to be 27,900 MW. The representative rivers and their discharges are as indicated in Table 3-11.

The water power developed and utilized up to the present amounts to a little more than 134 MW so that a very great part remains undeveloped.

Since the establishment of INECEL in 1961, surveys of hydroelctric development sites have progressed, sites to be develped have been recognized, and a part of them are beginning to be developed. The sites which have been surveyed up to the present and which are considered economically feasible are as indicated in Table 3-12.

Table 3-11 Discharge of Principal Rivers in Ecuador

Fluvial System	Rivers	Observatory	Average discharge (m^3/s)	Discharge per 100 km^2 (m^3/s)	Basin (km^2)
Esmeraldas	Gayllabamba	A. J. Rio Cubi	46.5	1.17	3,990
	San Pedro	Guangoporo	16.4	1.20	1.352
	Toachi	A. J. Rio Pilaton	37.3	2.60	1,435
Guayas	Chimbo	San Lorenzo	4.9	0.60	810
		D. J. Pangor	12.1	0.74	1,630
Jubones	Jubones	Ushcurumi	41.4	1.24	3.350
Napo	Coca	San Rafael	298.0	7.48	3,985

Source : Data of hydrology, 1964

Table 3-12 Principal Hydro Projects

Rivers	Projects	Maximum output (MW)
Rio Apaqui	Montufar	150
Rio Antisana	La Mica	20
Rio Guayllabamba	Guayllabamba	740
Rio Toachi	Toachi	350
Rio Chimbo	Chimbo-Pangor	419
Rio Paute	Paute	1,260
Rio Coca	Coca-Quijos	3,200
Rio Jubones	Jubones	380
Rio Santiago	Santiago	2,000
Rio Zamora	Zamora	747
Total		9,266

Development of the domestically available energy resource of water power is listed as one of the pillars of the Ecuadorian Government's policies, and it is anticipated that development will advance mainly in hydroelectric power for some time to come.

(2) Petroleum Resources

In 1967, Texaco-Gulf succeeded in finding a large oil field in the vicinity of Putumayo in the Oriente. Until that time, there was production of a mere 3,000 bbl/day in the vicinity of Santa Elena. The oil field of the Oriente was subjected to large-scale drilling of wells in 1971 to 1972 by a joint venture company of CEPE and Texaco-Gulf, and now has reached production of 200,000 bbl/day. The crude oil produced is being transported out by an oil pipeline crossing the Andes (capacity, 240,000 bbl/day; length, 500 km; section, Lago Agrio to Esmeraldas; completion, August 1972). The production recorded was 25 million barrels in 1972 and 71 million barrels in 1973.

According to the surveys up to the present, the oil deposits in the Oriente are estimated to amount to 750 million tons.

At present, CEPE is constructing an oil refining plant with a capacity of 50,000 bbl/day at Esmeraldas under the guidance of the Ecuadorian Government, which is scheduled to be completed around November in 1976.

(3) Natural Gas

Guayaquil Bay is an area which has been investigated for oil fields from some time ago, and recently, it was found that a huge amount of natural gas is deposited and development by the hands of CEPE is being planned. Also, there is a considerable amount of natural gas springing from the oil field in the Oriente which is presently being worked for petroleum, and there is a plan for this natural gas to be piped to Quito to be utilized as city gas and for thermal power generation, and the realization of this plan is looked forward to.

3-2 Electric Power Situation

3-2-1 Present State

Ecuador at present is at a transient stage of moving from the era of self-sufficiency in power supply within each province or city to an era of power supply from nation-wide interconnected system.

As of the end of 1974, Ecuador had a country-wide total of 452.3 MW of power generating facilities. Of this total, the generating facilities owned by the power companies and the electrification cooperatives amounted to 376.2 MW (83.2% of the whole) and the facilities for private use 76.1 MW (16.8% of the whole).

This corresponds to 65.5 W per capita. The present population receiving electricity is 32.6% (2.05 million) of the whole, and installed capacity per capita of population receiving electricity is 220.6 W.

Meanwhile, electric power consumption is 1,420 GWh annually (including the facilities for private use), and the peak load at the generating end is 311.5 MW (including the facilities for private use). The power consumption per capita is 218.5 kWh (48 W/capita).

The electric power enterprises of Ecuador are INECEL, a governmental organization, twenty-one electric power companies in various major cities and municipalities, and about forty local community-owned companies and electrification cooperatives.

The larger of the electric power companies are EEQ at Quito and EMELEC at Guayaquil. The installed power generating capacities of these two major electric power companies are 112.6 MW and 121.6 MW respectively, totaling 234.2 MW in capacity which makes up approximately 52% of the existing power generating facilities. The facilities owned by the other provincial electric power companies, the municipalities and the electrification cooperatives amount to 142.0 MW while the generating facilities for private use amount to 76.1 MW.

The existing power generating facilities by regional system as of the end of 1974 are indicated in Table 3-13, the transitions in the number of generating facilities in Table 3-14 and the power generation performance by province in 1973 in Table 3-15.

The power generation projects, which are presently being carried out by INECEL or electric power companies of the various regional systems, are as described below.

INECEL is undertaking power generation projects having all the country as their service area through the National Interconnected System proceeding with the construction of the projects of Norte Thermal Project, 30 MW, and Pisayambo Hydro Project, 69.2 MW, or a total of 99.2 MW. Further, the projects for which plans have been finalized and preparations are under way aiming at the start of construction within fiscal 1975 are the First Stage of Paute Hydro Project, 500 MW and the First Stage of Guayaquil Thermal Project, 73 MW.

Meanwhile, in the regional power systems, the power generation projects being carried out by the various provincial electric power companies and the electrification cooperatives with the cooperation of INECEL, combining those under construction and those being prepared for construction, amount to 181.6 MW in capacity, and the power generation projects being developed through the country total 733.8 MW in capacity,

Furthermore, INECEL has started work in 1975 in the fields of power transmission and power transforming based on a nation-wide interconnected power transmission and transforming program.

On the other hand, works are also being carried out in the regional power systems on intrasystem interconnecting lines and expansion of distribution lines.

Table 3-13 Existing Generating Facilities by Regional System at the End of 1974

Systems	Public		Total	Private Use		Total	Grand Total
	Hydro	Thermal		Hydro	Thermal		
(1) Norte	12,455	1,500	13,955	150	2,719	2,869	16,824
(2) Pichincha	83,964	36,550	120,514	4,158	7,975	12,133	132,647
(3) Centro-Norte	16,919	9,227	26,146	1,943	7,506	9,449	35,595
(4) Centro-Sur	8,619	11,682	20,301	0	6,500	6,500	26,801
(5) Sur	2,677	3,410	6,087	206	1,000	1,206	7,293
(6) Esmeraldas	0	5,220	5,220	0	4,228	4,228	9,448
(7) Manabi	0	24,175	24,175	0	4,180	4,180	28,355
(8) Guayas Los Rios	0	149,634	149,634	0	34,742	34,742	184,376
(9) El Oro	2,282	7,084	9,366	0	578	578	9,944
(10) Fuera de 9 Sistemas	334	457	791	0	224	224	1,015
Total	127,250	248,939	376,189	6,457	69,652	76,109	452,298

Table 3-14 Actual Installed Capacity and Generated Energy in Ecuador

Unit : MW and MWh

Year	Public Utilities and Associated by INECEL			EEQ and EMELEC			Municipalities and Others			Private Use			Entire Ecuador		
	Hydro	Thermal	Total	Hydro	Thermal	Total	Hydro	Thermal	Total	Hydro	Thermal	Total	Hydro	Thermal	Total
1964	15.7 (47,150)	4.9 (10,317)	20.6 (57,467)	32.1 (153,911)	58.5 (191,072)	90.6 (349,983)	12.2 (38,247)	10.7 (13,069)	22.9 (51,369)	4.9 (14,450)	31.2 (57,837)	36.1 (72,287)	64.9 (253,758)	105.3 (272,295)	170.2 (526,053)
1965	15.7 (50,758)	10.9 (16,895)	26.6 (67,653)	32.1 (164,480)	58.3 (213,347)	90.4 (377,827)	12.2 (38,444)	10.7 (13,524)	22.9 (51,968)	6.8 (16,698)	33.4 (55,521)	40.2 (72,219)	66.8 (270,380)	113.3 (299,287)	180.1 (569,667)
1966	15.9 (56,489)	15.9 (21,032)	31.8 (77,521)	32.1 (173,689)	58.3 (232,984)	90.4 (406,663)	12.7 (39,454)	11.4 (16,462)	24.1 (55,916)	8.0 (15,287)	31.9 (53,247)	39.9 (68,534)	68.7 (284,919)	117.5 (323,752)	186.2 (608,644)
1967	21.9 (65,555)	19.3 (26,205)	41.2 (91,760)	55.1 (188,571)	60.3 (255,121)	115.4 (443,692)	14.3 (39,399)	9.6 (16,474)	23.9 (55,873)	6.4 (21,014)	34.0 (59,344)	40.4 (80,358)	97.7 (314,539)	133.2 (357,144)	220.9 (671,683)
1968	21.9 (66,439)	23.2 (39,866)	45.1 (106,305)	53.2 (207,675)	73.8 (298,791)	127.0 (506,466)	14.6 (39,427)	7.9 (14,624)	22.5 (54,051)	5.9 (14,880)	38.3 (67,478)	44.2 (82,358)	95.6 (328,421)	143.2 (420,759)	238.8 (749,180)
1969	31.4 (76,490)	26.3 (49,290)	57.7 (125,780)	53.2 (223,387)	75.8 (333,109)	129.0 (556,496)	13.3 (42,203)	7.9 (20,245)	21.2 (62,448)	6.5 (21,983)	54.6 (83,711)	61.1 (105,694)	104.4 (364,063	164.6 (486,355)	269.0 (850,418)
1970	31.4 (89,248)	28.0 (57,078)	59.4 (146,326)	53.2 (244,432)	104.3 (376,146)	157.5 (620,578)	14.4 (44,871)	8.3 (16,795)	22.7 (61,666)	7.1 (26,027)	56.8 (94,211)	63.9 (120,238)	106.1 (404,578)	197.4 (544,230)	303.5 (948,808)
1971	31.7 (92,650)	42.0 (81,271)	73.7 (173,921)	52.1 (271,765)	117.5 (407,802)	169.6 (679,567)	14.2 (49,261)	6.3 (8,293)	20.5 (57,554)	7.2 (26,558)	56.8 (112,036)	64.0 (138,594)	105.2 (440,234)	222.7 (609,402)	327.9 (1,049,636)
1972	32.2 (105,398)	45.6 (89,080)	77.8 (194,478)	52.1 (265,780)	134.6 (464,736)	186.7 (730,516)	13.8 (44,261)	6.9 (7,497)	20.7 (51,537)	7.2 (29,947)	64.9 (110,639)	72.1 (140,586)	105.3 (445,165)	252.0 (671,953)	357.3 (1,117,118)
1973	83.4 (366,245)	101.8 (212,212)	185.2 (578,457)	- -	102.7 (463,220)	102.7 (463,220)	13.3 (44,032)	4.4 (7,751)	17.7 (45,885)	7.3 (30,765)	73.3 (138,011)	80.6 (435,144)	104.0 (435,144)	282.2 (821,194)	386.2 (1,256,338)

Note : Figures in parenthesis indicate generating energy in MWh.

Table 3-15 Actual Record of Generated Energy by Province in 1973

Systems	Provinces	Installed capacities (kW)	Generated energy			Energy consumption						
			Hydro (GWh)	Thermal (GWh)	Total (GWh)	Residential (GWh)	Commercial (GWh)	Industries (GWh)	Public Building (GWh)	Street lighting (GWh)	Others (GWh)	Total (GWh)
Norte	Carchi	2,350	7,540	29	7,569	2,570	1,387	493	220	1,333	6	6,009
	Imbabura	14,169	17,404	4,639	22,043	5,106	1,845	7,380	467	1,926	108	16,833
Pichincha	Pichincha	100,131	258,313	107,358	365,671	117,785	41,831	82,331	17,311	12,763	14,700	286,721
Centro-Norte	Cotopaxi	8,174	14,532	3,006	17,538	6,203	1,048	5,418	2	163	–	12,834
	Tungurahua	8,013	26,195	4,098	30,293	10,111	5,563	3,973	408	2,685	196	22,936
	Bolivar	1,830	2,864	109	2,973	912	240	153	136	732	17	2,190
	Chimborazo	10,843	30,083	359	30,442	4,278	4,019	14,117	372	2,045	1,373	26,209
Centro-Sur	Cañar	10,880	3,833	9,121	12,954	2,285	–	8,235	83	374	1	10,978
	Azuay	15,496	43,275	8,466	51,741	15,355	2,589	16,854	663	2,312	40	39,813
Sur	Loja	5,259	8,228	3,190	11,418	2,732	2,411	2,915	55	1,459	226	9,798
SIERRA Total		177,145	412,266	140,376	552,642	167,337	60,937	143,870	19,722	25,791	16,667	434,324
Esmeraldas	Esmeraldas	7,559	–	17,355	17,355	3,460	1,634	8,023	3	1,028	121	14,269
Manabi	Manabi	29,447	–	51,447	51,447	10,823	5,290	12,448	110	697	9,118	38,486
Guayas-Los Rios	Guayas	144,521	–	565,177	565,177	165,123	73,430	220,052	31,885	12,112	112	502,714
	Los Rios	10,025	–	20,627	20,627	3,145	2,168	9,763	457	1,671	188	17,392
El Oro	El Oro	10,217	9,337	16,005	25,342	5,828	3,570	5,384	856	2,536	21	18,195
COSTA Total		201,769	9,337	670,611	679,948	188,379	86,092	255,669	33,311	18,044	9,560	591,057
ORIENTE Total	Morona Santiago Napo Pastaza Zamora, Chinchipe	7,373	13,541	10,207	23,749	580	–	15,158	–	200	5,298	21,236
Total		386,287 1/	435,144	821,194	1,256,338	356,296	147,029	414,697	53,033	44,035	31,525	1,046,617
(%)			34.6	65.36	100	28.36	11.70	33.01	4.22	3.51	2.51	83.31

Note : 1/ including facilities owned by Private Use

3-2-2 Activities of INECEL

INECEL is one of the public utilities established in 1961 based on the Ley Basica de Electrificacion (Basic Law for Electrification) as a governmental organization responsible for electric power development.

As a governmental organization, INECEL fills the role of drawing up long-range electric power development programs on a nation-wide scale, and twice, in 1964 and 1972, formulated long-range electric power development programs based on which it has carried out development. Further, in 1974, INECEL made a revision of the program prepared in 1972.

In preparing those programs the fundamental development projects conceived by INECEL composed the following three items:

1) Investigation and study for development of large scale hydro and thermal project and their materializations

2) Establishment of nation-wide interconnected power system

3) Establishment of regional power system including expansion of distribution networks

The electric power facilities developed by INECEL up to the end of 1974 in the form of capital participation in electric power companies of the regional systems or as direct controlled projects are as indicated in Table 3-16, and these amount to 100 MW of power generating facilities, 11.4 MVA of power transforming facilities, 925 km of transmission lines (intraregional system interconnection), 116 km of distribution lines.

Table 3-16 Power Facilities Owned by Public Utilities and Associated by INECEL

Systems	Generating facilities	Transforming facilities	Transmission lines (km)				Customer
			34.5kV	22kV	13.8kV	69kV	
Norte	9,495	29,232		138	9		11,000
Pichincha	5,695	2,375			150		—
Centro-Norte	11,553	9,090			128	84	17,300
Centro-Sur	5,785	15,010					12,350
Sur	2,513	2,600					6,920
Esmeraldas	5,350	5,000					6,500
Manabi	23,150	20,000		111	39	32	10,800
Guayas-Los Rios	29,975	17,780	23		227		13,950
El Oro	6,432	10,250	20	30	50		8,000
Others	125	100					140
Total	1/ 100,073	111,437	43	279	603	116	89,960

Note : 1/ expect for the generating facilities installed by EEQ and EMELEC

CHAPTER 4

LOAD FORECAST

CHAPTER 4. LOAD FORECAST

4-1 Basic Considerations

The electric industry has peculiar features such as simultaneousness of production and consumption, and long gestation periods of capital. Because of this, in formulation of a development scheme which is to run over a long period of time, it is necessary to accurately prepare a long-range forecast of demand. Although there are various techniques for making long-range load forecasts, they may be broadly divided into the following:

i) Analytical method in which the electric power consumption is examined in detail by category of use and the demands are added up.

ii) Macroscopic method for grasping the general trend of demand forecasting loads from the relationship between economic indicators such as GNP, IIP (index of industrial production), etc. and power demand.

Either of the two methods is used for demand forecast considering the ative conditions between demands by category, the economic structure, method of arranging statistical data, etc., but the general practice is to use a combination of the two methods taking into account past trends in demand and economic indices.

Regardless of the methods for load forecast, since the forecast result is inferred from the statistical analysis on historic trends of the available data the result has to be considered to have a range. The load forecast will be made by an analytical method in the broad sense in which upon making analysis of past records, demands by category are added up based on trends. The outline is as described below.

a) Demand is classified according to the four categories of "residential," "commercial," "industrial" and "other" based on the method of arrangement conventionally used in Ecuador.

b) Forecasting factors are calculated in each regional system by analyzing the past records by demand category to obtain the past trends of such forecasting factors as energy consumption per customer and number of consumers, etc.

c) Based on the forecast factors calculated in b) above, energy demand at customer and are computed by regional system.

d) Regarding load factors and loss ratios, these are calculated based on past trends upon which sending end energy are computed.

The load forecasting method used herein is roughly as described above, and for reference, trial caluclations were also made by a macroscopic method using of the elastic coefficient between GNP and energy demand. The results are

Indicated in Appendix A-1-1

4-2 Past Record of Power Demand

The energy requirement at customer end, growth rates versus preceding year and composition ratios by demand category on a nation-wide basis for the ten year period from 1964 through 1973 are as shown in Table 4-1.

On looking at average growth rates for the above ten year period, they are 9.9% for industrial uses, 10.1% for residentail uses, 14.2% for commercial uses, and 6.3% for other uses, indicating an apparent growth pattern of demand comprising residential and commercial customers. This is thought to be due to the spread of electrification in urban areas as well as rural electrification being promoted as a national policy, and accordingly, the composition ratio of residential and commercial demand in the total demand, which was 44.9% in 1964, was raised to 48.3% in 1973.

As for industrial demand, this shows a high growth rate next to residential and commercial demand, but the composition ratio has shown a stage of remaining on the same level of approximately 40.0% every year. Meanwhile, "other demand" have stayed at a relatively low rate of growth, and this is because the demand from public lighting and government agencies in the large cities of Quito and Guayaquil, which composes the greater part of "other demand", is already filled, while the general trend in "other demand" in regional cities indicate a higher growth rate compared with residential, commercial and industrial demands.

4-3 Load Forecast Factors

4-3-1 Basic Conditions for Load Forecast

Regarding population trends, electrification pervasion rates, etc., which are basic conditions required for forecasting future demand, it was decided to respect the forecast values of INECEL.

(1) Future Trends in Population

It is estimated from the results of past national censuses that population will increase in the future at an annual rate of approximately 3% on a national basis, and forecast of population were made by regional systems in consideration of migration of the population to regional cities caused by increases in employment opportunities coming from locating of industries accompanying regional development. The results are indicated in Table 4-2.

(2) Electrification Ratio

Rural electrification is one of the basic policies of the Government and is being implemented with priority. The pervasion rates for the three representative years of 1974 (estimated actual), 1980 and 1984 are as indicated in Table 4-2.

Table 4 - 1 Entire Ecuador Actual Energy Demand at Customer End

Year		TOTAL	Demand category			
			Industrial	Pesidential	Commercial	Others
1964	Demand (GWh)	441.92	177.17	149.28	44.63	70.84
	Growth rate (%)	—	—	—	—	—
	Ratio of composition (%)	100.0	40.1	33.8	10.1	16.0
1965	Demand (GWh)	481.92	188.91	163.85	52.53	76.63
	Growth rate (%)	9.1	6.6	9.8	17.7	8.2
	Ratio of composition (%)	100.0	39.2	34.0	10.9	15.9
1966	Demand (GWh)	508.74	208.43	178.62	54.59	67.10
	Growth rate (%)	5.6	10.3	9.0	3.9	-12.4
	Ratio of composition (%)	100.0	41.0	35.1	10.7	13.2
1967	Demand (GWh)	561.95	215.85	196.51	70.19	79.40
	Growth rate (%)	10.5	3.6	10.0	28.6	18.3
	Ratio of composition (%)	100.0	38.4	35.0	12.5	14.1
1968	Demand (GWh)	638.95	242.99	220.12	81.47	94.37
	Growth rate (%)	13.7	12.6	12.0	16.1	18.9
	Ratio of composition (%)	100.0	38.0	34.5	12.8	14.7
1969	Demand (GWh)	728.59	283.50	251.58	93.04	100.47
	Growth rate (%)	14.0	16.7	14.3	14.2	6.5
	Ratio of composition (%)	100.0	38.9	34.5	12.8	13.8
1970	Demand (GWh)	796.44	321.04	279.71	103.38	92.31
	Growth rate (%)	9.3	13.2	11.2	11.1	-8.1
	Ratio of composition (%)	100.0	40.3	35.1	13.0	11.6
1971	Demand (GWh)	874.25	353.89	304.42	116.54	99.40
	Growth rate (%)	9.8	10.2	8.8	12.7	7.7
	Ratio of composition (%)	100.0	40.5	34.8	13.3	11.4
1972	Demand (GWh)	955.93	375.49	340.88	135.46	104.10
	Growth rate (%)	9.3	6.1	12.0	16.2	4.7
	Ratio of composition (%)	100.0	39.3	35.7	14.2	10.8
1973	Demand (GWh)	1040.62	414.68	356.31	147.04	122.59
	Growth rate (%)	8.9	10.4	4.5	8.6	17.8
	Ratio of composition (%)	100.0	39.9	34.2	14.1	11.8
	Average growth rate (%)	10.0	9.9	10.1	14.2	6.3

Table 4 - 2 Estimated Electrification Ratio by Regional System

System	1974		1980		1984	
	Population (10^3 person)	Electrification ratio (%)	Population (10^3 person)	Electrification ratio (%)	Population (10^3 person)	Electrification ratio (%)
Norte	330	37	371	55	401	64
Pichincha	936	57	1,215	66	1,444	75
Centro-Norte	965	23	1,097	40	1,198	53
Centro-Sur	503	24	579	49	636	60
Sur	378	13	436	23	479	43
Esmeraldas	203	16	261	33	305	59
Manabi	745	14	835	30	901	42
Guayas-Los Rios	1,969	40	2,395	62	2,733	72
El Oro	260	25	331	41	387	58
Total	6,289	33	7,520	51	8,484	66

Note: 1. Electrification pervision ratio means population beeing benefited by electricity.

2. Entire population in 1974 is 6,500 x 10^3 persons.

4-3-2 Load Forecast by Category

(1) Residential

The past trends of residential energy consumption accompanying the above population increases and the rises in electrification pervasion ratio are taken into account upon which the number of customers and the energy consumption per customer are forecast.

The national figures for the number of customers and the energy consumption per customer for the five-year period from 1966 through 1970 are indicated in Table 4-3.

Table 4 - 3 Historical Trend of Energy Consumption per Customer (Residential)

	1966	1967	1968	1969	1970	Average growth rate (%)
Number of customer (10^3)	164.2	184.9	204.3	218.7	241.1	10.1
Energy consumption per customer (kWh/customer)	1,073	1,057	1,075	1,144	1,148	1.7

The number of customers and the energy consumption per customer by system based on the above are forecast to be as shown in Tables A-1-(13) and (14), Appendix A-1, while the forecast results on a national basis for the three representative years of 1974, 1980 and 1984 are as indicated in Table 4-4.

Table 4 - 4 Estimated Energy Consumption per customer (Residential)

	1974	1980	1984	Average growth rate (%) 1974-1980	1980-1984	1974-1984
Number of customer (10^3)	342	633	884	10.8	8.7	10.0
Energy consumption per customer (kWh/customer)	1,207	1,370	1,535	2.1	2.9	2.4

(2) Commercial

Similarly to the case of residential, the past trends of commercial energy consumption accompanying population increases and rises in electrification pervasion rates are taken into account upon which the number of customers and the energy consumption per customer are forecast.

The national figures for the number of customers and the energy consumption per customer for the five-year period from 1966 through 1970 are indicated in Table 4-5.

Table 4 - 5 Historical Trend of Energy Consumption per customer (Commercial)

	1966	1967	1968	1969	1970	Average growth rate (%)
Number of customer (10^3)	30.2	32.9	35.0	39.5	42.1	8.7 (1967 - 1970)
Energy consumption per customer (kWh/customer)	1,811	2,138	2,331	2,355	2,422	4.1

The number of customers and the energy consumption per customer by regional system based on the above are forecast to be as shown in Tables A-1-(13), Appendix A-1, while the forecast results on a national basis for the three representative years of 1974, 1980 and 1984 are as indicated in Table 4-6.

Table 4 - 6 Estimated Energy Consumption per Customer (Commercial)

	1974	1980	1984	Average growth rate (%) 1974 - 1980	1980 - 1984	1974 - 1984
Number of customer (10^3)	73	124	161	9.3	6.7	8.3
Energy consumption per customer (kWh/customer)	2,415	2,990	3,515	3.6	4.1	3.8

(3) Other

Since this demand category possesses factors which should be considered based not only on the population in electrified districts, but also on the total population of the relevant systems including unelectrified districts, the energy consumption for the entire population is to be taken. The total population of each region and its energy consumption per person are indicated in Table 4-7.

Table 4 - 7 Historical Trend of Energy Consumption per Person (Others)

	1966	1969	1974 (Estimated)	Average growth rate (%) 1966 - 1969	1966 - 1974
Population (10^3)	4,871	5,515	6,289	4.2	3.3
Energy consumption per person (kWh/person)	13.1	15.7	17.9	6.2	4.0

Regarding "other demand," as also touched upon in Chapter 4-2, "Past Record of Power Demand", the growth rate of the energy consumption per person was high at 6.2% for 1966 to 1969 since the 1960s were a time of the process of urbanization, but demands such as for public lighting in large cities showed a trend with slight increase in demand so that for the period of 1966 through 1974 the rate was lowered to 4%.

On forecasting energy consumption per person by regional system based on these records, they are as shown in Tables A-1-(13), Appendix A-1, while the forecast results on a national basis for the three representative years of 1974, 1980 and 1984 are as indicated in Table 4-8.

Table 4 - 8 Estimated Energy Consumption per Person (Others)

	1974	1980	1984	Average growth rate (%) 1974 - 1980	1980 - 1984	1974 - 1984
Population (10^3)	6,289	7,521	8,484	3.0	3.1	3.0
Energy consumption per person (kWh/person)	17.9	22.8	26.1	4.1	3.4	3.8

(4) Industrial

Forecasting of industrial demand has to be done upon analysis of the energy consumption per unit production quantity by industrial sector, namely, analyses of energy consumption by the sector.

For this purpose, it is necessary for analyses to be made with basic data concerning industrial statistics on production facilities such as production system, production efficiency and working population by industrial sector, and it is also necessary for extensive examinations to be made regarding the industrial structure and its environment such as human resources, water resources, infrastructure etc. However, since survey data in this regard were not sufficiently available in making this load forecast, the method described below was empolyed.

Of industrial demands, the demand of new factory plants to be scheduled to be completed from 1975 to around 1980, were for the convenience, considered as a special demand and the rest of the industrial demands as general demand. The special demand was defined based on the results of a questionnaire survey of customers carried out by INECEL.

1) Large amount of increases in the special demand are foreseen in some systems, the major ones of which are described below.

i) Regarding the cement industry, a huge demand of cement is foreseen because of increase in activity in construction such as the large-scale hydroelectric development projects of Pisayambo and Paute, and other projects, and as establishment of new factories in the Norte System area and expansion of factories in the Centro Sur System area in 1977, and expansion of factories in the Centro Norte System area in 1978 are scheduled, the increase in power demands of these factories are expected, too.

ii) Increase in power demand is expected in the Esmeraldas System, where an oil refining plant is being constructed.

iii) Milagro and Babahoyo districts in the Guayas-Los Rios System and the El Oro System are in areas of low, marshy land and there are many places which are unsuitable for agricultural cultivation. Consequently, as a part of the regional promotion policy of the national government, drainage and irrigation projects are being carried out in low-elevation marshland areas, therefore, increases in drainage pump loads each year are taken into account.

iv) Increase in demand are expected arising from new installation and expansion of production facilities in the Pichincha System area which is the main producing center of textile products.

v) Increases in demand are anticipated arising from new construction and expansion of production facilities in the Guayas-Los Rios System area which is the major producing center of the foodstuffs processing industry.

vi) Increases in demand is looked forward to due to new construction and expansion of production facilities in the Guayas-Los Rios and Pichincha System areas which are the major centers of machine and chemical industries.

2) Forecasts for the general demand are to be made from the past trends up to 1973.

For facilitate statistical procedure, the following periods are selected to obtain the past trend of the demand. Which will be as indicated in Table 4-9.

Details of the forecast of industrial demand according to the above are as indicated in Tables A-1-(11) of Appendix A-1.

Table 4 - 9 Historical Increase Ratio of Industrial Demand

System	Average growth rate (%) 1974 -1980	1980 -1984	1974 -1984	Reference
Norte	12.0	12.0	12.0	1966 - 1973 : 12.0%
Pichincha	10.0	10.2	10.1	1964 - 1973 : 10.2%
Centro-Norte	7.4	7.4	7.4	1965 - 1973 : 7.4%
Centro-Sur	11.7	11.9	11.8	1966 - 1973 : 11.9%
Sur	11.9	11.9	11.9	1967 - 1973 : 11.9%
Esmeraldas	15.0	15.0	15.0	1964 - 1972 : 15.0%
Manabi	8.8	8.8	8.8	1964 - 1973 : 8.8%
Guayas-Los Rios	9.4	9.4	9.4	1964 - 1973 : 9.4%
El Oro	7.8	7.8	7.8	1968 - 1971 : 7.8%
Total	9.6	9.7	9.6	

4-4 Forecast Results

The power demands at customer ends calculated according to the above conditions are as shown in Tables A-1-(1) to (10) of Appendix A-1.

Loss factor and annual load factor were calculated based on past trends, and the values forecast on a national basis for the three representative years of 1974, 1980 and 1984 are as given in Table 4-10.

Table 4 - 10 Loss Factor of Transmission and Distribution Lines and Load Factor

	1974	1980	1984
Loss factor (%)	16.5	15.2	14.4
Load factor (%)	48	49	49

The maximum power demands and the annual energy demands at sending end calculated using the above loss factor and load factor are as shown in Table 4-12 and Table 4-13 respectively. According to these, the maximum power demand, which was 300 MW on a national basis in 1974, is forecast to become 1,019 MW in 1984 with a growth rate of 3.4 times, while energy demand at sending end, which was 1,248 GWh in 1974, is forecast to become 4,366 GWh in 1984 with a growth rate of 3.5 times. Regarding the average growth rate in maximum power demand, it would be 14.7% for 1974 to 1980, 10.5% for 1980 to 1984, and for 1974 to 1984 it would be 13.0 %. As for the average growth rate in energy demand at sending end,

It would be 15.3% for 1974 to 1980 and 10.5% for 1980 to 1984, and for 1974 to 1984 would be 13.3%.

Regarding the composition ratios of demand categories, they are as indicated in Table A-1-(12) of Appendix A-1, and the figures for 1974 and 1984 are also given in Table 4-11 below.

Table 4 - 11 Composition Ratios of Demand Categories

unit ; %

	Industries	Residential and Commercial	Others
1974	33	56	11
1984	43	51	6

As seen in the table, the ratio of industrial demand will be increased considerably during this ten year period and the change in the structure of demand will be prominent.

Table 4 - 12 Maximam Power Demand at Generating End

(unit : MW)

System	1974 (Estimated)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Growth rate (%) 1974 - 1980	1980 - 1984	1974 - 1984
Norte	7.34	8.16	9.13	19.68	21.38	23.00	24.84	26.58	28.51	30.65	33.01	22.5	7.4	16.2
Pichincha	89.24	97.86	108.77	121.71	135.60	151.41	169.35	189.27	211.31	235.71	262.68	11.3	11.6	11.4
Centro-Norte	26.95	31.16	35.47	39.65	49.92	55.31	62.15	68.25	75.47	83.09	91.69	14.9	10.2	13.0
Centro-Sur	12.57	14.11	16.01	24.01	27.57	31.21	38.56	42.04	45.96	50.45	55.54	20.5	9.6	16.0
Sur	4.41	5.50	6.42	7.23	8.33	10.60	12.78	14.92	17.51	19.97	22.55	19.4	15.3	17.7
Esmeraldas	4.64	5.56	6.49	7.59	9.06	10.64	14.27	16.81	19.54	22.19	26.23	20.6	16.4	18.9
Manabi	11.66	13.74	17.33	20.96	23.72	26.80	30.74	34.29	38.14	42.22	46.59	17.5	11.0	14.9
Guayas-Los Rios	135.97	158.26	184.92	212.53	246.96	278.88	312.42	342.63	375.88	413.21	453.01	14.9	9.7	12.8
El Oro	6.98	8.43	10.56	12.71	14.56	16.10	17.80	19.84	22.12	24.62	27.40	16.9	11.4	14.6
Total	299.76	342.78	395.10	466.07	537.10	603.95	682.91	754.63	834.44	922.11	1,018.70	14.7	10.5	13.0

Note: Figures in detail are shown in Appendix-A-1, Table A-1-(1) - (10).

Table 4 - 13 Maximam Energy Demand at Generating End

(unit : GWH)

System	1974 (Estimated)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Increase (%) 1974 - 1980	1980 - 1984	1974 - 1984
Norte	23.65	26.36	29.56	101.68	107.51	112.48	118.13	123.67	129.77	136.63	144.31	30.7	5.1	19.8
Pichincha	402.51	442.01	492.79	551.66	614.79	684.14	762.32	849.92	946.24	1,052.66	1,168.71	11.2	11.3	11.2
Centro-Norte	98.73	115.77	134.36	151.50	202.34	222.26	248.77	271.89	299.68	327.96	359.61	16.7	9.6	13.8
Centro-Sur	47.87	53.38	60.04	92.59	105.34	117.27	143.83	157.07	172.13	189.20	208.37	20.1	9.7	15.8
Sur	14.04	17.88	20.91	23.86	27.82	35.90	44.23	52.30	62.12	72.10	82.71	21.1	16.9	19.4
Esmeraldas	15.28	19.86	24.13	29.44	38.21	45.16	66.74	76.41	87.27	98.99	118.09	27.9	15.3	22.7
Manabi	43.69	52.87	68.26	84.58	96.59	109.99	128.75	143.47	158.89	175.27	192.84	19.7	10.6	16.0
Guayas-Los Rios	579.48	679.39	793.69	917.70	1,071.90	1,213.97	1,358.07	1,491.68	1,640.09	1,806.23	1,988.38	15.3	10.0	13.1
El Oro	22.39	27.55	35.28	42.66	49.75	56.08	63.03	71.32	80.76	91.37	103.34	18.8	13.2	16.5
Total	1,247.64	1,435.07	1,659.02	1,995.67	2,314.25	2,597.25	2,933.87	3,237.73	3,576.95	3,950.41	4,366.36	15.3	10.5	13.3

Note: Figures in detail are shown in Appendix-A-1, Table A-1-(1) - (10).

CHAPTER 5

PROJECTS COMPOSING LONG-RANGE ELECTRIC POWER DEVELOPMENT PROGRAM

CHAPTER 5. PROJECTS COMPOSING LONG-RANGE ELECTRIC POWER DEVELOPMENT PROGRAM

5-1 Power Generation Projects Destined for National Interconnected System

As of the end of 1974, the power generation projects destined for the National Interconnected System under construction or being prepared for construction by INECEL were as described below.

5-1-1 Projects under Construction

Pisayambo Hydroelectric Power Station

Power generating type	: dam-waterway
Effective storage capacity	: 90×10^6 m^3
Maximum available discharge	: 18.6 m^3/sec
Total head	: 475 m
Maximum output	: 69.2 MW
Annual energy production	: 296 GWh/year
Approximate construction cost	: US$ 75×10^6
Scheduled start-up	: January 1978

Norte Thermal Power Station

Power generating type	: diesel
Fuel used	: heavy oil
Maximum output	: 30,000 kW
Approximate construction cost	: US$ 23.2×10^6
Scheduled start-up	: March 1977

The total installed capacity of the above power generation projects under construction is 99.2 MW.

5-1-2 Projects Being Prepared for Construction

Paute Hydroelectric Power Station (First Stage)

Power generating type	: dam-waterway
Effective storage capacity	: 90×10^6 m^3
Maximum available discharge	: 100 m^3/sec

Total head	: 667 m
Maximum output	: 500 MW
Annual energy production	: 2,850 GWh
Approximate construction cost	: US$ 325.1 x 10^6
Scheduled start-up	: January 1981

Guayaquil Thermal Power Station (First Stage)

Power generating type	: steam
Fuel used	: heavy oil
Maximum output	: 73 MW
Approximate construction cost	: US$ 32 x 10^6
Scheduled start-up	: March 1977

The total installed capacity of the above power generation projects being prepared for construction is 573 MW.

5-1-3 Proposed Power Generation Projects

Judging from the results of studies of the demand and supply balance up to1984, as one of the power generation projects destined for the National Interconnected System, the Second Stage, 73 MW, of Guayaquil Thermal Project should be added to the four projects previously described. Regarding the time of putting this into service, it is necessary for start-up to be in April 1979. Considering that this would be commissioned one year later than the First Stage and its construction would be carried out in parallel with the First Stage, it is judged economical to adopt the same type of equipment as for the First Stage.

Summarizing the power generation projects to be carried out by 1984, it is necessary for a total of 745.2 MW to be developed as shown in Table 5-1.

Further, on studying the demand and supply balance from 1985 to 1990, it is found necessary for the new power generation facilities indicated in Table 5-2 to be put into service.

5-2 National Interconnecting Power Transmission and Transforming Program

The power system in Ecuador at present comprises the small or medium independent systems in the various municipalities. So long as there exist such independent systems of small demand, large power sources cannot be put into service, and for others than the districts such as Quito and Guayaquil where the demands are of large scale, there is nothing that can be done except to carry on constructing small-scale power sources. To continue with such a situation means that the water

Table 5 - 1 Power Plants to be Constructed up to 1984 for Comprising National Interconnected System

Projects	Max. output (MW)	Present conditions	Capital required (10^6 US$)	Date of compleation
Hydro				
Pisayambo	69.2	Under construction	49.6 1/	Dec., 1977
Paute 1st stage	500			
No. 1 and No. 2 Unit	200	Bidding	253.1	Jan., 1981
No. 3 Unit	100	Planning	72.0	Aug., 1982
No. 4 Unit	100	Planning	72.0	Aug., 1983
No. 5 Unit	100	Planning	72.0	Aug., 1984
Thermal				
Northern thermal (Diesel)	30	Under construction	23.2	March, 1977
Guayaquil thermal 1st stage (Steam)	73	Bidding	32.0	April, 1978
Guayaquil thermal 2nd stage (Steam)	73	Proposed plan	30.0	April, 1979
Total	745.2		459.9	

Note: 1/ Capital required in and after 1975.

Table 5 - 2 Power Plant to be Developed from 1985 to 1990

Project			Max. output (MW)	Year of compleation
Sto, Domingo	1st stage	Thermal	100	Dec. 1985
"	2nd stage	"	200	Dec. 1986
Toachi	1st stage	Hydro	150	Dec. 1987
"	2nd stage	"	75	Dec. 1988
Güayllabamba No. 1 unit	1st stage	"	210	Dec. 1989
Total			735	

power resources within the country would not be effectively utilized and is uneconomical from a national point of view. Taking these points into consideration, INECEL is planning to tie the regional systems scattered throughout the country by nationwide interconnecting transmission lines so that large power sources such as Paute Hydroelectric Power Plant can be put into service. The foundation of this Intercon-

necting Transmission Line Program is to construct an interconnecting power transmission line between the two largest load centers of Quito and Guayaquil and further extend the line to interconnect with Paute Hydroelectric Power Plant as shown in Fig. 5-1 to compose a trunk line for the National Interconnected System. For other regional systems, the plan is to make interconnections providing 138-kV transmission lines branching from this 230-kV trunk line. The purpose of constructing these branch lines is to make it unnecessary for small-scale power sources to be developed in the various regional systems.

The outline of the program presently planned by INECEL is as shown in Table 5-3.

5-2-1 Outline of Original Plan and State of Construction

(1) Quito-Ibarra Line (138 kV, 90 km)

Construction of this transmission line is to be done in parallel with construction of Norte Thermal, 30 MW, to connect the Pichincha System centered around Quito with the Norte System centered around Ibarra and Otavalo by 138 kV. Bidding for this project was completed in February 1975 and it was scheduled for construction to be started in April of the same year. Completion of the project is scheduled to be in December 1976 with the line to be used for transmission of the electric power of Norte Thermal Power Plant to the Norte System from March 1977. It is planned for this line to be used later also for receiving power from Pisayambo Hydroelectric Power Plant.

(2) Quito-Pucara-Ambato Line (138 kV, 244 km)

This transmission line was planned for transmitting the electric power of Pisayambo Hydroelectric Power Plant, 69.2 MW, to the Pichincha System and the Centro-Norte System, and this project is presently under construction and is scheduled to be completed in December 1976. This line is also to be used as an interconnecting transmission line between the Pichincha and Centro-Norte systems, and part of the electric power of Norte Thermal Power Plant is to be transmitted to the Centro-Norte System utilizing this line until December 1977, when the Pisayambo Hydroelectric Power Plant will be completed. In the future, as the demand in the Centro-Norte System increases and the time comes when all of the electric power of Pisayambo Hydroelectric Power Plant will be alloted to the Centro-Norte System, the line will have the role of receiving power from the National Interconnected System. When the Quito-Ibarra Line described in (1) and this line are completed, the northern mountain area of the National System will all be interconnected and efficient operation of the system will become possible under combined operation of Pisayambo Hydroelectric Power Plant and Norte Thermal Power Plant

(3) Quito-Pascuales Line (230 kV, 330 km)

This line is a trunk line of the National Interconnected System and interconnects Quito and Guayaquil, the two largest load centers of Ecuador. Santo Domingo and Quevedo are situtated on the route and these are starting points for branch lines (138 kV) to the Esmeraldas and Manabi systems respectively. The

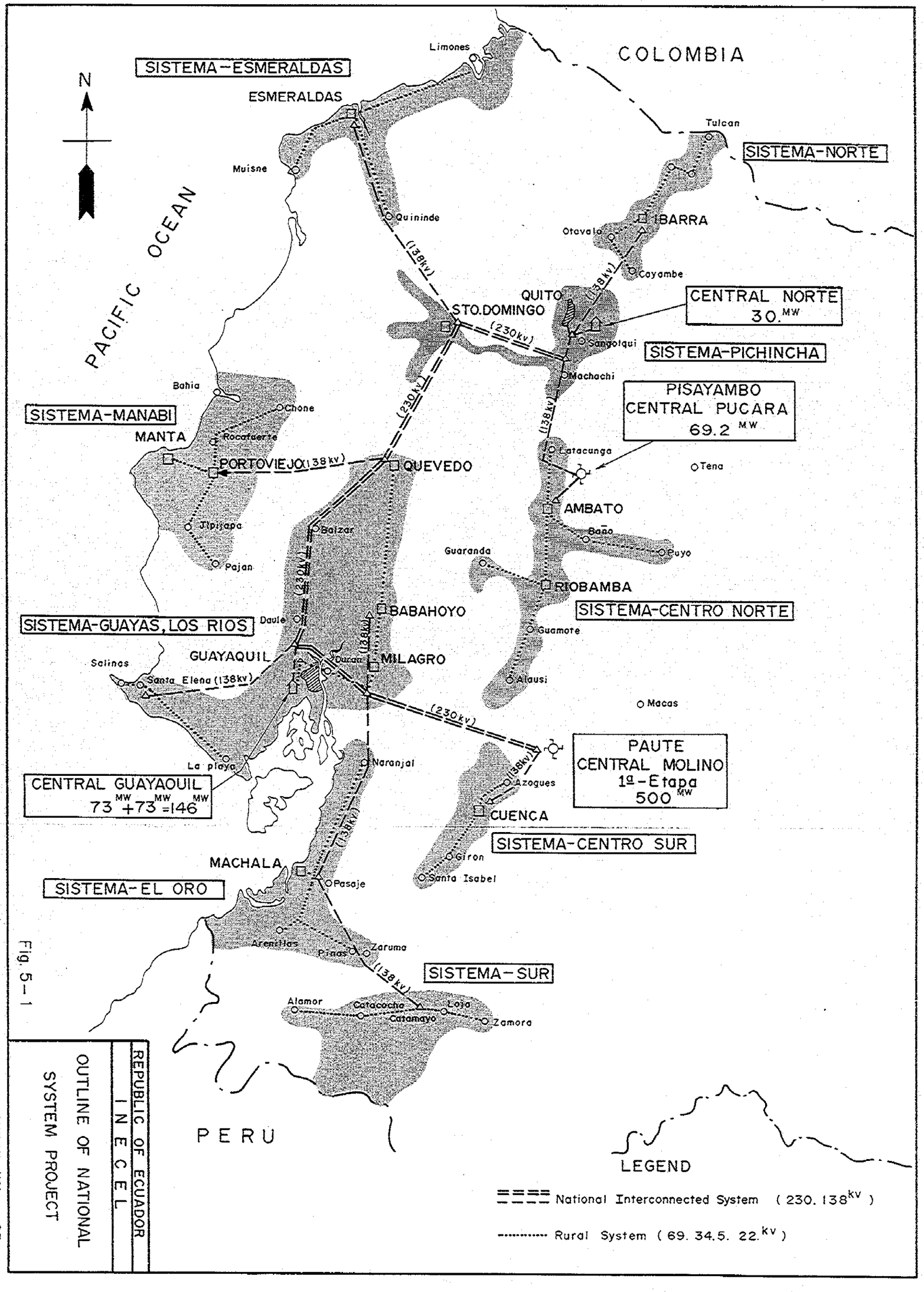


Fig. 5-1

OUTLINE OF NATIONAL SYSTEM PROJECT

INECEL

REPUBLIC OF ECUADOR

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Table 5 - 3 Transmission and Transforming Facilities Comprising National Interconnected System

Projects	Transmission lines				Substations		Estimated construction cost US$ 10^3	Year of compleation	Modifications by the Mission
	Voltage (kV)	Distance (km)	No. fo cct (c.c.t)	Conductor	Location	Capacity			
1 Pucara ~ Quito	138	115	1/2	ACSR 477 MCM	Pucara	80MVA-13.8/138kV	5,000	Dec. 1976	
2 Pucara ~ Ambato	138	29	1/2	ACSR 477 MCM	Ambato	30MVA-138/69kV	1,400	Dec. 1976	
3 Quito ~ Ibarra	138	90	1/2	ACSR 477 MCM	Ibarra	40MVA-138/34.5kV	6,300	Dec. 1976	
4 Poscuales ~ Quito	230	330	2	ACSR 1,113 MCM	Pascuales Sta-Rosa Quevedo Sto-Domingo	450MVA-230/138kV 225MVA-230/138kV 40MVA-230/138kV 20MVA-138/69kV 40MVA-230/138kV 20MVA-138/69kV	54,700	Jun. 1978	Pascuales S.S. 225 MVA
5 Pascuales ~ Guayaquil	138	16	2	ACSR 477 MCM	—	—	700	Dec. 1976	
6 Paute ~ Pascuales	230	200	2	ACSR 1,113 MCM	Milagro	225MVA-230/138kV 40MVA-138/69kV	32,400	Dec. 1979	Paute-Milagro 230kV 115km: 1 cct in addition to 2 cct.
7 Paute ~ Cuenca	138	40	1/2	ACSR 477 MCM	Cuenca	40MVA-138/69kV	5,400	Dec. 1979	
8 Quevedo ~ Portoviejo	138	120	1/2	ACSR 477 MCM	Portoviejo	40MVA-138/69kV	6,600	Dec. 1978	
9 Sto Domingo ~ Esmeraldas	138	170	1/2	ACSR 477 MCM	Esmeraldas	20MVA-138/69kV	8,500	Dec. 1978	Year of compleation: Dec., 1980
10 Milagro ~ Machala	138	125	1/2	ACSR 477 MCM	Machala	40MVA-138/69kV	8,400	Dec. 1980	
11 Milagro ~ Babahoyo	138	40	1	ACSR 477 MCM	Babahoyo	20MVA-138/69kV	2,800	Dec. 1979	
12 Pascuales ~ Sta, Elena	138	120	1	ACSR 477 MCM	Sta. Elena	20MVA-138/69kV	6,300	Dec. 1979	Year of compleation: Dec., 1978
13 Machala ~ Loja	138	150	1/2	ACSR 477 MCM	Loja	20MVA-138/69kV	8,700	Dec. 1980	
Total							147,200		Estimated total construction cost: 175,400

line is presently being put out to bid and is scheduled to be completed in June 1978 and will be utilized for economical operation of the Interconnected System with Pisayambo Hydroelectric Power Plant, Norte Thermal Power Plant, Guayaquil Thermal Power Plant, and Cumbaya Hydroelectric Power Plant and Nayon Hydroelectric Power Plant of EEQ as the main power stations until Paute Hydroelectric Power Plant is commissioned in 1981. Further, after start-up of Paute Hydroelectric Power Plant, the line will serve to transmit electric power to the northern areas.

(4) Paute-Pascuales Line (230 kV, 200 km)

This transmission line is for transmitting the electric power of Paute Hydroelectric Power Plant to the major load centers. This line is scheduled to be completed at the end of 1979, and the line will be used as a power interchange line from Guayaquil to the Centro-Sur System, in and after 1980.

(5) Guayaquil-Santa Elena Line (138 kV, 120 km)

This is a branch transmission line for transmitting power from Pascuales Substation located in Guayaquil to the Santa Elena District and is scheduled to be completed in December 1979.

(6) Santo Doming-Esmeraldas Line (138 kV, 170 km)

This transmission line is for transmitting power to the Esmeraldas System branching from Santo Domingo Substation on the 230-kV transmission line route and is scheduled to be completed at the end of 1978.

(7) Quevedo-Portoviejo Line (138 kV, 120 km)

This is a branch line from Quevedo Substation of the 230 kV trunk line and is scheduled to be completed at the end of 1978.

(8) Milagro-Babahoyo Line (138 kV, 40 km)

This is a branch transmission line from Milagro Substation of the 230 kV National Interconnected System to the Babahoyo District and is scheduled to be completed at the end of 1979.

(9) Milagro-Machala-Loja Line (138 kV, 275 km)

This is a branch transmission line from Milagro Substation on a 230-kV interconnecting transmission line to the Machala and Loja districts, and the target time for completion is the end of 1980. The peak load in 1981 for the two districts will be 32.6 MW in total, and the line is scheduled to be completed at the end of 1980 to receive electric power from Paute Hydroelectric Power Plant.

(10) Paute-Cuenca Line (138 kV, 40 km)

This is a line for transmission of power from Paute Power Plant to the Centro-Sur System and is to be completed in December 1979. The demand in the Centro-Sur System in 1980 will become 38.6 MW to produce a shortage of supply with the existing facilities and so it will be necessary to receive power from the Guayaquil System by this transmission line. In and after 1981, the power of Paute Power Plant will be received by this line.

The outline of the National Interconnecting Power Transmission and Transforming Program is as shown in Fig. 5-1.

5-2-2 Modifications of Original Plan

On studying the above National Interconnecting Power Transmission and Transforming Program since the 230-kV transmission lines, which constitute the nucleus of the Program, are either already under construction or are being prepared for construction (in bidding), the Survey Mission considered these lines as being already definitely decided, and examinations were made on the times of completion of the remaining parts consisting of branch lines, or the times of interconnection with the regional systems. The results are the following:

(i) The completion time for the 138-kV Santo Domingo-Esmeraldas Line is to be changed from December 1978 to December 1980.

(ii) The completion time for the 138-kV Pascuales-Santa Elena Line is to be hastened by one year changing from December 1979 to December 1978.

(iii) In the two-circuit, 230-kV Paute-Milagro-Pascuales Transmission Line, the section between Paute and Milagro is to be changed in design to triple-circuit with the third circuit to be completed in June 1983.

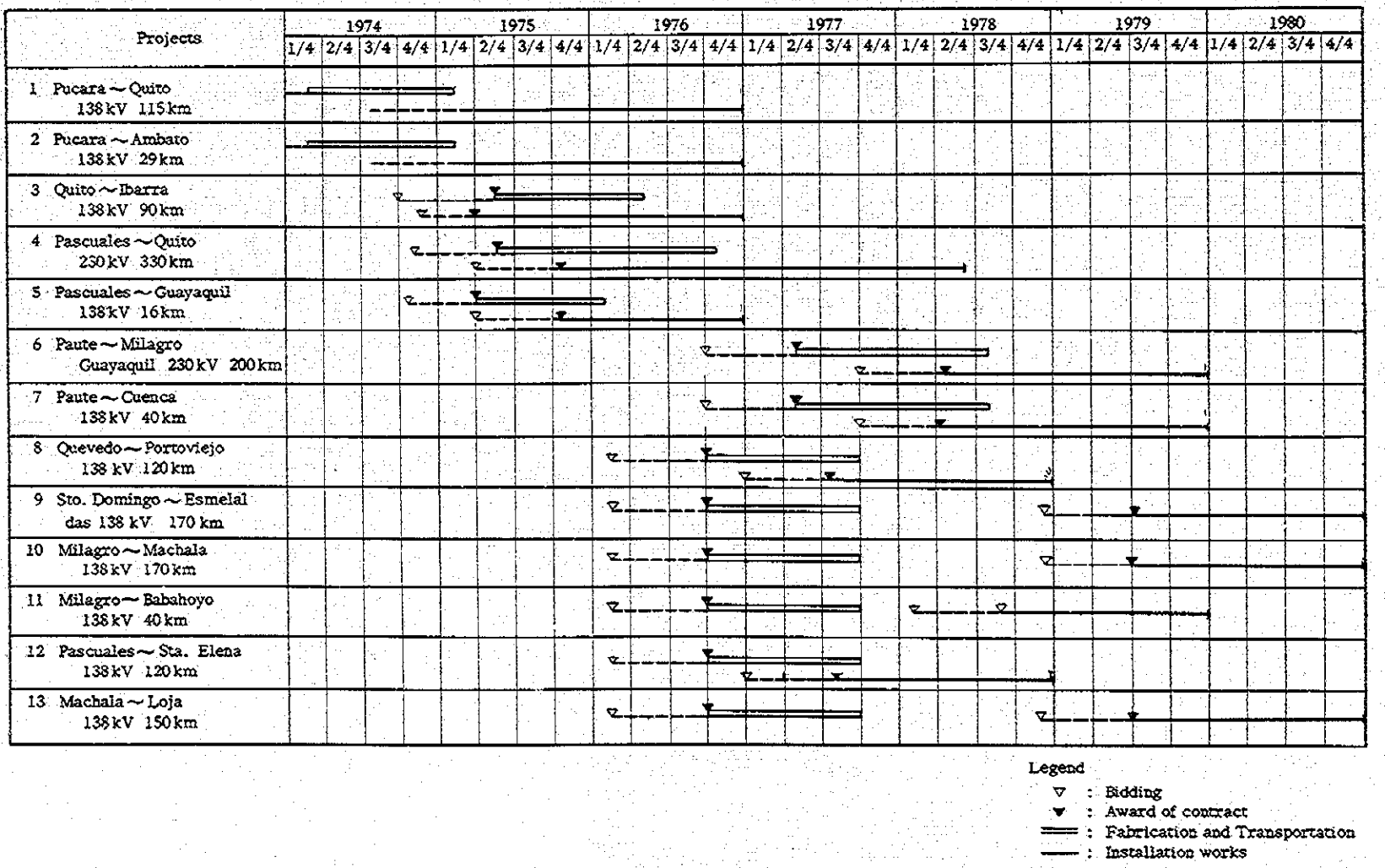
The construction schedule taking the above modifications into consideration is given in Table 5-4.

5-3 Regional Electrification Program

5-3-1 Structures of Regional Systems

The aim of the Regional Electrification Program is to integrate the small-scale electric power systems, which are presently scattered about in the various municipalities, into systems covering one or two provinces, with the ultimate aim at interconnecting these systems with the National Interconnected Transmission Line to receive economical energy to be generated by large-scale hydro-power plants such as Paute and Pisayambo Power Plants. Also, in order to raise the electrification rate of underdeveloped districts, it is planned for distribution lines to be expanded to non-electrified villages.

Table 5 - 4 Construction Schedule for National Interconnected System



In order to comply with the above Regional Electrification Program, INECEL is planning to expedite formation of ten regional systems enveloping the entire area of Ecuador including the Oriente and the Colon Islands (Galapagos Islands).

The composition of the regional systems planned by INECEL and the service areas are as shown in Table 5-5.

Table 5-5 Year of Integration of Each Regional System

Systems	Supply area by prefecture	Electric utilities	Year of integration
(1) Norte	Carchi, Imbabura Pichincha.	Ibarra, Tulcan, Montufar.	Dec., 1975
(2) Pichincha	Pichincha.	Quito, Sto, Domingo	June., 1978
(3) Centro-Norte	Cotopaxi, Tungurahua, Chimborazo, Bolivar, Pastaza.	Ambato, Riobamba, Alausi, Bolivar.	Dec., 1977
(4) Centro-Sur	Asuay, Cañar.	Cuenca, Azogues	Dec., 1979
(5) Sur	Loja, Zamora-Chinchipe	Regional del Sur	Dec., 1977
(6) Esmeraldas	Esmeraldas	Esmeraldas	Dec., 1977
(7) Manabi	Manabi	INECEL-Manta, Portoviejo.	Dec., 1975
(8) Guayas -Los Rios	Guayas, Los Rios	EMELEC, Sta. Elena, Los Rios, Milagro, Quevedo, Daule.	Dec., 1978
(9) El Oro	El Oro.	El Oro, Zaruma	Dec., 1976

5-3-2 Power Generation, Transmission and Transforming Projects in Regional Systems

Power generation projects in the Regional Electrification Program are planned to cope with the increase in power demands of the various regional systems until the National Interconnected System connects the various regional systems.

This plan for regional power generation projects is prepared in each of the nine regional systems and a total installed capacity of 181.6 MW has been determined for the whole country. But, as a result of the present load forecast, it was found that there would be a necessity to add power generation projects of 26.5 MW, amounting to a total of 208.1 MW together with the already definite projects. The definite transmission and transforming projects by regional system are shwon in Table 5-6 and additional power generation projects in Table 5-7.

Table 5 - 6 Transmission and Transforming Project for Regional Systems

(Proposed by INECEL)

Systems	Transforming capacity (kVA)	Transmission line				Distribution line (Number of customer)
		69kV	34.5kV	22kV	13.8kV	
(1) Norte	13, 200		8		130	16, 400
(2) Pichicha	61, 350	95		88	216	34, 410
Quito	46, 100			88	60	29, 000
Sto. Domingo	15, 250	95			156	5, 410
(3) Centro-Norte	13, 250	255			531	16, 230
Latacunga	1, 000	40			76	3, 400
Ambato	3, 450	35			61	6, 130
Riobamba	2, 800	130			131	4, 000
Guaranda	3, 500				213	700
Puyo	2, 500	50			50	2, 000
(4) Centro-Sur	109, 000	83		189		17, 000
(5) Sur	17, 550	166		22	462	8, 720
(6) Esmeraldas	14, 200	184			196	8, 000
(7) Manabi	24, 100		80		331	9, 600
(8) Guayas-Los Rios	71, 500	474			774	80, 000
Guayaquil, Duran	12, 000	8				34, 500
Salinas, Sta. Elena	22, 500	153			114	6, 000
Daule, Balzar	16, 250	100			151	8, 000
Milagro, Naranjar	4, 100	40			285	13, 200
Babahoyo, Quevedo	16, 750	173			224	18, 300
(9) El Oro	25, 250	188			166	9, 000
Total	349, 400	1, 445	88	299	2, 806	198, 880

Table 5 - 7 Generation Projects for Regional Systems

(Unit : MW)

Systems	Type	Installed capacity Hydro	Installed capacity Thermal	Construction schedule 1975	1976	1977
1) Norte						
Ibarra	Diesel		2.50			
Sub-Total.			2.50			
2) Pichincha						
Quito	Hydro	4.50				
"	Diesel		8.72			
"	Gas		24.10			
Sto. Domingo	Diesel		2.28			
"	"		1.58			
Sub-Total		4.50	36.68			
		41.18				
3) Centro-Norte						
Latacunga	Diesel		1.00			
"	"		2.50			
Ambato	"		6.00			
Riobamba	Hydro	2.60				
Guaranda	"		1.00			
Puyo	"		0.50			
Sub-Total		2.60	11.00			
		13.60				
4) Centro-Sur						
Cuenca	Diesel		2.28			
"	Hydro	8.00				
"	Diesel		8.52			
Sub-Total		8.00	10.80			
		18.80				
5) Sur						
Loja	Diesel		1.28			
Catamayo	"		2.50			
Sub-Total			3.78			
6) Esmeraldas						
Santa Bainas	Diesel		5.46			
Esmeraldas	Diesel		6.00			
Sub-Total			11.46			
7) Manabi						
Manta	Gas		10.00			
Sub-Total			10.00			
8) Guayas-Los Rios						
Guayaquil	Gas		2x21.50			
			43.00			
Santa Elena	Diesel		5.68			
Babahoyo	"		12.50			
Vince	"		1.00			
Quevedo	"		0.80			
"	"		5.66			
Sub-Total			68.64			
9) El Oro						
Machala	Diesel		5.66			
"	"		6.00			
Sub-Total			11.66			
Total		15.10	166.52			
		181.62				
Guayas, Los Rios[1/]	Gas		21.50			
Sur	Diesel		5.00			
Sub-Total			26.50			
Total		208.12				

Note: 1/ Proposed project by the Mission.

The plans for the various regional systems are described in the following.

(1) Norte System

The Norte System, with main 34.5-kV interconnecting line already completed, is ready for intraregional interconnection. Further, the time when this regional system can be tied to the National Interconnected System is December 1976 when the Quito-Ibarra Transmission Line (138 kV, 2cct. design, 1cct. stringing) will be completed. The proportion of hydraulic sources in the power generating facilities of this system is great being 90%. However, all of the hydroelectric plants are of run-of-river type with apparent output reductions during the dry season, and there is no surplus capacity in terms of balance of demand and supply. Accordingly, it has been planned for a 2.5-MW diesel power plant to be added in order to cope with increase in demand until it becomes possible for power to be received from Norte Thermal Power Plant in March 1977, and preparations are being made for bidding at present. Adding the determined projects of 2.5 MW to the existing facilities of 13.76 MW there will be a total of 16.26 MW in capacity within the system.

Meanwhile, it will be Ibarra Substation where the system will receive power from the National Interconnected System and 34.5-kV line is already completed from here as far as Turcan to the north and Cayambe to the south. The scheme shows that power will be distributed to communities along this transmission line trough the six substations (34.5/13.8 kV) of Turcan, San Miguel, El Angel, Ibarra, Juncal and Otavalo, and these substations are also already completed. Furthermore, expansion program of the distribution network of 13.8-kV lines is realized in 70% approximately.

(2) Pichincha System

The Pichincha System is a regional system supplying electric power to Pichincha Province and is presently divided into the Quito District and the Santo Domingo District.

i) Quito District

The system for Quito is located at the Quito District, the capital of Ecuador, and the surrounding towns and villages, and electric power is supplied by EEQ. The following power generation projects are Presently under construction by EEQ in this district:

		Scheduled date of completion
Pasochoa Hydro	4.5 MW	December 1975
Luluncoto Diesel, 2nd stage	8.72 MW	December 1975
Quito Gas	24.1 MW	August 1975
Total	37.32 MW	

With the above completed in 1975 being added to the existing 114.64 MW, the Quito District will have a total installed capacity of 151.96 MW. This capacity is sufficient to cope with increase in demand until the time of nation-wide interconnection and there will be no necessity for adding new power sources within the system. The distribution network is fairly provided in the capital area and the aim in the future is to expand the network to towns and villages remote from the capital area by 22-kV c. 13.8-kV lines.

ii) Sant Domingo District

The Santo Domingo District is 90 km distant from Quito and electric power supply is being carried out by the Santo Domingo Electrification Cooperative. Diesel thermal plants of 1.58 MW and 2.28 MW have been determined to be added to this system with start-up scheduled in the middle of 1976, and additional work of the existing powerhouse is presently under way. When these are completed, the district will have a total capacity of 8.02 MW combined with the existing installed capacity of 4.16 MW and will be capable of meeting demand until 1979. Since the system will be connected with the National Interconnected System in June 1978, there will be no necessity to add new power sources within the system. Distribution lines of 13.8 kV are being extended from Santo Domingo Diesel Power Station along national highways in the four directions to La Union, El Carmen, Alluriquin and Las Delicias and roughly 60% of the project has been completed up to the present. Further, in order to enlarge transmission capacity to meet future increases in demand in these four districts, it is being planned for 69-kV transmission lines (95 km, 3 substations) to be added.

(3) Centro-Norte System

This is a regional system composed of the five provinces of Cotopaxi, Tungurahua, Chimborazo, Bolivar and Pastaza, and presently is divided into five districts, namely, Latacunga District, Ambato District, Riobamba District, Guaranda District and Puyo District. INECEL plans to interconnect these districts by 69-kV transmission lines, and of this plan, the 50-km line between Ambato and Riobamba was completed in 1970 and is in operation.

The projects in each of the districts of this system are as described below.

(Latacunga District)

A 1.0-MW diesel thermal plant is presently under construction in this district, with a further 2.5-MW diesel thermal plant determined and in preparation for construction. With these additions to the existing facilities 5.34 MW, the district will have power generating facilities of 8.84 MW. There will be a shortage of electric power in 1976 with this capacity and it will be necessary to supplement it by transferring a reserve diesel, 2.18 MW x 1 unit, from the Quito District. A distribution network of 6.3 kV is

completely equipped in this district and there are no places where distribution lines must be newly extended. In preparation against future increases in power demand, INECEL plans to successively reconstruct the lines raising the voltage to 13.8 kV.

(Ambato District)

In this district, the Ambato Electric Power Company was constructing 6.0 MW of diesel (3.0 MW x 2 units) with completion scheduled for September 1975. With these completed, together with the existing facilities of 7.13 MW in the district, there will be a total of 13.13 MW of hydraulic and thermal facilities. However, when seen from the load forecast, there will be a shortage of power supply in 1976, and it will be necessary to transfer one 2.18 MW diesel unit from the Quito District in order to fill the shortage in power supply. It is planned to provide a primary substation (138/69 kV, 40 MVA) in the Ambato District to receive electric power from the National System, and from this substation power will be transmitted by 69 kV lines to distribution substations (69/13.8 kV) in the Latacunga, Puyo and Riobamba districts in the system. The distribution network in the Ambato District is practically provided, but there are a large number of antiquated facilities, and reconstruction work with the double purpose of renewal and raising the voltage to 13.8 kV is presently being hurried. The accomplished rate of this work is approximately 50%. Future projects planned are remodelling of 2.4 kV or 6.3 kV antiquated facilities and expansion of distribution network to partially remaining unelectrified areas.

(Riobamba District)

In this district the Riobamba Electric Power Company has planned the Second Stage, 2.60 MW, of Alao Hydroelectric Project, which is scheduled to be completed in the middle of 1977, and no further projects are being considered. Combining the existing facilities of 10.16 MW and the definite addition, the district will have 12.76 MW of power generating facilities, but since there will be a shortage in power supply in 1976, it will be necessary to transfer two 2.17-MW diesel generator units from the Quito District to augment the supply. This district is already interconnected with Ambato by a 69-kV line.

(Guaranda District)

Addition of a 1.0-MW diesel thermal plant scheduled to be completed in the middle of 1976, is definite in this district. The existing capacity is 1.43 MW and together with the additional plant decided, the district will have a capacity of 2.43 MW. Thereafter, if Guaranda system is interconnected with Riobamba by a 69-kV line in 1977, there will be no need to newly add power sources. The power demand of this district is concentrated at Guaranda and its surrounding villages and the district is the most lagging in electrification within the Centro Norte System. The reason for this is that the scale of demand is small and that distances for distribution to scattered villages are long to present an unfavorable condition for elec-

trification. The electrification scheme in the future for this district would be to complete; first, a 50-km, 69-kV interconnecting line between San Juan and Guaranda by 1976; second, the 13.8-kV distribution network within the district by 1979 to expand electrification.

(Puyo District)

The Puyo District, although in the Centro-Norte System, is a district located in the Oriente. Since an interconnection is to be made by a 69-kV line from Ambato to Baños, this line is planned to be further extended to Puyo. The scale of demand is presently small, but is expected to grow in the future because Puyo is the gateway for development of the Oriente, so INECEL makes it one of its policies to interconnect this district. Addition of a 0.5-MW diesel to be completed in the middle of 1976 has been determined for this district. Combined with the existing 0.46 MW of capacity, there will be a total of 0.96 MW, but since a shortage of electric power will be produced before interconnection with other districts of the system at the end of 1977, it will be necessary to transfer one 0.30-MW reserve diesel from another system to resolve the shortage of electric power.

As described above, the power generating facilities in the Centro-Norte System will be a total of 38.01 MW composed of 24.51 MW of the existing facilities and 13.50 MW of the definite projects.

(4) Centro-Sur System

Since this system will not be able to receive power from the National Interconnected System until start-up of Paute Hydroelectric Power Plant, the Cuenca Electric Power Company has determined construction of Monay Diesel Plant Project in the Second Stage of 2.28 MW and in the Third Stage of 8.52 MW, and Saucay Hydroelectric Power Project of 8.0 MW, or a total of 18.8 MW. After the start-up of these projects, this system together with the existing facilities of 17.25 MW will have power generating facilities totalling 36.05 MW. Demand up to 1979 can be filled with these facilities, but there will be a shortage in 1980. So it will be necessary that power is supplemented from the National System through the Paute-Pascuales Line and the Paute-Cuenca Line scheduled to be completed in December 1979 till the completion of the Paute Hydroelectric Power Plant. This system, which straddles the two provinces of Cañar and Azuay, already has Cuenca and Azogues interconnected by a 22 kV distribution line. Distribution to the communities in outlying areas is to be done by 22 kV lines from Cuenca and Azogues.

Cuenca is the third largest city of Ecuador, and in order to fill the demand of this city, it is planned for power to be received from Paute Hydroelectric Power Plant. Before addition of Paute Hydroelectric Power Plant, distribution is planned to be made to the various locations from the collective diesel plant of Cuenca, and particularly, intrasystem interconnection by 69-kV lines and expansion of distribution substations (69/22 kV) are planned. The Cañar District in the northern part of this system has only a small demand and can maintain a state of self-support for the time being and there will be no need to interconnect the District with Azogues in a hurry. However, at the time of start-up of Paute Hydroelectric Power Plant, it

will become necessary to construct a 22-kV interconnecting line between Cañar and Bibulian and to expand distribution lines to the villages around Cañar.

(5) Sur System

This system is the last to be incorporated in the National Interconnected System and for the time being it will be necessary to secure power sources within the system. At present, plans for Catamayo Diesel in the Second Stage of 1.28 MW, and in the Third Stage of 2.50 MW, with a total of 3.78 MW, have been determined when these are started up, the facilities will be 8.59 MW combined with the existing 4.81 MW and the demand up to 1978 can be coped with, but they are insufficient for supply capacity up to the time of interconnection with the National System and it will be necessary to additionally put into service 5.0 MW of diesel in 1978. The distribution network of this system is already constructed between Loja and Catamayo at 22 kV and between Loja and Vilcabamba at 13.8 kV. But the distribution lines in other communities such as Saragro, Catacocha, Celica, Alamor, Gonzanama, Cariamanga and Macara are not yet incorporated in the distibution network. Consequently, the main point in the electrification program is to construct the distribution network covering all the communities in the province with 69 kV, 22 kV or 13.8 kV distribution lines with Loja and Catamayo as network centers. Of such lines, the one presently under construction is a 22 kV line from San Francisco Power Plant to Zamora, which is scheduled to be completed at the end of 1975.

(6) Esmeraldas System

This system presently has the definite projects of Santa Bainas in the Second Stage, diesel, 5.46 MW, and in the Third Stage, diesel, 6.0 MW. Of these, Second Stage project is under construction and scheduled to be completed in August 1975. As for the Third Stage project, it will be completed in August 1976. The existing power generating facilities of this system amount to 4.86 MW and when the definite projects of 11.46 MW are completed the system will have 16.32 MW of generating facilities. This installed capacity will be capable of coping with the demand up to 1980. Since interconnection with the National System will be at the end of 1980 there will be no necessity to newly add power sources. Further, the Esmeraldas Petroleum Refining Plant is under construction in the area of this system and 18.0 MW (6 MW x 3 units) of gas turbine will be constructed for its private use. These generating facilities are scheduled to be interconnected with the power system of the Esmeraldas Electric Power Company and can be expected to be reserve capacity, although power interchange is not planned. The power demand of this system is composed mainly of that of Esmeraldas. Besides, there are other load areas, such as San Lorenzo, Limones, Quininde and Muisne, but with small scale of demand of about 100 to 200 kW. At present, 13.8 kV distribution lines are under construction centered around Esmeraldas and Quininde, parts of which have been completed. In the Regional Electrification Program, principal locations within the system are scheduled to be interconnected by 69 kV lines. However, since Valdes and San Lorenzo in the northern part of this system are located in the delta area of the Rio San Lorenzo, an interconnecting line will be costly, while the scale of power demand are small, so it is planned that these districts will remain electrically independent.

(7) Manabi System

This system is the model case for the Regional Electrification Program, where INECEL implemented integration of the system and stable supply of electric power is being carried out with Manta Diesel, 20.6 MW, already completed and other power plants. It is also definite that a gas turbine of 10 MW will be newly added at Manta by December 1976. Consequently, when the supply capacity of the definite projects is combined with that of the existing facilities of 20.60 MW, there will be a supply capacity totalling 30.60 MW and at least the demand up to 1979 can be coped with. Since a tie-up will be made with the National Interconnected System in December 1978 it will not be necessary to newly add power sources in the system. The power distribution network of this system, is already constructed between Manta-Portoviejo at 69 kV and between Portoviejo-Rocaferte-Tosaguea-Chone at 34.5 kV. The sections of Portoviejo-Hipijapa, 34.5 kV, 80 km and Bahia-Tosaguea, 34.5 kV, 30 km, are presently under construction and will be completed by the end of 1975. The plans for the future are to expand distribution lines to outlying towns and villages.

(8) Guayas-Los Rios System

In this system, which straddles the two provinces of Guayas and Los Rios, the power systems of the districts of Guayaquil and its surrounding area, Milagro, Babahoyo, Quevedo and Santa Elena are presently being operated independently of each other. According to the Regional Electrification Program of INECEL, these districts are to be integrated, the power generating facilities reinforced, and the distribution network expanded. Major substations of the National Interconnected System are scheduled to be provided in these five districts, but before that, for the purpose of power interchange between the districts, expansion of intraregional interconnection by 60 kV lines is planned. It was already determined that a total of 68.64 MW of power generating facilities would be added to this system and the greater part of them are now under construction. The outlines of the electrification programs for the various districts are described below.

(Guayaquil, Duran District)

Two 21.5 MW gas turbine thermal units are presently being installed in this District by EMELEC. These were both scheduled to be completed by August 1975, and combined with the existing 126.14 MW (Guayaquil 121.55 MW, Duran 4.59 MW), there will be a total of 169.14 MW of power generating facilities, and power demand up to the end of 1976 can be coped with. However, from the beginning of 1977 until April 1978 when Guayaquil Steam Thermal Power Plant in the First Stage of 73 MW is started up, there will be a shortage in supply capacity, so to cope with this shortage and that to be occasioned in the Milagro District to be descibed later, it is judged advantageous that a 21.5 MW gas turbine, of the same type as those presently being installed by EMELEC, will be additionally provided in the Duran District.

In the surrounding area of Guayaquil there are towns and villages such as Duran, Daule and Balzar which comprise independent systems, and it is planned that these systems will be interconnected with Guayaquil by

69 kV lines, with the section between Guayaquil and Daule, 50 km, presently under construction scheduled to be completed in the end of 1975. This line is planned to be extended to Balzar to distribute power to the communities along the route by 13.8 kV lines.

(Milagro District)

There is presently no expansion plan of power generating facilites in this District. Consequently, there are only 6.64 MW of the existing diesel thermal power plants, whereas the load of irrigation and drainage pumps will be added in 1976 to result in a shortage of supply capacity. The measure against this situation is to receive power from Babahoyo in 1976, and newly install a gas turbine plant of 21.5 MW at the Duran District in 1977 to receive power from this utilizing a 69 kV intrasystem interconnecting line. In and after 1978, the First Stage of Guayaquil Thermal Power Plant will have been started up and there will be no concern about a power shortage.

The abovementioned 69 kV interconnecting transmission lines has to be constructed, within 1976 between Milagro and Babahoyo, and between Duran and Milagro. As for communities in the area surrounding Milagro, 13.8 kV distribution lines are scheduled be completed by the end of 1976.

(Babahoyo District)

The major cities in this District are Babahoyo, Pueblo Viejo, Ventanas and Vinces, which presently have independent systems. These cities are scheduled to be interconnected by 69 kV lines by 1976 while 13.8 kV distribution network is planned to be successively built up and expanded. Power generating facilities presently determined in this District are Babahoyo Diesel Thermal Power Plant, 12.5 MW, and Vinces Diesel Thermal Power Plant, 1.0 MW. These are both scheduled to be completed within 1976, and combined with the existing facilities of 2.24 MW, there will be a total of 14.74 MW of power generating facilities in the District. These power generating facilities are on a scale which can cope with the demand up to 1977, and since it will become possible for power to be received from the National System in and after 1978, it will be unnecessary for new power generating facilities to be added in the system.

(Quevedo District)

Addition of diesel thermal plants of 0.8 MW in October 1975 and 5.66 MW in September 1976 in this District has already been determined. Adding these to 2.76 MW of the existing facilities, the power generating facilities will become a total of 9.22 MW and will be capable of coping with the demand up to 1978. Thereafter, since it will become possible for power to be received from the National Interconnected System, there will be no necessity for new power generating facilities to be added. The distribution network for Quevedo, the center of this district system, and for the surrounding communities is comparatively well-provided with only 40 km of

13.8 kV distribution lines remaining to be finished. The main objective of future power transmission and distribution construction works is to complet a 69 kV interconnecting line with Babahoyo within 1976.

(Santa Elena District)

This District is presently constituted of the two electrically independent sub-districts, one centered around Santa Elena and Salinas, and the other around Playas. The Santa Elena sub-district is already completely provided with 13.8 kV distribution lines and the work to be done thereafter is to complete intrasystem interconnection between Santa Elena and Playas by a 69 kV line. Furthermore, there are projects to expand the distribution network to Palmar in the northern part with a 69 kV line, and further north with a 13.8 kV line. When these are completed, power distribution to the entire system will become possible by interconnection with the National System at Santa Elena Substation.

At the time of the present survey, there were 5.68 MW of diesel thermal power plants under construction, which were scheduled to be completed in September 1975, and there is nothing else definitely determined. Therefore, when combined with the existing facilities of 5.24 MW, the total will be 10.92 MW which will be sufficient to cope with the demand up to 1977. However, the scheduled tie-up with the National Interconnected System is at the end of 1978 and there will be a shortage of supply capacity in 1977. As a countermeasure for this situation it will be necessary to transfer one 2.18 MW diesel generator from Quito to augment the supply.

In the Guayas-Los Rios System described above, the power generation projects in the system already determined of 68.64 MW, the facilities considered necessary to be added as a result of the present study of 21.5 MW, supply capacity to be transferred of 2.18 MW and 143.03 MW of the existing facilities make 235.35 MW in total and there will be no concern about shortage of supply capacity for the demand until start-up of the First Stage of Guayaquil Thermal Power Plant in April 1978.

(9) El Oro System

Diesel thermal facilities in this system which are already definite are the project of 5.66 MW now under construction and that of 6.0 MW scheduled for completion in December 1976. Adding these to the existing facilities of 8.66 MW there will be a total of 20.32 MW of facilities in the system. These facilities will be capable of meeting the demand up to 1980. Furthermore, since a tie-up with the National Interconnected System will be made at the end of 1980, there will be no need to add any new power source within this system.

Meanwhile, in the power distribution sector, 13.8 kV distribution lines have already been completed from Machala through Santa Rosa and Arenillas to Huaquillas (in the border with Peru), and also in the districts of Pasaje and El Guabo. The problem for the future is to make interconnections within the system

with 69 kV lines, and it is scheduled for interconnections by 69 kV lines to be made with the Piñas and Zaruma districts from Machala by 1977.

Furthermore, although belonging to the Guayas-Los Rios System, Naranjal is planned to be supplied power from Machala. Intrasystem interconnections are to be completed with 13.8 kV lines by 1977 and 69 kV lines by 1978. Still further, a 13.8 kV line is planned to be extended from Pasaje to Santa Isabel to include the latter in the system.

The outlines of the electrification programs for the regional systems described above are as indicated in Tables 5-6 and 5-7. Further, the electric power development projects which must be added to the INECEL plan for regional systems are as indicated in Table 5-8.

Table 5-8 Generating Facilities to be added

Systems (Proposed project by the Mission)	Type	Installed capacity (MW)	Year of Compleation
Guayas-Los Rios	Gas	21.5	Dec. 1976
Sur	Diesel	5.0	Dec. 1978
Sub-Total		26.5	
(Definite project)		181.62 (Refer to Table 5-7)	
Total		208.12	

CHAPTER 6

DEMAND AND SUPPLY BALANCE