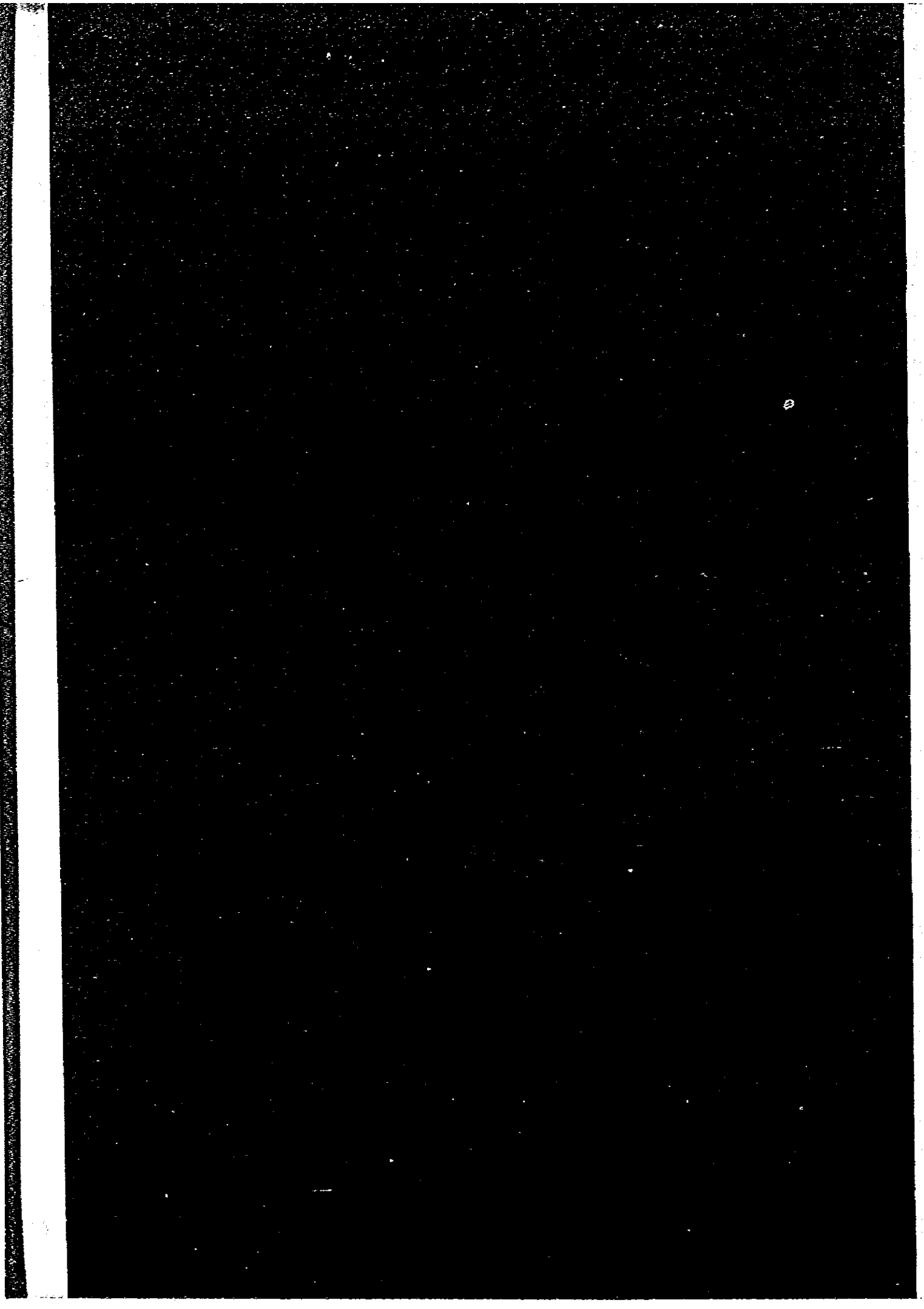
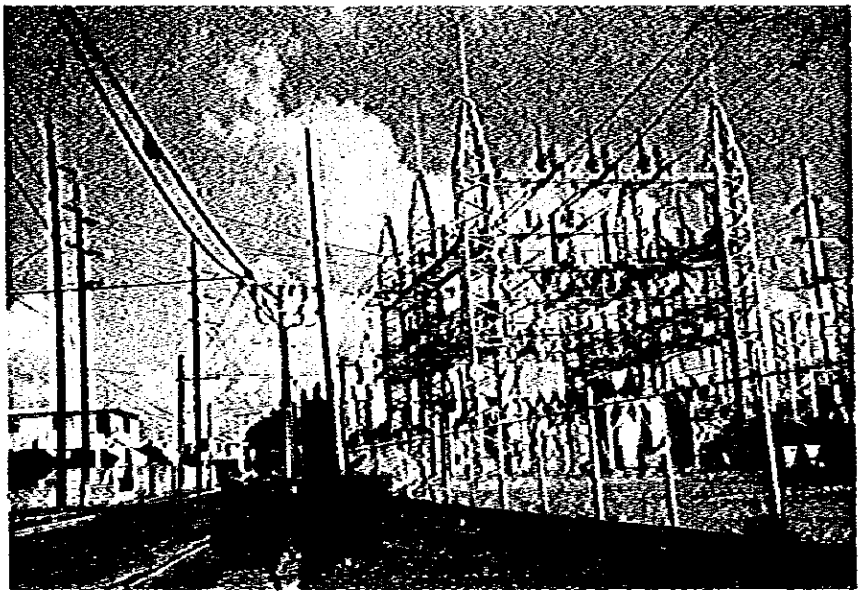
THE FEASIBILITY REPORT
ON
THE MODERNIZATON PLAN OF POWER DISTRIBUTION SYSTEM
IN
THE CITY OF SANTO DOMINGO, DOMINICAN REPUBLIC

September 1980

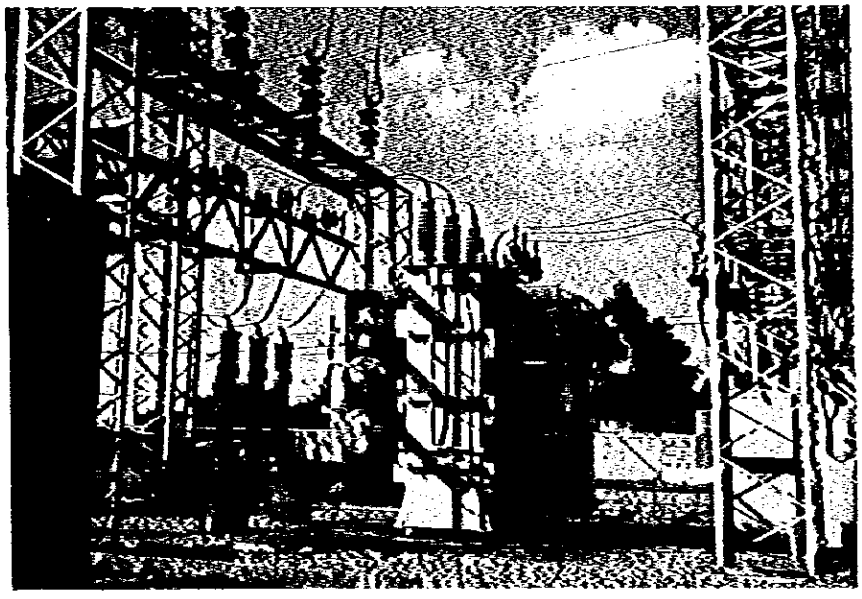
JAPAN INTERNATIONAL COOPERATION AGENCY



Santo Domingo City

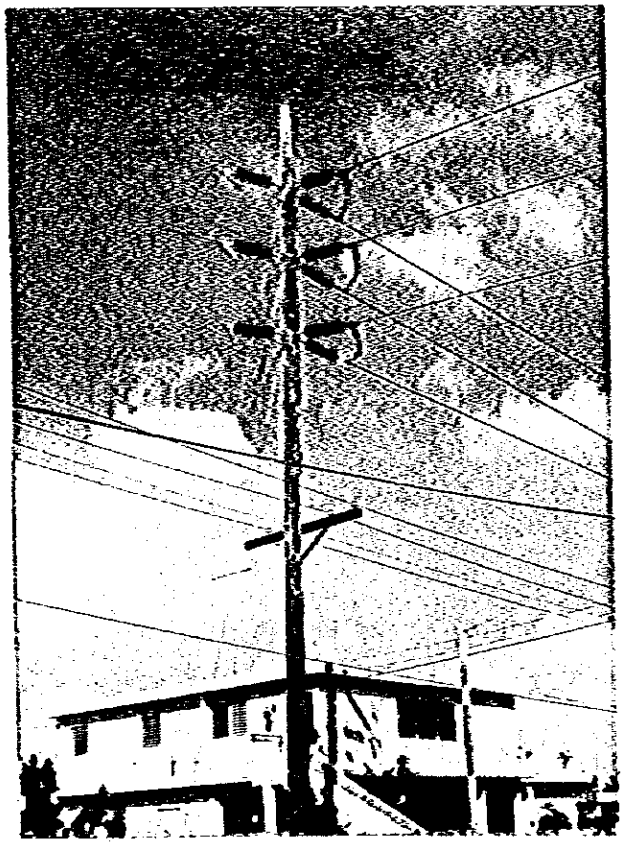


69 kV Substation at Embajador

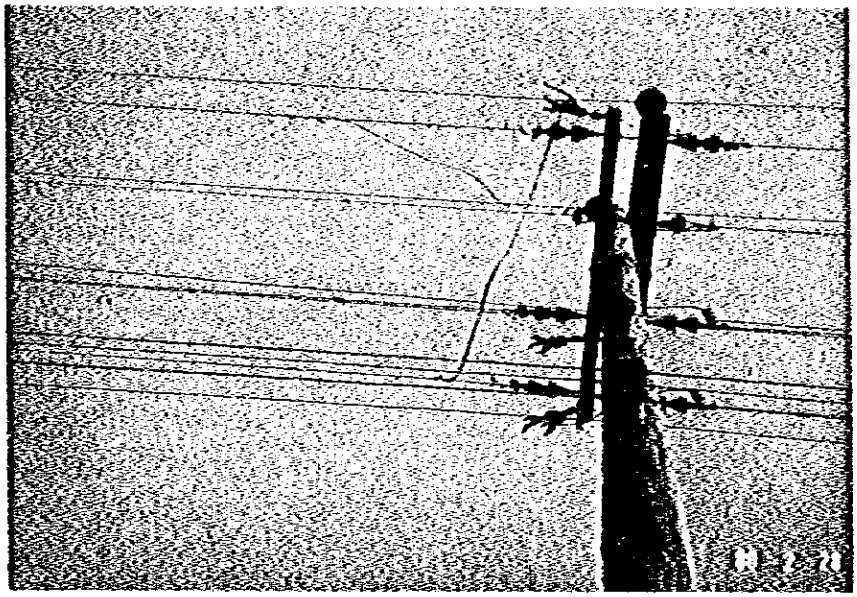


3-Phase 60 Hz 67/12.47 kV 14 MVA Transformer at Embajador.

69kV Transmission line (Tangent structure)

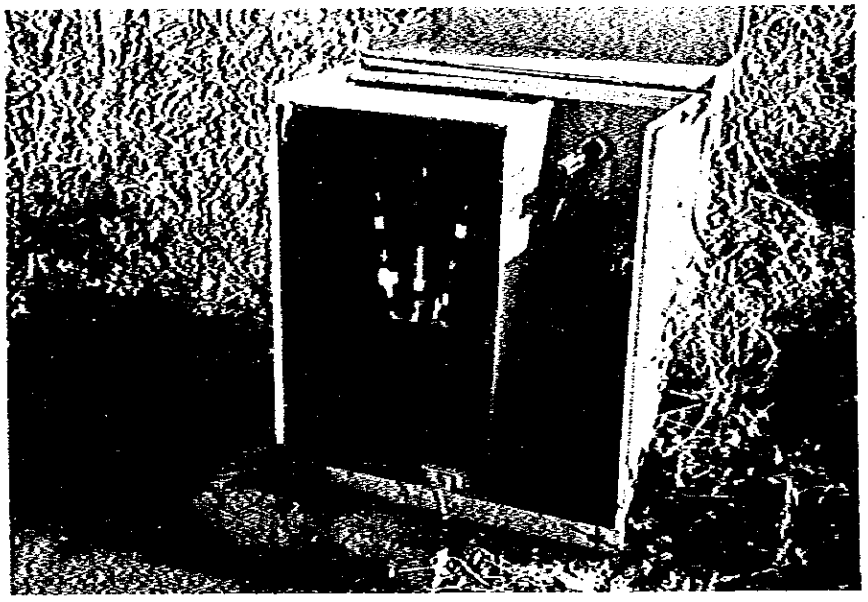


69kV Transmission line (Vertical Structure)

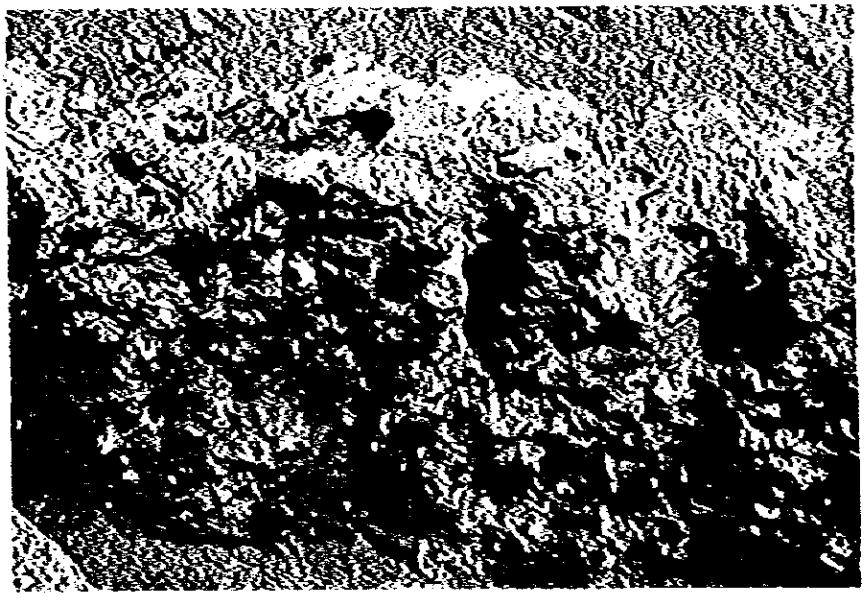


High voltage distribution line (3-phase,4-wires,12.5kV)

Low voltage distribution line (Single-phase,3-wires, 120V& 240V)

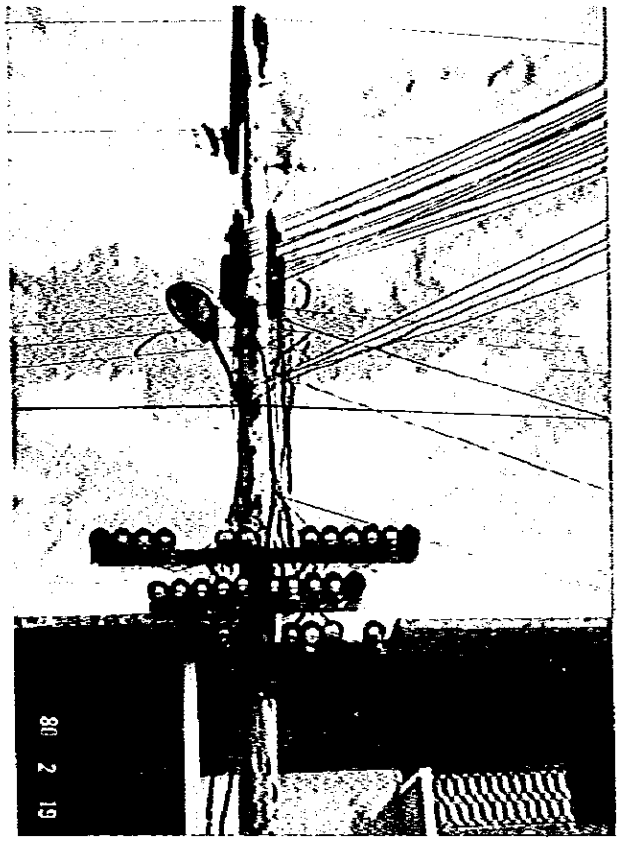


Underground residential distribution system
(Padmount facility of U.R.D.)



Coral-reef (Limestone)

Service wires in slum area.



W.H.M. are installed on the pole.

MAPA FISICO-POLITICO DE LA REPUBLICA DOMINICANA

SITUACION: Entre 17° 40' y 19° 56' longitud norte y 68° 20' y 72° 01' latitud oeste

SUPERFICIE: 48 442 Km²
LONGITUD DE LA COSTA: 1 576 Km.
HABITANTES: 4 011 000 (1970)
PROVINCIAS: 27

PRINCIPALES MONTES:

Pico Duarte 3 175 m.
La Pelona 3 150 m.
La Rucia 3 029 m.
Alto Bandera 2 380 m.
Monte Nieba 2 260 m.
Monte Mejo 2 200 m.
El Aguacate 2 100 m.
Monte Tina 2 059 m.
Naiga de Maco 1960 m.
Monte Gallo 1 840 m.

PRINCIPALES RIOS:

Yaque del Norte
Yuna
Yaque del Sur
Nizao
Ocoa
Chavón

PRINCIPALES CORDILLERAS:

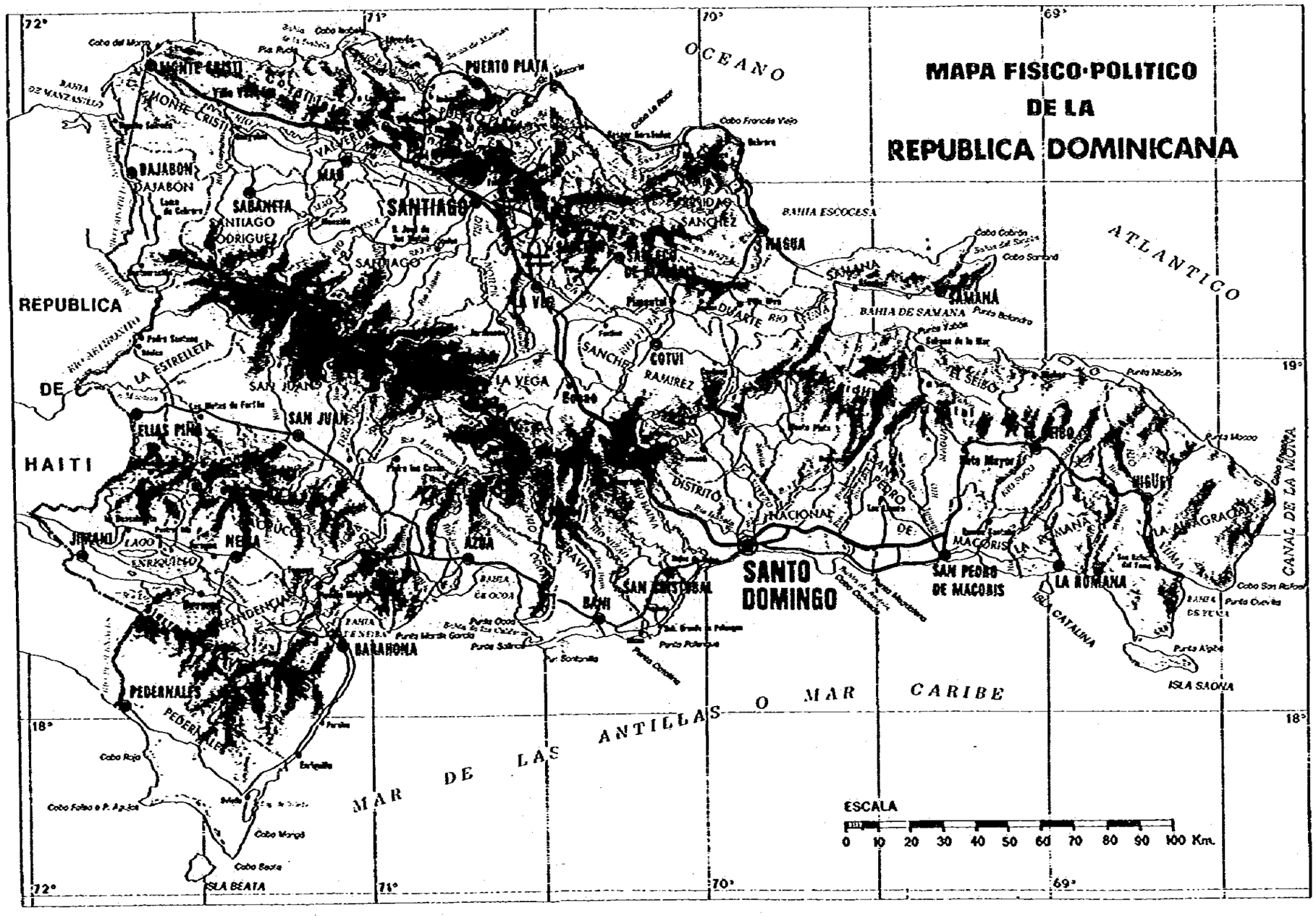
Cordillera Central
Cordillera Septentrional
Cordillera Oriental
Sierra de Neiba
Sierra de Baoruco

PRINCIPALES VALLES:

Valle de Cibao
Valle de Bonao
Valle de San Juan
Valle de Constanza
Valle de Neiba

PRINCIPALES LLANURAS:

Llano de Balaborico
Llano de Puerto Plata
Llano de Yásica
Llano de Boba
Llano de Nagua
Llano de Azua
Llano de Baní
Llano de Oviedo
Llano de Pedernales
Llanura Oriental



PREFACE

In response to the request of the Government of the Dominican Republic, the Japanese Government decided to conduct a feasibility study on the Modernization of Electric Distribution System Project and entrusted the Japan International Cooperation Agency with the study. The J.I.C.A. sent to the Dominican Republic a survey team headed by Mr. Yutaka Matsumoto from February 12 to March 7, 1980.

The team had discussions with the officials concerned of the Government of the Dominican Republic and conducted a field survey in Santo Domingo City area. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two contries.

I wish to express my deep appreciation to the officials concerned of the Government of the Dominican Republic for their close cooperation extended to the team.

September, 1980

Keisuke Arita

Keisuke Arita

President

Japan International Cooperation Agency

September 1980

Mr. Keisuke Arita
President
Japan International Cooperation Agency

Sir:

We have the pleasure to submit to you a feasibility study report for "The Santo Domingo City Electric Distribution System Modernization Project."

In compliance with your request, we organized a study team coprising seven specialists from your agency and West Japan Engineering Consultants Inc. in February 1980 to carry out a feasibility study for the project.

The study team visited Domincan Republic during a period of 21 days from February 14 to March 5, 1980 and made necessary studies and surveys of electric distribution system and held discussions relative to the project with the government officials concerned and the counterparts of Corporacion Dominicana de Electricidad.

After returning to Japan, the team made a further study and analysis of the collected data and information and completed a kW peak demand forecast, a design of improved (modernized) distribution system, estimation of construction cost and economic assessment of the project, which were summarized in a draft feasibility study report. The draft report was submitted to CDE for their comments and a final report was completed after the exchange of opinions with CDE staffs.

The outline of the construction plan of the project is as follows:

1. Construction period:

   From 1980 to 1990, which will be divided in three stages.

2. Main Facilities to be provided:

   138 KV transmission line 2 circuits 13.0 km

69 KV transmission line	1 circuit	8.2 km
138 KV substation	1 station	240 MVA
69 KV substation	3 stations	

Addition of substation transformer to increase the capacity to 644 MVA

Construction of high voltage distribution lines 78 feeders

Additional installation of kWh meters 50,000 pcs

3. Construction cost

1st Stage :	¥ 7,442,000,000	($ 29,763,000)
2nd Stage :	¥ 6,870,000,000	($ 27,526,000)
3rd Stage :	¥ 5,579,000,000	($ 22,305,000)

We are grateful to you that we have been given the opportunity of preparing this report and hope that the report will be useful for the successful implementation of the project.

For the preparation of the report, kind coopration and assistance were extended to the team by the officials of the Government of Dominican Republic, CDE counterparts, staffs of the Japanese Embassy and JICA branch office in Dominican Republic. Valuable suggestions and advices were also made by the Ministry of International Trade and Industry of the Japanese Government and JICA. To them, we express our sincere gratitude and appreciation.

September 1980

Yutaka Matsumoto
Team Leader
Study Team for the Santo Domingo
City Electric Distribution System
Modernization Project

CONTENTS

i. Letter of Symbols

Item	Unit	Symbol	Remark
LENGTH	Centimeter	cm	0.01 m
	Meter	m	
	Kilo meter	km	1000 m
AREA	Square milimeter	mm^2	0.01 cm^2
	Square centimeter	cm^2	
	Kilo circular mil	kCM	
	or Mille circular mil	MCM	0.567 mm^2
	Square meter	m^2	10,000 cm^2
	Square kilometer	km^2	10^6 m^2
	Hectare	ha	10,000 m^2
VOLUME	Cubic meter	m^3	
TIME	Second	s or sec	
	Minute	min	
	Hour	h	
MASS	Gram	g	
	Kilo gram	kg	
VELOCITY	Meter per second	m/s	
	Miles per hour	mph	0.447 m/s
TEMPERATURE	Centigrade degree	°C	
	Fahrenheit degree	°F	9/5°C + 32
ELECTRIC ENERGY	Watt hour	Wh	
	Kilo watt hour	kWh	
	Mega watt hour	MWh	1,000 kWh
ELECTRIC POWER	Watt	W	
	Kilo watt	kW	
	Mega watt	MW	1,000 kW
APPARENT POWER	Volt ampere	VA	Current + Voltage
	Kilo volt ampere	kVA	
	Mega volt ampere	MVA	1,000 kVA

Item	Unit	Symbol	Remark
VOLTAGE	Volt	V	
	Kilo volt	kV	
CURRENT	Ampere	A	
	Kilo ampere	kA	
FREQUENCY	Herz	Hz	
RATIO	Percent	%	
MONETARY	Japan . . . Yen	¥	
	Dominica . . Peso or . RD Dollar	₱ RD$	
	U. S. A. . . . US Dollar	US$	
EXCHANGE RATE	1 US$ = 250 ¥ = 1 RD$		

ii. Abbreviation

CDE ..... Corporacion Dominicana de Electricidad

JICA ..... Japan International Cooperation Agency

S.S. ..... Substation

T/L ..... Transmission Line

D/L ..... Distribution Line

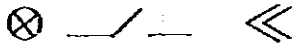
PS ..... Power Station

cct ..... Circuit of T/L or D/L

SOFRELEC ..... Société Française d'Etudes et de Réalisations d'Equipments Electriques

iii. Symbol Marks in Drawing

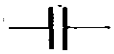
CIRCUIT BREAKER 

DISCONNECTING SWITCH 

TRANSFORMER 

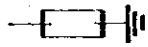
STAR CONNECTION 

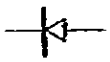
DELTA CONNECTION 

CAPACITOR 

POTENTIAL TRANSFORMER 

CURRENT TRANSFORMER 

LIGHTNING ARRESTER 

RECTIFIER 

BATTERY 

iv. Principal Materials of Survey

Classification	No.	Name of Document
General	1	Geografia Dominicana 1977
	2	– ditto – 1978
	3	el territorio dominicano
	4	Indicadores Basicos 1978
	5	Plan Trienal de Inversiones Publicas 1980-1982
	6	Estaditica Industrial de la Republica Dominicana 1976-1977
	7	Plan de Expansion del Sistema Electrico de la CDE 1979-1992
	8	– ditto – 1980-1992
	9	Balance General y Estados Supplemento Junio, Noviembre 1979
	10	Mapa de la Republica Dominicana
Substation & Transmission	11	Map of Transmission System
	12	Drawing of Substation Layout, Single Line Diagram
	13	Report: Protection, Communication and Transmission Expansion (Nov. 1978)
	14	ALCOA, Al. Conductor Standard – Bare
	15	Map of Santo Domingo City
Distribution	16	Map of Distribution Line in Santo Domingo City
	17	Price List of Distribution Materials

PART I. GENERAL

1. Outline of Feasibility Study

1-1. Background and Object of Study

In compliance with the request of the Government of Dominican Republic for a feasibility study for the Santo Domingo City Electric Distribution System Modernization Project in May 1979, the Government of Japan sent a study team to that country for a preliminary survey in October 1979. As a result of this survey, the Terms of Reference was issued by Corporacion Dominicana de Electricidad (CDE), a government owned agency for the power industry in the country. The Government of Japan then decided to conduct a feasibility study for the modernization program which was aimed to accomplish the following.

i) Improvement and increase of capacities of high and low voltage distribution systems with consideration given to proper system protection and coordination.

ii) Installation of the necessary pole-mounted transformers and substation transformers.

The above-mentioned work is expected to bring about the following benefits to CDE.

a. Stable operation of distribution system, which enables CDE to cope with the increasing power demand.

b. Reduction of distribution loss, which will contribute to the improvement of financial condition of CDE.

The study team, therefore, concentrated its effort on field survey for the collection of necessary data for planning of construction and drafting of a project implementation program.

The study area was limited to the present urban area of Santo Domingo City.

1-2. Organization of Study Team and Survey Period

The Study Team was composed of the following members and a field survey was conducted during a period of February 13 through March 8, 1980.

Based on the findings of field survey and collected data, the team completed a kW peak demand forecast, distribution system modernization program, construction schedule and economic assessment of the project and finalized a feasibility study report.

ORGANIZATION OF STUDY TEAM

Team Leader	Yutaka Matsumoto Overall supervision and load forecast; (Head of Electric Department), West Japan Engineering Consultants, Inc.
Member	Isao Asai Coordination; Japan International Cooperation Agency
Member	Yoshikazu Tatekawa Planning of Distribution System (Line); (Deputy Head of Electric Department), West Japan Engineering Consultants, Inc.
Member	Hideo Yabusa Planning of Transmission System (Line) and Substations; (Section Head, Electric Department), West Japan Engineering Consultants, Inc.
Member	Hiromu Kawamoto Planning of Distribution System (Line); (Deputy Section Head, Electric Department), West Japan Engineering Consultants, Inc.

Member Katsuya Ichinose

Planning of Transmission System (Line) and Substations;
(Senior Engineer, Electric Department),
West Japan Engineering Consultants, Inc.

Member Toshiro Noguchi

Planning of Distribution System (Line):
(Electric Department),
West Japan Engineering Consultants, Inc.

2. Conculsion

2-1. Present State and Problems of Distribution System in Santo Domingo City

A) Existing Distribution System

In Dominican Republic, the 69 kV transmission system is being used to supply power to all major cities in the country. Santo Domingo City receives its power from the Haina thermal power plant (277.8 MVA) located in the western suburb of the city and the Timbeque thermal power plant (114.1 MVA) located on the right bank of the Ozama River which runs in the eastern part of the city by 69 kV transmission lines via 11 distribution substations. The frequency of the power system is 60 Hz and the voltage of the most of high voltage distribution lines is 12.5 kV, with 4 kV system adopted in part. The voltage of low voltage distribution lines is 120 V/240 V. For neutral grounding, the Petersen grounding system is presently used for 69 kV transmission lines, while the direct grounding, 3 phase, 4 wire system is used for high voltage distribution lines.

B) Problems of Existing Distribution System

i) Transmission Line

The Haina power plant and the Timbeque power plant are interconnected by the 69 kV transmission line running through the northern part of the city. Since this transmission line supplies power to a number of substations along its route, it is

rather weak as an interconnecting transmission line. Besides, small size conductors used in some sections have caused a bottle neck in power transmission.

ii) Distribution Substation

The number of substations, which is eleven at present, is considered sufficient for the operation of the power system. The capacity of transformers, however, is too small in some substations where additional installation of transformers will be required.

iii) High Voltage Distribution Line

The maximum peak load demand in the ciyt is estimated at 250–260 MW at present. The number of feeders is 46 and the load varies greatly between feeders. Many feeders show high figures of voltage drop and/or distribution loss. There are also a number of feeders which have an excessively unbalanced current between phases, thereby causing an increase of distribution loss.

iv) Low Voltage Distribution Line

There are many low voltage bus bars and service wires of long spans in the built-up area, which should be improved immediately for the safety of the residents.

There are also many consumers who steal electricity. Improvement of low voltage lines is required also for the prevention of such unauthorized use of electricity.

v) Workmanship of Existing High and Low Voltage Distribution Lines

There are many cases in the city where improvement of work method or techniques is required in the construction of high and low voltage distribution line, especially in the technique of joining conductiors.

2-2. Load Forecast

Based on the load forecast for the country and for each block provided by the French Consultant (SOFRELEC) for CDE, the maximum kW demand by district in the city was

estimated with consideration given to the actual figures for July and December 1979.

Table I-1 shows the maximum kW demand forecast. As shown in the Table, the maximum kW demand is expected to increase from 250 MW recorded in January 1980 to 309 MW in 1982, 411 MW in 1985, 534 MW in 1988 and eventually to 580 MW in 1990.

2-3. Construction Plan for Modernization of Distribution System

A) Basis for Construction Plan

The construction plan for modernization of distribution system covers a period of 10 years from 1980 and is designed to provide a reliable distirbution system capable of coping with the increase of demand up to 1995. In making a construction plan, emphasis was placed on the following points as main objectives.

i) To establish a reliable distribution system with some reserve supply capabilities to meet the increase of demand.

ii) To modernize distribution system with main emphasis placed on the reduction of distribution losses.

iii) To uprate 4 kV distribution lines to 12.5 kV cables in the old town (Colonial district).

iv) To provide improved facilities for prevention of illicit use of electricity.

The construction work will be carried out in the following three stages.

Stages	Construction Period	Target Year
1st Stage	1980 – 1982	1985
2nd Stage	1983 – 1985	1990
3rd Stage	1988 – 1990	1995

Table I-1 Peak Power Demand in Santo Domingo City
(in 1982, 1985, 1988, 1990, by Ciclo) Unit: MW

No. of Ciclo	1982	1985	1988	1990
01	2.88	3.69	4.77	5.09
02	37.46	51.99	66.91	71.07
03	26.40	37.55	49.45	53.49
04	11.89	14.21	19.00	20.75
05	15.61	21.07	28.25	30.89
06	3.86	5.29	6.99	7.56
07	13.53	22.05	28.29	30.04
08	29.90	37.47	50.50	55.53
09	35.36	45.57	58.69	62.14
10	15.83	23.26	29.89	31.79
11	15.83	21.03	27.87	30.32
12	11.15	14.53	18.68	24.17
13	24.29	32.33	43.70	48.25
14	10.26	13.45	17.60	18.98
15	5.33	6.76	8.76	9.36
16	9.54	11.74	15.15	16.12
17	4.01	5.20	6.86	7.41
18	3.98	5.14	6.79	7.37
19	26.59	38.69	47.09	50.16
Total	308.70	411.02	534.64	580.49

Note: Ciclo No. 19 includes customers who receive power from 69 kV line directry.

B) 1st Stage Construction Work

i) Transmission Lines

a. Construction of 69 kV transmission lines between Feria and Timbeque for a total length of 8.2 km (To augment the existing 69 kV interconnecting line between Haina PS and Timbeque PS).

b. Replacement of conductors of existing 69 kV transmission line between Matadero and Feria for a length of 2 km (To augment the existing 69 kV interconnecting line between Haina PS and Timbeque PS).

ii) Substation Facilities

a. Construction of Rojas substation and discontinuance of Feria substation (To uprate existing 4 kV distirbution lines to 12.5 kV lines).

b. Addition and relocation of main transformers

Installation of 7 units of 28 MVA transformers (Embajador ss and 6 other ss)

Relocation of 2 units of 14 MVA transformers (To Arroyo Hondo ss and one other ss)

Construction of outgoing lines for high voltage distribution lines – 27 feeders

iii) Distribution Lines

a. Replacement of 4 kV feeders with 12.5 kV feeders – 8 feeders

b. Installation of underground cables in Colonial district – 4 feeders

c. Installation of new feeders – 27 feeders (73 km)

d. Replacement of conductors of high voltage distribution lines – 100 km

e. Change of single phase lines to 3 phase lines – 70 km

f. Improvement of facilities for prevention of illicit use of electricity

High voltage line..... 20 km

Low voltage line..... 115 km

Service wires and kWh meters ..... For 25,000 households

g. Modernization of low voltage lines – 100 km

h. Vehicles and tools – One complete set

C) 2nd Stage Construction Work

i) Transmission Lines

a. Construction of 138 kV transmission lines from Haina PS to the center of the city (1 cct stringing / 2 cct support) – 13 km

b. Replacement of conductors in part of 69 kV line between Timbeque and Arroyo Hondo – 8.1 km

ii) Substation Facilities

a. Construction of one 138 kV substation – 120 MVA

b. Construction of two 69 kV distribution substation – 56 MVA

c. Addition and relocation of main transformers

Installation of 5 units of 28 MVA transformers (Herrera and three other ss)

Relocation of 2 units of 14 MVA transformers (To Matadero and one other ss)

d. Construction of outgoing lines for high voltage distribution lines – 24 feeders

iii) Distribution Lines

a. Installation of new feeders – 24 feeders (65 km)

b. Replacement of conductors of high voltage distribution lines – 100 km

c. Change of single phase lines to 3 phase lines – 70 km

d. Improvement of facilities for prevention of illicit use of electricity

High voltage line..... 20 km

Low voltage line..... 115 km

Service wires and kWh meters ..... For 25,000 households

e. Modernization of low voltage lines – 100 km

f. Measures for improvement of system reliability (installation of fault detecting relay system with time delay magnetic swtich) – 124 sets

g. Protection against lightning (installation of arrestors) – 1,600 banks

h. Installation of insulated cables for high voltage lines for personal safety – 20 km

D) 3rd Stage Construction Work

i) Transmission Lines

Stringing of additional 138 kV line for 2 cct lines bwtween Haina PS and the center of the city.

ii) Substation Facilities

a. Installation of one 138 kV transformer – 120 MVA × 1

b. Addition and relocation of main distribution transformers

Installation of 8 units of 28 MVA transformers (Los Prados and 7 other ss)

Relocation of one unit of 14 MVA transformer (To Matadero ss)

c. Construction of outgoing lines for high voltage distribution lines – 27 feeders

iii) Distribution Lines

a. Installation of new feeders – 27 feeders (73 km)

b. Modernization of low voltage lines – 200 km

c. Protection against lightning (installation of arrestors) – 1,600 banks

d. Installation of insulated cables for high voltage lines for personal safety – 20 km

e. Vehicles and tools – One complete set

2-4. Construction Cost

Construction cost for each stage is estimated as follows.

(in millions)

Stages	Period	F. C.	L. C.	Total	Remarks
1st Stage	1980–1982	¥ 4622 (US$ 18.5)	¥ 2820 (US$ 11.3)	¥ 7442 (US$ 29.8)	Price 1981
2nd Stage	1983–1985	¥ 5577 (US$ 22.3)	¥ 1293 (US$ 5.2)	¥ 6870 (US$ 27.5)	Price 1984
3rd Stage	1988–1990	¥ 4810 (US$ 19.2)	¥ 769 (US$ 3.1)	¥ 5579 (US$ 22.3)	Price 1989
Total		¥ 15,009 (US$ 60.0)	¥ 4,882 (US$ 19.6)	¥ 19,891 (US$ 79.6)	

Note i. Exchange rate (1 US$ = 1 RD$ = 250 ¥)

ii. Escalation rate ..... 5%/ year with 1980 as base year

iii. F.C. ... Foreign currency; L.C. ... Local currency

2-5. Benefits and Economic Viability

A) Benefits

i) Reduction of transmission and distribution losses

	1979	1980	1982	1985	1990
T/L & S.S %	2.4	2.5	2.1	2.7	2.0
D/L %	21.8	23.4	20.0	17.3	16.3
Total %	24.2	25.9	22.1	20.0	18.3

The transmission and distribution loss will be reduced by 7.6% from 25.9% (estimate) in 1980 to 18.3% in 1990.

ii) Prevention of stealing of electricity

Most of illegal consumers estimated at about 50,000 households may be changed to legal consumers.

iii) Modernization of facilities

iv) Reserve capacity of facilities

a. Since the utilization factor of substation transformes in 1990 is estimated at 70%, these transformers have sufficient capabilities to meet the load increase in 1995.

b. Since the number of high voltage feeders will reach 126 in 1990 to supply 580 MW of power, the average load per feeder will be 4.6 MW. This figure is less than 50% of the capacity of feeder and there will be a large reserve capacity of feeders.

B) Economic Viability

The IRR for the Ist stage of construction work is calculated as follows.

Interest rate		10%	20%	25%
Total cost (present value)	10^6 RD$	24.95	21.31	19.81
Total gain (present value)	10^6 RD$	44.00	21.25	16.10

IRR 20.05%

3. Recommendations

A) In view of inadequacy of power distribution systems in Santo Domingo City to meet a sharp growth of power demand and a rapid increase of the number of consumers with the sharp growth of population, the project, when completed, will provide modern facilities and will ensure sufficient reserve capacities for future demand. The project is also economically feasible.

B) For the prevention of stealing of electricity, it will be important to complete the related laws and educate consumers through public relations campaigns. In respect of facilities, replacement of bare wires with insulated conductors and installation of a kWh meter in each household will be an effective means of preventing the stealing of

electricity.

C) Training courses should be provided for linemen of CDE for improvement of their technical skills and for learning latest technuques.

D) The organization of project planning should be substantiated and adequate facilities for recording and data collection should be provided as early as possible.

PART II. FINDINGS

Chapter 1. Outline of Dominican Republic

1-1. Geography

Dominican Republic occupies the eastern part of Espaniola Island situated in the center of West Indies Islands. The territory extends from Latitude 20°N to 17°30'N between Longitude 68°20'W and 71°40'W, with a total area of approximately 49,000 square Kilometers. The climate is relatively mild, with an average temperature of 25.7℃ (in Santo Domingo City), rainfall of 1,400mm (in Santo Domingo City) and humidity of 83.7%. This country is a popular winter resort and many tourists from the United States visit this place during the winter season. The relatively high Central Mountain Range (the highest peak is 3,175m) runs from NW to SW in the central part of the country and the North Mountain Range lies in the north. Sandwiched by these two mountain ranges is the Shibao plain which a granary of the country. The Occidental plain lies in the west and most of the eastern part is also a plain area.

1-2. Population

The population of Dominican Republic in 1978 was 5,120,000, with the population density of 105.7 persons/ km^2. The average growth rate of population between 1973 and 1978 was 3.0% (Refer to Table 1-1). Children and the youth under 19 years old account for 58% of the total population. A total of 1,232,000 inhibitants (24.6%) reside in and around the capital city. The population of the capital zone covered by this project is estimated at 1,040,000. The second largest population is 500,000 in the Province of Santiago in the north.

Fig. 1-1 Map of Population Distribution in Santo Domingo

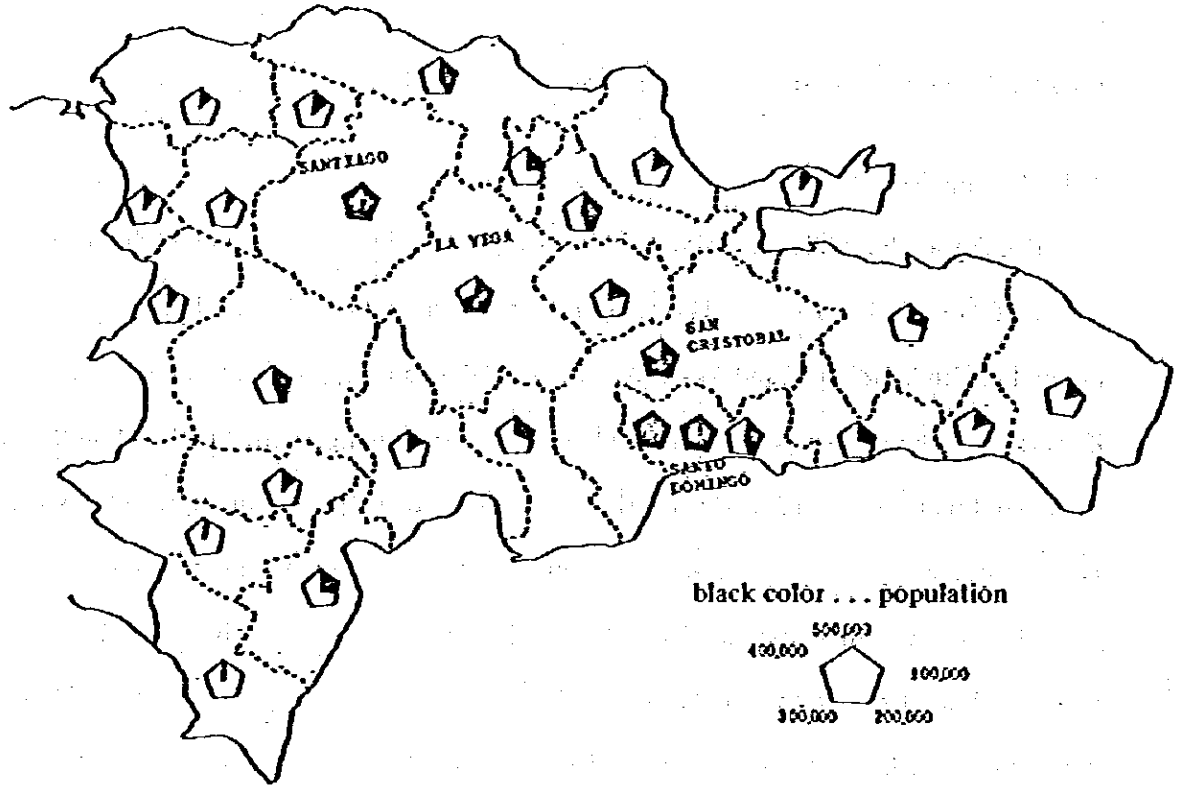


Table 1-1 Total Population of The Dominican Republic

July 1, in each year, 1973 ~ 1978

Year	Total	%	Urban	%	Rural	%
1973	4,431,738	100	1,914,519	43.2	2,517,229	56.8
1974	4,562,341	100	2,018,909	44.2	2,543,432	55.8
1975	4,696,793	100	2,128,561	45.3	2,568,232	54.7
1976	4,835,207	100	2,243,632	46.4	2,591,575	53.6
1977	4,977,701	100	2,362,717	47.5	2,614,984	52.5
1978	5,124,394	100	2,487,243	48.5	2,637,151	51.5

From "INDICARDORES BASICOS" P. 159.

1-3. Political System

The country is a republic and the present President was elected in 1978. The next election is scheduled for 1982. The central government consists of 10 ministries and the country is divided into 27 administrative districts comprising 26 provincias and the capital zone. The National Assembly comprises the Upper House which has 27 members elected from 26 provincias and the capital zone and the Lower House which has 91 members elected at the rate of one member for every 60,000 voters of 18 years old or over.

1-4. Education

The 1976 statistics shows that 91% of children of school age between 7 and 14 years old go to school. Approximately 20% of the youth receive high school education. Beside the Santo Domingo University which was established in 1538, there are three other universities established since 1966. The total number of college students is approximately 50,000 according to the 1976 statistics. In the allocation of budget for education, the central government has been placing emphasis on the education of adults and technical training.

1-5. Industry

The gross national product (GNP) of the Dominican Republic achieved and actual annual growth rate of 6.5% during the 1973–1977 period. While agriculture and forestry had a low growth rate of 3% during this period, the mining and manufacturing industries attained high growth rated of 9.3% and 7.5%, respectively. The medium-term economic outlook for the period from 1978 to 1982 announced by the central government puts the growth rate during this period at 5.8% (Refer to Table 1-2). According to this outlook, the growth rate of agriculture is estimated at 3.5% which is lower than the average and the growth rate of the mining industry is put at high 11.0%, while that of the manufacutring industry is estimated at 5.9% which is close to the average.

Table 1-2 GNP (Unit: Million RD$)

Item	1973	1974	1975	1976	1977	Rate of inc. I	1978	1979	1980	1981	1982	Rate of inc. II
Agriculture	356.6	357.6	346.4	396.7	401.6	1.030	465.0	452.3	488.8	510.8	533.8	1.035
Mineria	95.6	102.2	111.8	140.5	136.6	1.093	115.9	145.1	155.3	165.4	176.2	1.110
Manufactura	286.7	315.7	334.8	369.1	382.7	1.075	491.3	499.5	539.1	576.8	617.4	1.059
Construccions	114.3	116.8	129.1	136.2	150.8	1.072	187.5	186.8	209.3	222.9	237.4	1.060
Comercio	308.8	335.7	350.2	379.6	389.7	1.060	441.0	455.5	493.3	525.4	559.6	1.061
Transporte	93.9	102.2	107.9	112.8	114.1	1.050	194.8	195.8	210.5	225.2	241.0	1.055
Comunicaciones	11.9	12.8	15.4	17.0	19.5	1.131	28.3	29.6	31.8	34.0	36.4	1.065
Electrididad	29.0	31.0	32.8	34.1	42.5	1.100	44.2	42.0	48.7	53.6	59.0	1.075
Finanzas	25.6	31.0	36.6	44.7	46.7	1.162	62.2	68.7	71.7	74.6	77.6	1.057
Viviondas (Housing)	121.2	136.8	152.3	166.0	182.6	1.108	175.4	178.4	191.8	203.3	215.5	1.053
Gibierno	105.8	113.1	123.4	132.0	126.1	1.045	190.1	234.1	246.5	257.6	269.2	1.091
Otros (Others)	157.0	169.8	187.0	200.1	205.9	1.070	239.3	233.3	252.1	265.0	278.5	1.039
Total	1706.4	1824.7	1927.7	2128.9	2198.8	1.065	2635.1	2721.1	2938.9	3114.6	3301.6	1.058
		Aprecios de 1962						Aprecios de 1970				

Note: Rate of Inc. I . . . .Average value of rate of increase from 1973 to 1977

Rate of Inc. II . . .Average value of rate of increase from 1978 to 1982

From "Indicadores Basicos" and "Plan Trienal de Inversion" publica 1980-1982

Changes and the anticipated future trends of consumer price index adopted by SOFR-ELEC for its load forecast are shown in Table 1-3.

Achievements and future outlook of export are shown in Table 1-4. The share of sugar products, which are main export items of the country, increases from 28.3% in 1979 to 31.6% in 1982. Export of minerals, especially that of gold, shows a big growth in 1982 and the share of minerals in export is expected to exceed that of sugar products in the total amount.

Achievements and future outlook of import are shown in Table 1-5. The share of petroleum products in import is growing annually and is expected to come close to 30% in 1982. Import of machinery, electric appliances and vehicles is expected to grow gradually and the share of these items will account for approximately 20% of total import.

The amounts of export and import in 1982 are estimated at RD$ 1,460 million and RD$ 1,690 million, respectively. The trend of unfavorable balance of trade will remain unchanged still in 1982 and the amount of import is expected to reach RD$ 2,300 million in that year.

The balance of foreign currency is shown in Table 1-6. As shown in the table, the deficit on trade account, which is RD$ 310 million in 1979, is expected to reach RD$ 560 million in 1982.

In the agricultural sector, cultivation of sugar cane and coffee beans has great weight with export. The former is cultivated nation-wide but is more active in the plain east to Santo Domingo City, while the latter is grow mainly in the hilly area of the north but is also grown in the hilly area of the south-western district.

Mineral resources include ferro-nickel, gold and silver and mines are distributed in the central district and in the hilly area of south-western district.

Table 1-3 Index of Consumer Price in Dominican Republic

(1969 = 100%)

Year	Index	Average rate of increase	Year	Index	Average rate of increase
1969	100		1979	260.0	
1970	105.2		1980	286.0	
1971	107.2		1981	313.2	
1972	116.8		1982	341.4	
1973	134.4	10.9%	1983	370.4	7.7%
1974	152.1		1984	400.0	
1975	174.2		1985	430.0	
1976	193.0		1986	462.3	
1977	212.0		1987	497.0	
1978	253.3		1988	534.1	
			1989	574.1	
			1990	617.4	
			1991	663.7	
			1992	723.4	

Note: From "Load Demand Forecast" of SOFRELEC

Table 1-4 Table of Exportation

(Unit : Million RD$, Current Price)

Item	1978	1979*	1980	1981	1982
TOTALES	673.9	874.5	1,109.9	1,270.1	1,457.7
I. Traditional	427.2	516.2	621.3	691.9	774.5
A. Sugar and Derivation	212.7	247.2	365.6	406.6	460.5
1) Crude sugar	172.4	205.9	312.5	347.2	393.5
2) Molasses	10.1	15.7	20.9	22.8	25.0
3) Sirop	-	-	1.2	1.5	1.7
4) Furfural	30.2	25.6	31.0	35.1	40.3
B. Coffee Bean	85.1	152.3	141.1	158.7	176.4
C. Unfinished Tobacco	44.3	41.0	45.8	51.3	57.0
D. Cacao Bean	85.1	75.7	68.8	75.3	80.6
II. No Traditional	246.7	358.3	488.6	578.2	683.2
A. Mineral	171.1	260.5	364.3	420.0	482.3
1) Ferro Nickel	73.8	116.2	142.4	165.3	185.2
2) Gold	71.5	96.9	146.2	170.0	204.0
3) Silver	23.1	20.9	40.4	45.8	49.7
4) Bauxite	0.8	23.3	31.3	35.0	39.0
5) Plaster	1.8	1.4	1.6	1.8	2.0
6) Stone Chalice	0.1	1.5	1.7	1.8	2.1
7) Others		0.3	0.3	0.3	0.3
B. Processed Goods from Agriculture	19.9	18.4	22.1	26.6	31.9
C. Industrial Products	55.7	79.4	102.2	131.6	169.0

* Estimado.

Fuente: Centro Dominicano de Promocion de Exportaciones (CEDOPEX)
Proyecciones de ONAPLAN

Table 1-5 Table of Importation

(Unit : Million RD$, Current Price)

Item	1978	1979*	1980	1981	1982
General	39.6	38.0	42.0	46.0	51.0
Oils & Grease	30.8	45.0	40.0	42.0	44.0
Fuel & Mineral	194.2	250.0	325.0	422.5	549.3
Drugs	28.8	30.0	34.8	40.4	46.8
Plastic	25.8	32.2	38.6	46.4	55.6
Lumber & Woods	16.4	19.2	20.0	21.0	22.0
Paper & Carton	27.3	30.9	37.1	44.5	53.4
Iron & Steel Products	52.1	56.0	67.2	80.6	96.8
Machines for Mining	93.8	100.0	120.0	144.0	172.8
Machines & Appliances of Electricity	32.3	37.0	43.7	51.5	60.8
Vehicles	66.5	68.0	80.2	94.7	111.7
Sub Total	607.6	706.3	848.6	1,033.6	1,264.2
Others	251.5	293.7	324.3	372.9	428.8
Grand Total	859.1	1,000.0	1,172.9	1,406.5	1,693.0

Note: * Estimado

From Oficina Nacional de Estadistica. Proyecciones de ONAPLAN

Table 1-6 Balance of Foreign Currency

(Unit : Million RD$)

ITEM	1978	1979	1980	1981	1982
Exportation	675.5	874.5	1,109.9	1,270.1	1,457.7
Importation	859.7	1,000.0	1,172.9	1,406.5	1,693.0
A) Balance of Trade	-184.2	-125.5	- 63.0	-136.4	-235.3
Income of Service	154.1	227.5	262.9	246.0	285.0
Freight & Insurance	11.2	13.0	16.6	19.0	21.0
Other Transportation	8.4	9.2	10.5	11.0	12.0
Tourism	87.9	104.0	131.4	158.2	190.6
Transaction by Government	2.1	2.2	2.3	2.4	2.6
Investment	6.9	7.7	8.6	9.7	10.8
Others	37.6	91.4	93.5	45.7	48.0
Payment for Service	398.2	490.8	528.7	599.8	686.6
Freight & Insurance	129.0	130.0	168.3	189.9	228.5
Other Transportation	8.9	9.7	10.8	11.9	14.0
Tourism	100.0	110.0	122.3	132.1	142.6
Transaction by Government	2.2	2.5	2.7	3.0	3.3
Payment for Investment	114.6	188.6	177.1	196.7	222.0
Others	43.5	50.0	57.5	66.2	76.2
B) Balance for Service	-244.1	-263.2	-265.8	-353.8	-401.6
C) Total Balance of Service	-428.3	-388.8	-328.8	-490.2	-636.9
D) Donations	54.0	78.3	63.6	69.3	75.5
GRAND TOTAL	-374.3	-310.5	-265.2	-420.9	-561.4

FUENTE: Banco Central de la Republica Dominicana. Cuentas Nacionales.

Chapter 2. Power Situation in Dominican Republic

2-1. CDE

Except some districts serviced by private power plants owned by industries, the whole country is serviced by Corporation Dominicana de Electricidad (CDE), established under the Office of the President by Law No. 4018 legislated on December 30, 1954, which is responsible for generation, transmission and distribution of electric power.

1) Organization of CDE

Organization of CDE is shown in Fig. 2-1. The top executive body of CDE is Concejo Diredivo which is composed of committee members from governmental bodies and the Adminstracion General of CDE.

Under the Administracion General there are two Sub-Administracion Generals, one of whom is responsible for overall administration and the other is stationed in Santiago in the north and is responsible for administration of the northern region.

CDE has a total of 5,044 employees comprising 4,797 staffs and 247 temporary employees, as of November 1979. By division, there are 211 employees in the Operation Division, 1,743 in the Transmission and Distribution Division, 886 in the Power Generation Division and 1,364 in other divisions. Personnel assignment by region is as follows (from Wage Statistics of August 1979).

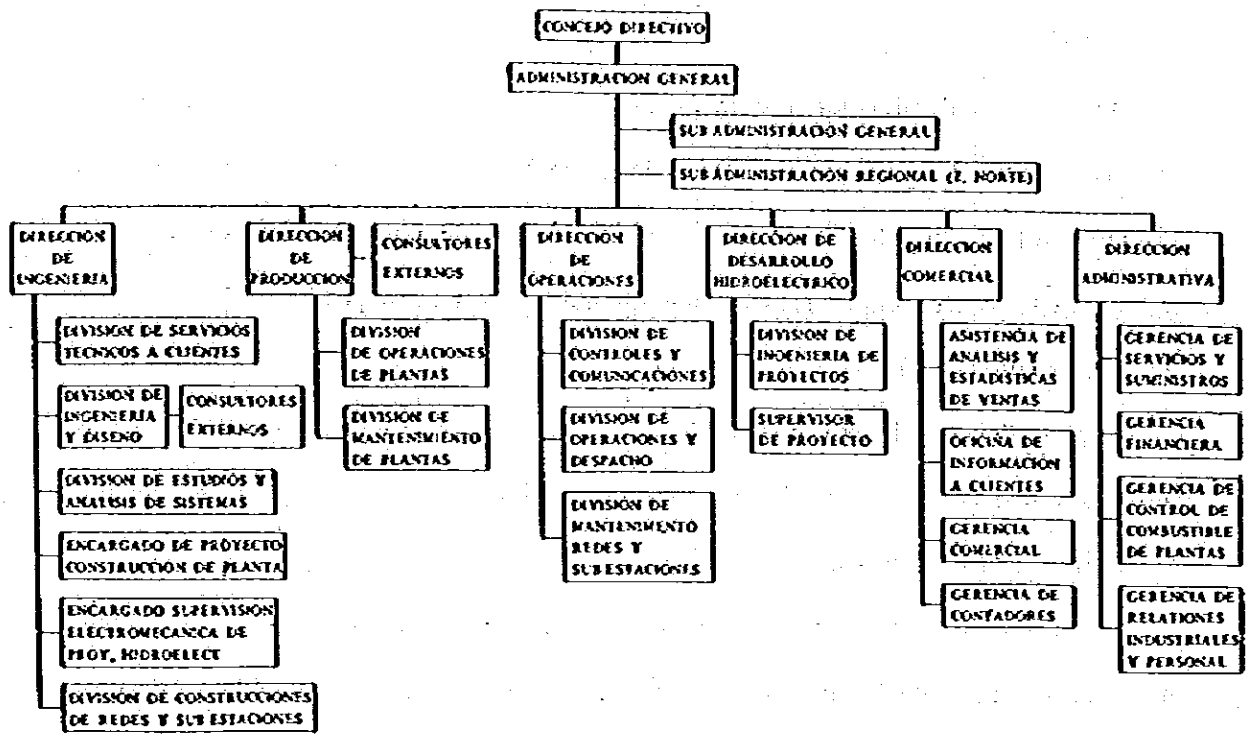
Head Office, Santo Domingo District ..... 3,200 persons

Northern Region ..... 1,100 persons

South-Western Region ..... 320 persons

Eastern Region ..... 210 persons

Fig. 2-1. CORPORACION DOMINICANA DE ELECTRICIDAD



2-2. Tariff System of CDE

The tariff system of CDE applies different unit rates according to the type of consumers which are divided into Residential, Commercial, Small Industry, Large Industry and Public Uses.

For residential, the unit rate is low at RD$ 0.04 up to 50 kWh but a higher unit rate is applied when power consumption exceed this figure.

For industrial use, the unit rate decreases with the increase of consumption.

The 12 month moving average rate up to November 1979 is as follows.

	Residential	Commercial	Industry
RD$/ kWh	0.051	0.069	0.055
	Public Illumination	Public Building	Average
RD$/ kWh	0.083	0.064	0.0565

In March 1980, the power rate was raised by RD$ 0.01 per kWh for all consumers except Residential due to the rising cost of fuel oil.

2-3. Power System in Dominican Republic

In Dominican Republic, the 60 Hz, 69 kV transmission lines having a total length of 1,200 km interconnect all major cities of the country as trunk lines. In some districts, however, 34.5 kV transmission lines are being used. High voltage distribution lines are 12.5 kV lines and 4.2 kV lines but the latter is gradually uprated to 12.5 kV lines. Low voltage distribution lines are rated at 120/240 V. All high voltage distribution lines adopt the effective grounding method (have their neutrals effectively grounded to the earth).

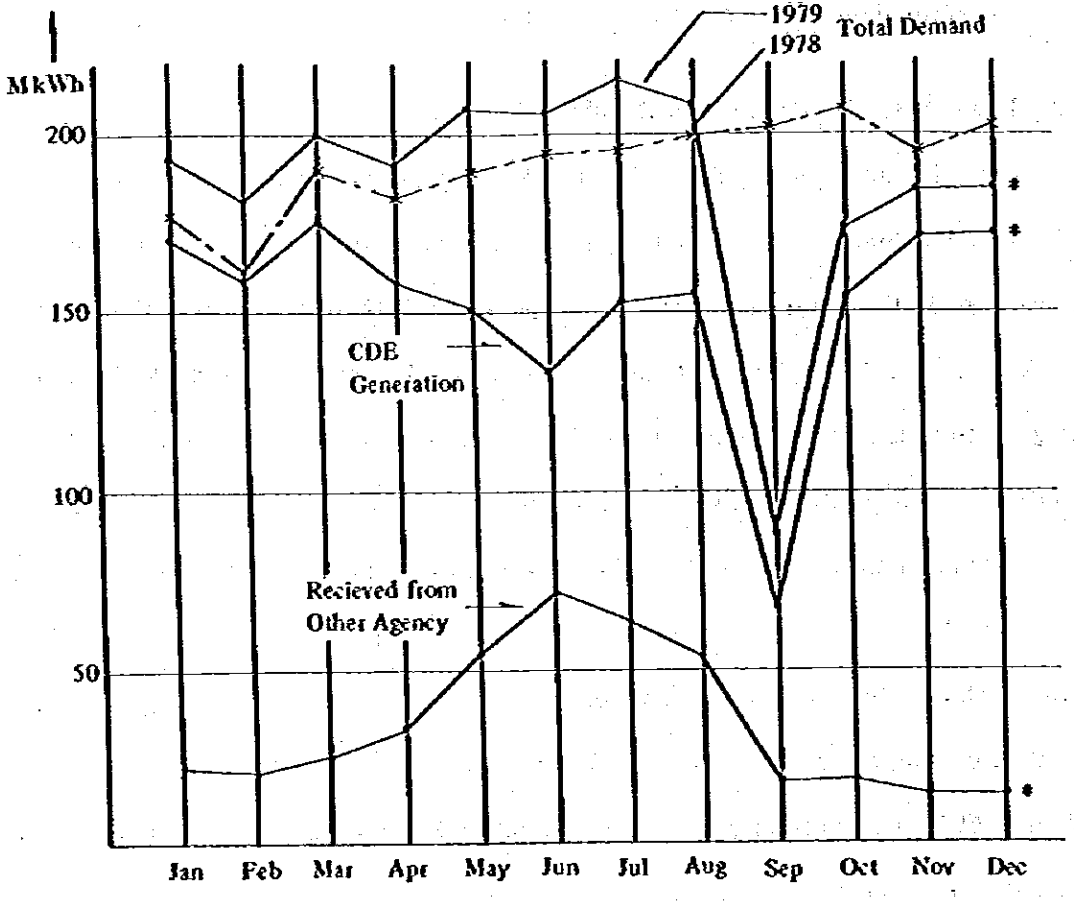
Power generation statistics of 1978 and 1979 are shown in Fig. 2-2. Power demand in September 1979 dropped to nearly 40% of that in the previous month because of the hurricane David which hit the country from the end of August to the beginning of September 1979, causing extensive damages to Santo Domingo City and its western suburbs and collapsing 69 kV transmission lines connecting Santo Domingo City and Santiago City in the north. However, the demand recovered to nearly 90% of normal time in December of the same year as a result of smooth progress of rehabilitation work.

The power generating facilities of CDE are interconnected with government owned Tavera (80 MW), Valdesia (54 MW) and Rincon (10 MW) hydro-power plants and a thermal power plant (198 MW) owned by Falcon Bridge Co. The total capacities of the plants by owner and capacities of main power plants are shown in Table 2-1 and 2-2, respectively.

2-4. Power System under Construction or Planning

While the maximum power generation is 410 MW and the annual power demand is 1,666 GWh in 1979, the demand in expected to grow at an annual rate of 10% for some time. For this reason, additional power plants are now under construction or under plan-

Fig. 2-2 Progress of Generation by Month



Note * Presumption

Table 2-1 FACILITIES OF GENERATING PLANTS

	CDE		OTHER AGENCY		TOTAL	
	CAPACITY (kW)	NO. OF PLANT	CAPACITY (kW)	NO. OF PLANT	CAPACITY (kW)	NO. OF PLANT
THERMAL	377,350	3	198,000	1 (Private)	535,350	4
GAS	113,800	4	-	-	113,800	4
DIESEL	28,750	7	-	-	28,750	7
HYDRO	15,250	3	144,100	3 (Government)	159,350	6
TOTAL	535,150	17	342,100	4	877,250	21

Table 2-2 MAIN POWER PLANTS

THERMAL			HYDRO		
i	CDE	kW	i	CDE	kW
	Haina	84,900 x 2		Jimenoa	7,500 x 1
		54,000 x 2		Las Damas	7,500 x 1
		277,800		Constanza	250 x 1
	Timbeque	26,500 x 1		Total	15,250
		12,650 x 3	ii	Other Agency (Government owned)	
		7,500 x 1		Tavera	40,000 x 2
		71,900			80,000
	Puerto Plata	27,600 x 1		Valdesia	27,000 x 2
ii	Other Agency				54,000
	Falcon Bridge	66,000 x 3		Rincon	10,100 x 1
		198,000		Total	144,100
		(CDE use 30,000)	iii	Total	159,350
iii	Total	575,350			

ning as shown in Fig. 2-3 under the Power Resouces Development Program so that approximately 20% reserve capacity may be secured for peak demand in 1982.

Under the Power Resources Development Program, emphasis is placed on the construction of thermal power plants. Construction of the Haina thermal power plant No. 5 (85,000kW) to be completed in 1981 and the Itabo thermal plant No. 1 (125,000kW) to be completed in 1983 is now under way and construction of other large capacity power plants is under planning.

Since the existing 69kV transmission line is not adequate to cover the whole country, construction of 138kV transmission lines and substations is now in progress. As shown in Fig. 2-3, the 138kV transmission lines are designed as interconnecting lines between the Tavera hydro-power plant in the north, Canabacoa substation in the suburbs of Santiago City and Palamara substation, between Palamara substation, Itabo PS and Haina PS and between the eastern region and the south-western region.

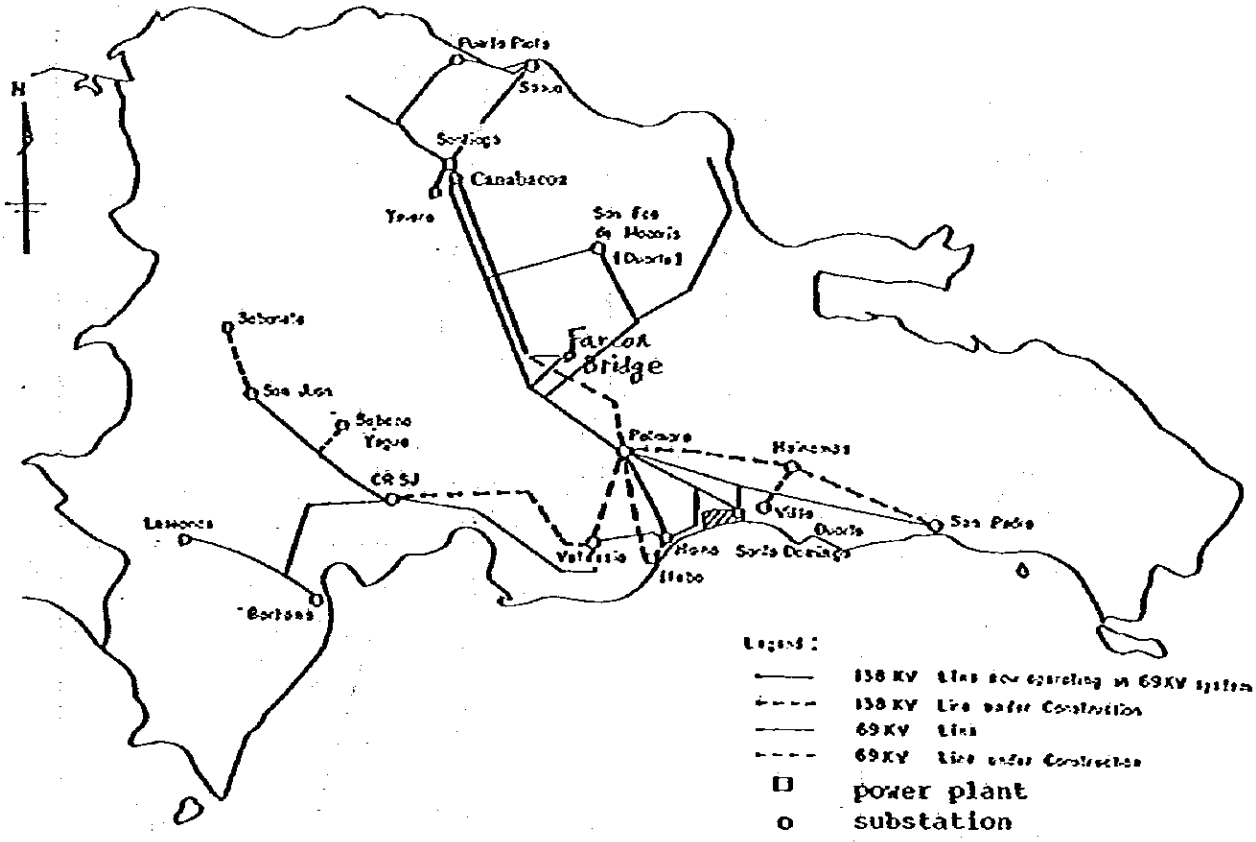
At present, the section between Tavera PS, Conabacoa substation and Palamara substation is completed and part of which is in operation at 69kV. The rest of the system is now under construction. In the future, the 138kV trunk lines will be operated with the effective grounding system and the conversion of the P.C. grounding system of 69kV system to the effective grounding before the operation of the 138kV system is either in progress or under planning.

2-5. Future Power System and Power Generation Plan

Based on the demand forecast up to 1992 made by French consultant (SOFRELEC), CDE and SOFRELEC are now preparing a 10 year power system and power generation program to be completed by the end of 1980.

For reference, a power resources development plan up to 1982 is shown in Fig. 2-4.

Fig. 2-3. Principal Power System Map of Dominican Republic



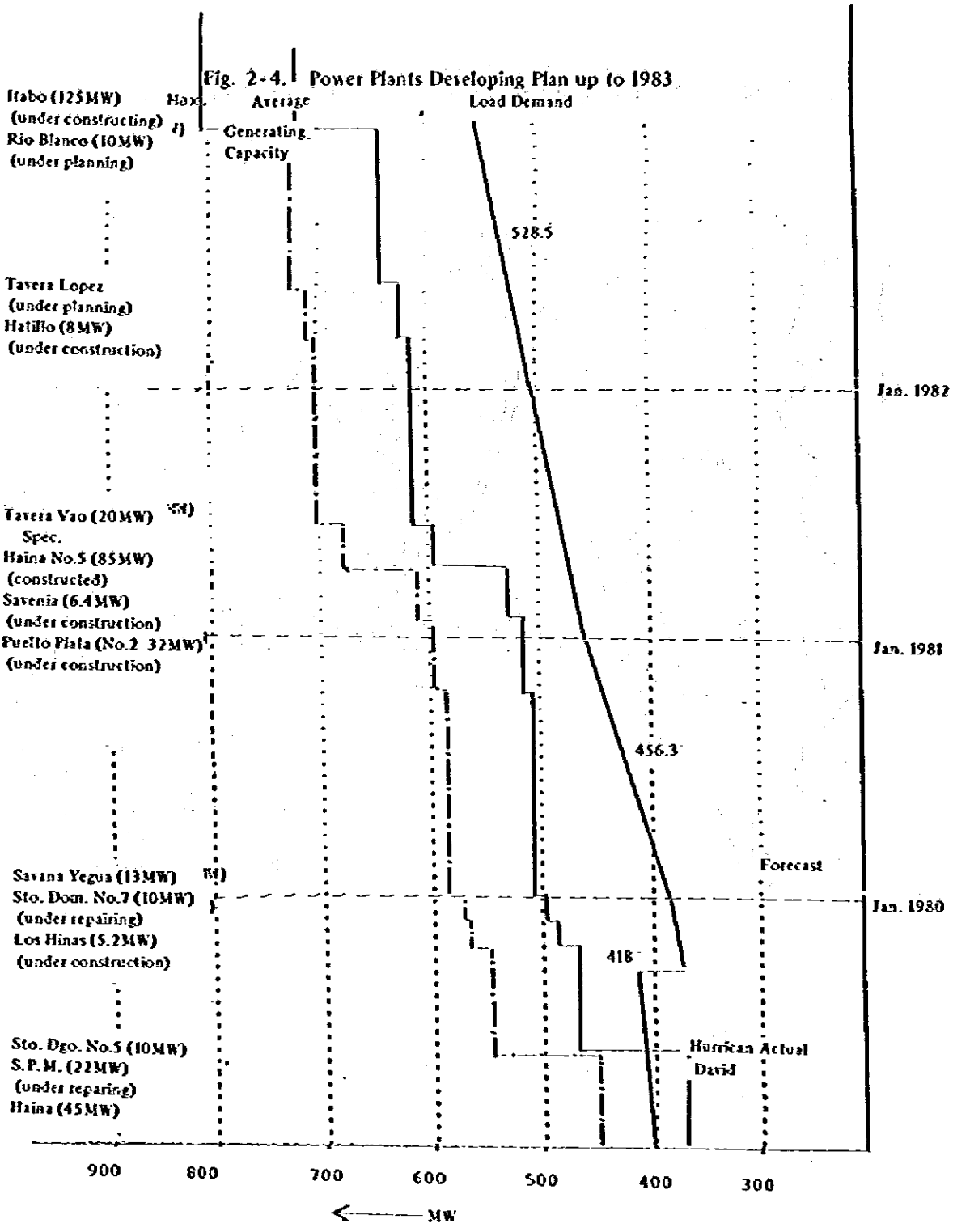


Fig. 2-4. Power Plants Developing Plan up to 1983

Chapter 3. Outline of Santo Domingo City and Power Situation

3-1. Outline of Santo Domingo City

Santo Domingo City, where the population of the urban area reached 1,040,000 in 1977, has rapidly expanded as the capital city in the past 20 years. Santo Domingo is the place where Columbus expedition fleet made a first port call when he discovered America and the present city was built as a base for Spain's overseas activities. Since the population of the urban area is expected to grow at an annual rate of 4.23% by immigration from local areas and natural growth, the population of the city in 1990 is estimated at 2,350,000 (Refer to Table 3-1).

Table 3-1. Population and Number of Families in Santo Domingo City

	1977	1978	1980	1985	1990
Total Population in Santo Domingo City	1,044,979	1,112,171	1,259,795	1,720,363	2,349,311
No. of Families	205,300	218,501	247,504	337,989	461,554

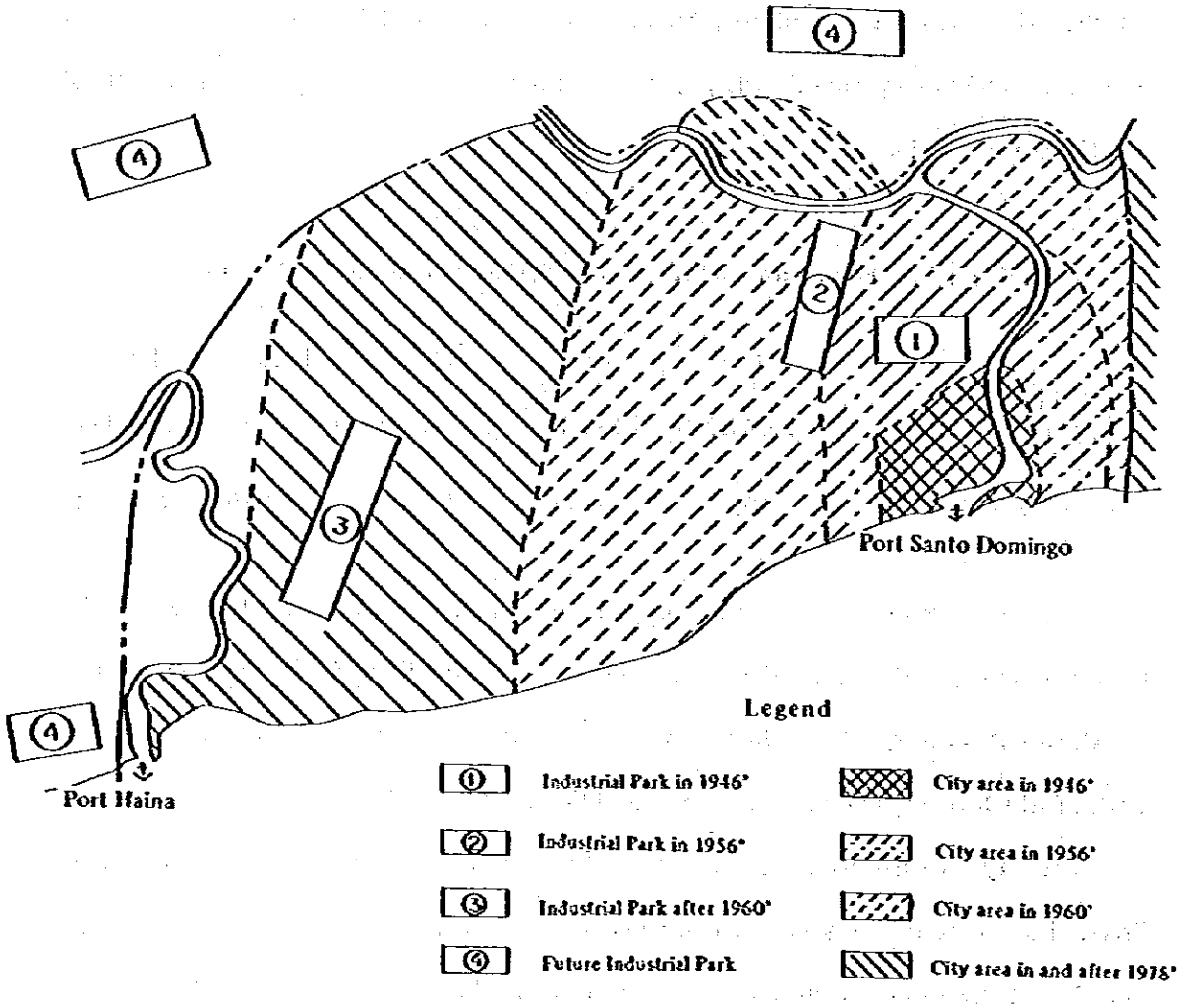
The Ozama River runs in the east of the city and the Isabela River, a tributary of the Ozama, cuts across the north of the city. In the west is the Haina River. At the mouth of the Ozama River is Port Santo Domingo and at the mouth of the Haina River is Port Haina, both of which are capable of berthing the 10,000 ton class vessels.

The city area has been expanding toward west and north-west as shown in Fig. 3-1. Private homes are generally one or two story building but the apartment buildings recently built have three stories or more reflecting the rising land price in the city area. Most of the high rise building in the city are government buildings or hotel buildings.

Approximately 60% of the manufacturing industry of the country are concentrated in the city. Industries operating in the city are petroleum, cement, chemicals and arc-furnace factories.

Transport facilities of the city includes buses and taxis, and complete trunk motor ways are provided from the central part to the western region.

Fig. 3-1. Map of the Process of Development in Santo Domingo City



The area along the bank of the Ozama River, especially the northern district and the north-western suburbs, is densely populated by imigrants from local areas. In the future, the residential area is expected to expand to the north-western suburbs and the district north of the Isabela River.

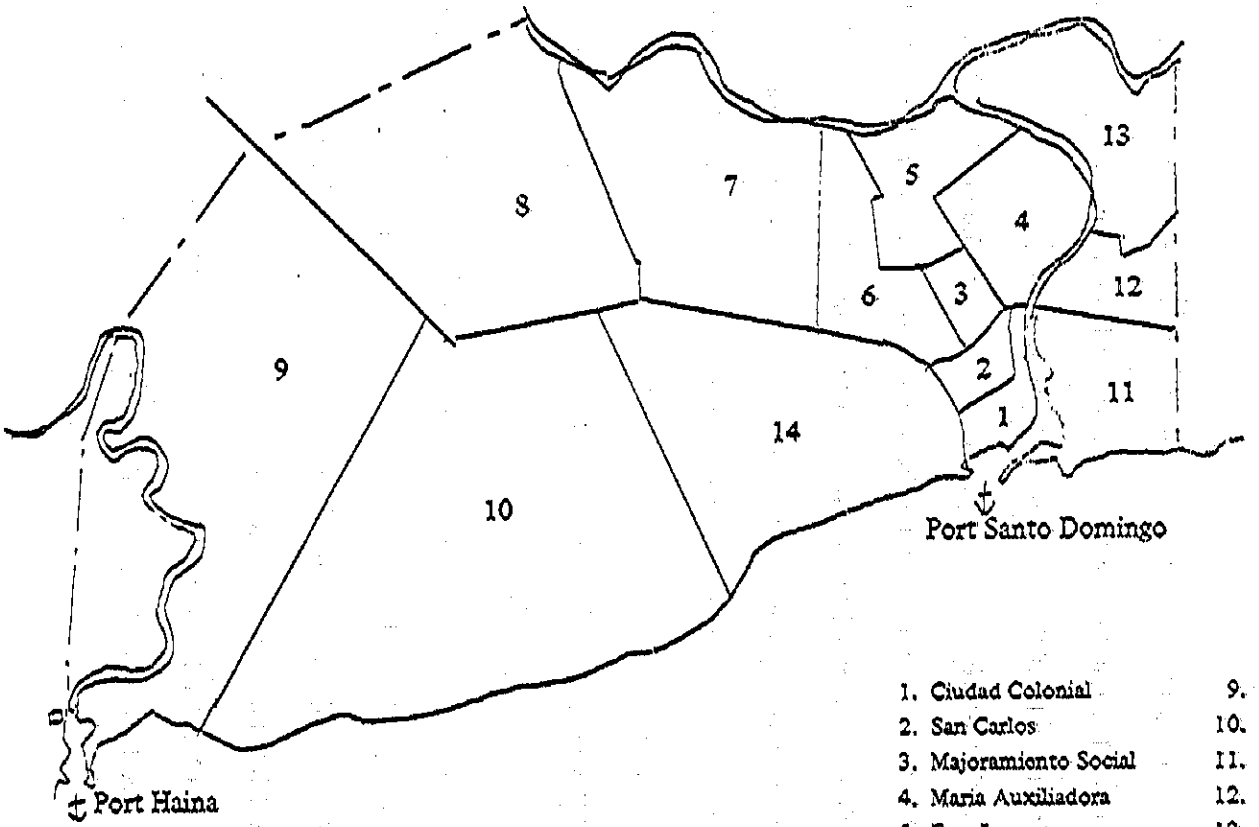
The city planning of Santo Domingo calls for the construction of a great loop road, starting from Port Haina, detouring the north of the Isabela River and reaching the Haina-mosa district in the north of the east bank of the Ozama River.

The population of city area of Santo Domingo is 1,040,000 as of 1977. An annual growth of 4.3% by natural increase and immigration is expected. It is said that apporxi-mately 60,000 families (250,000 persons) live in the residential area of the middle class or above and the low-income class families who have immigrated from local areas and con-centrated on the area along the banks of the Ozama River are estimated at about 130,000 families (750,000 persons).

The present condition and problems of each district of the city are summarized in Table 3-2 (Also refer to Fig. 3-2).

It is known from the table that there is little room for development in the old city center which corresponds to districts 1, 2 and 3. While there is need for redevelopment in districts 4, 5, 6 and 9 where the immigrants from local areas have made uncontrolled devel-opment of the land, the population is nearing saturation. District 7, 8, 10 and 14 have great potentialities for develpoment as residential areas. Besides, districts 11 and 12 in the east and their vicinities have also potentialities for development in the future (Refer to Fig. 3-3).

Fig. 3-2 Map of District No. in Santo Domingo City



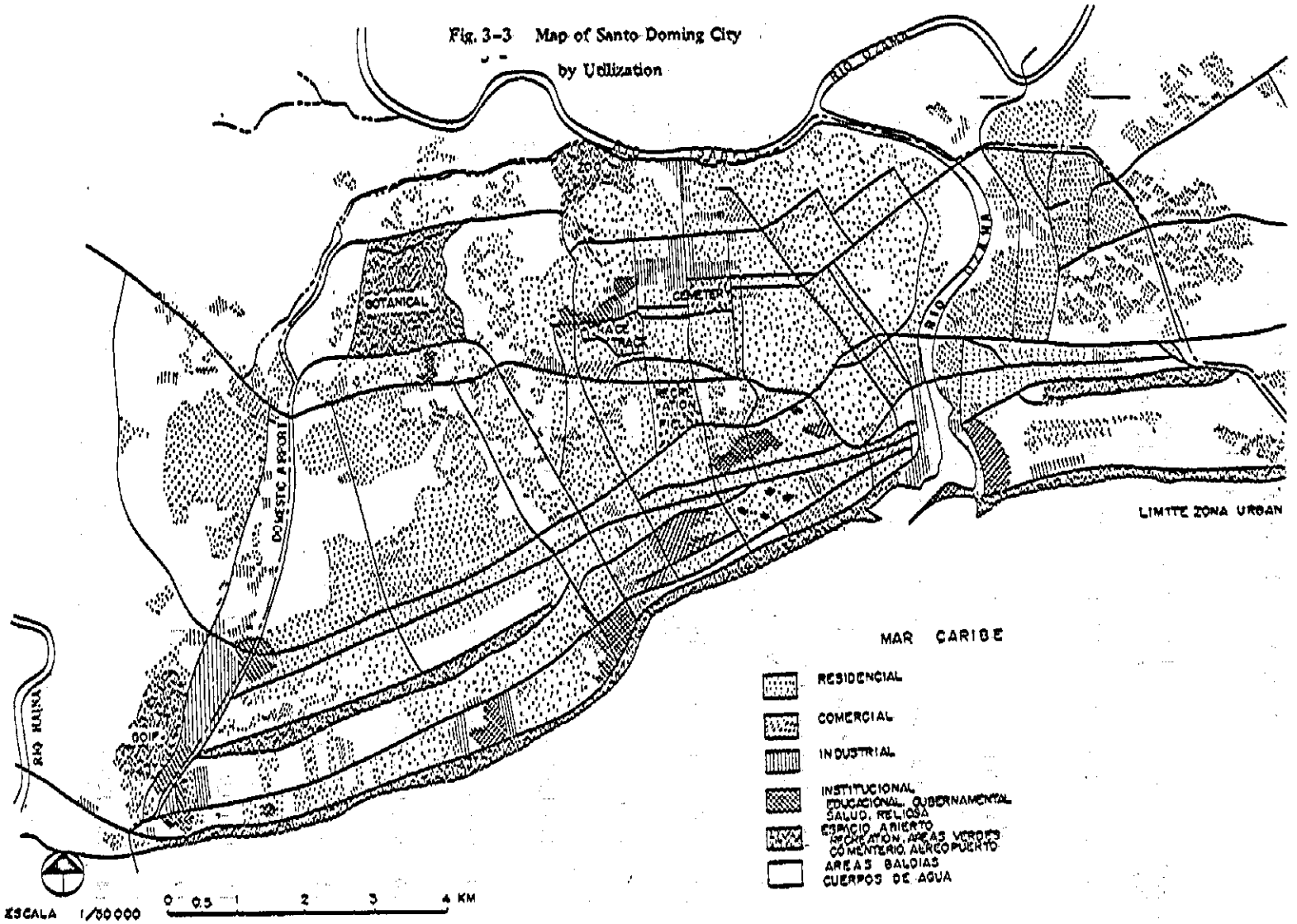
1. Ciudad Colonial
2. San Carlos
3. Majoramiento Social
4. Maria Auxiliadora
5. Ens. Luperon
6. Villa Consuelo
7. La Fe
8. Los Jardines
9. Costa Verde
10. San Jeronimo
11. Villa Duarte
12. Ens. Ozama
13. Los Minas
14. Mira Flores

Table 3-2 Status Quo of Santo Domingo City

(In 1978)

No. in Map	Name	Density of Population	Expected inc. of Population	Problems	Use of Land for
1	Ciudad Colonial	175/ha.	No increase	Keep Old Build.	Resid. Office Shop. Hist. Building.
2	San Carlos	324/ha.	–ditto–	Need to Rebuild resid.	Mainly Resid. Park, Shop.
3	Majoramiento Social	338/ha.	–ditto–	–ditto–	Resid. Hospital, Market
4	Maria Auxiliadora	214/ha.	Increase	–ditto–	Mainly Residence
5	Ens. Luperon	N. 324/ha. S. 199/ha.	North Increase South No	–ditto–	Residence, Market.
6	Villa Consuelo	196–233/ha.	North Increase	–ditto–	Medium Industry, Residence
7	La Fe	34–77/ha.		Future Development of Resid.	Resid., Park, Industry
8	Los Jardines	6/ha.	Hilly Land	–ditto–	Botanical Garden
9	Costa Verde	very few		Same to No. 2	Residence, Industry
10	San Jeronimo	7–53/ha.	Undeveloped	Same to No. 7	Residence, Office, Indust.
11	Villa Duarte	37/ha.		–ditto–	Residence, Park, Indust., Sight Seeing
12	Ens Ozama	74/ha.		–ditto–	Residence
13	Los Mina	114/ha.	Private Dev.	Same to No. 2	Residence, Shop
14	Mira Flores	22–53/ha.	Future Apartment House	Same to No. 7	Resid., Office, Sports Fac.

Fig. 3-3 Map of Santo Doming City
by Utilization



3-2. Power System in Santo Domingo City

1) Summary

The Santo Domingo power station (also called Timbeque PS) with a capacity of 114.1 MW, located on the west bank of the downstream of the Ozama River, was the main power station to supply power to the city in the past. Recently, however, a new power station (Haina PS) has been constructed at the mouth of the Haina River in the western part of the city to cater to the expansion of power system resulting from the rapid expansion of city area and sharp increase of population and is now the main source of power supply to the city with an output of 277.8 MW. While the 69 kV transmission lines interconnect the Haina PS and the Timbeque PS by way of the Palamara switching station in the north and substations in the city area, these transmission lines are branched to a number of distribution substations and are not fully displaying their ability as interconnecting lines. The 4.2 kV distribution lines cover only the Colonial district in downtown serviced by the Timbeque PS and the central coastal area serviced by the Feria substation.

2) Transmission Lines

Transmission lines in Santo Domingo City are the 69 kV 3 phase 3 wire 60 Hz system and have a total length of 80 km.

Supporting structures are all wooden poles except the two steel towers used for one span to cross the Ozama River in the eastern part of the city (Refer to photos).

Conductor used are 477 MCM (242 mm^2) ACSR and 559.5 MCM (282 mm^2) AASC. Besides, 1/0 (53.5 mm^2) Cu, 2/0 (67.3 mm^2) Cu and 4/0 (107.2 mm^2) are used in part.

The suspension type insulators are used for long span poles and large angle poles and the line-post type insulators are used for all small angle and tangent poles.

Table 3-3 shows details of 69 kV transmission lines by section and Fig. 3-4 is a route

map of 69 kV transmission lines.

Problems of the existing 69 kV transmission lines are as follows.

(1) As shown in the route map, one circuit system is used for the entire area of the city except the Timbeque-LA 40-Arroyo Hondo-Palamara section. Since the transmission lines form a loop in most sections, there is not much problem for the reliability of power supply to substation. However, in the case of Metropolitano, Penson and La Feria substation which receive power with only one circuit, power outage lasts for a long time whenever there is any fault in the transmission line.

(2) Since the power stations in Dominican are interconnected by 69 kV lines, the power system is unstable and needs to be strengthened. As a step to reinforce the power system, construction of 138 kV transmission lines interconnecting the main stations has been planned and part of the system has already been completed and operated at 69 kV.

(3) The 69 kV transmission lines use PC (Peterson coil) grounding system, and installation of additional PC will be required with the expansion of the 69 kV system in the future. As a measure to cope with the situation, conversion to the effective grounding system is being considered.

3) Substations

Eleven substations with transformers having a total capacity of 345.7 MVA are supplying power to Santo Domingo City (including distribution transformers at Timbeque PS).

Substation transformers are natural air/forced air cooling type of the US standard. Most of them have a unit capacity of 14 MVA and 22.4 MVA, with the average capacity being 15.7 MVA.

Problems of substations are as follows.

(1) Power fuses are being used instead of circuit breakers on the 69 kV receiving terminal in many substations. This makes disconnecting of the fault section difficult in the case of

a system fault.

However, this problem will be solved in the future since the installation of circuit breakers being planned together with the conversion of grounding system mentioned in the section of transmission lines.

(2) Of the 22 main transformers, 12 are equipped with on-load tap changers (OLTC). In the section where OLTC is not provided, distribution lines are equipped with a voltage regulator, except some portions. Feeders without voltage regulator should be provided with such equipment.

Table 3-4 is a summary of substation transformers.

Fig. 3-4 Map of Specified Area
Corporacion Dominicana de Electricidad
Santo Domingo

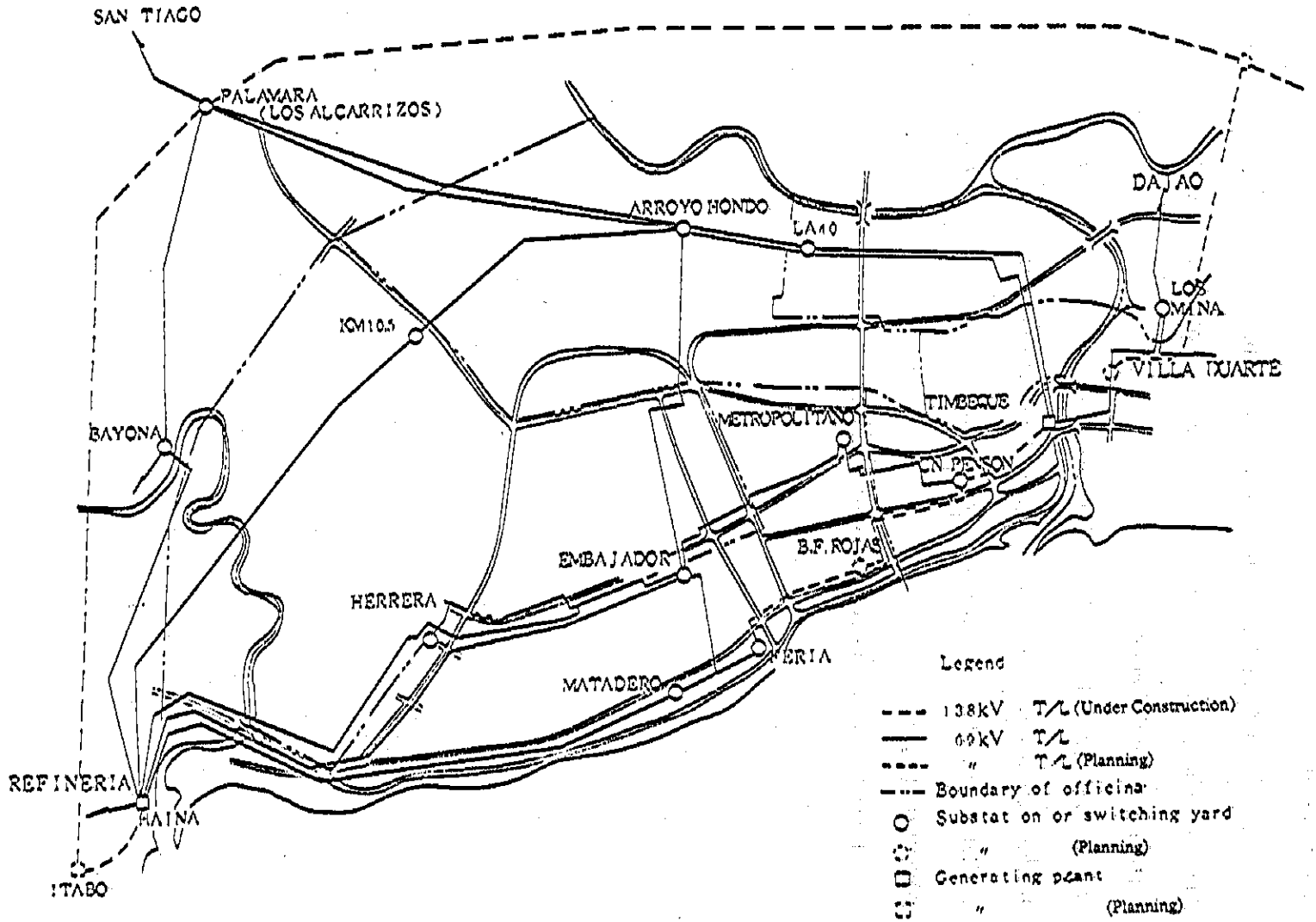


Table 3-3. The Existing Transmission Lines

BUS From	BUS to	Length (km)	Base (kV)	Conductor		Thermal Rating Amperes
				Size in MCM	Type	
Haina	KM 10.5	9.0	69	477	ACSR	605
〃	Herrera	6.0	〃	〃	〃	〃
〃	Matadero	7.8	〃	559.5	AASC	〃
Matadero	Embajador	2.0	〃	〃	〃	〃
Embajador	Herrera	4.5	〃	477	ACSR	〃
〃	Metropolitano	4.3	〃	〃	〃	〃
Metropolitano	C. N. Penson	3.3	〃	〃	〃	〃
KM 10.5	Arroyo Hondo	5.15	〃	〃	〃	〃
Arroyo Hondo	Timbeque	8.05	〃	1/0	Cu	295
〃	LA 40	2.576	〃	2/0	〃	345
LA 40	Timbeque	5.474	〃	〃	〃	〃
Timbeque	Los Mina	3.36	〃	4/0	AAAC	330
Embajador	Arroyohond	6.6	〃	477	ACSR	605
Matadero	La Feria	2.3	〃	1/0	Cu	295
Haina	Embajador	10.5	〃	477	ACSR	605
	Total	80.91	〃			

Table 3-4. The Existing Substation Transformers

Substation	Number of Bank	manufac-turer	Class	Voltage Rating	capacity (MVA)	MVA Rating			LTC	Remarks
						OA	FA	FOA		
Timbeque	1	G. E	OA/FA	67000-4160Y/12700Y/7200	14.0	10	12.5-14	—	—	
	2	〃	OA/FA/FOA	〃	22.4	12	16	20-22.4	—	
	3	W. H	OA	69000Y/12470	13.0	15	—	—	—	
	4	G. E	OA/FA/FOA	67000-12470Y/7200	28.0	15	20	25-28	—	
Los Mina	1	G. E	OA/FA/FOA	67000-12470Y/7200	22.4	12	16	20-22.4	—	
	2	〃	OA/FA	〃	14.0	10	12.5-14	—	13717-11223 V	
LA 40	1	G. E	OA/FA/FOA	67000-12470Y/7200	22.4	12	16	20-22.4	—	
	2	〃	OA/FA	〃	9.37	7.5	9.37	—	13717-11223 V	
Metropolitano	1	W. H	OA/FA	67000-12470Y/7200	14.0	10—12.5	12-14	—	14974- 9976 V	
	2	〃	〃	〃	〃	〃	〃	—	〃	
	3	G. E	〃	〃	〃	10	12.5-14	—	—	
C. N. Penson	1	G. E	OA/FA	67000-12470Y/7200	14.0	10	12.5-14	—	13717-11223 V	
	2	W. H	〃	〃	〃	10-12.5	12.5-14	—	14976- 9976 V	
Arroyo Hondo	—	G. E	OA/FA	67000-12470Y/7200	14.0	10	12.5-14	—	13717-11223 V	
Embajador	1	G. E	OA/FA/FOA	67000-12470Y/7200	22.4	12	16	20-22.4	—	
	2	〃	OA/FA	〃	14.0	10	12.5-14	—	—	
Matadero	—	G. E	OA/FA/FOA	67000-12470Y/7200	22.4	12	16	20-22.4	—	
LA. Feria	—	〃	OA/FA	67000-4160Y/2400	10.5	7.5	9.375-10.5	—	4576- 3744 V	
KM 10.5	1	ASEA	ONAN/ONAF	67000-12470	14.0	10	14	—	77060-56940 V	
	2	SIMENS	OA	67000-12550	7.5	—	—	—	13557-11542 V	
Herrera	1	W. H	OA/FA	67000-12470Y/7200	14.0	10-12.5	12-14	—	13717-11223 V	
	2	SIMENS	OA/FA	67000-12470	9.375	7.5	9.375	—	13557-11542 V	
Total					22 units 345.745					

3-3. State of Distribution Lines and Problems

1) State of Distribution Lines

High voltage distribution lines are 3 phase 4 wire direct grounding system. Two voltages of 12.5 kV and 4.16 kV are being used in mixture but the 4.16 kV system is being uprated to the 12.5 kV system if occasion offers. The number of high voltage feeders coming from 11 substations is 46. While most of high voltage feeders use the 4 wire horizontal arrangement, part of the newly constructed feeders adopts the triangle arrangement using line-post insulators, which requires only a narrower right of way. In the city area, high voltage distribution lines and 69 kV transmission lines use a common pole (are attached to the same pole) in many sections. Low voltage lines are 120/240 V lines and are drawn to each consumer separately from the pole, with Wh meter provided at a high place of service entrance of the house or on the service pole.

2) Problems of Distribution Lines and Remedies

a) High Voltage Lines

i) Distribution Voltage

In Santo Domingo City, there are 46 high voltage distibution feeders. Because of two voltage systems — 12.5 kV and 4.16 kV — load transformer is not possible between systems in case of a system failure. Besides, there is need to provides two types of pole transfonners and other equipment. This must be said a great disadvantage from the viewpoint of system operation.

38 feeders ..... 12.5 kV line

8 feeders ..... 4.16 kV line

(6 feeders from Timbeque ss serve the Colonial district and 2 feeders from Feria ss serve coastal areas).

ii) Voltage Drop

Despite the short length of a feeder, which is 4.5 km on the average, 12 feeders out of 46 feeders (26%) had a voltage drop exceeding 6% as of February 1980 because of large load current on the 4.16 kV lines (Refer to Fig. 3-5).

Since the annual increase of load is expected to exceed 10% in the near future, the number of feeders with a voltage drop exceeding 6% will be increased by about 10 in one or two years.

iii) Loss Rate

The loss of energy calculated from the actual load of feeders in February 1980 amounts to 48 GWh, which is equivalent to about 3% of the total energy at the sending end of distribution lines. The loss rate of distribution lines in Fukuoka City, Japan, which resembles Santo Domingo City in size and population, is only 0.8% despite the fact that the rated voltage of distribution lines is 6.6 kV. The loss rate in Santo Domingo City is about 3.75 times that in Fukuoka City by simple comparison (Refer to Fig. 3-6).

This large loss rate may be attributed to the following.

a. Conductor size is too small for the load.

b. The length of single phase load line accounts for nearly 30% of the total length of H. V. distribution lines and a large unbalanced current constantly flows in the system (Refer to Table 3-5).

c. Because of the difference in the size of service areas, there is a considerable variation in feeder current.

iv) Reliability of Power Supply

Although a definite conclusion cannot be made due to lack of reliable statistics of distribution system faults for the whole city area, the rate of system fault is abnormally

Fig. 3-5 Percent Voltage Drop

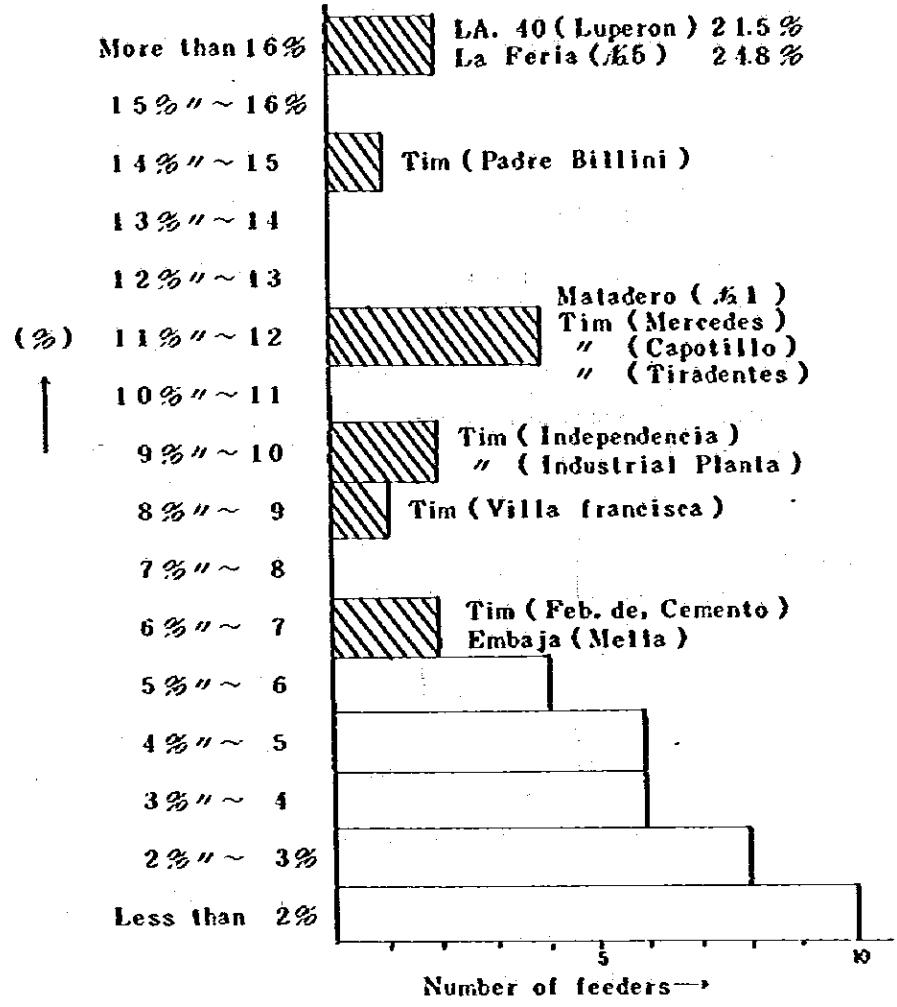


Fig. 3-6 Percent Loss

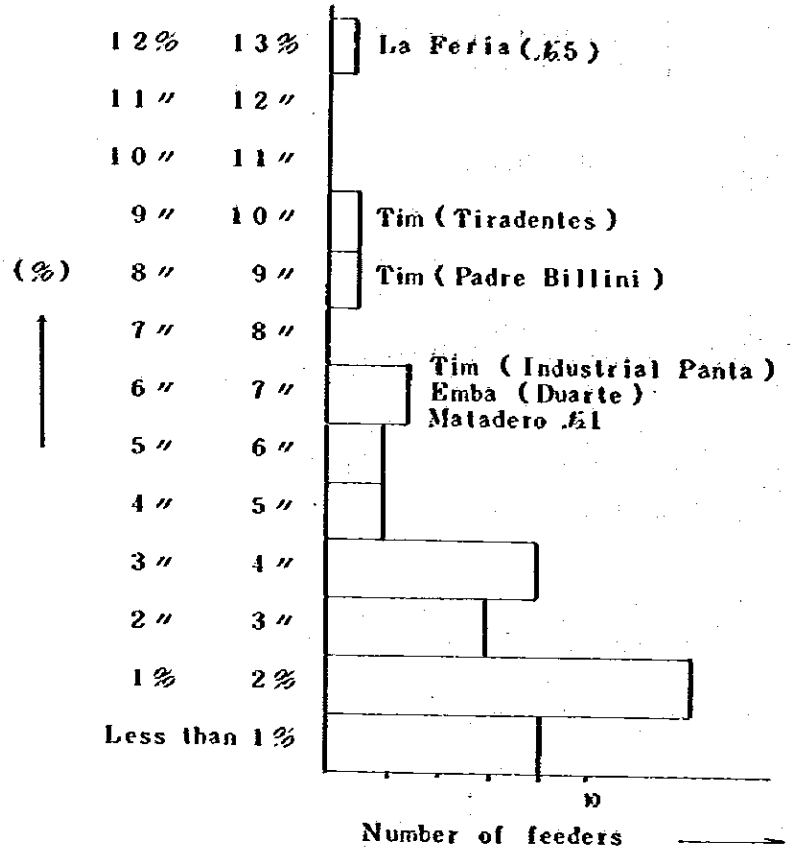


Table 3-5 Real State of High Voltage Distribution Lines in Santo Domingo City (In January 1980)

Name of Substation	No. of feeders exceeded unbalance ratio 0.2	Feeder's current	
		Max. (A)	Min. (A)
Los Mina	2/4	390	60
Timbeque	6/14	880	40
C. N. Penson	2/4	370	30
La 40	1/4	510	240
Metropolitano	1/4	520	20
Embajador	3/4	480	310
Matadero	0/2	310	300
La Feria	1/2	760	500
Arroyo Hondo	2/2	320	180
KM 10.5	2/3	326	150
Herrera	2/3	400	200

Note: Unbalance ratio = $\frac{\text{Max. phase current} - \text{Min. phase current}}{\text{Min. phase current}}$

high judging from the high operating frequency of circuit breakers. Even when the operating frequency of CB for load shedding, maintenance work and test and adjustment is taken into account, the operating frequency of CB for fault is estimated at more than 100 times in a year, which is higher than that in Japan by several tens.

		1975 – 1979 No. of CB Operation	No. of CB Operation / Year	Remarks
Metropolitano	A	650	162	
	B	950	237	
Kyushu (Japan)		—	0.67	No. of faults 1,726 No. of feeders 2,548

While major causes of the system fault cannot be determined, it is assumed that the fault is largely due to salt contamination, lightning, wind and rainfall. (Poor workmanship, incomplete conductor joint, for example, may also be considered as major reasons.)

b) Pole Mounted Transformers and Other Distribution Facilities

i) Low Voltage Lines

The conductor size of low voltage lines is too small in general. In many cases, #4 and # 6 Cu cables are used. For insulation cover, cross-linked polyethylene, which is too expensive for low voltage, is used. The low cost vinyl chloride insulated conductor is considered sufficient for this purpose.

ii) Pole Mounted Transformers

The total capacity of pole mounted transformers is approximately 390 MVA against 220 MW of peak sending kW demand of substation for the whole area of Santo Domingo City. This means the utilization rate of pole mounted transformers is only

56%. The rate in Fuluoka City, Japan, which resembles Santo Domingo City in many respects, is 111% (MW demand/installed capacity MVA = 439/395 = 1.11). This big difference between the two cases is due to the fact that in Japan a 160% overload against the rated capacity is permitted for a few hours every day. If CDE allows overload only for a short time at peak load which is mainly a load for lighting, the utilization rate of pole mounted transformers may be improved considerably.

iii) Service Wires

The condition of service wires is such that in many cases wires are in contact with trees and are laid on fenses or roofs. Under such conditions, wires are easily blown by wind and rubbed, with the resultant damage to the insulation cover. This will lead to frequent line faults and may be hazardous to personal safety. To improve this situation, the following measures should be considered.

- o Clearing of trees in the right of way
- o Relocation of service wire
- o Installation of protection fuses

iv) Stealing of Electricity and Remedies

Stealing of electricity is frequent in the densely populated area on the banks of the Ozama river, where many immigrants reside, and in the western and northern suburbs. They lay wires from the low voltage support located several tens meters away to their homes in their own ways to steal electricity. These private wires are tied to a nearby tree or supported by a piece of wood. Some wires are drooping about one meter above the ground, which are sometimes used as cloth hangers. This is very dangerous for personal safety.

In the slum area surveyed by the study team, there was a fire about a week ago, which destroyed some 40 homes. It was said at that time that the fire might have been

caused by a short circuit of private wires which came in contact with a tin roof. Improvement of facilities is very important also from the standpoint of ensuring personal safety.

To prevent stealing of electricity, necessary legal procedures and education of the residents would be most important. The following measures should be taken for prevention of stealing of electricity and for personal safety.

- o High voltage distribution lines and pole mounted transformers in the slum area should be expanded and modernized to suit the environment of existing residential area.
- o Insulated conductors should be used for low voltage feeders to standardize the system.
- o kWh meters should be provided for all households at the expense of CDE and meter inspection and billing should be implemented.

c) Setup for Maintenance of Facilities

i) Planning

The quantity of distribution facilities increases in proportion to the increase of power demand. In principle, planning for construction should be based on a long-term vision. In the absence of basic data, however, planning should start with the proper assessment of the present situation. In this sense, substantiation of the Planning Section (increase of manpower and improvement of skills of personnel) will be of the prime importance.

ii) Performance of Workmen

The way conductors are joined is extremely poor. Joints of copper wires are especially bad and joints by hand winding are frequently observed. Workmen should be trained on the use of connectors.

iii) Improvement of Meters and Instruments and Establishment of Monitoring System

It is extremely difficult to determine actual power demand from observations at fewer frequency and at the limited number of observation stations because of different system operating conditions and load fluctuations depending on consumers.

Since the requirement for facilities increases with the growth of power demand, efficient investment for facilities is very important. In this sense, efficient and reliable instruments should be provided for transmission and distribution lines to establish a complete monitoring system.

Chapter 4. Demand Forecast for Urban Areas of Santo Domingo City

4-1. Load Forecast

A long-term load forecast was made by the French Consultant SOFRELEC in 1978 at the request of CDE, which is revised every year on the basis of actual figures.

The forecast was made for the whole country and for districts (the country is divided into 5 districts). The load forecast was made on the basis of the coefficient of correlation between the gross national product (GNP) and actual power demand with consideration given to the movement of population and future trends of GNP. The load forecast for districts also takes into account the actual demand of the past, social conditions of each district and the trend of consumer type.

Actual figures and forecast of gross national product (GNP) of the country is shown in Table 4-1 and 4-2. Statistics show that the compound average growth rate of GNP was 6.5% during the period from 1960 to 1977, while the average growth rate for the period from 1988 to 1991 is estimated at 7.8%.

The GNP which was RD$ 2265 × 10^5 in 1977 is expected to grow to RD$ 6968.6 × 10^6 in 1992, on increase of 3.1 times over the figure in 1977.

Power demand for the country forecast by SOFRELEC on the basis of the above figure is shown in Table 4-3. In this forecast, the load, which was 1.66 billion kWh in 1979, is estimated to grow to 3.24 billion kWh in 1985 and 7.61 billion kWh in 1992. The compound growth rate for the 1979-1985 period is 11.8%/year and that for the 1985-1992 period is 13.0%/year.

By consumer type, power consumption in rural area has been increasing with the progress of rural electrification. However, there is no remarkable change in the share of residential, industry, and commercial in the total demand.

Table 4-1. Producto Bruto Interno .... PBI 1960 ... 1977
(Amount of National Production) Unit ... 10^6 RD$

Year	1960	1964	1968	1970	1974	1977
PBI	775.6	1,008.3	1,037.1	1,272.5	1,894.8	2,265.0

Note: From SOFRELEC Demand Forecast

Table 4-2. Producto Bruto Interno Forecast 1980 ... 1992
Unit ... 10^6 RD$

Year	PIB Total	PIB Industry	PIB Agriculture	PIB Commercial
1977	2,265.0	402.0	412.0	408.0
1980	2,882.3	575.4	509.4	504.5
1982	3,384.7	730.7	586.9	581.2
1985	4,203.5	1,041.6	691.6	684.9
1988	5,220.3	1,484.8	814.9	807.3
1990	6,031.4	1,880.6	909.2	900.3
1992	6,968.6	2,381.9	1,014.3	1,004.4

Note: From SOFRELEC Demand Forecast

Table 4-3. Forecast of Power Demand: Whole Country by Consuming Categories

Unit: 10^6 kWh

Year	1979	1982	1985	1990	1992
Residential	459.6	658.3	922.1	1,675.1	2,152.2
Commercial	200.0	272.7	384.9	694.5	883.7
Industry	621.1	831.8	1,232.4	2,313.5	2,959.4
Government	144.1	173.6	214.7	308.3	357.0
Rural	204.9	312.8	483.8	967.7	1,261,2
Grand Total	1,665.8	2,249.1	3,238.1	5,959.0	7,613.5
Average rate of increase (%)	..... 11.8%/Y			..... 13.0%/Y	

Note: From SOFRELEC Demand Forecast

4-2. Study of Actual Load for Santo Domingo City

1) Changes in Consumer Types

Changes in the number of consumers by type up to July 1979 are shown in Table 4-4.

Table 4-4. Number of Consumers by Categories of Demand
From 1974 to 1979

	Residential	Commercial	Industry	Government
1974	82,820	9,510	673	912
1975	82,978 (1.00)	9,821 (1.03)	711 (1.05)	987 (1.08)
1976	82,671 (0.99)	10,311 (1.05)	770 (1.08)	1,005 (1.02)
1977	86,073 (1.04)	10.936 (1.06)	871 (1.13)	1,029 (1.02)
1978	91,881 (1.07)	11,576 (1.06)	890 (1.02)	1,068 (1.04)
1979	116,598 (1.27)	13,968 (1.21)	1,641 (1.84)	5,329 (4.99)

Note: The figures in the parentheses show the rate of increase in % against that of the previous year respectively

For each consumer type, the number of consumers increased remarkably in 1979 as compared with previous years. The increase rate of industry and govenment is especially noteworthy. The increase in the government sector reflects a great stride in the improvement of street lights. Of the total 1,441 industrial consumers, 1,213 consumers (74.0%) consume less than 30,000 kWh per month and most of them are small consumers operating small motors with an average power consumption of less than 11 kW. The sharp increase of small industrial consumers in 1979 is due to the availability of sufficient power and the government policy for promotion of local industries.

2) Propensity of Monthly Power Demand

Changes in monthly energy demand by consumer type up to July 1979 are shown in Table 4-5.

Since the expansion of power generating facilities in 1977, power consumption by various consumer types has increased all at once. However, the 1979 statistics shows that the increase rate of residential use was only 1.04 times over the previous year, while the increase rate for other consumer types was remarkable, with the government use showing

Table 4-5. Monthly Power Demand from 1974 to 1979
('74 . . . '78: August, '79: July) Unit: 10^6 kWh

Year	Residential	Commercial	Industry	Government
1974	20.3	6.8	27.9	4.6
1975	21.3 (1.05)	7.3 (1.07)	27.8 (0.99)	4.8 (1.06)
1976	18.1 (0.85)	5.9 (0.80)	25.9 (0.93)	3.8 (0.79)
1977	26.1 (1.44)	9.7 (1.65)	34.9 (1.34)	5.6 (1.48)
1978	27.7 (1.06)	10.3 (1.06)	38.5 (1.10)	5.4 (0.96)
1979	28.8 (1.04)	15.7 (1.53)	61.7 (1.60)	16.1 (2.99)

Note: The figures in the parentheses show the rate of increase or decrease as against that of the previous year, respectively.

an outstanding growth rate of nearly three times. As a result, the share of residential use in the total consumption decreased from 33.8% in 1978 to 23.5% in 1979.

4-3. Forecast of Annual Energy Demand

The forecast annual energy demand for urban areas of Santo Domingo City made by SOFRELEC is shown in Table 4-6. According to the table, the ratio of government sector in energy demand is decreasing little by little annually, while the ratio of residential, commercial and industry do not show major changes in each year. The total demand in the residential and commercial sectors nearly equals to that in the industrial sector.

On the other hand, the energy demand in Santo Domingo City, which accounted for 56% of the total energy demand in the country in 1979, is expected to decrease annually and the ratio is expected to decrease to 54.0% in 1985 and 53.1% in 1992.

This forecast, however, is for urban areas of Santo Domingo City and also covers the load in the north and west districts, into which the city is expected to expand in the future, and which is not included in the project. It is important, therefore, to take into account this point in forecasting energy demand for existing urban areas of the city which will be

Table 4-6. Demand Forecast for Urban Area of Santo Domingo by Categories of Demand Unit: 10^6 kWh

Year	1979	1982	1985	1990	1992
Residential	303.3	407.8	578.1	1,064.9	1,374.0
Commercial	131.3	184.1	266.0	495.0	636.4
Industry	438.8	573.0	828.2	1,516.9	1,928.4
Government	64.7	70.7	79.1	98.2	108.2
Total	938.0	1,235.7	1,751.4	3.175.0	4,046.9
Ratio to whole country Demand (%)	56.3	to 54.9	54.1	53.3	whole 53.1

Note: From SOFRELEC Load Forecast.

covered by the project after 1985.

1) Load Factor, Loss Rate and Number of Consumers

a) Load Factor and Loss Rate

Fig. 4-1 shows daily load curves by consumer type. Load factors by consumer type calculated from the load curve is shown in Table 4-7. Load factor for residential is 68% while that for industry is 83%.

According to SOFRELEC's forecast, the load factor for the entire system is assumed to be nearly constant up to 1992 (Refer to Table 4-8). Accordingly, the load factor by consumer type shown in Table 4-7 is expected to remain the same in the future.

The loss rate forecast by SOFRELEC is shown in Table 4-9. The transmission and distribution loss rate is assumed to decrease annually from 26.5% in 1980 to 16% in 1992.

The rate of stolen power included in the loss rate, which is assumed to be 6% in 1980, is expected to decrease to 1% in 1985. The net transmission and distribution loss is also expected to decrease from the original 20.5% to 15% in 1992, according to the CDE plan.

b) Estimation of the Number of Illicit Consumers

The power demand by residential consumer in the urban area of Santo Domingo City is considerably different from the average of other cities.

The number of small residential consumers using less than 50kWh per month accounts for 40.9% of the total number of consumers in the city but the actual power consumption by them accounts for only 5.3% of the total demand in the residential use. The number of consumers using less than 200kWh also accounts for 40.9% of the total number but the actual consumption by them accounts for only 28.8% of the total demand. The difference between the SOFRELEC data and actual figures are shown in Table 4-10. From the table, it is known that the percentage of large residential consumers in Santo

Fig.4-1 LOAD CURVES BY CONSUMMERS TYPE AND POWER LOSS

(Yearly average)

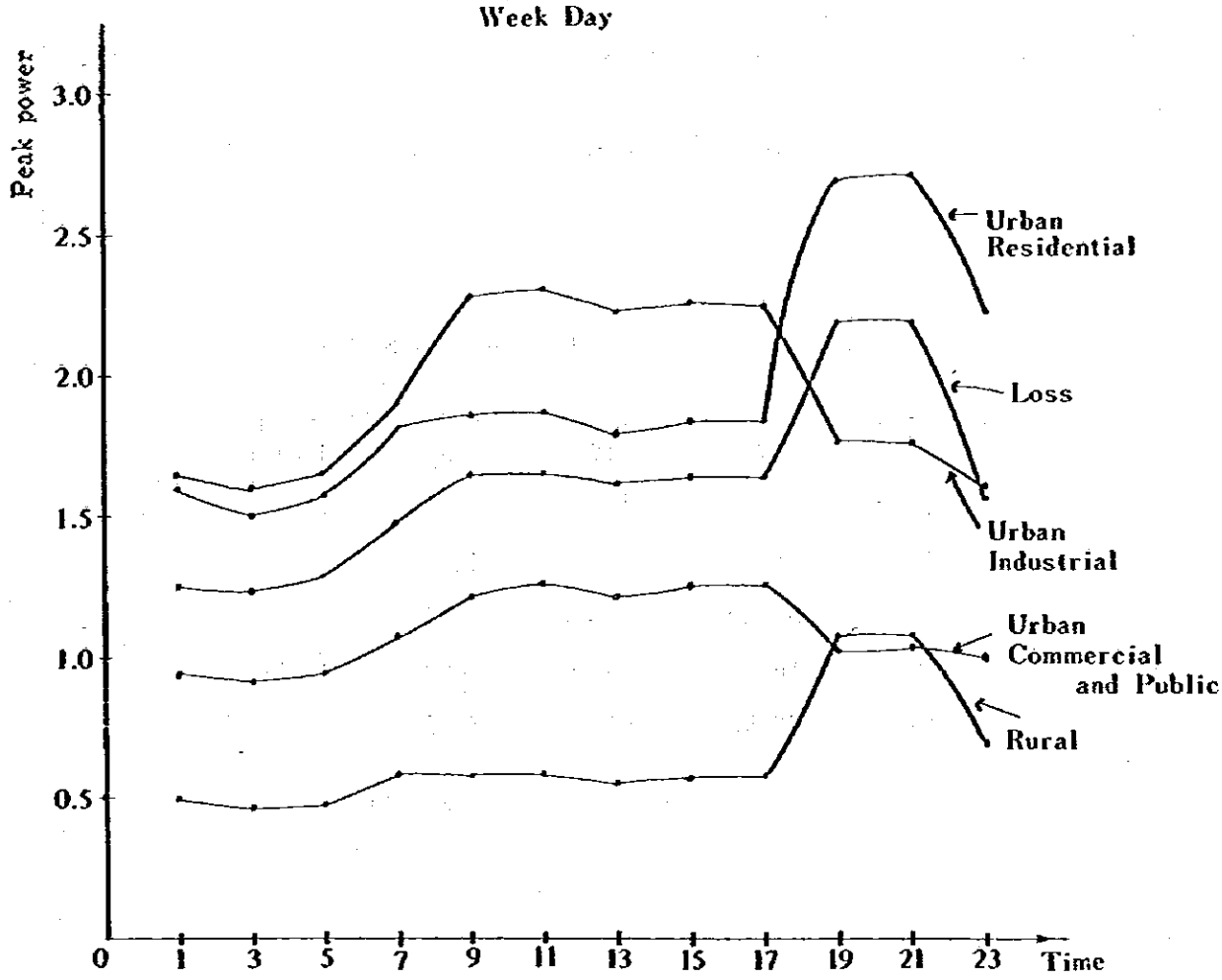


Table 4-7. Load Factor by Consuming Categories: Actual, Daily

	Evening	Day Time	Night	Load Factor
Residential use	0.27 (4 H.)	0.18 (12 H.)	0.15 (8 H.)	0.68
Industrial use	0.16 (4 H.)	0.225 (10 H.)	0.16 (10 H.)	0.83
Governmental & Commercial use	0.094 (4 H.)	0.125 (10 H.)	0.094 (10 H.)	0.714

Note: Power Demand Forecast by SOFRELEC

Table 4-8. Annual Load Factor in the System

Años	Energia (GWh)	Potencia (MW)	Horas (h)	Load Factor
1980	2478.9	456.3	5433	62.0%
1982	2883.3	528.5	5456	62.3%
1985	3982.0	728.0	5471	62.4%
1988	5669.7	1037.8	5463	62.4%
1992	9060.1	1660.8	5455	62.3%

Note: Power Demand Forecast by SOFRELEC

Table 4-9. Rate of Loss Energy

	Robes %	Red %	Total %
1980	6	20.5	26.5
1982	4	20.2	24.2
1985	1	17.7	18.7
1988	1	16.7	17.7
1990	1	15.7	16.7
1992	1	15.0	16.0

Note: Power Demand Forecast by SOFRELEC

Domingo City is greater than the average of other cities in the country.

Table 4-10. Distribution of Number of Houses and kWh Consumed in %

Type	Above 1000 kWh		1000..300 kWh		299..50 kWh		Less 50 kWh	
	No. of Con. %	Total MWh	No. of Con. %	Total MWh	No. of Con. %	Total MWh	No. of Con. %	Total MWh
Forecast by SOFRELEC '80	0.4	8.1	10.3	36.5	35.8	42.3	53.5	13.9
Jul., '70 Sto. Dgo.	4.5	37.2	13.5	28.5	40.9	28.8	40.9	5.3

Power consumption by illicit consumers is estimated at about 6% of the total energy demand of the country. The number of illicit consumers in Santo Domingo City may be checked by the following two approaches.

i) Estimated from Population Distribution by District

A comparison of the number of consumers by oficio estimated from the July 1979 consumer statistics by Ciclo and the estimated population distibution in 1980 contained in the city's long-term program is shown in Table 4-11. In oficio 1 and 8 where there are many new residential districts, the average number of family members is considered to be five, while in oficio 2, 3, 4, 5, 6, and 7, where two generations seem to live in one house in many cases, that is considered to be seven. If the number of families is considered to the number of consumers, the biggest difference between the number of families and the number of consumers provided with kWh meters is found in oficio 6 where the number of potential consumers exceeds 36,000. From this fact, it can be assumed that the total number of potential consumers exceeds 50,000 in the whole city.

Table 4-11 Comparison between No. of Elec. Consumer and No. of Family by Oficico, in Santo Domingo

Oficina	Resid.	Com.	Total (A)	Population 1980	No. of Family (B)	Balance (A-B)
1	11,340	692	12,032	63,304	12,660	- 628
2	19,637	4,109	23,746	171,817	24,545	- 800
3	20,730	2,747	23,477	166,756	23,822	- 350
4	17,868	2,730	20,598	171,861	24,551	- 3,953
5	7,776	720	8,496	82,230	11,747	- 3,251
6	11,061	930	11,991	332,443	47,491	-35,500
7	15,332	1,130	16,462	136,740	22,790	- 6,328
8	10,900	700	11,600	60,002	12,000	- 400
Total						-51,210

ii) Estimation from Income Distribution

Statistics of families by income level in Santo Domingo City for 1977 furnished by Banco Central is shown in Table 4-12.

The distribution rate of 179,905 families, the total number of families with incomes of more than RD$ 100 is shown in the lower line of the table (Families with incomes of less than RD$ 100 are considered to live with other families and are excluded from the table).

The distribution of residential and commercial consumers by amount of consumption for July 1979 is shown in Table 4-13.

Assuming the number of residential consumers using less than 50 kWh has increased by 50,000, the distribution rate of consumers by the amount of consumption shows a striking similarity with the distribution rate by income. In other hand, the number of potential consumers reaches nearly 50,000 also in this study.

Table 4-12. Number of Family by Incomes in Santo Domingo in 1977

Annual Income (RD$)	Up to ···100	100 ···300	300 ···700	800 ··1500	Above 1500
No. of Families	25,395	96,581	63,024	15,000	5,300
Ratio against to the Whole Families above RD$ 100/Year	-	53.7%	35.0%	8.3%	2.9%

Table 4-13. Number of Residential Consumers by Monthly Power Consumption in Santo Domingo in July 1979

	Less 50 kWh	Less 300 kWh	Less 1000 kWh	More 1001 kWh	Total
Residential	47,695	47,773	15,801	5,329	116,598
Commercial	3,894	3,350	(4,124)*	(2,600)*	7,244
Total	51,589	51,123	15,801	5,329	123,842
Ratio %	41.6	41.2	12.7	4.3	100.0
In case of 50,000 of Consumers using less than 50 kWh be added	101,589	51,123	15,801	5,329	173,842
Ratio %	58.4	29.4	9.1	3.1	100.0

Note: * Excluded from the table

ⅲ) Conclusion

From any of the preceding studies i) and ii), it can be assumed that the number of potential consumers reaches 50,000. The distribution of these potential consumers by oficio is considered to be that described in the preceding paragraph i). However, the power consumption by these potential consumers is included in distribution loss from substations and has no effect on load forecast by substation.

2) Estimation of Increase Rate of Power Demand by District

a) Changes in Power Demand by Substation Group

Changes in power demand at sending end of distribution lines at various substations in the city are show in Table 4-14. At the Timbeque, Metropolitano and C.N. Penson substations, which supply power to the old central town and the Colonial district, the annual increase rate was only 7.5% during the 1972-1976 period, which was the lowest rate in the city. Higher increase rate were recorded by the substation group including Embajador ss which supplies power to the western district and KM 10.5 ss which covers the northern district, with high increase rates of 17.5% and 17.1%, respectively.

Table 4-14. Change in Demand by Substation Group from 1972 to 1976 Unit: GWh at Sending End.

Group	1972	1973	1974	1975	1976	Ratio of Increase
Timbeque	272.8	248.7	242.1	266.5	265.8	Two Groups
Metropolitano & Penson	17.2	76.4	98.6	135.3	161.6	7.5%
KM 10.5	20.4	29.0	36.3	38.7	38.3	17.1%
La 40 & Arroyo Hondo	74.0	103.3	85.3	119.3	123.2	13.6%
Embajador, Matadeol & Herra	100.9	120.4	124.2	164.8	192.2	17.5%
La Feria	42.8	49.1	57.8	55.4	64.4	10.7%
Los Mina & Villa Duarte	62.7	68.3	79.1	89.5	91.1	9.8%
*Re-illustrate (Large Industry)	56.9	80.7	84.2	88.6	87.8	11.4% ('73..'76) (2.9%)
					Average	12.5%

b) Trends of Industrial Load

The fact that the growth rate of load for large industrial consumers during the 1973-1976 period was low at 2.9% may be an indication that the production capacity and operating rate of large industries in the city have reached the saturation point. In the case of Metaldom (arc furnace load), however, construction of additional factory buildings is under way as of March 1980. When the size of additional facilities is taken into consideration, it is certain that the power consumption by this industry will double by 1982. In the northern district of the city, there is a cement factory equipped with a long kiln. With the growth of the construction industry in the future, this long kiln of the cement factory will sooner or later be replaced with short kilns to increase cement production and power consumption by this factory is expected to double after 1985.

When the extent of housing and industrial development in the existing urban area of Santo Domingo City is taken into consideration, it is likely that the future industrial zones will be located in the western and northern districts which are not covered by the present project. For this reason, the new, large industrial loads were not included in the load forecast for the project area.

c) Trends of Residential and Commercial Load

The Capital Zone City Planning Committee with the Mayor of Santo Domingo City as Chairman was established by the government in the beginning of 1980. This committee is aimed at formulating a long-term city development plan in two years by referring also to the national census to be taken in March 1980. The committee members have just started their functions and the extent of the planning by the Committee known at present is limited to the previously described future vision of Santo Domingo City.

On the other hand, the following opinions were heard as basic considerations for

future city planning.

(1) To invite some small scale industires to the densely populated northern area on the east bank and the northern area on the west bank of the river.

(2) To restrict the establishment of new large and medium scale industries in the present urban area.

(3) Not to encourage positively the relocation of large and medium scale industries from the existing urban area at present but to wait for the time when the industries find it difficult to expand their facilities at the present location and seek relocation of their facilities to the suburbs of their own free will.

(4) To prohibit renewal of building in the old city area (Colonial district).

(5) It is very likely that the vacant lots in the city center will be occupied by high rise apartment buildings because of rising land price but the western residential district will be mostly for private homes of one or two stories.

With reference to these opinions and the trend of each district of the city forecast by the city's long-term planning, the trend of each ciclo was carefully studied and the growth rate of load by ciclo was forecast as shown in Table 4-15.

Fig. 4-2 Map of Ciclo in Santo Domingo

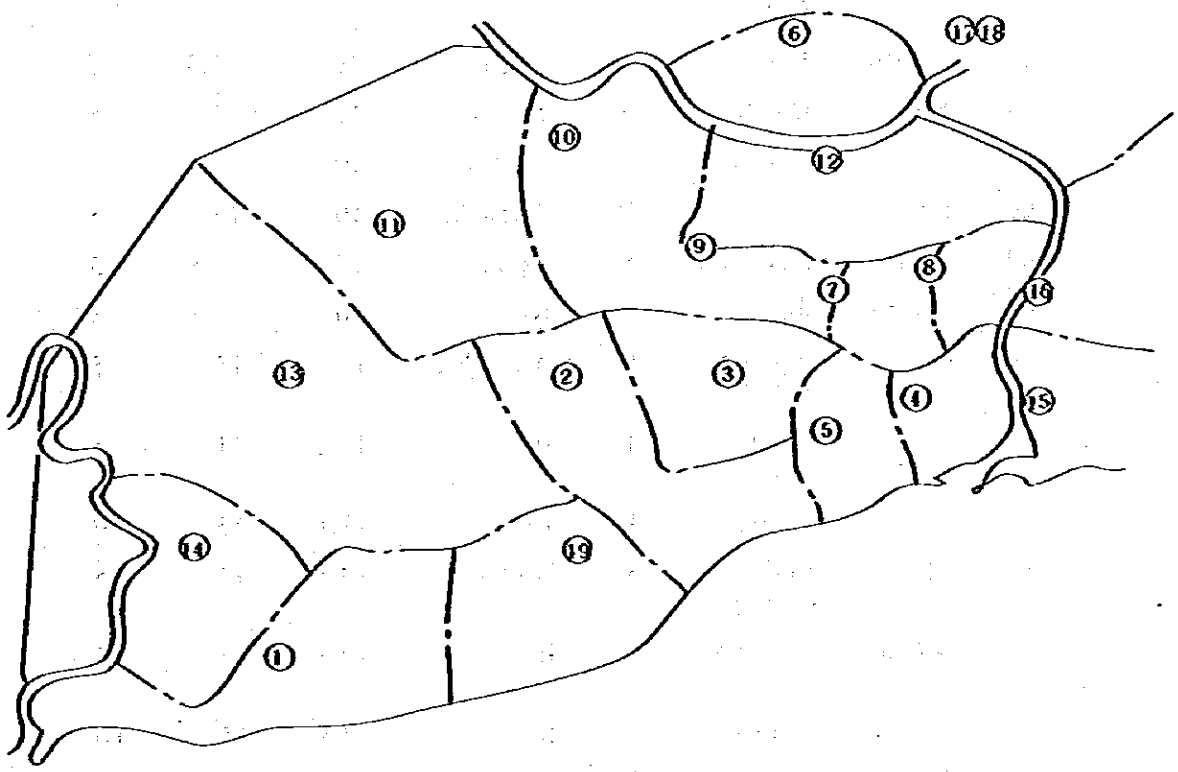


Table 4-15. Estimated Increasing Rate of Power Demand by Ciclo

No. of Ciclo	Location	Use	Scope	Population	Increasing rate of power demand in % '72–'76	'80–'85	'86–'90
01	SW	Rs. S In.	L	Inc.	17.5	15	5
02	S. Center	Rs. Office Hotel	M	A few Inc.	10	7.5	5
03	–ditto–	Res. Office	S	–ditto–	10	7.5	5
04	SE	Old Town	S	No Inc.	10	7.5	5
05	SE	Res. Hotel	S	–ditto–	10	9	5
06	E Center	Res.	M	A few Inc.	10	15	5
07	–ditto–	Res. S Ind.	S	No Inc.	10	7.5	5
08	–ditto–	Res.	S	No Inc.	10	7.5	5
09	Center	Res. S & M Ind.	M	A few Inc.	10	15	5
10	N of Center	–ditto–	L	Inc.	13.6	11	5
11	NW	–ditto–	L	Inc.	17.1	15	10
12	NE	Res. densely	S	No Inc.	13.6	11	5
13	W Center	Res. M & S Ind.	L	Inc.	17.5	15	10
14	–ditto–	–ditto–	L	Inc.	17.5	15	10
15	S, E of River	Res. Park	L	Inc.	9.8	8.5	5
16	Center, E of River	Res. S Ind.	M	Inc.	9.8	8.5	5
17	N, East of River	Res.	S	A few Inc.	9.8	8.5	5
18	–ditto–	Res.	L	Inc.	9.8	8.5	5
19	Center of S	Res. L Ind.	M	A few Inc.	10.7	15	5
(Ind. Total)					(3%)		
				Total . . .	12.5	10	5

Note: Location . . . E east, W west, S south, N north.
L . . . Large, M . . . Medium, S . . . Small,
"Scope" is scope of development.

3) Forecast of Power Demand in July in the Respective Year by Ciclo in Santo Domingo

Table 4-16. Monthly Demand Forecast by Ciclo

Total Unit: 1000 kWh

No. of Ciclo	July 1979	1982	1985	1988	1990
01	1189	1477	1850	2232	2534
02	14203	18979	26002	31327	35548
03	9359	13435	18725	22957	26352
04	5185	5935	6798	8221	9348
05	6045	7649	9711	11558	12959
06	1493	1966	2605	3167	3612
07	8128	9006	9985	11250	12204
08	12243	14572	17200	20509	23110
09	14554	17198	20766	23301	25172
10	6446	7896	11055	12880	14312
11	6340	7786	9816	11622	13058
12	4541	5519	6837	7917	8745
13	9726	11776	14613	17301	19451
14	4164	5061	6306	7406	8273
15	2199	2750	3447	4212	4819
16	4036	4735	5590	6525	7252
17	1622	2072	2644	3268	3762
18	1617	2038	2573	3152	3613
19	8409	12890	17111	19795	21874
Total	121489	152740	193636	228580	256004

Table 4-17. Forecast of Power Demand for Residential Use in July in the Respective Year by Ciclo

Residential Unit: 1000 kWh

No. of Ciclo	July 1979	1982	1985	1988	1990
01	572	741	960	1209	1410
02	6019	9156	13922	17537	20456
03	4595	6988	9792	12335	14387
04	1716	1984	2297	2894	3375
05	1069	1384	1793	2259	2634
06	623	852	1166	1469	1713
07	792	916	1061	1336	1559
08	1036	1935	2942	3706	4323
09	1272	1934	2929	3405	3755
10	1873	2562	3504	4414	5148
11	1017	1546	2351	2961	3454
12	997	1346	1865	2349	2740
13	639	975	1479	1863	2173
14	702	1068	1624	2046	2386
15	1255	1603	2048	2580	3009
16	1074	1372	1752	2207	2574
17	929	1187	1516	1910	2227
18	799	1021	1304	1643	1916
19	1881	2861	4351	5481	6393
Total	28856	41427	58656	73504	85632

Table 4-18. Forecast of Power Demand for Commercial Use in July in the Respective Year by Ciclo

Commercial Unit: 1000 kWh

No. of Ciclo	July 1979	1982	1985	1988	1990
01	82.6	107	138	175	204
02	1188.3	1807	2748	3462	6280
03	1847.8	2810	4274	5384	6280
04	1441.4	1669	1932	2433	2838
05	1054.4	1365	1768	2227	2598
06	286.5	392	536	675	787
07	479.3	5555	642	809	944
08	5109.1	5914	6847	8625	10060
09	577.1	878	1335	1682	1961
10	948	1296	1775	2234	2605
11	252.8	384	585	736	859
12	643.7	880	1203	1394	1536
13	237.3	361	549	691	806
14	162.6	247	375	473	552
15	223.7	286	365	460	536
16	310.2	396	506	637	743
17	309.3	395	504	636	741
18	307.8	393	502	632	738
19	283.4	431	656	826	963
Total	15745.1	20566	27238	34191	39789

Table 4-19. Forecast of Power Demand for Industrial Use in July in the Respective Year by Ciclo

Industry Unit: 1000 kWh

No. of Ciclo	July 1979	1982	1985	1988	1990
01	289	315	345	377	400
02	6122	6689	7310	7988	8474
03	1865	2038	2227	2423	2582
04	1038	1127	1232	1346	1428
05	883	965	1054	1152	1222
06	281	307	335	366	389
07	6216	6793	7423	8111	8605
08	5214	5697	6226	6803	7217
09	11493	12558	13722	14996	15908
10	3343	3653	5251	5622	5887
11	4332	4734	5175	5653	5996
12	2446	2672	2920	3191	3385
13	7047	7700	8414	9195	9754
14	2972	3248	3549	3878	4114
15	322	352	384	420	445
16	2273	2483	2714	2966	3146
17	8	9	10	11	11
18	148	162	177	194	206
19	4473	6905	8011	8745	9287
Total	60759	68407	76476	83436	88455

Table 4-20. Forecast of Power Demand for Government-Use in July in the Respective Year by Ciclo

Government Unit: 1000 kWh

No. of Ciclo	July 1979	1982	1985	1988	1990
01	243	314	407	471	520
02	874	1329	2022	2340	2580
03	1051	1599	2432	2815	3103
04	998	1155	1337	1548	1707
05	3039	3935	5096	5900	6505
06	303	415	568	657	724
07	641	742	859	994	1096
08	886	1026	1187	1375	1516
09	1202	1828	2780	3218	3540
10	282	385	527	610	672
11	738	1122	1707	2272	2749
12	454	621	849	985	1084
13	1803	2742	4171	5552	6718
14	328	498	758	1009	1221
15	398	509	650	752	829
16	379	484	618	715	789
17	376	401	614	711	785
18	362	462	590	683	753
19	1772	2693	4093	4743	5231
Total	16129	22340	31266	37351	42128

4-4. KW Demand Forecast for Urban Area of Santo Domingo City

When the city planning and the trend of population increase are taken into account, the power demand in the project area is as shown in the previous Table 4-16. Factors for KW forecast with reference to the Loss Rate Reduction Plan and Load Factors shown in Table 4-7 and 4-9, respectively, are considered as follows (as shown in Table 4-21).

Table 4-21. Factors for Peak Demand Forecasting by Year

	1982	1985	1988	1990
Rate of Loss	24%	18%	17%	16%
Load Factor				
Residential	0.6	0.6	0.6	0.6
Others	0.6	0.6	0.6	0.6
Rate of Day Time Peak against Evening Peak				
Residential	0.67	0.67	0.67	0.67
Others	1.41	1.41	1.41	1.41

Consequently, the result that the daytime peak exceeds the evening peak has been obtained as shown in Tables 4-22 and 4-23. According to the measurement of feeder load at substations in 1978 and 1980, the rate of the evening peak is decreasing as shown in Table 4-24. In view of the tendency of increasing power consumption by industry and public buildings, it is only natural that the daytime peak is the peak power for the entire city area.

A comparison of peak demand forecast by the team and that for Santo Domingo City by SOFRELEC is shown in Table 4-25. Since the forecast by SOFRELEC includes the demand in rural district, the corresponding kW demand should be excluded. It is also necessary to consider the future development of the city in the western and northern districts which are not covered by the project and the possibility of advancement of large

Table 4-22. Peak Power Demand in Santo Domingo City
(In 1982, 1985, 1988, 1990 by Ciclo) Unit: MW

No. of Ciclo	1982	1985	1988	1990
01	2.88	3.69	4.77	5.09
02	37.46	51.99	66.91	71.07
03	26.40	37.55	49.45	53.49
04	11.89	14.21	19.00	20.75
05	15.61	21.07	28.25	30.89
06	3.86	5.29	6.99	7.56
07	18.53	22.05	28.29	30.04
08	29.90	37.47	50.50	55.53
09	35.36	45.57	58.69	62.14
10	15.83	23.26	29.89	31.79
11	15.83	21.03	27.87	30.32
12	11.15	14.53	18.68	24.17
13	24.29	32.33	43.70	48.25
14	10.26	13.45	17.60	18.98
15	5.33	6.76	8.76	9.36
16	9.54	11.74	15.15	16.12
17	4.01	5.20	6.86	7.41
18	3.98	5.14	6.79	7.37
19	26.59	38.69	47.09	50.16
Total	308.70	411.02	534.64	580.49

Note: Ciclo No. 19 includes a customer who receives power from 69 kV line directly.

Table 4-23. Evening Peak Power Demand in Santo Domingo City
(In 1982, 1985, 1988, 1990 by Ciclo) Unit: MW

No. of Ciclo	1982	1985	1988	1990
01	3.11	3.94	5.03	5.70
02	39.92	56.19	71.60	80.96
03	28.92	40.22	52.04	59.42
04	11.31	13.27	17.45	19.75
05	13.09	17.43	23.15	25.85
06	3.97	5.36	6.97	7.91
07	14.48	17.11	21.91	23.64
08	24.03	30.67	40.94	45.86
09	27.91	36.41	45.91	49.22
10	14.97	21.36	27.28	30.23
11	17.24	18.17	23.85	26.67
12	9.86	12.90	16.48	21.23
13	18.65	24.99	33.57	37.49
14	8.84	11.80	15.29	17.02
15	6.11	7.64	9.75	11.12
16	8.76	10.75	13.78	15.27
17	4.57	5.78	7.48	8.57
18	4.29	5.45	7.07	7.08
19	23.03	33.48	40.96	45.14
Total	283.06	372.92	480.51	538.49

Table 4-24 Distribution of Peak Time of the Distribution Lines in Santo Domingo City

	1978	1980
Peak Time in Evening	42%	26%
Peak Time in Daytime	58%	59%
Peak Time in Midnight	—	15%

Table 4-25 Comparison of Peak Demand Forecasts for Santo Domingo City

	1980	1982	1985	1988	1990	1992
District of Sto. Dgo. by SOFRELEC MW. (A)	275.3	320.5	444.3	636.5	832.0	1028.0
Planning Area (by JICA Team) MW. (B)	-	308.7	411.0	534.0	580.0	-
Ratio B/A	-	0.96	0.925	0.839	0.697	-

Note: After 1985, development of the city will extend outer parts of the present urban area.

industries into these districts because of favorable conditions for industrial location.

When these two points are taken into consideration, the kW demand forecast for the project area is considered quite reasonable. The kW demand forecast by substation based on actual figures for January 1980 for each substation, with consideration given to the rate of increase in each district, is shown in Table 4-26.

Table 4-26. kW Forecast by Substations

	Jan. 1980		1982	1985	1988	1990	(1995)
	Fa. MW	L. MW	L. MW	L. MW	L. MW	L. MW	L. MW
Timbeque 12.5 kV	40.3	36.0	41.6	51.7	59.8	66.0	84.2
4.16 kV	36.4	18.6	21.5	26.7	30.9	34.0	43.4
Load subtotal	-	54.6	63.1	78.4	90.7	100.0	127.6
Facility subtotal	79.4	79.4					
Ratio of Fa. util.		68.7					
Metro Politano	42.0	28.0	32.4	40.2	46.6	51.4	65.6
C. N. Penson	28.0	20.4	23.6	29.3	33.9	37.4	47.7
Load subtotal	-	48.4	56.0	69.5	80.5	88.8	113.3
Facility subtotal	70.0	70.0					
Ratio of Fa. util.		69.1					
La 40	31.7	30.1	37.1	50.7	58.7	64.7	92.5
Arroyo Hondo	14.0	10.9	13.4	18.3	21.2	23.3	29.7
Load subtotal	-	41.0	50.5	69.0	79.9	88.0	122.2
Facility subtotal	45.7	45.7					
Ratio of Fa. util.		89.7					
Herrera	23.0	17.5	23.1	35.2	43.1	49.4	63.0
Embajador	36.4	26.6	35.2	53.5	65.5	75.0	95.7
Matedero	22.4	13.0	17.2	26.1	32.0	44.9	57.3
La Feria	10.5	12.6	15.0	19.5	22.5	25.0	31.9
Load subtotal	-	69.7	90.5	134.3	163.1	194.3	247.9
Facility subtotal	92.3	92.3					
Ratio of Fa. util.	75.5						
KM 10.5							
Load subtotal	-	14.2	18.8	28.5	34.9	39.9	50.9
Facility subtotal	21.5	21.5					
Ratio of Fa. util.		66.0					
Los Mina	36.4	23.2	27.3	34.9	40.4	44.5	56.8
Villa Duarte	-	6.0	7.1	9.0	10.4	11.5	14.7
Load subtotal	-	29.2	34.4	43.9	50.8	56.0	71.5
Facility subtotal	36.4	36.4					
Ratio of Fa. util.		80.2					

(continued)

	Jan. 1980		1982	1985	1988	1990	(1995)
	Fa. MW	L. MW	L. MW	L. MW	L. MW	L. MW	L. MW
Load Total	-	257.1	313.3	423.6	499.9	567.0	733.4
Facility Total	345.3	345.3					
Ratio of Fa. util.		74.4					

Note:

i)

	Rate of increase 1980 . . . 1985	Rate of increase 1986 . . . 1990
Timbeque	7.5 %	5 %
Metropolitano	7.5 %	5 %
La 40, Ayorro	11 %	5 %
Herrera	15 %	10 %
KM 10.5	15 %	10 %
Los Mina	8.5 %	5 %

	Rate of increase 1991 . . . 1995
Whole Area	5 %

ii) Fa. . . . . Facility
L. . . . . Power Load
util. . . . . utilization

Chapter 5. Construction Plans for Distribution System in Modernization Program

5 - 1 Basic Concept of Planning

1) Planning of Construction by Priority

In planning measures for solution of problems of power system in the project area described in Chapter 3 and formulating a construction plan aimed at coping with the increasing power demand mentioned in Chapter 4, the relative importance and economic validity of the project were fully taken into consideration and the project was divided into the following three stages for implementation.

	Construction Period	Target Demand Year
1st Stage Construction	1980 – 1982	1985
2nd Stage Construction	1983 – 1985	1990
3rd Stage Construction	1988 – 1990	1995

Main work items of distribution lines in each stage of construction are considered as follows:

1st Stage	2nd Stage	3rd Stage
← Uprating from 4.16 kV to 12.5 kV →		
← [Installation,] replacement ← and conversion to three phase of 12.5 kV district lines	→	
Change to underground ← cables in colonial district →	← Improvement of supply reliability →	
Improvement of ← facilities in slum area →	→	

In planning construction of transmission lines and substation facilities, consideration was given to the technical and economic coordination between the arrangement of distribution substations and the construction work of distribution lines. For the 2nd stage of construction, extension of 138 kV transmission lines to the center of the city was considered to augment the power system.

2) Considerations for Supply Reliability

a) Transmission Line

The number of circuits and conductor size will be determined on condition that in case of a failure of one circuit, other circuits must be able to withstand overload up to 110 % of their transmission capacity.

b) Substation

The number of banks in a substation will be three in the final stage. In case of a failure of one bank, other banks must be able to withstand overload up to 120 % of the rated capacity and the load which cannot be accommodated by this overload must be provided by interconnecting lines from the adjacent substation. The utilization rate of substation main transformers will be 70 %.

c) Distribution Line

The utilization rate of high voltage distribution lines will be limited to less than 70 % of the rated capacity in consideration of the necessity for power transfer in case of a failure of other adjacent interconnecting lines. Also, the adoption of a fault section detection device will be considered to minimize the affected area.

3) Permissible Voltage Fluctuations for Consumers

The permissible voltage fluctuation at the service entrance of consumers will be as follows:

For residential use .....120 V ± 6 V

For commercial and industrial use .....240 V ± 20 V

For this purpose, the rate of voltage drop of each facility will be limited to the following (in term of 120 V):

High voltage distribution line .....6 V

Low voltage distribution line .....6 V

Pole mounted transformer .....3 V

Service wire .....3 V

4) Items Excluded from the Project

The following items, which are separately planned by CDE, are excluded from the construction plan for this project.

a) Protecting Relay System

At present, the Peterson coil (PC) grounding system is adopted for CDE's 69 kV transmission lines, and there is a separate plan to change this system to the effective grounding system in the future. For this reason, the work of changing the grounding system (change to the effective grounding system, change of system protecting relay system and installation of additional 69 kV circuit breakers) is excluded from the planning.

b) Installation of Static Condenser

Installation of a static condenser, which is required for the improvement of power factor of the system, is being planned separately (Refer to the Report of Montreal Engineering Company) and therefore is excluded from this planning.

c) Communication Facilities

The work required for automatic control of substations and distribution lines, including the expansion of communication systems, is scheduled to be planned separately and therefore is excluded from this planning.

5 - 2 Design Conditions

1) Meteorology

The project area, which is situated approximately at Latitude 18° N, belongs to the tropics and has a climate of high temperature and high humidity. The maximum temperature is about 33° C and the maximum humidity reaches 96 % (Refer to Table 5 - 1). There is much rainfall in general but it varies greatly with area. The rainfall in and around Santo Domingo City is about 1200 mm (Refer to Fig. 5 - 1). Lightning is frequent and the number of lightning days in 1979 was 131 (Refer to Table 5 - 2). Hurricanes hit this area only on rare occassions but at one time, the maximum wind velocity recorded was 55 m/sec.

Table 5-1 The quantity of rainfalls in Santo Domingo by Month

STATION SANTO DOMINGO N° 78486 LAT. 18 ° 28'N LONG. 69 ° 54 'W. ALT. 14 m

ITEM / Month	Air Pressure		Temperature (℃)										Humidity (%)				Evapo-transpiration
	mm.	mbar.	GMT 1200	GMT 1800	GMT 2400	MAX. A	MIN B	A+B/2	MAX. ABS.	DIA	MIN. ABS.	DIA	GMT 1200	GMT 1800	GMT 2400	ΣHR	
			Local time 0700	Local time 1300	Local time 1900								Local Time 0700	Local Time 1300	Local Time 1900		
Jan.	760.8	1014.3	20.6	27.7	23.2	29.1	19.4	24.3	31.0	04	17.0	23	93	64	83	82	0121
Feb.	761.1	1014.7	20.5	25.8	22.8	29.1	18.6	23.8	31.0	02	17.0	07	94	71	85	85	0112
Mar.	760.4	1013.8	21.9	28.6	24.6	29.7	19.9	24.8	31.9	05	18.2	01	91	66	82	82	0123
Apr.	760.0	1013.3	23.1	28.1	24.3	29.7	20.8	25.2	31.4	12	18.2	03	86	67	83	80	0168
May	759.9	1013.1	25.1	29.5	25.6	30.4	22.2	26.3	32.0	05	20.8	10	86	70	84	83	0197
Jun.	761.5	1015.3	25.5	29.4	25.9	30.7	22.7	26.7	32.9	20	21.0	13	89	75	86	85	0157
Jul.	761.2	1014.8	25.3	29.0	25.2	30.7	22.4	26.5	32.8	05	20.9	07	88	75	88	86	0167
Aug.	760.1	1013.4	24.8	29.7	25.3	30.6	22.5	26.5	31.7	23	21.2	26	92	75	90	88	0155
Sep.	759.1	1012.1	24.9	30.3	26.1	31.4	22.5	26.9	32.9	15	21.0	10	92	73	87	86	0145
Oct.	759.2	1012.1	23.6	29.1	24.3	30.9	21.9	26.4	32.9	05	20.9	17	96	77	93	89	0113
Nov.	759.1	1012.1	22.3	28.9	24.3	30.2	20.9	25.5	31.9	08	18.6	21	95	71	89	87	0101
Dec.	760.6	1014.1	21.4	27.9	23.2	29.6	20.2	24.9	31.2	02	18.4	23	94	68	86	84	0107
Yearly Total																	1659
Average	760.3	1013.6	23.3	28.6	24.6	30.2	21.2	25.7					91	71	86	85	

Note: GMT ···Greenwich Mean Time 1971

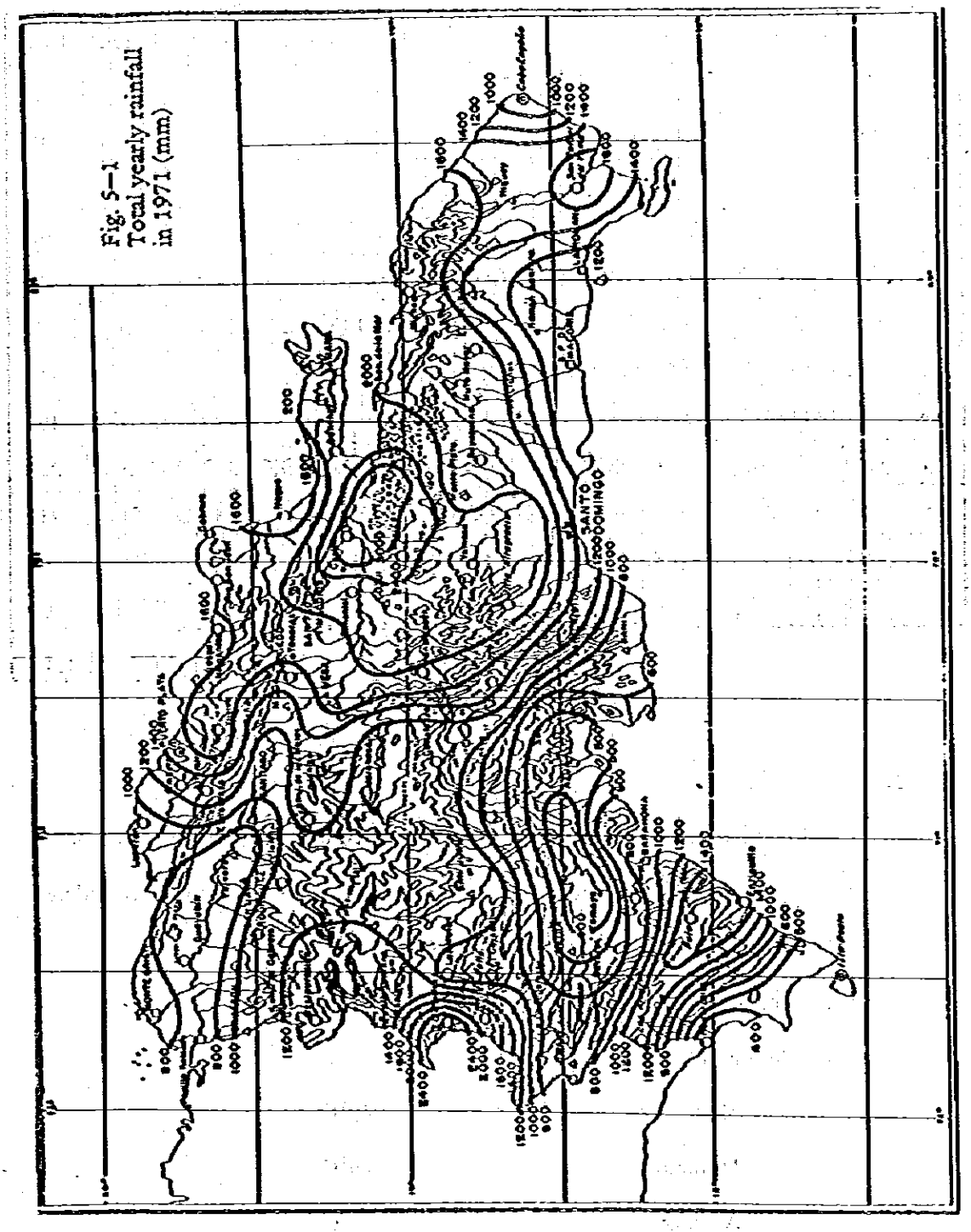


Fig. 5—1
Total yearly rainfall in 1971 (mm)

Table 5 - 2 ISOKERAUNIC LEVEL OF SANTO DOMINGO CITY

As of Mar. 4, 1980
Dominican Weather Bureau

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
Jan.																																0
Feb.																																0
Mar.																																0
Apr.																																2
May.																																11
Jun.																																23
Jul.																																21
Aug.																																15
Sep.																																26
Oct.																																24
Nov.																																4
Dec.																																5
																											Total				131

2) Design Elements

With reference to the design conditions adopted by CDE and the meteorogical conditions mentioned in the previous paragraph, the design elements considered in the planning of construction work are as follows:

a) Meteorological Conditions

i) Ambient temperature

Maximum	40°C
Minimum	10°C
Average	26°C

ii) Maximum Wind Velocity

40 m/sec (89.3 mph)

iii) Seismic Force

(Horizontally) 0.2G

b) Vertical and Horizontal Clearance of Overhead Lines from Other Objects

a. Clearance above Ground to Overhead Line	Low voltage	12.5 kV line	69 kV line
Rail road	27' (8.2 m)	28' (8.5 m)	38' (11.6 m)
Roads and streets	18' (5.5 m)	20' (6 m)	29.6' (9 m)
Residential drive–ways and commercial areas	18' (5.5 m)	20' (6 m)	29.6' (9 m)
Spaces or ways for pedestrians	15' (4.6 m)	15' (4.6 m)	24' (7.3 m)
Other lands	18' (5.5 m)	20' (6 m)	29.6' (9 m)
Buildings	10' (3 m)	10' (3 m)	29.6' (6 m)
b. Horizontal Clearance from other structure	5' (1.5 m)	8' (2.4 m)	17.6' (5.4 m)

c) Safety Factors

Supporting structures More than 2

Foundations More than 2

For supporting structures, wooden poles will be used for all lines except for 132 kV transmission lines and river-crossing lines of long spans for saving of initial investments and in consideration of the experience of CDE.

5 - 3 Ist Stage Construction Plan

1) Transmission Line

According to the basic considerations for the project described in the previous Section 5 - 1, it has become necessary to construct new 12.5 kV distribution

feeders, uprate the 4.2 kV distribution lines and convert the trunk distribution lines to underground cables to meet the increasing power demand in Santo Domingo City. To meet these requirements, however, there is need to provide a new substation (Rojas SS) and install additional main transformers in the existing substations.

As the 1st stage of construction work for transmission facilities, it is necessary to construct one circuit of transmission lines to the above mentioned new substation.

The outline of this transmission line is as follows:

a) Route of Transmission Line

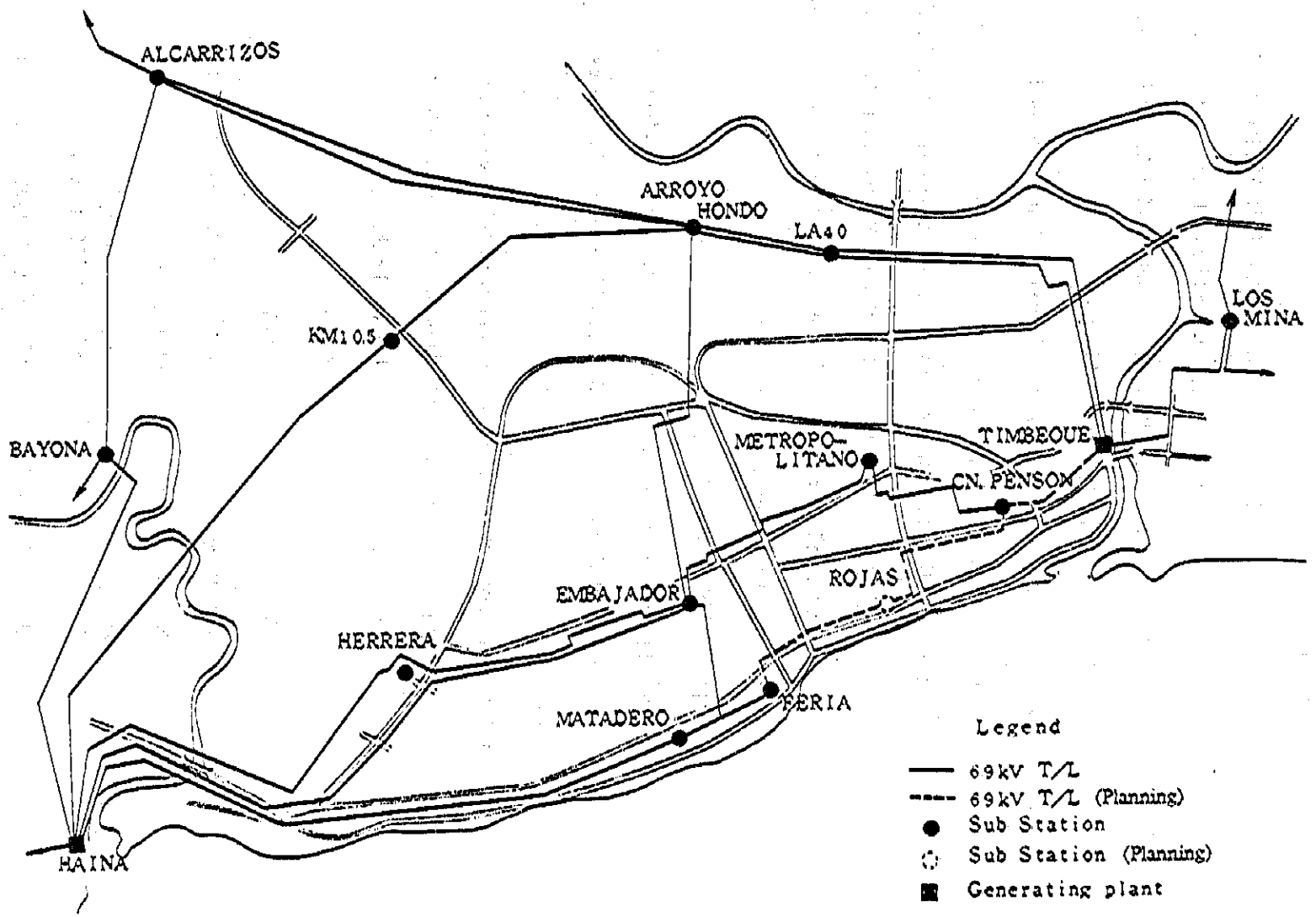
The Rojas substation to be newly constructed is scheduled to be located almost halfway between the Feria SS and the C.N. Penson SS.

On the other hand, the existing transmission lines interconnecting two power stations, Timbeque PS in the east and Haina PS in the west, are only routed through Timbeque–LA 40–Arroyo Hond–KM 10.5–Haina in the northern part of the city.

This arrangement, of transmission lines will be disadvantageous for stability of power supply as the demand increases. To improve the present composition of one route for one substation, the newly planned transmission line will be routed through Feria–Rojas–Penson–Timbeque to strengthen the power system in the southern part of the city (Refer to Fig. 5 - 3).

The route of transmission lines was selected as linear as possible along the road for the convenience of future operation and maintenance.

Fig 5-3 69kV TRNSMISSION LINE ROUTE MAP



b) Conductor

Conductors will be 240 mm² ACSR (559.5 MCM ASCR), which are of the same standard of conductors currently used by CDE, for the following reason.

i) This conductor has an allowable current of 600 A, which is considered adequate for the future demand increase.

ii) This conductor is used for the existing 69 kV transmission lines and inter-chargeability of spare parts, accessories and tools may be obtained.

The I/O CU conductor used in the existing transmission line for the part of the Matadero–Feria section for about 2 km will be replaced with the same size conductor mentioned above, as the difference in conductor size may cause a bottleneck in the system operation.

c) Supporting Structures

For supporting structures of transmission lines, wooden poles will be used for savings of initial investments and in consideration of the past experience of CDE.

d) Outline of Construction of Transmission Facilities in the Ist Stage

i) Transmission line for the Feria–Timbeque Section (new line)

Line section:	Feria – Timbeque
Total length:	8.2 km
Voltage:	69 kV
Electric system:	3–phase, 3–wire system, 60 Hz
No. of circuits:	One circuit
Conductor:	240 mm² ACSR (559.5 MCM, AASC)
Overhead ground wire:	55 mm² (3/8") galvanized steel stranded wire
Insulators:	254 mm suspension insulators and line post insulators
Supports:	Wood poles

ii) Transmission line for the Matadero–Feria Section
(replacement of conductors)

Line section:	Matadero – Feria
Total length:	2 km
Voltage:	69 kV
Conductor:	240 mm^2 ACSR

2) Substation Facility

Following the construction of 12.5 kV distribution feeders, uprating of 4.2 kV distribution lines and the change of distribution lines to underground cables in some district to meet the increasing power demand, overloading of main transformers at the existing substations may be unavoidable in some districts. As a result, it has become necessary to provide additional transformers or relocate transformers to other substations.

In addition, the construction of a new substation (Rojas SS) has been included in the plan with the target operation in 1982 as a measure to meet the demand in heavy load area. It is also planned to discontinue the use of Feria SS with 4.2 kV distribution lines at the time of uprating to 12.5 kV lines for the following reason.

i) Replacement of substation equipment becomes necessary as a result of uprating of distribution lines to 12.5 kV but the replacement costs as much as the construction of a new substation.

ii) Feria SS is located close to Matadero SS and the planned Rojas SS and the area served by substation will be covered by the trunk distribution lines after uprating of the line. Therefore, its utility value has become smaller.

iii) Facilities are old and the station site is limited in area.

The outline of substation facilities to be provided in the Ist stage is as follows.

a) Capacity of Transformer

The unit capacity of main transformers in the new substation was determined to be 28 MVA in line with the basic concept of the planning and in consideration of the load forecast and the carrying capacity in case of a system fault and also the past experience of CDB. The unit capacity of additional transformers to be provided in the existing substations, except for transformers to be relocated, was also determined to be 28 MVA so that the total capacity of existing substations will be the same as that of a new substation in the final stage for coordination of system operations.

b) Design of Insulation

The standard insulation strength of substation equipment was determined to be the following with consideration given to the coordination of insulation with transmission lines.

69 kV equipment	BIL 350 kV
13.5 kV equipment	BIL 110 kV

For protection from lightning, shielding of a substation by overhead ground wires was considered.

c) Specifications of Main Equipment

i) Main Transformer

Main transformers shall be provided with on-load tap changers (OLTC) in consideration of voltage fluctuations for consumers. Connection of wires shall be Delta–Star connection because of multiple direct grounding system used for 12.5 kV distribution lines. Also, the 3–phase transformer (common tank) shall be used.

ii) Circuit Breaker

The rated breaking-current of circuit breakers shall be as follows in consideration of calculated and standard values for a system fault and the past experience of CDE.

69 kV	20 kA (2,500 MVA)
12.5 kV	25 kA (520 MVA)

d) A summary of substation facilities to be provided in the Ist stage construction.

Outline of a new substation (Rojas SS) (Refer to Figs. 5 - 4 and 5 - 5).

o Main transformer 3-phase 28 MVA with 67/12.47 kV OLTC	1 unit
o 69 kV transmission line drawing-in equipment for 3 circuits	
72 kV 20 kA OCB	1 unit
72 kV disconnecting switch	3 sets
o 12.5 kV distribution line drawing - one equipment for 3 circuits	
15.5 kV 25 kA OCB	4 units
15 kV disconnecting switch	8 sets

Table 5 - 3 Outline of Substation Facility Works – 1st Stage (Changes in Transformer Capacities)

Substation	Existing (MVA)	MVA Ultimate	Increase or decrease		Remarks
			To be Installed	To be Abolished	
Rojas	MVA 0	MVA 28.0	MVA x units 28 x 1	–	Added
Timbeque	79.4	93.4	28 x 1	14 x 1	
LA 40	31.77	59.77	28 x 1	–	
Metropolitano	42.0	56.0	28 x 1	14 x 1	
Embajador	36.4	78.4	28 x 2	14 x 1	
Herrera	23.375	51.375	28 x 1	–	
Arroyo Hondo	14.0	28.0	14 x 1	–	Transformer ex Metropolitano
KM 10.5	21.5	35.5	14 x 1	–	Transformer ex Embajador
CN. Penson	28.0	56.0	28 x 1	–	
Matadero	22.4	22.4	–	–	
Los Mina	36.4	36.4	–	–	
Feria	10.5	0	–	10.5 x 1	Discontinue
Total	22 units 345.745	28 units 545.245	10 units 252.0	– 4 units – 52.5	

Fig 5-4 SINGLE LINE DIAGRAM OF SUBSTATION

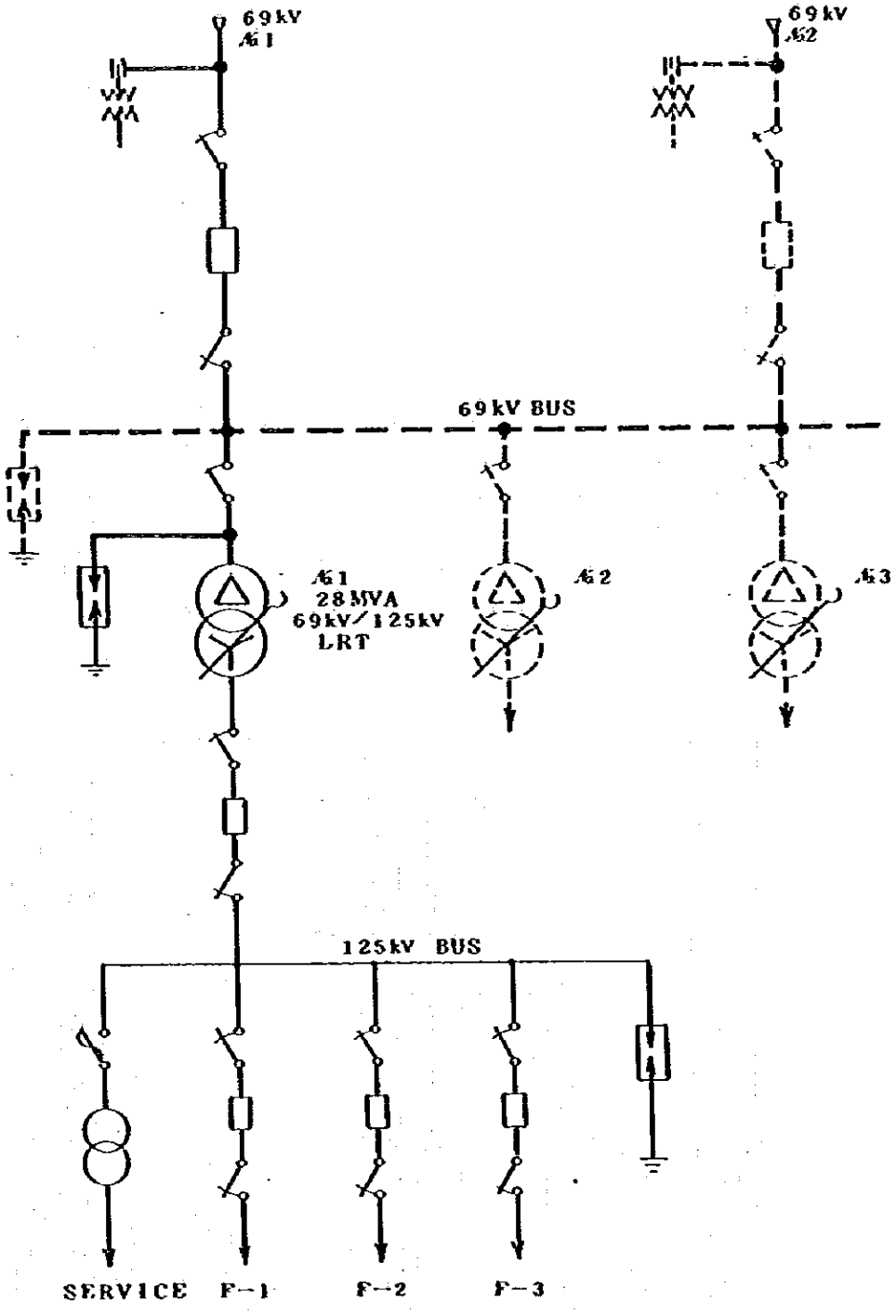
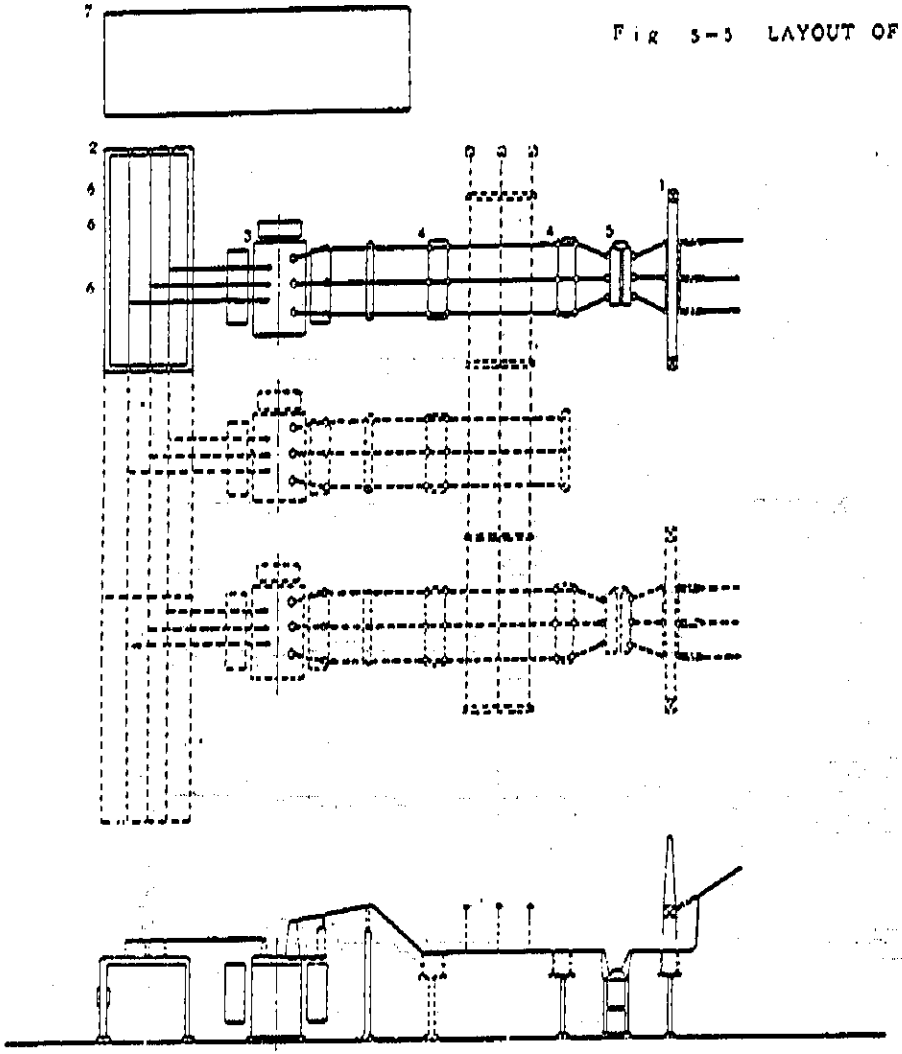


Fig 3-3 LAYOUT OF SUBSTATION



1. STRUCTURE 69kV
2. " " 125kV
3. TRANSFORMER 69kV/125kV 26MVA, LRT
4. DISCONNECTING SWITCH 69kV
5. O C B 69kV
6. C. B 125kV
7. HOUSE

Fig 3-6 69kV POWER SYSTEM DIAGRAM
(SANTO DOMINGO)

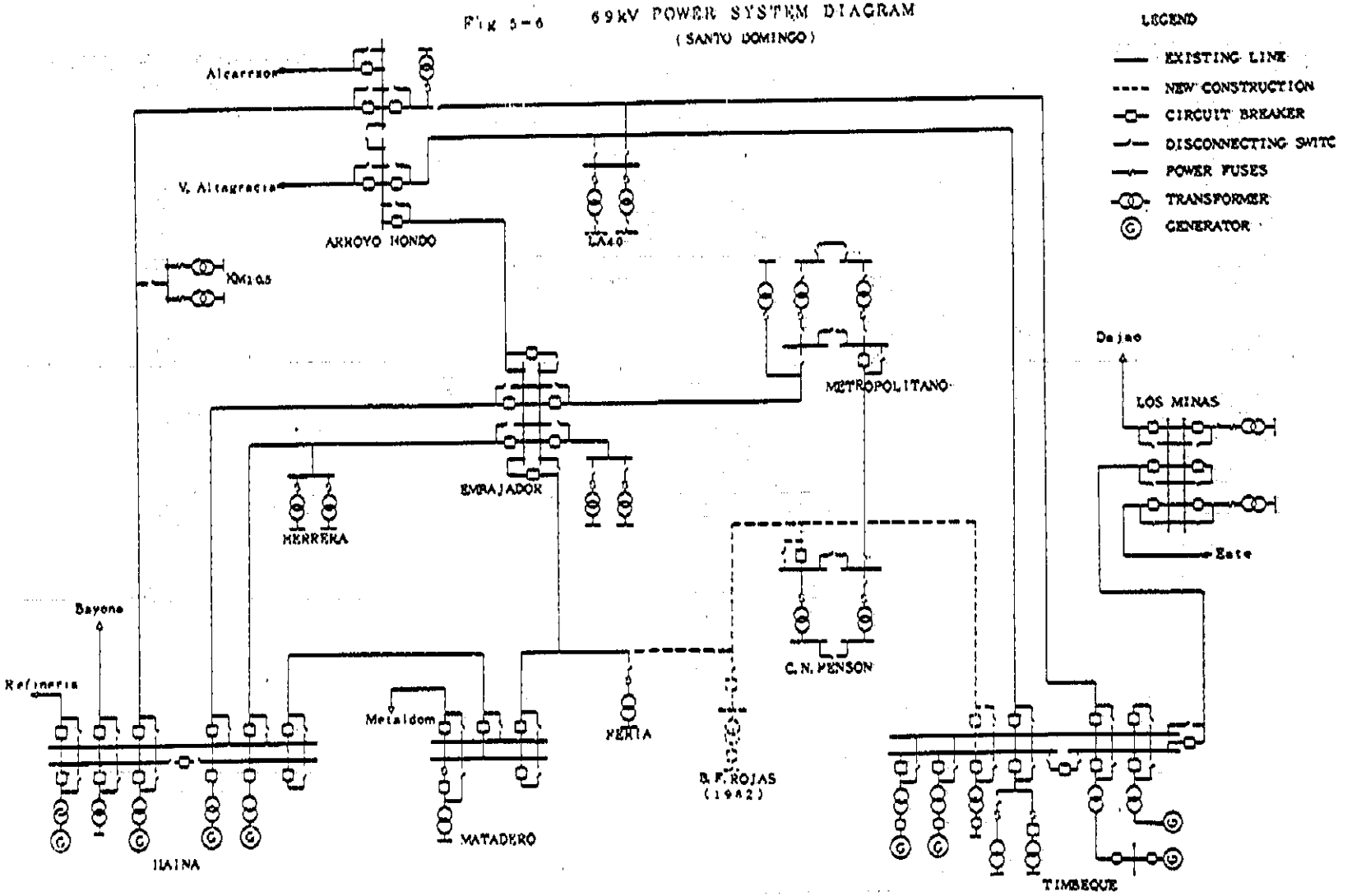
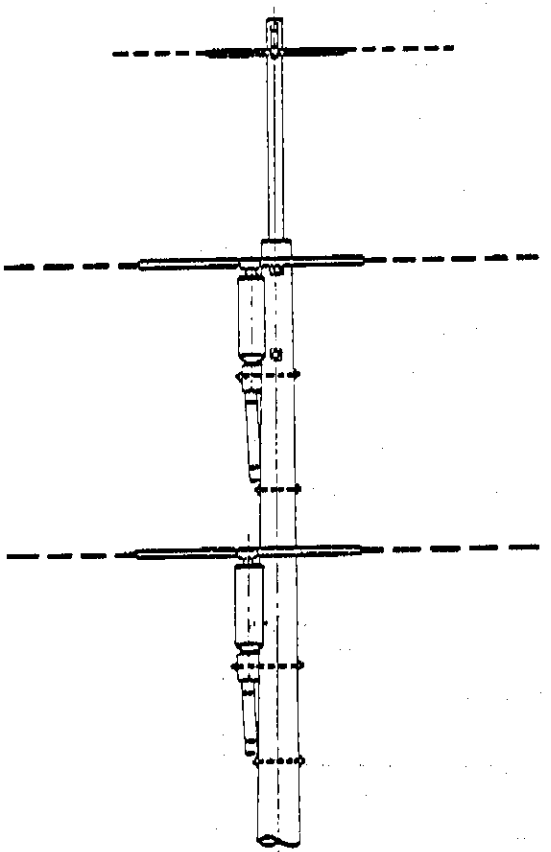
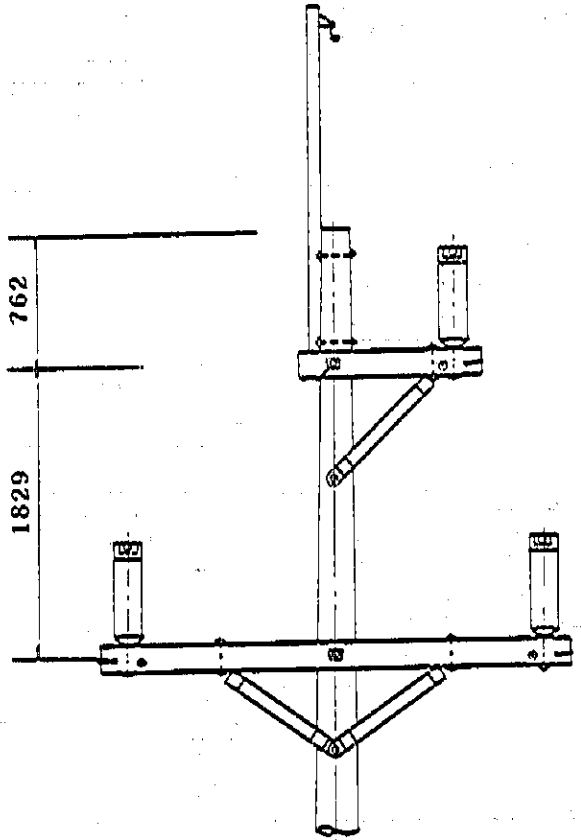


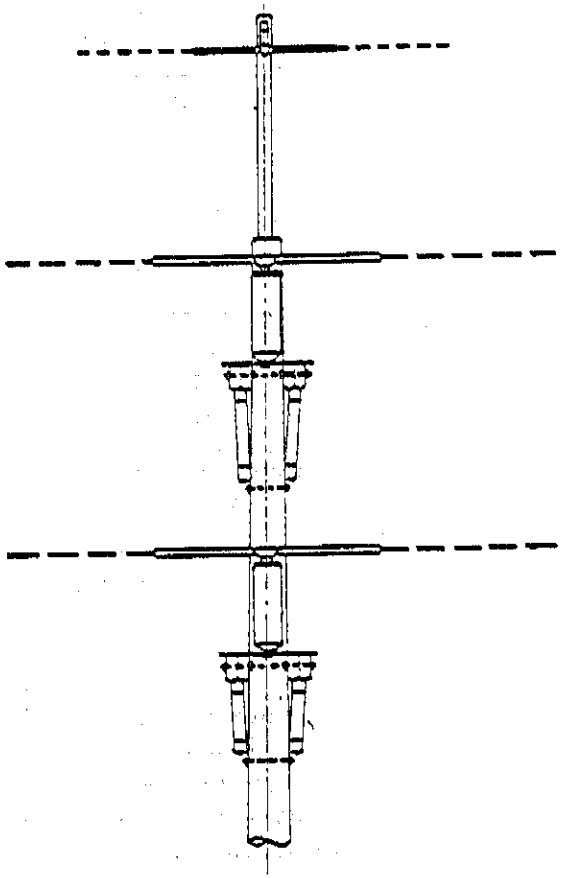
Fig 5-7

69 kV TRNSMISSION LINE TANGENT STRUCTURE (SINGLEPOLE TYPE)



TP-1G
SINGLE CROSSARM

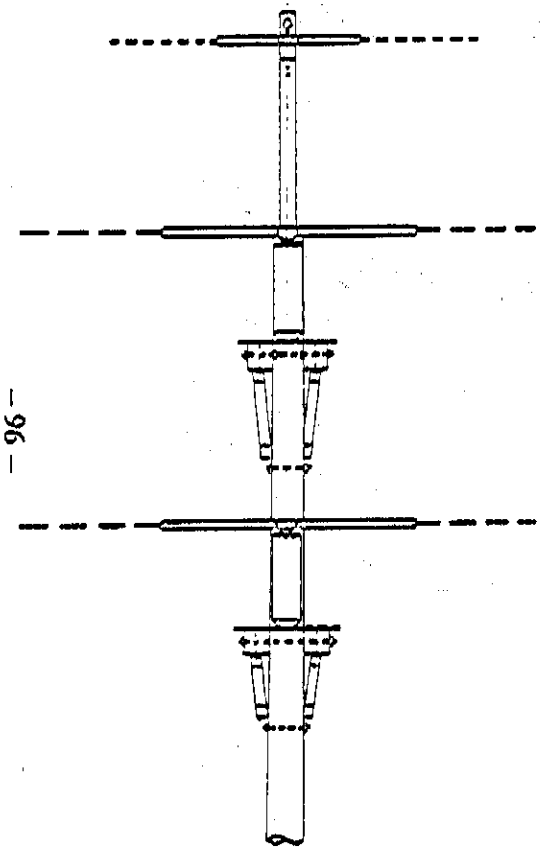




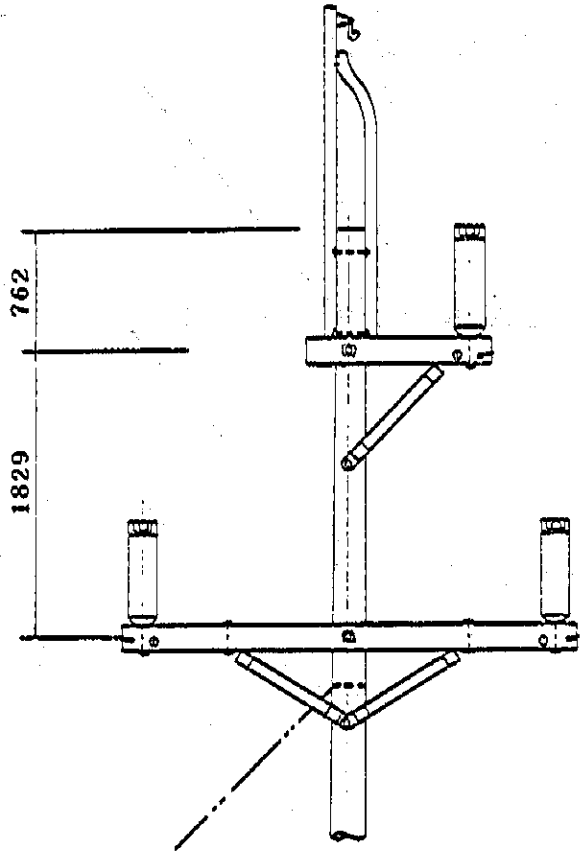
TP-2G
DOUBLE CROSSARMS

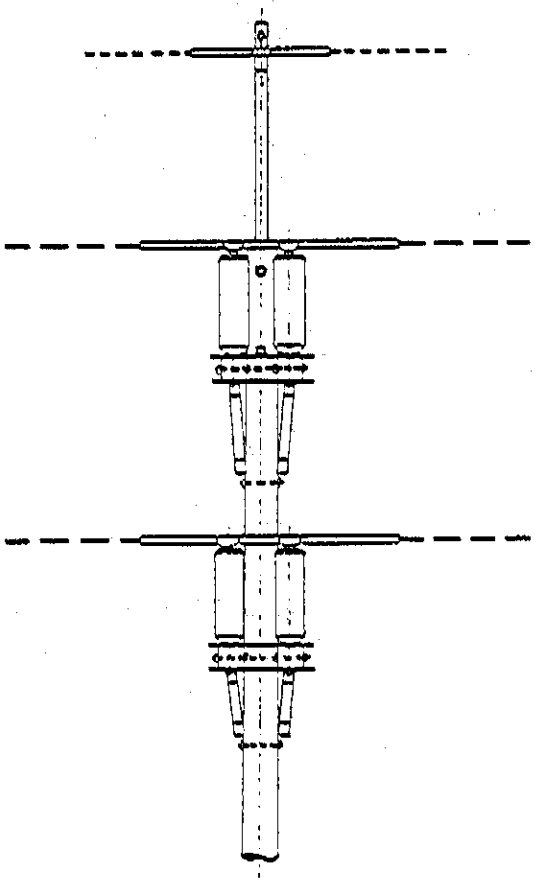
Fig 5 – 8

69 kV TRANSMISSION LINE LIGHT ANGLE STRUCTURE (SINGLEPOLE TYPE)



TP-3G
LIGHT ANGLE (1° – 3°)

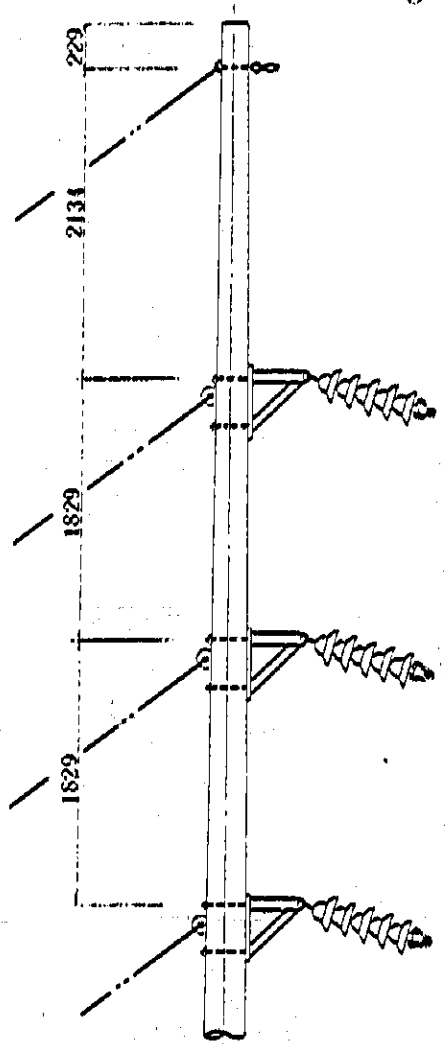




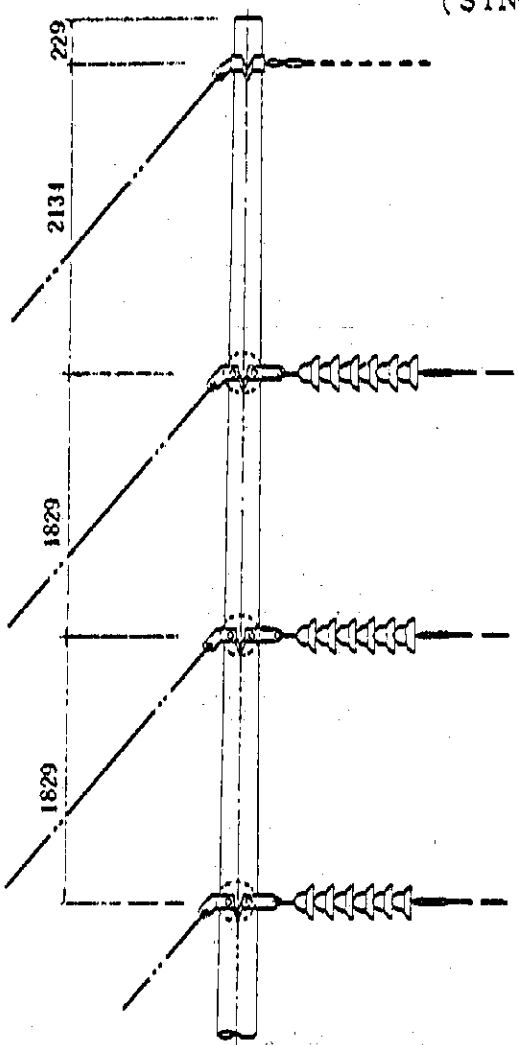
TP-3GA
LIGHT ANGLE (4° – 8°)

Fig 5-9

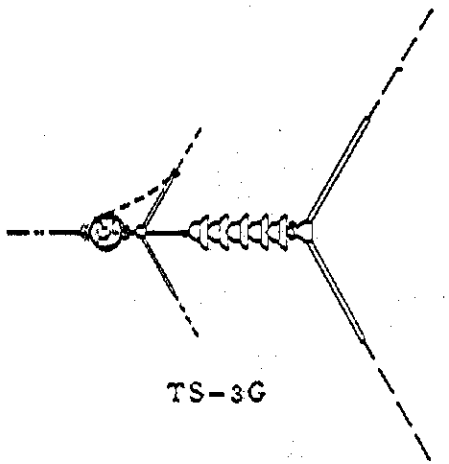
69 kV TRNSMISSION LINE VERTICAL STRUCTURE
(SINGLE POLE SUSPENSION TYPE)



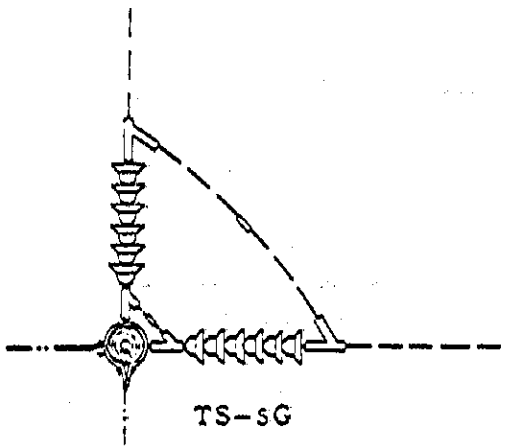
TS-3G
MEDIUM ANGLE



TS-5G
DEAD END



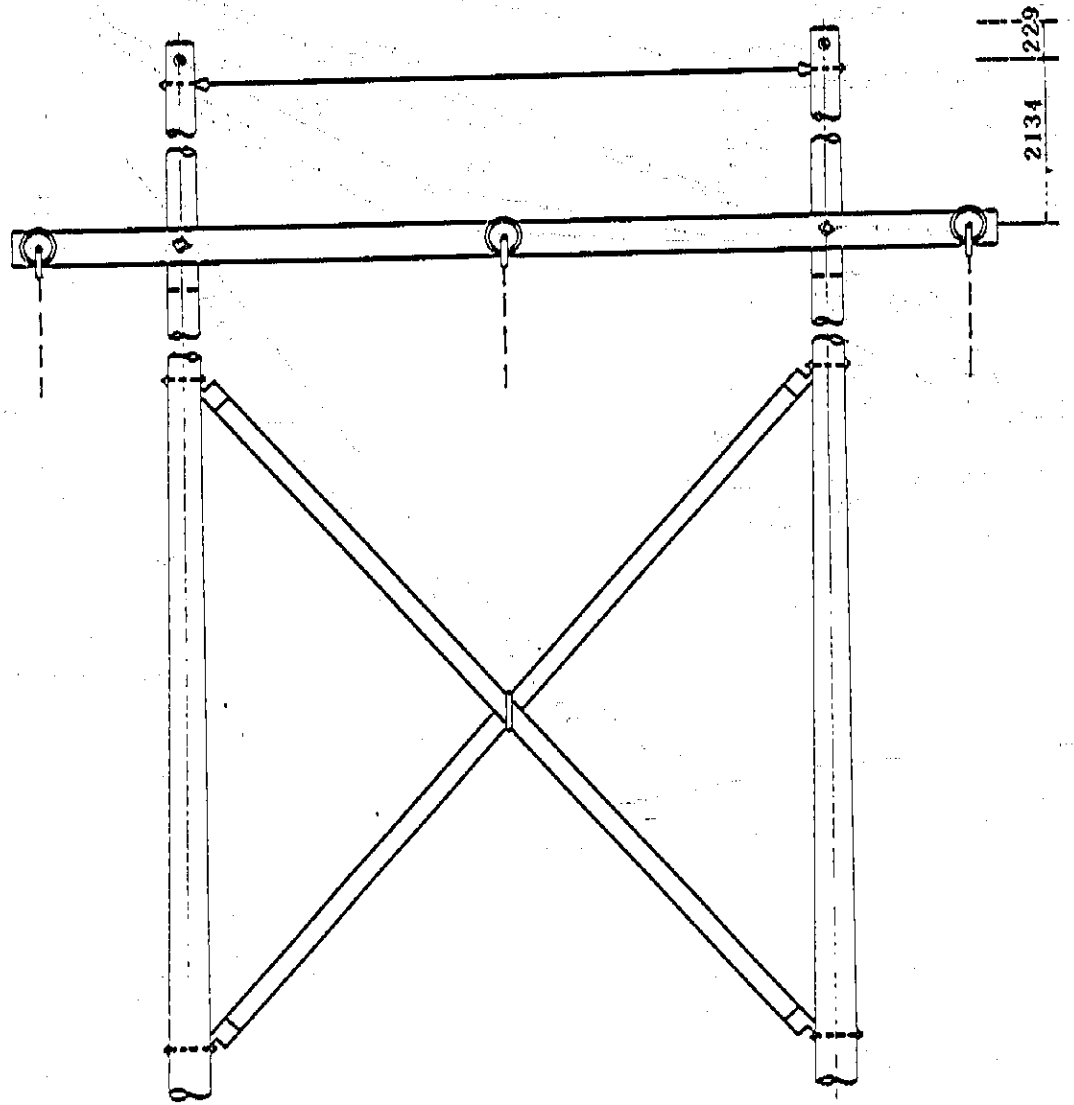
TS-3G



TS-5G

Fig 5-10

69kV TRNSMISSION LINE DEAD END STRUCTURE
(H-FRAME SUSPENSIN TYPE)



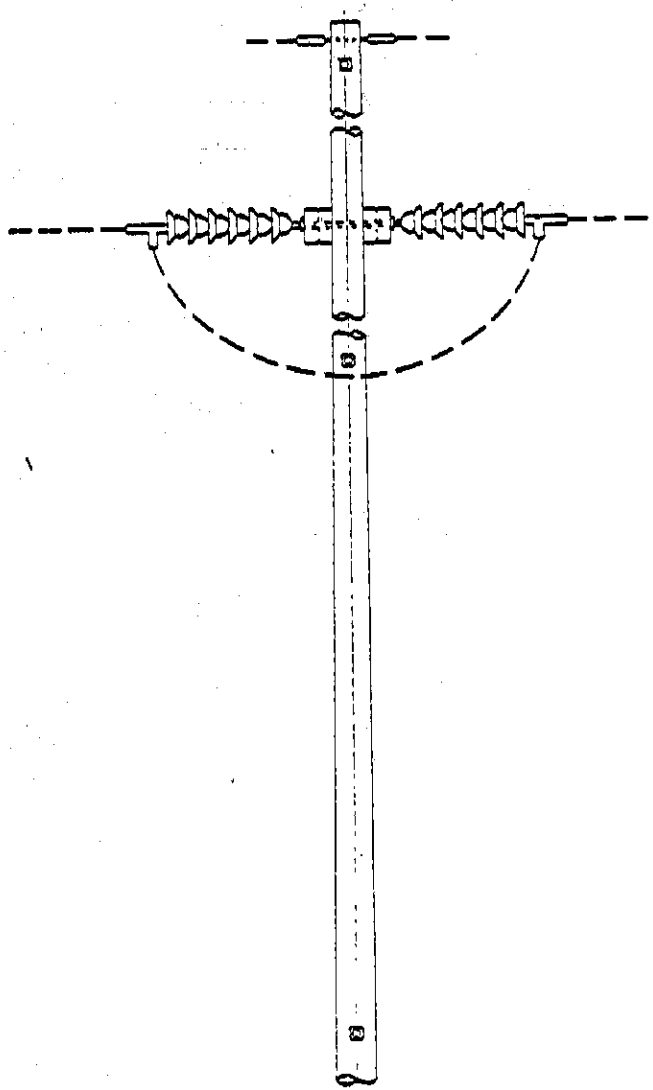


Fig 5-11 POWER SYSTEM DIAGRM IN SANTO DOMINGO