DOMINICAN REPUBLIC

CORPORACION DOMINICANA DE ELECTRICIDAD

DIRECCION DE DESARROLLO HIDROELECTRICO

EL TORITO - LOS VEGANOS

HYDROELECTRIC COMPLEX DEVELOPMENT PROJECT

ON UPPER YUNA RIVER

FEASIBILITY REPORT

VOL. II ANNEX

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JULY 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX A

ANNEX - A

GENERAL ECONOMIC BACKGROUND

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A. GENERAL ECONOMIC BACKGROUND

A.1 POPULATION AND EMPLOYMENT

A.1.1 Population and Household

The Dominican Republic has, within its territory of 48,442 km2, population of 5.75 million in 1983. Population increased from 3.05 million in 1960 to 4.01 million in 1970 (average growth rate of 2.8% per annum) and to 5.4 million in 1980 (growth rate of 3.0% per annum in 1970's). It is estimated that population of the Republic will reach 6.10 million in 1985 and 6.8 million in 1990. Urban population has been growing at a higher rate in recent years. According to the population census in 1970 and 1981, urban population increased from 40% to 52% of total population. It is predicted that rapid growth in urban population will continue in future, and it will represent nearly 59% in 1990. (Refer to Table A-01)

About 47% of total population are resided in the Southeast region, which includes the National District of Santo Domingo. The National District embraces 27.5% of total population and 44.7% of urban population of the country. San Cristobal, San Pedro de Macoris and La Romana are other provinces of the Southeast region, where 11.1% of total urban population are concentrated. (Refer to Table A-02 and A-03) Another concentration of population is observed in the Central Cibao sub-region which includes Santiago and La Vega provinces where 15.7% of urban population of the country are resided. (These provices concentrated with urban population are linked by trunk lines of power transmission, as described in Annex B.2.3.)

According to the VI national census in 1981, total household of the Republic numbered 1,114,800. About 40% are located in the Valdesia sub-region, including the National District, and around 22% in the Central Cibao sub-region. An average size of household was 5.1 persons. (Refer to Table A-03)

A.1.2 Employment

Economically active population (EAP) was about 1.2 million, or 30.2% of total population in 1970. About 45% of EAP was in the agricultural sector. EAP in the agricultural sector has been decreasing, while EAP in the service sector has been increasing rapidly. (Refer to Table A-04)

Unemployment rate has been substantially high. According to the 1970 census, about 24% of EAP was unemployed (23.9% in urban area and 24.1% in rural area). A sample survey in urban area in 1980 indicated the unemployment rate of 16.5% for male and 25% for female. It also revealed that the rate of underemployment was as high as 43% in urban area. The underemployment rate was estimated to be in the range of 40% to 50% in rural area.

A study by the Institute of Population and Development Studies predicted that EAP will increase to 2.2 million in 1985 and 2.6 million in 1990, while the demand for employment was estimated at 1.45 million and 1.64 million in respective year. This will lead to the implication that the unemployment rate will exceed over 30% in 1985-90 unless appropriate measures are taken to increase employment opportunities.

Despite the high rate of unemployment, qualified technicians are relatively limited in number, and it is assumed that wages paid are a better approximation of the economic cost of using labors. However, the prevailing situation of unemployment and underemployment seriously affects the employment of unskilled labors, and the opportunity cost of unskilled labors is much lower than the market wage rate. A study on the social accounting prices by IDB in 1979 indicated that a conversion factor of the unskilled labors was 0.745 in the northern region.

A.2 ECONOMIC SITUATION

A.2.1 Gross Domestic Product

Gross Domestic Product (GDP) of the Dominican Republic amounted to RD$7,227 million at current price in 1981. A real growth rate calculated at 1970 constant prices was 3.6% per annum on an average in 1976-78 and 2.5% per annum in 1980-82. (Refer to Table A-05) The Central Bank predicted that GDP will grow at 3.1% in 1983. GDP per capita in 1981 was RD$1,280 at current price, or RD$532 at 1970 constant price. In real term, GDP per capita demonstrated a slight decrease in the period from 1980 to 1982. (Refer to Table A-06)

The agricultural sector contributed for 17-19% of GDP in the last five years. Contribution of the mining sector, which was over 5% in the late 1970's, dropped to 3.2% in 1982 due mainly to the suspension of ferro-nickel smelting at Falconbridge. The suspension of Falconbridge, though temporary as it was, is said to be mainly attributable to the unfavorable market situation worldwide, but it might be partly attributable to an increased fuel cost for steam power generation.

GDP in the manufacturing sector increased at an average rate of 3.5% a year in 1978-82. Contribution of the sector to the total GDP of the country, however, remained constantly at around 18%. Such a stagnation might have been caused by multiplex national and international economic situation. However, a fact is that many industries are suffering from unstable supply and increased cost of electric power. Numbers of factories had to install in-house generators to cope with frequent black-out by CDE network. It is of fundamental significance for the acceleration of the industrial development to secure stable supply of electric power at reasonable prices.

A.2.2 Expenditure on GDP

GDP and import of goods and services from the final offer, totaled RD$3,766 million in 1980. On the other hand, private consumption and government consumption accounted for 59.3% and 7.1% of the total demand, respectively. The investment has been steadily increasing in recent years, with an average growth rate of 6.4% per annum in 1976-80. It comprised RD$151 million in the public sector and RD$582 million in the private sector in 1980. (Refer to Table A-07)

The opportunity cost of capital investment has not been assessed in an authentic way. However, an analysis by IDB in 1979 indicated that the opportunity cost of capital was around 12% in the Dominican Republic.

A.2.3 Balance of Payment

Trade balance of the Dominican Republic has remained unfavorable in recent years. Until 1981, export increased rather steadily, but import increased at a higher rate. In 1982, export of sugar which was the primary export product and minerals (ferronickel, bausite and gold-silver alloy) dropped sharply and total export value amounted to RD$768 million, or decrease by 35% from the previous year. Since the import remained at a considerably high level, the trade balance in 1982 showed a deficit amounting to RD$480 million. (Refer to Table A-08 and Table A-09)

Import of petroleum and its products was one of the principal reasons in increasing the value of import and aggravating the trade balance, because the Dominican Republic depends entirely on the imported petroleum. In 1982, import value of crude petroleum and petroleum products amounted to RD$450 million, which was equivalent to 36% of total import or 59% of total export of the country. (Refer to Table A-10) In this context, development of local resources to substitute the import of fossil energy will be of prime significance for the national economy in a short and long run.

A.2.4 Foreign Exchange

The unfavorable external balance of payment is reflected in the foreign exchange rate, too. The Dominican Republic has two exchange rates; one is the official exchange rate which is set at par with the US Dollar and is applied by the Central Bank in liquidating the trade of essential commodities, and the other is the quasi-legal extra-bank market exchange rate, or alternatively called the parallel market rate, applicable to the non-essential commodity transaction. For instance, import of petroleum and fuel is liquidated at the official exchange rate, but import of construction equipment is not considered as essential and it has to be paid at the parallel market rate.

The extra-bank market rate has a premium of 20-25% over the official rate in 1979-81. However, the premium sharply increased to around 44% on an average in 1982, and ascended to nearly 60% in mid 1983. (Refer to Table A-11) Although the parallel rate does not indicate a shadow exchange rate in a true sense, it affects commodity pricing in the same way as a tax and subsidy would affect. It might therefore be more practical to apply it as an approximation to the shadow exchange rate than to calculate a shadow rate or a standard conversion factor of social accounting prices on the basis of assumed value of taxes and subsidies.

A.2.5 Taxes

There exist a variety of taxes in the country. However, it was an usual practice of the government to exempt such taxes in the case of construction projects executed by CDE. The exemption has been applied to import tax and custom duties of construction equipment, vehicles and materials for exclusive use of the project, as well as corporate income tax and personal income tax of expatriate firm and personnel engaged in the project. However, taxes included in the local market prices of products, either locally produced or imported, shall not be reimbursed if they are purchased at such market prices.

Usually, the tax of 5% is applied to local purchase under the law No. 346. Such a tax is to be excluded in the estimate of economic prices as a transfer payment. In the case of fuels, CDE is accorded with the privilage to import bunker C oil, gas oil and diesel for power generation at tax free, but prices of diesel oil and gasoline purchased by CDE for vehicle and equipment operation include the above-mentioned 5% tax.

A.2.6 Price Index

A consumer price index, as shown on Table A-12, indicates that the market price was rather sharply inflated in 1980, but it was alleviated in 1981 and 1982. The consumer prices increased 9.9% in the National District and 7.1% in La Vega province, or 7.5% on a national average in 1981. Prices in 1982 increased at 7.6% on a national average. In estimating the financial contingencies for the construction cost, in a rather conservative manner, the rate of inflation in local currency is estimated at around 8%.

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TABLES

Table A-01 TOTAL POPULATION
(POBLACION TOTAL)

Unit: 1,000 prs

Year	Total	Urban	Rural
1960 (Jan. 9)*	3,047.1 (100.0%)	929.9 (30.5%)	2,117.2 (69.5%)
1970 (Jan. 9)*	4,009.5 (100.0%)	1,593.3 (39.7%)	2,416.2 (60.3%)
1970	4,058.3	1,031.7	2,426.6
71	4,165.0	1,716.2	2,448.8
72	4,276.9	1,805.3	2,471.6
73	4,396.2	1,899.3	2,496.9
74	4,517.3	1,998.7	2,518.6
75	4,646.4	2,103.5	2,542.9
76	4,782.1	2,214.4	2,567.7
77	4,923.4	2,331.0	2,592.4
78	5,073.4	2,455.0	2,610.4
79	5,230.9	2,585.6	2,645.3
1980	5,394.0	2,721.7	2,672.3
81	5,569.5	2,869.6	2,699.9
81 (Dec. 5)*	5,648.0 (100.0%)	2,935.9 (52.0%)	2,712.1 (48.0%)
1982	5,753.8	3,024.9	2,728.9
1985 **	6,096 (100.0%)	3,337 (54.7%)	2,759 (45.3%)
1990 **	6,803 (100.0%)	3,990 (58.7%)	2,813 (41.3%)

Note: * Census year and date. Population in other years is the estimated mid-year population.

** Estimated by Institute of Population and Development Studies, Bib. (6)

Table A-02 POPULATION BY REGION
(POBLACION POR REGIONES)

Unit: 1,000 prs.

Region/Sub-Region **	1960	1970	1980*
CIBAO	1,483.3	1,798.6	2,176.9
Urban	(310.0)	(504.3)	(801.5)
Rural	(1,173.3)	(1,294.3)	(1,375.4)
Cibao Occidental	202.9	246.3	290.0
Cibao Central	816.1	1,005.8	1,260.3
Cibao Oriental	464.3	546.5	626.6
SUROESTE	439.9	557.4	695.1
Urban	(108.5)	(171.6)	(277.1)
Rural	(331.4)	(385.8)	(418.0)
El Valle	270.4	334.8	430.6
Enriquillo	169.5	222.6	264.5
SURESTE	1,123.9	1,653.4	2,522.0
Urban	(511.4)	(917.4)	(1,643.1)
Rural	(612.5)	(736.0)	(878.9)
Valdesia	825.2	1,266.2	2,022.2
Yuna	298.7	387.2	499.8
Total	3,047.1	4,009.5	5,394.0

Note: * Estimated

** For Provinces incorporated in each sub-region, refer to Table A-03.

Table A-03 POPULATION AND HOUSES BY REGION
(Census in 1981)
(POBLACION Y VIVIENDAS POR REGIONES)

Region, Sub-Region and Province	Number of Houses			Population		
	Total	Urban	Rural	Total	Urban	Rural
CIBAO						
Cibao Occidental	60,588	24,456	36,132	296,846	116,439	180,407
Santiago Rodr.	10,362	2,872	7,490	55,411	14,639	40,772
Valverde	20,896	10,987	9,909	100,319	52,692	47,627
Dajabon	11,110	3,557	7,553	57,709	17,810	39,899
Montecristi	18,220	7,040	11,180	83,407	31,298	52,109
Cibao Central	245,860			1,306,189		
Santiago	100,661	57,947	42,714	550,372	316,041	234,331
La Vega	71,105	27,329	43,776	385,043	143,618	241,425
Espaillat	30,650	7,755	22,895	164,017	38,170	125,847
Puerto Plata	43,444	n.a	n.a	206,757	n.a	n.a
Cibao Oriental	122,905	34,486	88,419	639,630	173,764	465,866
Salcedo	18,331	3,371	14,960	99,191	16,805	82,386
Duarte	45,069	16,865	28,204	235,544	85,340	150,204
Sanchez R.	24,125	5,047	19,078	126,567	27,026	99,541
Samana	12,764	2,892	9,872	65,699	14,377	51,322
Maria T.S.	22,616	6,311	16,305	112,629	30,216	82,413
SUROESTE						
El Valle	79,616	27,126	52,490	448,111	152,671	295,440
Elias Pina	11,825	2,446	9,379	65,384	13,640	51,744
San Juan	42,561	14,122	28,439	239,957	78,595	161,362
Azua	25,230	10,558	14,672	142,770	60,436	82,334
Enriquillo	50,456	26,073	24,383	271,570	144,152	127,418
Independencia	7,046	3,787	3,259	38,768	21,210	17,558
Pedernales	3,118	1,679	1,439	17,006	9,435	7,571
Bahoruco	14,784	6,158	8,626	78,636	34,522	44,114
Barahona	25,508	14,449	11,059	137,160	78,985	58,175
SURESTE						
Valdesia	440,433			2,164,994		
Santo Domingo	321,120	270,931	50,189	1,550,739	1,313,172	237,567
Peravia	30,955	n.a	n.a	168,123	n.a	n.a
San Cristobal	88,358	29,066	59,292	446,132	150,295	295,837
Yuna	114,975	55,706	59,269	520,637	265,225	255,412
El Seibo	35,215	10,704	24,511	157,866	52,336	105,530
S P. Macoris	34,200	17,665	16,535	152,890	82,473	70,417
La Romana	24,570	20,132	4,438	109,769	93,796	15,973
Altagracia	20,990	7,205	13,785	100,112	36,620	63,492

Source: Oficina Nacional de Estadistica Bib.(5)

Table A-04 ECONOMICALLY ACTIVE POPULATION
(POBLACION ECONOMICAMENTE ACTIVA)

Sector	1950		1960		1970	
	Pop. 10^3	(%)	Pop. 10^3	(%)	Pop. 10^3	(%)
Agriculture	466.2	(56.5)	525.3	(60.6)	549.3	(45.3)
Mining	0.3	(0.0)	1.5	(0.2)	0.8	(0.0)
Manufacturing	57.1	(6.9)	71.6	(8.2)	101.0	(8.3)
Electricity, gas	1.5	(0.2)	3.3	(0.4)	1.7	(0.1)
Construction	19.5	(2.4)	22.3	(2.6)	28.5	(2.4)
Commerce	40.8	(4.9)	58.0	(6.7)	77.1	(6.4)
Transport	12.7	(1.5)	22.5	(2.6)	43.3	(3.6)
Services	68.2	(8.3)	134.5	(15.5)	153.9	(12.7)
Others	159.3	(19.3)	27.8	(3.2)	256.1	(21.2)
Total EAP	825.6	(100.0%)	866.8	(100.0)	1,211.7	(100.0)
(EAP/Total Pop.)			28.4%		30.2%	

Source: Bib. (6)

Table A-05 GROSS DOMESTIC PRODUCT BY SECTOR
(At 1970 Prices)
(PRODUCTO INTERNO BRUTO POR SECTORES)
(A Precios de 1970)

Unit: Million RD$

	1976	1977	1978	1979*	1980*	1981**	1982**
Agriculture	429.2	436.8	456.8	461.7	483.3	509.1	592.8
Mining	146.7	143.0	114.3	146.5	124.8	136.2	95.9
Manufacturing	457.4	483.2	482.6	504.8	530.2	546.1	574.4
Construction	153.2	168.7	174.5	183.5	196.5	198.0	188.3
Commerce	414.0	429.8	438.8	451.5	473.6	491.6	508.8
Transport/ Communic.	190.8	211.8	218.9	225.4	230.5	242.7	254.0
Electricity	30.9	39.3	42.9	43.7	49.0	53.4	48.3
Finance	58.2	63.4	66.4	67.9	70.4	73.2	76.5
Housing	156.8	169.8	177.2	186.0	198.1	199.7	197.9
Government	189.9	191.2	200.4	236.1	277.8	274.7	287.9
Others	215.8	227.4	246.8	234.5	265.4	278.1	287.8
Total	2,442.9	2,564.5	2,619.5	2,741.6	2,899.6	3,002.8	3,048.6

Unit: %

	1976	1977	1978	1979*	1980*	1981**	1982**
Agriculture	17.6	17.1	17.4	16.8	16.6	17.0	19.4
Mining	6.0	5.6	4.4	5.3	4.3	4.5	3.2
Manufacturing	18.7	18.8	18.4	18.4	18.3	18.2	18.8
Construction	6.3	6.6	6.7	6.7	6.8	6.6	6.2
Commerce	16.9	16.8	16.8	16.5	16.3	16.4	16.7
Transport/ Communic.	7.8	8.2	8.3	8.2	8.0	8.1	8.3
Electricity	1.3	1.5	1.6	1.6	1.7	1.8	1.6
Finance	2.4	2.5	2.5	2.5	2.4	2.4	2.5
Housing	6.4	6.6	6.8	6.8	6.8	6.6	6.5
Government	7.8	7.4	7.6	8.6	9.6	9.1	9.4
Others	8.8	8.9	9.4	8.6	9.2	9.3	9.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: * Preliminary figures ** Estimated figures

Source: Central Bank, National Account 1976-80 and Monthly Bulletin

Table A-06 GROSS DOMESTIC PRODUCT PER CAPITA
(PRODUCTO INTERNO BRUTO POR CAPITA)

	1978	1979*	1980*	1981**	1982**
Population (thousand prs.)	5,124.4	5,275.4	5,430.9	5,648.0	5,811.8
increase rate (%)		2.9	2.9	3.9	2.9
GDP at 1970 prices (million RD$)	2,619.5	2,714.6	2,899.6	3,002.8	3,048.6
increase rate (%)	2.1	3.6	6.8	3.6	1.5
GDP at current prices (million RD$)	4,728.4	5,525.4	6,649.0	7,226.5	n.a
GDP per capita					
at 1970 prices (RD$)	511.2	514.6	533.9	531.7	524.6
at current prices (RD$)	922.7	1,047.4	1,224.3	1,279.5	n.a

Note: * Preliminary figures ** Estimated figures
Source: Central Bank, National Account 1976-80 and Monthly Bulletin

Table A-07 EXPENDITURE ON GROSS DOMESTIC PRODUCT
(At 1970 Prices)

(OFERTA Y DEMANDA FINALES)
(A Precios de 1970)

Unit: Million RD$

	1976	1977	1978	1979*	1980*
GDP	2,442.9	2,564.5	2,619.5	2,741.6	2,899.6
Import of Goods & Services	618.8	652.3	621.1	735.9	866.2
Total OFFER	3,061.7	3,216.8	3,240.6	3,477.5	3,765.8
Private Consumption	1,838.7	1,896.4	1,887.1	1,902.2	2,233.1
Government Consumption	134.7	151.5	175.3	215.7	265.7
Investment:	572.7	618.9	635.6	687.3	732.8
Private Sector	(410.8)	(444.6)	(473.4)	(553.4)	(581.7)
- Construction	(167.3)	(191.1)	(209.6)	(271.2)	(294.4)
- Equipment	(197.1)	(212.5)	(203.0)	(248.2)	(235.0)
- Inventory	(46.4)	(41.0)	(60.8)	(34.0)	(52.3)
Public Sector	(161.9)	(174.3)	(162.2)	(133.8)	(151.2)
- Construction	(142.8)	(150.4)	(143.6)	(100.0)	(103.1)
- Equipment	(19.1)	(23.9)	(18.6)	(33.8)	(48.1)
Subtotal	2,546.1	2,666.8	2,697.9	2,805.1	3,231.6
Export of Goods & Services	515.6	550.0	542.7	672.4	534.2
Total DEMAND	3,061.7	3,216.8	3,240.6	3,477.5	3,765.8

Note: * Preliminary figures

Source: Central Bank, National Account 1976-80

Table A-08 EXPORT AND IMPORT

(EXPORTACIONES E IMPORTACIONES)

Unit: Million RD$

	Export (FOB)	Import (FOB)	Balance
1977	780.5	847.8	- 67.3
1978	675.5	859.7	-184.2
1979	868.6	1,080.4	-211.8
1980	961.9	1,498.4	-536.5
1981*	1,188.0	1,450.2	-262.2
1982*	767.7	1,248.4	-480.7
1983**	785.2	1,250.0	-464.8

Note: * Preliminary figures

** Forecasted by the Central Bank in August 1983.

Source: Central Bank, Bib. (3) (8)

Table A-09 EXPORT BY MAJOR CATEGORIES

(EXPORTACIONES POR CATEGORIAS)

Unit: Million RD$

	1978	1979	1980	1981	1982
Sugar & By-products	210.1	232.1	326.1	560.4	308.6
Coffee & By-products	97.0	157.7	76.8	75.9	95.6
Cacao & By-products	85.5	73.1	51.1	50.1	59.0
Tobacco & By-products	45.8	54.9	34.8	67.3	22.9
Fish & Marine Products	*	*	*	1.2	1.3
Minerals	168.6	272.1	388.5	334.0	193.1
- Ferronickel	(72.7)	(123.4)	(110.5)	(110.5)	(24.2)
- Bauxite	(23.1)	(20.9)	(18.5)	(15.7)	(5.3)
- Gold-silver Alloy	(72.8)	(127.8)	(259.5)	(207.8)	(163.6)
Others	68.5	78.7	84.6	99.1	87.2
Total EXPORT	675.5	868.6	961.9	1,188.0	767.7

Note: * included in Others

Source: Central Bank, Monthly Bulletine

Table A-10 IMPORT OF PETROLEUM AND PRODUCTS
(IMPORTACIONES DE PETRÓLEO)

Unit: Million RD$

	Crude Petroleum	Petroleum Product	Total
1973	29.4	12.9	42.3
1974	118.5	29.1	153.6
1975	143.8	29.7	168.5
1976	146.6	24.5	171.1
1977	158.0	29.8	187.8
1978	151.9	47.1	199.0
1979	250.6	64.3	314.9
1980	337.7	111.1	448.8
1981	398.6	98.8	497.4
1982	324.6	124.9	449.5*
1983	327.8	138.6	466.4*

Note: *Preliminary figures
Source: Central Bank

Table A-11 EXTRA-BANK MARKET EXCHANGE RATE OF MONEY ORDER (US$)

(TASA DE CAMBIO DEL MONEY ORDERS EN EL MERCADO EXTRABANCARIO)

		Selling (%)	Buying (%)
1979		20.31	18.89
1980		24.06	22.62
1981		26.07	24.84
1982		44.36	43.06
1983	January	50.30	48.76
	February	49.39	47.84
	March	49.33	48.31
	April	50.81	49.41
	May	55.13	53.55
	June	55.12	53.59

Source: Central Bank, Bib.(3)

Table A-12 CONSUMER PRICE INDEX

(INDICE DE PRECIOS AL CONSUMIDOR)

		National		Santo Domingo		La Vega	
		Index	Change (%)	Index	Change (%)	Index	Change (%)
May 1976-April 1977		100.00	-	100.00	-	100.00	-
1978		107.11	7.11	108.24	8.24	103.40	3.40
1979		116.93	9.17	117.17	8.25	116.54	12.71
1980		136.52	16.75	138.73	18.40	132.39	13.60
1981		146.81	7.54	152.49	9.92	141.84	7.14
1982		158.02	7.64	164.34	7.77	155.52	9.64
1983	January	163.98		170.32		169.23	
	February	163.13		169.80		162.28	
	March	161.76		170.07		166.51	
	April	162.17		170.02		167.20	
	May	163.12		170.84		167.17	
	June	163.14		170.90		166.99	

ANNEX B

ANNEX - B

DEMAND AND SUPPLY OF ELECTRIC POWER

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B. DEMAND AND SUPPLY OF ELECTRIC POWER

B.1 INTRODUCTION

Electric power supply is one of the infrastructures of prime importance to sustain and foster economic development of the Republic. Dominican Electric Corporation (CDE) is an autonomous corporation responsible for power supply over the country. CDE owned and operated its proper power plants and purchased electric power from the state-owned, but CDE operated, hydro power stations developed under the multipurpose dam projects.

In general, electric power supply by CDE has been insufficient to meet the growing power demand, and various studies have been made to improve its situation. Among others, the Expansion Plan of CDE Electric System in 1979-1992 was prepared by CDE-SOFRELEC in 1979-80. The Plan forecasted future demand and programed strategic expansion plan up to year 1992. This Expansion Plan was authorized by the government as a master plan to be eventually followed for the development of electric power in the Republic.

In defining the scope of study on power situation for El Torito - Los Veganos Hydroelectric Complex, CDE insisted that modification of power demand forecast and expansion plan should not be intended, but the study on El Torito - Los Veganos Complex should be made in the framework of CDE-SOFRELEC Expansion Plan. JICA had no intention to update the Expansion Plan, but considered it as necessary to review the demand forecast incorporating the updated information.

The case study on power demand in Chapter 3 herein is therefore made by analysing sensitivity of demand forecast which is affected by some variable factors. The review on power expansion program in Chapter 4 is also made to clarify the role of El Torito - Los Veganos Hydroelectric Complex. A brief review on financial situation in Chapter 6, as well as the review on expansion program, will afford a basis for planning and evaluation of El Torito - Los Veganos Complex.

B.2 SITUATION OF POWER DEMAND AND SUPPLY

B.2.1 Past Trend of Demand

Consumption of electric power grew steadily in 1970's. The energy sold by CDE increased from 684 GWh in 1970 to 1,914 GWh in 1980, with an average annual growth rate of 10.8%. Although the growth rate decreased slightly to 8.9% in 1981, the potential demand remained considerably high. The sold energy dropped to 1,890 GWh in 1982 due to extraordinary increase in energy loss. (Refer to Table B-01 and Fig. B-01)

Power consumption by sector has demonstrated little change since 1970. Energy sold in the residential sector accounted for 38-39% of total energy sold by CDE. It increased at the average rate of 8.8% per annum in 1977-81. The average power consumption per customer in the residential sector remained in the order of 2,000 - 2,100 kWh per annum in 1977-80. The energy sold in the commercial sector accounted for 12-13% of total sold energy, demonstrating little historical change since 1970. (Refer to Table B-02 and B-03)

In the industrial sector, the rate of increase in sold energy was slightly lower than the average increase rate of total energy sold by CDE. It was around 7.1% per annum on an average in 1977-81. The relatively low growth rate of energy sold in the industrial sector will be attributable partly to the fact that the growth of GDP in manufacturing sector remaind rather stagnated or increased at the rate of 3.1% per annum in 1977-81 as shown on Table A-05, and partly to the unreliable power supply by CDE. In fact, numbers of factories were obliged to install their in-house generators to cope with frequent black-out of CDE power supply. The energy sold in the industrial sector accounted for 35-38% of the total energy sold by CDE. (Refer to Table B-02 and B-03)

About 75% of power customers resided in urban areas. (Refer to Table B-04) The customers in rural areas have been steadily increased year by year, as a result of development in rural electrification. It is noted, however, that the electrification rate remained relatively low, or 29.8% over the country at the end of 1982.

Santo Domingo area, or the National District was salient in power consumption. It represented about 40% of total number of CDE customers, consuming nearly 64% of power billed over the country. Over 60% of customers in the industrial sector are located in the National District, and they consumed more than 70% of energy sold by CDE in this sector. In Santiago region, where approximately 13% of customers are located, the energy consumption accounted for about 11% of total sold energy. The East zone comprises relatively large scale industries located in San Pedro de Macoris and La Romana. Despite the number of customers was smaller than any other region, average power consumption per customer was comparatively large in the East zone. In the North zone, average power consumption by customer was lower, though the number of power customers was relatively large, representing around 24% of total CDE customers. (Refer to Table B-05)

Total sending end energy, inclusive of energy purchased from the state-owned hydro power plants and the Falconbridge steam power, reached 2,849 GWh in 1982. The sending end energy increased at the average rate of 11.7% in 1970's. (Refer to Table B-01)

The energy loss, equivalent to a balance between the sending end energy and the sold energy, has been substantially high. During the period from 1975 to 1980, an energy loss factor ranged from 24% to 27%. In 1982, the loss factor increased extraordinarily up to 33.6%. Reasons for such a sharp increase in energy loss are uncertain, but it is said to be partly attributable to an increase in power tariff. The mean energy loss to sending end energy in 1976-78 comprised 7.6% in transmission lines and 18.5% in distribution systems. (Refer to Table B-06)

The maximum or peak demand increased from 180 MW in 1970 to 462 MW in 1980, with an average growth rate of 9.9% per annum. It reached at 504 MW in 1982. A load factor ranged from 62% to 67%, or averaged at 64.6% in 1978-82. (Refer to Table B-01)

Typical daily load curves on week-day and holidays are illustrated on Figure B-02. The peak load usually takes place at around 7:00 pm, and the demand decreases after 10:00 pm. In week-days another peak hour, though much lower than the evening peak load, occurs at around 3:00 pm, which might reflect the fact that the government and public offices close at around 2:30 pm. Duration of peak hours over 407 MW, which was the firm average capacity of steam power as noted in the subsequent Section 2.2, was less than 6 hours a day on an average. The peak load during these hours appears to be caused mainly by consumption in the residential sector.

B.2.2 Situation of Power Generation

Electric power is fed by CDE-owned hydro, steam, gas turbine and diesel plants and by purchase from the state-owned hydro power plants and the Falconbridge steam power. Total installed capacity of the plants, including the state-owned hydro plants (165 MW) and Falconbridge (78 MW), was around 907 MW. About 81% of the installed capacity is thermal power (steam, gas and diesel) and the hydro power represented only 19%. (Refer to Table B-07)

The guaranteed or firm generating capacity is much lower than the installed capacity. In hydro power, the guaranteed capacity was 88 MW in 1982. The firm capacity of thermal power is estimated by means of actually generated energy and operation hours in 1981-82. The firm average capacity was around 407 MW in steam power (including Falconbridge), 102 MW in gas turbine and 3 MW in diesel power. Consequently, the firm capacity for power supply was about 600 MW in total. (Refer to Table B-08)

Out of total sending end energy, hydro power contributed 10.9% in 1982 and 18.4% in 1981. (Due to damage in hydro power schemes by Hurricane David, hydro power contributed only 7.9% in 1980.) Contribution of gas turbine power was rather constant, or 9.3-9.9% in 1979-82, and diesel power contribution was quite marginal. The remaining energy (79% in 1982 and 72% in 1981) was fed by steam power plants. (Refer to Table B-09)

Major hydro plants, including Tavera-Bao, Valdesia, Sabana Yegua, Rincon and Sabaneta, are state-owned. The CDE-owned hydro power is presently limited to rather small plants, like Las Damas and Constanza. The Tavera-Bao power station (80 MW), Valdesia power station (54 MW) and Rincon power station (10.1 MW) have been designed and operated to cover peak load, while

Sabana Yegua station (13 MW) and Las Damas station (7.5 MW) were basically designed to cover a base load. Total hydro power output reached 512 GWh in 1981 and 311 GWh in 1982. The planned operation of hydro power plants are summarized on Table B-10.

Steam power plants are located in Haina, Santo Domingo and Puerto Plata. Haina power station, having 5 generating units, is the principal power source to cover the base load with the total installed capacity of 362.7 MW. It contributed for nearly half of the total sending end energy of the CDE network. In case a unit of Haina station is down and out of supply, the power supply situation faces with a critical condition. Santo Domingo steam power station, having 3 generating units with a total installed capacity of 51.7 MW, has also been fully operated (over 8,000 hours a year). The second unit (36.8 MW) of the Puerto Plata steam station started its commercial operation in November 1982, while operation of the first unit (27.6 MW) was suspended in April, 1982. Operation of the steam power plants in 1981 and 1982 is summarized on Table B-11.

The plant factor was around 49% on an average at the Haina steam power station and 65% at Santo Domingo station. Haina station consumed 466,800 kiloliters of bunker-C oil, with an average power output of 3.32 kWh per liter (0.301 liter per kWh) in 1982. Oil consumption at Santo Domingo station was less favorable, or 2.73 kWh per liter (0.366 liter per kWh).

Gas turbine power stations have been operated to supplement the power generation by steam and hydro power. The operation hours, however, have been relatively long. For instance, Los Minas station and Weber station were operated over 3,500 hours a year in 1982. (Refer to Table B-11) An averaged plant factor of CDE gas turbine stations was 19.4% in 1982. Oil consumption for gas turbine power stations totaled 124,300 kiloliters, with an average power output of 2.28 kWh per liter (0.439 liter per kWh). (Refer to Table B-12)

Prices of fuel purchased by CDE (tax free) have increased year after year, though they were discounted in 1982 following the world trend. Bunker-C oil for steam power plants cost RD$29.85 per barrel in 1981, RD$24.78 per barrel in 1982 and RD$26.00 per barrel in early 1983. For gas turbine power plants, the average price of gas oil was RD$42.65 per barrel in 1981, RD$43.74 per barrel in 1982, and RD$44.50 per barrel in early 1983. (Refer to Table B-13)

Synthetically, power supply by CDE is heavily dependent on thermal power generation which is entirely fueled by imported oil, and development of hydro power has been lagged behind. Black-out by shut-down of major thermal plants due to repair or shortage of fuel has been quite frequent, and such an instable power supply caused serious problems in the industrial sector, as well as residential and commercial sectors.

B.2.3 Power Transmission and Distribution

Power is sent to major consuming centers through 138 kV and 69 kV transmission lines. 138 kV lines (ACAR 450 MCM) have been put into operation since 1979. The principal trunk line extends from the Tavera-Bao hydro power station to Canabacoa (15.9 km) and from the Puerto Plata steam power station to Canabacoa, and it is further extended to Palamara (125 km) located to the northwest of Santo Domingo. At Palamara (also called Los Alcarrizos), 138 kV lines from the Valdesia hydro power station (45 km) and from Itabo coal fired steam power station (15 km) are being connected. For power supply to the East zone, 138 kV line was extended from Palamara to San Pedro de Macoris (83 km). (Refer to Fig. B-03)

69 kV grids were formerly constituted the trunk lines. By 1977, the lines extended for a total length of 1,187 km. They are located 624 km in the North zone, 292 km in the South zone, 192 km in Santo Domingo and 79 km in the East zone. The grid was further extended thereafter, and it reached at around 2,000 km in total by 1982.

The transmission system around the study area for El Torito - Los Veganos Hydroelectric Complex is presently networked by 69 kV lines.

Power generated at the Rincon hydro power station is transmitted for 20 km to La Vega and 22 km to Bonao. Power purchased from Falconbridge is sent to the tap Falconbridge-Bonao (8 km) and extended to Bonao city (3 km), Piedra Blanca (17 km) and to Arroyo Hondo (78 km) which is located to the north of Santo Domingo and is connected with a 69 kV line from Haina. For the Rio Blanco hydroelectric project (25 MW), however, a 138 kV line was designed to be constructed to Bonao, which will be used at first at 69 kV and ultimately at 138 kV by integrating other hydroelectric schemes to be constructed in the upper Yuna river basin. Consequently power to be generated at El Torito - Los Veganos Complex will be transmitted by a 69 kV line to the switchyard of the Rio Blanco power station.

For power distribution, power voltage is stepped down to 12.5 kV and 4.16 kV at substations. In Santo Domingo, for instance, there are 11 substations with a total capacity of 345 MVA, 38 feeders for 12.5 kV lines and 8 feeders for 4.16 kV lines. The load on 4.16 kV lines has been considerably large, and voltage drop was over 6% in a substantial part of the feeders. Since 1980, improvement of distribution systems in Santo Domingo has been planned, and it is under design stage at the moment for improvement of the first stage program. Study and basic plan has also been prepared for other 11 major cities, including Santiago, San Pedro de Macoris, La Romana, San Cristobal, San Francisco de Macoris, San Juan, etc.

B.3 POWER DEMAND FORECAST

B.3.1 Forecast by CDE-SOFRELEC in 1980

As noted in Chapter 1 herein, future power demand was forecasted by CDE-SOFRELEC under the Expansion Plan of CDE Electric System. Under this study, the forecast was made from 1979 up to 1992 by three alternative analysis. The first method was called the autonomous projection and it estimated the future demand on the basis of regression analysis on the past trend of demand. It was estimated that the sold energy will reach 3,663 GWh in 1985 and 8,041 GWh in 1992 (average annual growth rate of 11.9% in 1979-92). The second method applied macroeconomic analysis on the basis of GDP growth by sectors. The estimated sold energy reaches 3,238 GWh in 1985 and 7,614 GWh in 1992 (average growth rate of 12.4% in 1979-92). The third alternative forecast was made on the basis of demand projection by categories, such as the demand in the residential sector forecasted by classifying it into categories of some income levels. Under the third method, the sold energy was estimated to reach 4,140 GWh in 1985 and 7,927 GWh in 1992 (average growth rate of 10.4% in 1980-92). CDE-SOFRELEC predicted that the forecast by the second method would be the most probable estimate. (Refer to Table B-14)

With respect to the energy loss, the Expansion Plan predicted that it would decrease sharply. It was expected that a loss factor would drop to 20% in 1983 and 16% in 1992. By applying such a loss factor, the sending energy was calculated to reach 3,983 GWh in 1985 and 9,060 GWh in 1992.

A load factor of 62.5% - 62.7% was applied in estimating the maximum demand. It was eventually estimated that the peak demand will reach 728 MW in 1985 and 1,661 MW in 1992. (Refer to Table B-15)

B.3.2 Review of Previous Forecast

Socio-economic indicators in recent years demonstrated some variation, if they are compared with the estimate adopted in the CDE-SOFRELEC study in 1979-80. As noted in Annex A.1.1., a growth rate of population of the Republic is expected to be lowered, as a result of updated estimate on the basis of the population census executed in 1981. The population growth rate is estimated at 2.4% per annum on an average in 1980-90, while it was predicted to be 3.7% under the CDE-SOFRELEC study. An increase in urban population is also expected to be slightly lower than the CDE-SOFRELEC prediction.

Due to stagnated national economy, GDP increased at the average growth rate of 3.5% in 1977-82, while it was predicted to be 8.4% under the CDE-SOFRELEC study in that period. Although there is no long-term national economic development plan authorized by the government, it would not be realistic that GDP would grow at an average rate of 7.7% in 1980-90 as predicted by the previous study. In the manufacturing sector, the CDE-SOFRELEC study forecasted that the growth rate of the sector in 1977-82 was 12.7% per annum on an average, but the real growth was 3.5% a year in that period.

Despite such variations in macroeconomic indicators, the forecast of the sold energy by CDE-SOFRELEC demonstrated fairly good values in 1979-81, if they were compared with the actual record. For instance, the CDE-SOFRELEC predicted that the sold energy was 2,013 GWh in 1981, while it was 2,085 GWh actually. The energy actually sold in 1982 was exceptionally low due to an extraordinary increase in energy loss. (Refer to Table B-16 and Fig. B-04)

A salient variation between the actual record and the CDE-SOFRELEC prediction is an energy loss factor. As noted in Section 3.1 above, it was predicted that the loss factor would decrease to 20% in 1983 and 16% in 1992. The actual values of loss factor were much higher in recent years, even though the loss factor in 1982 was considered as exceptional. In 1981, the loss factor was actually 25.2% while it was predicted to be 24.2% by the previous study. The loss factor will in no way drop to 20% in 1983. Although 138 KV transmission lines have been put into operation and CDE has been promoting improvement of distribution systems as noted in Section 2.3 above, it is considered that such an improvement in distribution systems will take a longer period than expected and the improvement in the loss factor will be retarded substantially.

Another point of notable variation is the load factor. In estimating the maximum demand, the CDE-SOFRELEC study applied the load factor of 62.5% - 62.7% as noted in Section 3.1 above. Actually, however, the factor increased to 64.9% in 1980, 67.0% in 1981 and 64.5% in 1982. In view of the pattern of industrial development and the use of electricity in other sectors, it would be more realistic to consider that the load factor would remain at a higher value than predicted by CDE-SOFRELEC.

By incorporating the two salient variations as noted above, case studies have been executed to evaluate their sensitivity on the forecast of the maximum demand. In these case studies, the energy loss factor is assumed to be gradually improved at a slower pace, or to be lowered to 22.5% in 1992. (Refer to Fig. B-05) The load factor, on the other hand, is assumed to be at a higher rate, or approximately 65%.

Two case studies have been executed on different forecast of the sold energy. The Case-1 applied the sold energy predicted by CDE-SOFRELEC. The Case-2 study is made on the basis of the sold energy forecasted by means of evolution by regression in recent power record. Since the sold energy in 1982 was extraordinary and the trend of demand in 1960's would, if incorporated, lead to predict higher value because of substantially low demand in 1960-64, the regression analysis is made on the basis of evolution in 1970-81.

Under the Case-1 study, the maximum demand is estimated to reach 771 MW in 1985 and 1,725 MW in 1992. On the other hand, the sold energy under the Case-2 study is estimated at 3,200 GWh in 1985 and 6,450 GWh in 1992. The maximum demand is predicted to be 762 MW in 1985 and 1,461 MW in 1992. The above-estimated maximum demand is higher under the Case-1 study and much lower under the Case-2 study than the CDE-SOFRELEC prediction. (Refer to Table B-17 to B-19)

B3.3 Revised Forecast by CIE-SOFRELEC

Further study on future power demand was made by CIE-SOFRELEC as reported in the Actualization Plan of Electric System Expansion of CIE, authorized in 1983. In this report, the forecast for sending end energy and maximum power demand from 1983 to 1992 and 93 taking account of those data from 1960 to 1982. According to the media forecast in the study, the sending end energy will reach 3,639 kWh in 1985 and 7,316 kWh in 1992 and 8,157 kWh in 1993, respectively; equivalent to an annual average increase rate of 10%. The load factor of 62% is assumed through the period in forecast and as the result, the maximum power demand is expected to reach 670 MW in 1985 and 1,347 MW in 1992 and 1,502 MW in 1993. (Refer to Table B-19.) This forecast is referred to as the Case-3 study.

B.4 POWER EXPANSION PROGRAM

B.4.1 CDE Expansion Plan

The Expansion Plan proposed by CDE-SOFRELEC has basic strategies to 1) develop coal fired thermal power plants to cover the major part of base load, 2) minimize the use of steam power plants, and 3) develop hydro power to the maximum extent. Gas turbine plants are planned to be used, though limited, to cover a part of the peak load.

Four units of coal fired plants (115 MW each) have been planned to be installed at Itabo by 1987, and additional three units of 115 MW are planned to be installed by 1992. Installation of the coal fired plants were recommended as a result of economic evaluation on the basis of presumed coal price estimated at US$15.5 per 10^6 kcal and price of heavy oil estimated at US$26.3 per 10^6 kcal.

All the hydroelectric projects identified by the time of the CDE-SOFRELEC study were listed up on the inventory, and they were incorporated in the Expansion Plan to the maximum extent. It was estimated that the hydro power to be developed by 1992 would reach at the mean capacity of 620 MW or about 510 MW in the drought years. The steam power plants were proposed to supplement the deficit of hydro power in the drought years and the deficit of supply to cover a limited extent of the base load. A proposed pattern of each type of power generation is illustrated on the load duration curve on Figure B-06.

B.4.2 Expansion Program up to 1989

In the light of the Expansion Plan, CDE has been taking various actions to develop facilities for power generation, transmission and distribution. By incorporating the available information on such actions taken in 1980 by CDE, power expansion up to 1989 appears to be programable, while it seems rather premature to define a plan after 1990. According to the Actualization of Expansion Plan just authorized in 1983, expansion plan of hydropower plants up to 1992 is programmed. However the completion for a majority of those hydropower plants programmed in 1990-92 seems to be less realistic, because it involves the construction of power plants of their total capacity exceeding over those to be implemented until 1989. Attempt has therefore been made to first evaluate the situation up to 1989.

The power installation program is envisaged at the moment as summarized on Table B-20. During the period from 1983 to 1989, two units of coal fired power plants (230 MW in total) will be installed at Itabo. These plants depend on imported coal, because the Dominican coal mine at Sanchez was revealed, though preliminary as it was, to be rather limited in reserve and relatively low in quality (according to a summary report on the phase two exploration program of Sanchez coal mine by Douglas Robertson & Associated in 1982). In any way, the coal fired plants will cover the base load, together with the existing steam power plants (329 MW, exclusive of Falconbridge).

Several hydro power schemes are scheduled to be implemented by 1989, with the firm capacity of about 197 MW. They will be operated together with the existing plants (88 MW in guaranteed capacity). Under such situation of hydro power, as well as coal fired and oil fired steam power, the gas turbine stations will have to be operated as they have been before (102 MW). Further, in order to meet the maximum demand forecasted to reach at 1,218 MW (Case-1) or 1,104 MW (Case-2) or 972 MW (Case-3), additional installation of power plants will have to be implemented unless the third unit of Itabo coal fired plant is hastened to start its operation in 1987 or earlier.

On the other hand, the firm installed capacity scheduled to be completed by 1989 and the estimated maximum demand in 1992 under the case studies have been compared in the light of load duration curve, so as to identify the capacity and characteristics of the schemes to be implemented until 1992. In principle, the coal fired plants and oil fired steam plants are used to cover the base load, and the gas turbine plants are shifted to cover the peak load supplementing the hydro power. The hydro power plants are to be programmed to set in in accordance with the guaranteed operation hour of each scheme. Fig. B-07(1), B-07(2) and B-07(3) illustrate the

the balance between the estimated 1992 demand and the programmed 1989 capacity under the Case-1, Case-2 and Case-3 demand forecasts. It is clear that development of power plants should be implemented in an acceleration form to cover both the base load and the peak load. Fig. B-08(1), B-08(2) and B-08(3) illustrate the balance between the peak demand and generating capacity realized in 1982, and forecasted ones up to 1992. As clearly seen on those figures, the generating capacity existing plus hydropower planned up to 1989 will be short of demand soon from 1984 for both the Case-1 and Case-2, and from 1990 for the Case-3, that gives the most conservative demand in the case study.

B.4.3 Role of El Torito - Los Veganos Complex

In view of the CIE Expansion plan to develop coal fired plants to cover the base load and the possibility to supplementally utilize the existing oil fired steam plants for the base load, El Torito - Los Veganos Hydroelectric Complex will desirably be developed to cover the peak load. In the light of the load curve and load duration curve, the Complex would be designed to guarantee the minimum operation of 6 hours a day. It is also recommendable to device the operation of the Complex so as to utilize the available discharge to the maximum extent. Further, it is desirable to make use of the merit of characteristics inherent to hydro power plant to start quickly from standing state to full load operation and to respond to ever fluctuating load for stable operation of entire power system, where coal fired and oil fired steam power plants are the majority of power supply source.

Under such circumstances, economic feasibility of El Torito - Los Veganos Complex should be studied by evaluating the alternative capacity value of gas turbine power. The primary energy value should also be evaluated with the energy value of alternative gas turbine power. The secondary energy value of the Complex, on the other hand, should be evaluated with the alternative value of coal fired power and/or oil-fired power.

From the view point of power situation as reviewed in the foregoing Section, it is desirable that the Complex will be implemented at the earliest possible time. (Refer to Fig. B-07(1), B-07(2) and B-07(3).)

B.4.4 Power Transmission System to the Complex

The power transmission system from the El Torito - Los Veganos Hydroelectric Complex is presently expected to be connected to the existing 69 kV lines from Bonao II Substation from which a construction power supply for the Complex will also be expected. Since the implementation of the Rio Blanco is underway, power from the Complex is connected to the Rio Blanco. In view of expansion of power system for-sighted future, the 69 kV transmission line from Bonao Substation to the hydro power plants in Alto-Yuna District, including Rio Blanco now undersay and Piedra Gorda in future, will have to be stepped up to 138 kV in operation voltage in future. (Refer to Fig. B-09 and B-10).

B.5 ORGANIZATION

B.5.1 CDE Organization

CDE is an autonomous corporation. Members of the Board of Directors are nominated by the President of the Republic. They are not necessarily representing the ministries, except for a member representing the CDE syndicate. The General Administrator, who acts as a secretary of the Board of Directors, is responsible for operation and management of all the activities and functions of CDE. Under the General Administrator, 8 departments are organized, including Engineering, Power Production, Operation, Hydroelectric Development, Non-conventional Energy Development, Commercial, Planning and Administration Departments. (Refer to Fig. B-11)

In 1982, a total of 5,520 personnel were employed by CDE. About 1,800 employees were engaged in Operation and Power Production Department, inclusive of the state-owned hydro power stations, while some 690 are employed for Engineering, Planning and Hydroelectric Department. Commercial and Administration Departments employed approximately 2,600 persons. (Refer to Table B-22)

B.5.2 Organization for Hydro Power Development

Development of hydroelectric power is in the jurisdiction of the Department of Hydroelectric Development (DDH) which is administered under the Director General. DDH incorporates such engineering divisions as hydrology, hydraulics, geo-technic, design and hydroeconomic divisions. Implementation of the development projects has been administered under the project supervisor to be appointed for each project under the Director General. El Torito - Los Veganos Hydroelectric Complex will also be managed under the supervisor to be nominated for the project. Such an organization will enable shortest management approach from the project supervisor to DDH Director General and directly to the General Administrator.

After the project is completed, the responsibility for operation and maintenance of the hydro power plants is shifted to the Department of

Production. Under this department, there exists a division responsible for the hydroelectric plants. Since the division has been engaged in operation of several existing hydro plants, it has enough experience for operation and maintenance of new hydro power projects to be implemented in the future.

One of the points suggestible to be considered for the operation of El Torito - Los Veganos Complex is a coordinated operation among the hydro plants to be installed in the upper Yuna river basin. The Rio Blanco project (25 MW) is being implemented at a site close to Los Veganos power station, and a hydroelectric project (Piedra Gorda or alternatively called Alto Yuna scheme) is being studied at a site immediately downstream from the Rio Blanco and Los Veganos power stations. Further downstream, the Hatillo power station (8 MW) is shortly put into commercial operation. Besides, the Rincon power station (10.1 MW at present) will also be incorporated into the upper Yuna hydroelectric systems. It is desirable that these power stations are integratedly operated in the most efficient manner.

B.6 FINANCIAL SITUATION

B.6.1 Power Tariff

Power tariff has been established in accordance with various categories, including 1) residential use, 2) commercial use, 3) industrial use, 4) public illumination, and 5) government and municipal use other than public illumination. In addition to the basic tariff applicable to each category, fuel adjustment tariff has been applied.

The tariff for residential use (code: R-1) is set with the minimum consumption of 15 kWh per month. For commercial use (C-2), the tariff is set on a graduated scale and at a higher rate than the residential use. The tariff for industrial use (I-4) is set in accordance with both kVA capacity and kWh energy consumption. Bulky consumption is charged at lower rates for kWh. For the use of public illumination, the tariff comprises illumination with watt-hour meter (G-5) and without meter (G-6). For government and municipal use other than public illumination, the tariff F-3 and G-3 are applied for small demand within 25 kVA and the tariff G-2 and G-4 for other demand.

The fuel adjustment tariff has been introduced to compensate the increased fuel prices. The adjustment tariff is calculated in accordance with the following formula:

$$B = \frac{P - H}{T} \cdot \frac{(F / G) - 0.0325}{(P / G) \cdot (1 - 0.5) \cdot (1 - L)}$$

where: B = Basic fuel adjustment tariff
P = Sending end energy of CDE plants
H = Sending end energy of CDE hydro plants
T = Sending end energy of CDE and purchased energy
F = Cost of fuel
G = Fuel quantity in galon
L = Energy loss factor

The basic fuel adjustment tariff is applied 100% to the industrial use (I-4) and the government and municipal use (G-2, G-3 and G-4), and 50% to the small government demand (F-3). For residential and commercial use, a rate ranging from 25% to 50% and from 20% to 60¥ of the basic fuel adjustment tariff is applied respectively.

The average price per kWh in each sector of power consumption is separately calculated on the basis of total revenue and sold energy in each sector, as shown on Table B-23. In 1982, the average price was 10.2 cent per kWh in the residential sector, 16.3 cent in the commercial sector and 15.1 cent in the industrial sector. A mean revenue was 13.32 cent per kWh. The unit revenue per kWh increased 32.9% in 1979-80, 47.8% in 1980-81 and 19.4% in 1981-82.

B.6.2 Expenses in Operation

For operation and maintenance of power plants, including purchase of energy from the state-owned hydro power and Falconbridge steam power, CDE spent RD$137.5 million in 1980, RD$166.6 million in 1981 and RD$171.0 million in 1982. The unit expense of power generation in 1982 was 5.6 cent per kWh (sending end energy) for steam power, 13.2 cent per kWh for gas turbine power and 28.3 cent per kWh for diesel power. (Refer to Table B-24) The expenses of steam and gas turbine power generation was higher in 1981, because fuel prices were slightly decreased in 1982.

The expenses of CDE-owned hydro power operation was 0.8 cent per kWh in 1982. Operation and maintenance of facilities for power transmission and distribution cost 0.6 cent per kWh on an average. For power sales, accounting, administration and general expenses, CDE spent 1.1 cent per kWh as a whole. The average expense incurred for operation and maintenance of power plant, transmission, distribution and sales was 7.78 cent per kWh sending end energy in 1981 and 7.82 cent in 1982. If energy loss was taken into account, the average expenses was 10.40 cent per kWh sold energy in 1981 and 11.76 cent in 1982. (Refer to Table B-24 and B-25)

B.6.3 Financial Situation

In terms of sold energy, the operation revenue and other revenue averaged in 1982 at 13.32 cent and 0.29 cent per kWh respectively, totaling

13.61 cent per kWh. On the other hand, the operation-maintenance expenses and other expenses (depreciation, taxes, interests and others) averaged at 11.76 cent and 2.20 cent per kWh respectively, totaling 13.96 cent per kWh. Consequently, CDE suffered from a loss in energy sale (0.35 cent per kWh) in 1982. (Refer to Table B-25)

Although CDE gained gross profit from power sales in 1981 (0.31 cent per kWh) as a result of sharp increase in power tariff, the net income was negative due to increased amount of reduction and miscellaneous loss. Under such circumstances, the accumulated deficit of CDE amounted to RD$43.6 million in 1981 and RD$57.7 million in 1982. (Refer to Table B-26)

Greatest financial burden is the fuel cost for power generation. CDE paid RD$135.5 million in 1981 and RD$126.8 million in 1982 for purchase of fuel. This amount is equivalent to 67% and 62% of total operation cost, or 58% and 50% of total CDE operational revenue, respectively. Such a payment in foreign currency is equivalent, in another sense, to 11.4% and 16.5% of total export of the Republic in 1981 and 1982, respectively. In other words, the total export earning of coffee, cacao and their by-products in 1981-82 (Refer to Table B-09) was spent out for purchase of fuel for the thermal power generation in these two years. Unless appropriate measures are taken, such a financial situation will be aggravated in the future.

CDE's fixed assets in electrical equipment and other properties accounted for about 82% of total assets. They have been properly depreciated year after year. CDE's capital stock amounted to RD$132.1 million, but the net equity after deduction of accumulated deficit was about RD$98 million in 1982, which accounted for about 18% of total equity and liabilities. The financial balance sheet of CDE is shown on Table B-27.

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5) Annual Report of C.D.E. in 1978

6) Annual Report of C.D.E. in 1980

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TABLES

Table B-01 ACTUAL POWER TREND

(TENDENCIA DE ENERGIA)

Year	Energy Send'g End (GWh)	Energy Sold (GWh)	Energy Loss (GWh)	Max.Demand (MW)	Energy Loss Factor (%)	Load Factor (%)
1970	871.5	684.4	187.1	180.9	21.5	55.0
1971	1,000.7	772.5	228.2	201.7	22.8	56.6
1972	1,138.4	871.1	267.3	209.4	23.5	62.0
1973	1,325.9	1,023.1	302.8	268.8	22.8	56.3
1974	1,447.6	1,097.0	350.6	287.2	24.2	57.5
1975	1,545.3	1,170.7	374.6	299.0	24.2	59.0
1976	1,639.2	1,207.9	431.3	340.8	26.3	54.9
1977	2,058.7	1,535.4	523.3	396.0	25.4	59.4
1978	2,300.3	1,674.0	626.3	411.0	27.2	63.9
1979	2,252.9	1,706.8	546.2	412.0	24.2	62.4
1980	2,629.8	1,913.6	716.2	462.0	27.2	64.9
1981	2,787.7	2,084.6	703.1	475.0	25.2	67.0
1982	2,849.1	1,890.6	958.3	504.0	33.6	64.5
1983*	3,122.3	1,962.8	1,159.4	538.0	37.1	68.4

Source: CDE

* Preliminary

Table B-02 POWER CONSUMPTION BY SECTOR

(CONSUMO DE LA ENERGIA POR SECTORES)

Unit: GWh

Year	Residential	Commercial	Industrial	Government	Public	Total
1970	263.6 (38.5%)	87.0 (12.7%)	243.8 (35.6%)	71.8 (10.5%)	18.0 (2.7%)	684.4 (100.0%)
1971	296.8	97.2	280.9	77.4	20.2	772.5
1972	344.4	114.4	311.5	80.3	21.0	871.5
1973	392.9	131.7	379.9	94.6	23.5	1,022.6
1974	415.8	139.9	419.3	102.0	20.0	1,097.0
1975	450.7	153.1	429.5	117.3	20.1	1,170.7
1976	459.6 (38.0%)	150.6 (12.5%)	461.2 (38.2%)	120.4 (10.0%)	16.1 (1.3%)	1,207.9 (100.0%)
1977	584.4	196.7	577.1	144.2	18.3	1,520.7
1978	639.4	214.1	617.5	181.8	29.9	1,673.7
1979	635.7	214.2	661.9	173.9	20.8	1,706.8
1980	723.9	230.6	719.5	214.9	24.6	1,913.6
1981	817.8	256.4	757.9	226.6	25.9	2,084.6
1982	732.3 (38.7%)	228.4 (12.1%)	673.2 (35.6%)	230.8 (12.2%)	25.5 (1.3%)	1,890.2 (100.0%)

Source: CDE, Basic Infomation Dept.

Table B-03 POWER CONSUMERS BY SECTOR
(CONSUMIDORES POR SECTORES)

	Residential	Commercial	Industrial	Gov/Public	Total
Number of Customers					
1975	243,180	26,734	1,214	4,693	275,821
1976	262,402	28,537	1,293	4,816	297,048
1977	283,414	30,925	1,395	5,020	320,754
1978	304,376	32,542	1,352	5,248	343,518
1979	306,726	33,125	1,656	4,954	346,461
1980	351,842	35,627	1,820	5,222	394,511
Average Consumption by Customer (kW)					
1975	1,853	5,727	353,789	29,278	4,244
1976	1,752	5,277	356,690	28,343	4,066
1977	2,062	6,361	413,692	32,371	4,741
1978	2,101	6,579	456,731	40,339	4,872
1979	2,073	6,466	399,698	39,302	4,926
1980	2,057	6,473	395,330	45,864	4,851

Source: CDE, Annual Report

Table B-04 NUMBER OF POWER CONSUMERS
(CONSUMIDORES POR ZONAS)

Year	Urban	Rural	Total
1970	159,099 (82.6%)	33,530 (17.4%)	192,629 (100.0%)
1971	169,634	38,925	208,559
1972	177,621	42,571	220,192
1973	196,032	51,254	247,286
1974	200,658	60,033	260,691
1975	207,810 (76.1%)	65,302 (23.9%)	273,112 (100.0%)
1976	218,259	72,926	291,185
1977	234,175	82,056	316,231
1978	252,041 (74.9%)	84,290 (25.1%)	336,337 (100.0%)

Source: CDE, Bib. (1)

Table B-05 POWER CONSUMPTION BY REGION

(CONSUMO DE ENERGIA POR REGIONES)
(IN AUGUST 1977)

	South Zone	East Zone	North Zone	Santiago	S.Dgo	Total
Number of Customers						
Urban						
Residential	20,594	22,688	46,380	29,086	86,073	204,821
Commercial	2,162	2,628	5,252	3,186	10,936	24,164
Industrial	79	93	160	191	871	1,394
Gov./Public	523	374	1,442	428	1,029	3,796
Subtotal	23,358	25,783	53,234	32,891	98,909	234,175
Rural	25,453	2,268	23,052	6,803	24,480	82,056
Total	48,811	28,051	76,286	39,694	123,389	316,231
	(15.4%)	(8.9%)	(24.1%)	(12.6%)	(39.0%)	(100.0%)
Power Consumption per Month (10^3 kWh)						
Urban						
Residential	2,377	2,813	5,297	4,444	26,137	41,068
Commercial	653	836	1,706	1,695	9,711	14,601
Industrial	2,258	5,422	2,731	4,265	34,904	49,580
Gov./Public	2,109	639	1,565	2,329	5,625	12,267
Subtotal	7,397	9,710	11,299	12,733	76,377	117,516
Rural	2,273	178	3,492	1,014	7,195	14,152
Total	9,670	9,888	14,791	13,747	83,572	131,668
	(7.3%)	(7.5%)	(11.2%)	(10.5%)	(63.5%)	(100.0%)
Power Consumption per Month per Customer (kWh)						
Urban						
Residential	115	124	114	153	303	200
Commercial	302	318	324	532	888	604
Industrial	28,582	58,301	17,068	22,329	40,073	35,567
Gov./Public	4,032	1,708	1,085	5,441	5,480	3,225
Subtotal	316	376	212	387	772	502
Rural	89	78	151	149	294	172
Total	198	353	194	346	677	416

Source: CDE, Bib. (1)

Table B-06 **BREAKDOWN OF ENERGY LOSS**
(PERDIDA DE ENERGIA)

	Send'g End Energy (GWh)	Loss in T/L (%)	Loss in Distrib. (%)	Other Loss (%)	Total Loss (%)	Sold Energy (GWh)
1970	871.5	87.1 (10.0)	98.0 (11.2)	2.0	187.1 (21.5)	684.4
1971	1,000.7	95.0 (9.5)	133.2 (13.3)		228.2 (22.8)	772.5
1972	1,138.4	99.9 (8.8)	163.4 (14.4)	4.0	267.3 (23.5)	871.1
1973	1,325.9	143.3 (10.8)	157.4 (11.9)	12.0	302.8 (22.8)	1,023.1
1974	1,447.6	167.8 (11.6)	181.1 (12.5)	1.7	350.6 (24.2)	1,097.0
1975	1,545.3	115.2 (7.5)	258.0 (16.7)	1.4	374.6 (24.2)	1,170.7
1976	1,639.2	110.8 (6.8)	318.9 (19.5)	1.6	431.3 (26.3)	1,207.9
1977	2,058.7	156.2 (7.6)	362.5 (17.6)	4.6	523.3 (25.4)	1,535.4
1978	2,300.3	187.4 (8.1)	427.0 (18.6)	11.9	626.3 (27.2)	1,674.0
1979	2,252.9	n.a	n.a	n.a	546.2 (24.2)	1,706.8
1980	2,629.8	n.a	n.a	n.a	716.2 (27.3)	1,913.6
1981	2,787.7	n.a	n.a	n.a	703.1 (25.2)	2,084.6
1982	2,849.1	n.a	n.a	n.a	958.3 (33.6)	1,890.8

n.a = not available

Source: CDE and CDE-SOFRELEC

Table B-07 POWER GENERATION
(GENERACION DE ENERGIA)

	Power Station	Installed Capacity (MW)	Sending End Energy (GWh) 1981	1982
HYDRO				
(CDE)	Las Damas	7.5	35.9	45.9
	Constanza	0.25	0.8	0.5
	Sub-total	(7.75)	(36.7)	(46.4)
(State)	Tavera	40 x 2	248.0	108.5
	Valdesia	27 x 2	119.5	68.1
	Rincon	10.1	35.8	18.6
	Sabana Yegua	13.0	53.1	34.4
	Sabaneta	7.5	19.1	35.1
	Sub-total	(164.6)	(475.5)	(264.7)
	Total HYDRO	172.4 (19.0%)	512.2 (18.4%)	311.1 (10.9%)
STEAM	Haina	54 x 2, 84.9 x 3	1,384.4	1,456.5
	Santo Domingo	12.6 x 2, 26.5 x 1	293.9	278.2
	Puerto Plata	27.6	123.1	39.7
		36.8	-	3.1
	Total STEAM	478.8 (52.8%)	1,801.4 (64.6%)	1,777.5 (62.6%)
GAS	Los Minas	35 x 2	126.8	195.7
	Timbeque	21.1	17.0	40.9
	S.P. Macoris	28.3	90.8	2.4
	Weber	20.0	13.5	16.9
	Barahona	28.3	25.3	24.1
	Total GAS	167.7 (18.5%)	273.5 (9.8%)	280.0 (9.9%)
DIESEL	Santiago (3)	6.0		
	Constanza (4)	2.45		
	Pedernales	1.45		
	Total DIESEL	9.9 (1.1%)	6.6 (0.2%)	6.4 (0.2%)
(Falconbridge)		78.0 (8.6%)	192.9 (6.9%)	466.1 (16.4%)
	TOTAL	906.8	2,786.6	2,841.1

Source: CDE, Monthly Production Record

Table B-08 GENERATING CAPACITY
(CAPACIDAD DE GENERACION)

	Power Station	Installed Capacity (MW)	Guaranteed or Average /1 Capacity (MW)
HYDRO			
(CDE)	Las Damas	7.5	5.0
	Constanza	0.25	0.2
(State)	Tavera-Bao	80.0	33.0
	Valdesia	54.0	36.0
	Rincon	10.1	6.0
	S. Yegua	13.0	5.7
	Sabaneta	7.5	2.1
	Total HYDRO	172.4	88.0
STEAM	Haina	362.7	255.9
	S. Domingo	51.7	38.4
	P. Plata	64.4	34.4
	Total STEAM	478.8	328.7
GAS	Los Minas	70.0	50.2
	Timbeque	21.1	14.2
	S.P. Macoris	28.3	17.9
	Weber	20.0	4.8
	Barahona	28.3	14.8
	Total GAS	167.7	101.9
DIESEL	Santiago	6.0	1.8
	Constanza	3.45	1.1
	Pedernales	1.45	0.4
	Total DIESEL	9.9	3.3
(Falconbridge)		(78.0)	78.0
	TOTAL	906.8	599.9

/1 Guaranteed capacity of hydro power stations, and average generating capacity in 1981-82 of thermal power stations.

Table B-09 SENDING END ENERGY BY POWER SOURCE
(ENERGIA ENVIADA POR PLANTAS)

Unit: GWh

	Total	Hydro			Steam		Gas	Diesel
		CDE	State	Total	CDE	Falcon		
1978	2,300.3	54.5	225.2	279.7	1,634.9	68.1	310.6	6.9
(%)		(2.4)	(9.8)	(12.2)	(71.1)	(3.0)	(13.5)	(0.3)
1979	2,252.9	49.9	n.a	n.a	1,563.4	n.a	219.6	6.5
(%)		(2.2)			(69.4)		(9.7)	(0.3)
1980	2,629.8	48.1	159.6	207.7	1,882.6	283.3	245.3	10.9
(%)		(1.8)	(6.1)	(7.9)	(71.6)	(10.8)	(9.3)	(0.4)
1981	2,787.7	36.7	475.5	512.2	1,801.4	192.9	273.5	6.6
(%)		(1.3)	(17.1)	(18.4)	(64.6)	(6.9)	(9.8)	(0.2)
1982	2,849.1	46.4	264.7	311.1	1,777.5	466.1	280.0	6.4
(%)		(1.6)	(9.3)	(10.9)	(62.6)	(16.4)	(9.9)	(0.2)

Source: CDE, Annual Report and Monthly Production Record

Table B-10 OPERATION OF HYDRO-POWER PLANTS
(OPERACION DE PLANTAS HIDROELECTRICAS)

Station	Capacity (MW) Rated	Capacity (MW) Guaranteed	Energy Output (GWh) Mean	Energy Output (GWh) Guaranteed	Planned Hour /1	Operation Order
(EXISTING)						
Las Damas	7.5	5.0	19.9	15.5	3,100	(12)
Tavera-Bao	80.0	33.0 (80.0)	n.a 270.0	n.a 143.0	n.a 1,788	(13)
Valdesia	54.0	36.0	81.3	60.0	1,667	(14)
Rincon	10.1	6.0	24.0	19.0	3,167	(11)
S. Yegua	13.0	5.7	70.0	50.0	8,760	(1)
Sabaneta	7.5	2.1	20.0	12.5	5,952	(4)
(PLANNED)						
Jimenoa	11.0	8.0	42.0	34.0	4,250	(9)
Hatillo	8.0	6.0	34.0	26.0	4,333	(8)
L. Angostura	18.0	18.0	128.0	98.0	5,444	(6)
Los Toros	12.0	5.5	63.0	48.5	8,760	(2)
Rio Blanco	25.0	15.0	96.7	62.5	3,472	(10)
Pequenos	9.6	3.2	43.0	17.5	6,195	(3)
Manabao-B	20.2	8.1	48.2	31.9	5,951	(5)
Mao	45.0	14.6	140.0	67.7	4,637	(7)

Note: /1 Calculated by dividing guaranteed energy output by guaranteed installed capacity

Table B-11 THERMAL POWER OPERATION
(OPERACION DE PLANTAS TERMOELECTRICAS)

Station	Installed Capacity (MW)	Operation in 1981 Energy/1 (GWh)	Hour (hrs)	Available Capacity (MW)	Operation in 1982 Energy/1 (GWh)	Hour (hrs)	Available Capacity (MW)	Average Available Capacity (MW)
STEAM								
Haina #1	54.0	306.2	7,807	39.2	286.2	8,131	35.2	37.2
#2	54.0	281.5	8,018	35.1	272.6	8,072	33.8	34.5
#3	84.9	420.2	6,990	60.1	158.4	2,928	54.1	57.1
#4	84.9	461.1	7,881	58.5	419.4	7,964	52.7	55.6
#5	84.9	-	-		414.1	5,792	71.5	71.5
Subtotal	362.7	1,469.0		192.9	1,550.7		247.3	255.9
S. Domingo #5	12.6	71.2	7,259	9.8	69.0	8,020	8.6	9.2
#6	12.6	72.7	8,065	9.0	67.7	8,100	8.4	8.7
#8	26.5	166.6	7,800	21.4	158.0	8,082	19.5	20.5
Subtotal	51.7	310.5		40.2	294.7		36.5	38.4
P. Plata #1	27.6	130.6	6,713	19.5	42.1	2,173	19.3	19.4
#2	36.8	-	-		3.1	206	15.0	15.0
Subtotal	64.4	130.6		19.5	45.2		34.3	34.3
Total-STEAM	478.8	1,910.1		252.6	1,890.6		318.1	328.7
GAS								
L. Minas #1	35.0	73.0	2,959	24.7	86.6	3,150	27.5	26.1
#2	35.0	55.3	2,398	23.1	111.3	4,443	25.1	24.1
Subtotal	70.0	128.3		47.8	197.9		52.6	50.2
Timbeque	21.1	17.0	1,352	12.6	41.2	2,610	15.7	14.2
Macoris	28.3	91.6	5,142	17.8	2.4	133	18.0	17.9
Weber	20.0	14.7	3,364	4.4	18.5	3,535	5.2	4.8
Barahora	28.3	25.7	1,864	13.8	24.4	1,541	15.8	14.8
Total-GAS	167.7	277.3		96.4	284.4		107.3	101.9
DIESEL								
Santiago	6.0	-	-	-	0.8	432	1.8	1.8
Constanza	0.25	0.1	1,410	0.1	0.1	637	0.1	0.1
	1.10	3.2	7,212	0.4	1.9	4,150	0.5	0.5
	1.10	-	-	-	2.2	4,421	0.5	0.5
Pedernales	0.35	0.7	3,820	0.2	0.3	2,037	0.2	0.2
	1.10	0.8	4,024	0.2	1.0	5,519	0.2	0.2
Total-DIESEL	9.90	4.8		0.9	6.3		3.3	3.3
Total THERMAL	656.4	2,192.2		349.9	2,181.3		428.4	433.6

Source: CDE, Monthly Production Record

Table B-12 THERMAL POWER GENERATION IN 1982
(GENERACION POR PLANTAS TERMOELECTRICAS EN 1982)

	Installed Capacity (MW)	Generated Energy (GWh)	Sending Energy (GWh)	Plant Factor (%)	Fuel Consump. (10^3kl)	Energy for Fuel (kWh/l)
STEAM Haina #1	54.0	286.2	266.5	60.5	87.4	3.27
#2	54.0	272.6	256.0	57.6	84.2	3.24
#3	84.9	158.4	149.6	21.3	46.8	3.38
#4	84.9	419.4	389.7	56.4	133.6	3.14
#5	84.9	414.1	394.7	55.7	114.8	3.61
Subtotal/ (average)	362.7	1,550.7	1,456.5	(48.8)	466.8	(3.32)
S. Dgo #5	12.6	69.0	65.0	62.5	30.8	2.24
#6	12.6	67.7	63.9	61.3	27.6	2.45
#8	26.5	158.0	149.3	68.1	49.7	3.18
Subtotal/ (average)	51.7	294.7	278.2	(65.1)	108.1	(2.73)
P.Plata #1	27.6	42.1	39.7	17.4	13.0	3.24
#2	36.8 /1	3.1	3.1	1.0	1.4	2.21
Subtotal/ (average	64.4	45.2	42.8	8.0	14.4	(3.14)
Total	478.8	1,890.6	1,777.5	(45.1)	589.3	(3.21)
GAS L.Minas #1	35.0	86.6	85.4	28.2	35.1	2.47
#2	35.0	111.3	110.3	36.3	47.6	2.34
Timbeque	21.1	41.2	40.9	22.3	17.6	2.34
S.P.Macoris	28.3	2.4	2.4	1.0	1.2	2.00
Weber	20.0	18.5	16.9	10.6	8.9	2.07
Barahona	28.3	24.4	24.1	9.8	13.9	1.76
Total/ (average)	167.7	284.4	280.0	(19.4)	124.3	(2.28)
DIESEL Santiago	6.0	0.8	0.7	1.5	0.3	2.86
Costanza	2.45	4.2	4.2	19.6	1.4	2.92
Pedernales	1.45	1.5	1.5	11.8	0.7	2.17
Total/ (average)	9.9	6.5	6.4	(7.5)	2.4	(2.71)

Note: /1 Operation started in November 1982

Source: CDE, Monthly Production Record

Table B-13 AVERAGE PRICE OF FUEL PURCHASED BY CDE
(PRECIO PROMEDIO DE COMBUSTIBLES COMPARADOS POR CDE)

	Bunker "C"		Gas Oil	
	RD$/Barrel	RD$/$10^6$ kcal/2	RD$/Barrel	RD$/$10^6$ kcal/2
1978	11.6718	7.501	15.7668	10.133
1979	14.9604	9.615	19.0806	12.263
1980	21.3696	13.734	30.7524	19.764
1981	29.8494	19.183	42.6505	27.410
1982	24.78	15.925	43.74	28.111
1983/1	26.00	16.710	44.50	28.599

Note: /1: Average in January - June 1983
/2: Heating value at 1.556 x 10^6 kcal/bbl

Source: CDE, Balance General, Estados Suplementarios

Table B-14 DEMAND FORECAST BY CDE-SOFRELEC /1
(PROYECCION DE DEMANDA POR CDE-SOFRELEC)

	Alt.1 /2	Alt.2 /3	Alt.3 /4	Alt.4 /5	Actual
1979	1,866.5	1,665.8			1,706.8
1980	2,088.5	1,821.4	2,194.9		1,913.6
1981	2,336.8	2,013.3			2,084.6
1982	2,614.6	2,249.1	2,853.3		1,890.8
1983	2,925.5	2,539.6	3,232.1	3,120	
1984	3,273.3	2,867.5		3,370	
1985	3,662.5	3,238.1	4,139.7	3,639	
1986	4,098.0	3,657.2	4,602.3	3,930	
1987	4,585.2	4,130.8	5,040.7	4,245	
1988	5,130.4	4,666.6		4,733	
1989	5,740.5	5,272.9	6,056.4	5,277	
1990	6,423.0	5,959.0		5,884	
1991	7,186.7	6,735.1	7,240.7	6,561	
1992	8,041.2	7,613.6	7,926.6	7,316	
1993				8,157	

Note: /1 Demand in sold energy
/2 Alternative-1 projected on the basis of regression analysis (11.89%)
/3 Alternative-2 projected on the basis of macroeconomic analysis
/4 Alternative-3 projected on the basis of microeconomic analysis
/5 Alternative-4 according to latest plan of SOFRELEC: Actualizacion Plan de Expansion

Source: (1) CDE-SOFRELEC, Plan de Expansion
(2) CDE-SOFRELEC, Actualización Plan de Expansión del Sistema Eléctrico de la CDE, Octobre 1983

Table B-15 MAXIMUM DEMAND PROJECTED BY CDE-SOFRELEC
(DEMANDA MAXIMA ESTIMADO POR CDE-SOFRELEC)

Unit: MW

	Total Demand	Santo Domingo	Santiago	South Zone	East Zone	North Zone	Loss
Initial	555.1	316.6	60.3	83.6	37.2	41.9	2.8
1984	601.0	356.1	61.2	84.7	38.7	44.1	2.7
1985	670.0	407.0	66.9	92.1	42.2	48.4	2.0
1986	724.0	436.3	72.9	100.0	45.2	52.2	2.4
1987	782.0	472.3	76.2	106.9	50.8	56.2	2.5
1988	871.0	523.9	85.7	119.2	57.1	63.3	2.5
1989	972.0	580.3	97.4	134.3	64.3	70.4	2.6
1990	1,083.0	644.0	109.0	150.7	71.6	79.5	2.6
1991	1,208.0	718.7	119.1	166.4	82.2	89.9	2.7
1992	1,347.0	797.6	133.0	187.2	92.7	100.1	2.7
1993	1,502.0	893.4	147.2	207.0	101.8	110.5	2.8

Source: CDE, Bib. (1)

Table B-16 <u>ACTUAL AND FORECASTED DEMAND</u>
(PROYECCION Y DEMANDA ACTUAL)

Year	1979	1980	1981	1982
Sending end energy (GWh)				
Forecast:		2,478.9	2,655.5	2,883.3
Actual:	2,252.9	2,629.8	2,787.7	2,849.1
Energy sold (GWh)				
Forecast:		1,821.4	2,013.3	2,249.1
Actual:	1,706.8	1,913.6	2,084.6	1,890.8
Energy loss (GWh)				
Forecast:		657.5	642.2	634.2
Actual:	546.1	716.2	703.1	958.3
Energy loss factor (%)				
Forecast:		26.5	24.2	22.0
Actual:	24.2	27.2	25.2	33.6
Maximum demand (MW)				
Forecast:		456	491	529
Actual:	412	462	475	504
Load factor (%)				
Forecast:			62.5	62.6
Actual:	62.4	64.9	67.0	64.5

Note: Forecast by CDE-SOFRELEC

Table B-17 FORECAST (CASE-1)
(PROYECCION (CASO-1))

Year	Energy /1 Sold (GWh)	Energy Loss (GWh)	Energy Loss (%)	Sending End Energy (GWh)	Load Factor (%)	Maximum Demand (MW)
1983	2,539.6	958.5	27.4	3,498.1	65	614
1984	2,867.5	1,049.8	26.8	3,917.3	65	688
1985	3,238.0	1,149.5	26.2	4,387.5	65	771
1986	3,657.2	1,258.4	25.6	4,915.6	65	863
1987	4,130.8	1,376.9	25.0	5,507.7	65	967
1988	4,666.6	1,514.3	24.5	6,180.9	65	1,086
1989	5,272.9	1,665.1	24.0	6,938.0	65	1,218
1990	5,959.0	1,830.5	23.5	7,789.5	65	1,368
1991	6,735.1	2,011.8	23.0	8,746.9	65	1,536
1992	7,613.5	2,210.4	22.5	9,823.9	65	1,725

Note: /1 Sold energy predicted by CDE-SOFRELEC

Table B-18 FORECAST (CASE-2)
(PROYECCION (CASO-2))

Year	Energy /1 Sold (GWh)	Energy Loss (GWh)	Energy Loss (%)	Sending End Energy (GWh)	Load Factor (%)	Maximum Demand (MW)
1983	2,619.8	988.7	27.4	3,608.5	65	634
1984	2,895.5	1,060.1	26.8	3,955.6	65	695
1985	3,200.4	1,136.2	26.2	4,336.6	65	762
1986	3,537.2	1,217.1	25.6	4,754.3	65	835
1987	3,909.7	1,303.2	25.0	5,212.9	65	916
1988	4,321.2	1,402.2	24.5	5,723.4	65	1,005
1989	4,776.1	1,508.2	24.0	6,284.3	65	1,104
1990	5,278.9	1,621.6	23.5	6,900.5	65	1,212
1991	5,834.7	1,742.8	23.0	7,577.5	65	1,331
1992	6,448.9	1,872.3	22.5	8,321.2	65	1,461

Note: /1 Estimated on the basis of regression analysis on the trend in 1970-81.

Table B-19 FORECAST (CASE-3)
(PROYECCION (CASO-3))

Year	Sending End Energy (GWh)	Load Factor (%)	Maximum Demand (MW)
	/1		
1983	3,120	62	555
1984	3,370	62	601
1985	3,639	62	670
1986	3,930	62	724
1987	4,245	62	782
1988	4,733	62	871
1989	5,277	62	972
1990	5,884	62	1,083
1991	6,561	62	1,208
1992	7,316	62	1,347
1993	8,157	62	1,502

Note: (1) /1 Estimated by CDE-SOFRELEC in 1983 on the trend in 1960-82.

(2) Increase rate: 82-83 : 9.5%
83-87 : 8.0%
87-93 : 11.5%
83-93 : 10.0%

Table B-20 POWER EXPANSION PROGRAM
(PROGRAMA DE EXPANSION)

Station	Type	Capacity (MW) Rated	Firm	Actual Situation
Itabo #1	Coal		115.0	Under construction. Commercial operation scheduled to start in 1984.
Itabo #2	Coal		115.0	Construction contract awarded in August 1983. Completion scheduled for 1987.
Jimenoa	Hydro	11.0	8.0	Repair damaged by Hurricane David is underway, and scheduled to complete in October 1983.
Hatillo	Hydro	8.0	6.0	Construction work is at final stage, and is expected to complete by end 1983.
Lopez (afterbay)	-	-	(47.0)	After completion of afterbay weir at Lopez in 1985, guaranteed capacity of Tavera-Bao power station can be increased from 33 MW to 80 MW.
Lopez - Angostura	Hydro	18.0	18.0	Construction contract awarded in 1983. Scheduled to complete by January 1986.
Small Schemes	Hydro	-	3.2	Baiquague (1.1 MW) is under tendering stage. Jamanu (0.9 MW), Gurabo (0.62 MW) and Guazaras (0.62 MW) are under study. They are scheduled to complete in 1986.
Los Toros	Hydro	12.0	5.5	Under study. Completion scheduled for 1987.
Rio Blanco	Hydro	25.0	15.0	Tenders for construction works underway. Completion scheduled for February 1987.
Riego Yaque N.	Hydro	10.4	5.1	Under study. Completion scheduled for 1988.
Manabao - Bejucal	Hydro	20.2	8.1	Tender for construction was called in July 1983. Completion scheduled for end 1989.
Bejucal - Tavera	Hydro	80.0	76.0	Tender for construction will be called in April 1984. Completion scheduled for 1990.
Mao	Hydro	45.0	25.0	Under study. Completion scheduled for 1989.
La Diferencia	Hydro	11.0	0.81	Under study. Completion scheduled for 1989.
Amina	Hydro	36.5	36.5	Under study. Completion scheduled for 1989.

Table B-21 EXISTING PLUS PLANNED GENERATING CAPACITY
(CAPACIDAD ACTUAL Y PROGRAMADA)

Year	Station	Hydro	Thermal Coal	Thermal Steam	Thermal Gas	Thermal Diesel	Total
1981, 1982	L. Damas	5.0					
	Constanza	0.2					
	Tavera-Bao	33.0					
	Valdesia	36.0					
	Rincon	6.0					
	S. Yegua	5.7					
	Sabaneta	2.1					
	Haina			255.9			
	S. Domingo			38.4			
	P. Plata			34.4			
	L. Minas				50.2		
	Timbeque				14.2		
	S.P. Macoris				17.9		
	Weber				4.8		
	Barahona				14.8		
	Diesel					3.3	
	Total	88.0		328.7	101.9	3.3	521.9
1983	Jimenoa	8.4					
	Hatillo	6.0					
	Itabo #1		115.0				
	Total	102.4	115.0	328.7	101.9	3.3	651.3
1985	Lopez after bay	47.0					
	Total	149.4	115.0	328.7	101.9	3.3	698.3
1986	L. Angostura	18.0					
	Pequena	3.2					
	Total	170.6	115.0	328.7	101.9	3.3	719.5
1987	Rio Blanco	20.0					
	Los Toros	7.0					
	Itabo #2		115.0				
	Total	197.6	230.0	328.7	101.9	3.3	861.5
1988	Riego Yaque N.	5.1					
	Total	202.7	230.0	328.7	101.9	3.3	866.6
1989	Manabao B.	20.0					
	La Diferencia	0.8					
	Mao	25.0					
	Amina	36.5					
	Total	285.0	230.0	328.7	101.9	3.3	948.9

Note: Total except for Hydropower is 663.9 MW.

Table B-22 CDE PERSONNEL
(PERSONAL DE CDE)

Year	1980	1981	1982
General Administration	202	245	254
Dept. Planning	27	38	40
Dept. Non-conventional Energy	14	31	2
Dept. Engineering	421	461	494
Dept. Production	836	931	931
Dept. Operation	749	840	866
Dept. Hydroelectric	138	147	156
Dept. Commercial	1,598	1,679	1,713
Dept. Administration	860	908	922
Sub-total	4,845	5,280	5,378
Temporary	778	416	142
Total	5,623	5,696	5,520

Table B-23 ENERGY SALE BY SECTOR
(VENTA DE ENERGIA POR SECTORES)

Year	1978	1979	1980	1981	1982
Revenue (10^6 RD$)					
Residential	29.6	32.5	40.6	71.2	74.4
Commercial	13.5	14.8	22.2	34.2	37.2
Industrial	31.7	36.8	60.8	94.2	101.5
Government	10.7	11.1	19.1	29.8	36.2
Public ill.	1.6	1.7	1.9	3.2	2.5
Total	87.1	96.9	144.6	232.6	251.8
Energy Sold (GWh)					
Residential	639.4	635.7	723.9	817.8	732.3
Commercial	214.1	214.2	230.6	256.4	228.4
Industrial	617.5	661.9	719.5	757.9	673.2
Government	181.8	173.9	214.9	226.6	230.8
Public ill.	29.9	20.8	24.6	25.9	25.5
Total	1,673.7	1,706.8	1,913.6	2,084.6	1,890.2
Average Price (RD¢/kWh)					
Residential	4.63	5.11	5.60	8.71	10.16
Commercial	6.28	6.90	9.64	13.35	16.29
Industrial	5.13	5.55	8.44	12.43	15.08
Government	5.89	6.40	8.90	13.14	15.68
Public ill.	5.30	8.36	7.74	12.29	9.96
Total	5.20	5.68	7.55	11.16	13.32

Table B-24 OPERATION AND MAINTENANCE EXPENSES OF CDE
(GATOS DE OPERACION Y MANTENIMIENTO)

	1980	1981	1982
Operation and Maintenance Expenses (10^3 RD$)			
Steam power generation	89,430	107,093	99,624
Gas power generation	26,554	40,177	36,935
Diesel power generation	1,441	1,647	1,810
Hydro power generation	267	451	371
Other expenses for generation	19,780	17,186	32,306
Subtotal	137,472	166,554	171,046
Transmission	2,203	3,224	3,661
Distribution	12,450	13,399	15,492
Sales, accounting, administration and general expenses	28,056	33,591	32,004
Total	180,181	216,768	222,203
Sending-end Energy (GWh)			
Steam power	1,882.6	1,801.4	1,777.5
Gas power	245.3	273.5	280.0
Diesel power	10.9	6.6	6.4
Hydro power	48.1	36.7	46.4
Energy purchased	442.9	668.4	730.8
Total	2,629.8	2,786.7	2,841.1
O & M Expenses per Energy (RD¢/kWh)			
Steam power generation	4.8	5.9	5.6
Gas power generation	10.8	14.7	13.2
Diesel power generation	13.2	25.0	28.3
Hydro power generation	0.6	1.2	0.8
Other expenses (purchased)	4.5	2.3	4.4
(Average)	(5.2)	(6.0)	(6.0)
Transmission	0.1	0.1	0.1
Distribution	0.5	0.5	0.5
Sales, accounting, administration and general expenses	1.1	1.2	1.1
Total	6.9	7.8	7.8

Table B-25 ENERGY COST OF CDE
(*COSTO DE ENERGIA*)

Unit: RD¢/kWh

	1980	1981	1982
Revenue:			
Per Sold Energy			
Operation revenue	7.55	11.16	13.32
Other revenue	1.20	1.15	0.29
Total	8.75	12.31	13.61
Per Sending-end Energy			
Operation revenue	5.58	8.39	8.92
Other revenue	0.87	0.86	0.19
Total	6.45	9.25	9.11
Expenses:			
Per Sold Energy			
O & M expenses	9.42	10.40	11.76
Other expenses	1.38	1.60	2.20
Total	10.80	12.00	13.96
Per Sending-end Energy			
O & M expenses	6.85	7.78	7.82
Other expenses	1.01	1.20	1.47
Total	7.86	8.98	9.29
Gross Income:			
Per Sold Energy	-2.05	0.31	-0.35
Per Sending-end Energy	-1.41	0.27	-0.18

Table B-26 PROFIT AND LOSS ACCOUNT OF CDE
(INGRESOS Y GASTOS DE CDE)

Unit: 10^3 RD$

		1981 /1		1982 /1	
Revenue:	Operation	233,853		253,448	
	Others	23,902		5,506	
	Total (A)		257,755		258,954
Expenses:	Operation	201,258		205,645	
	(Fuel for plants)	(135,521)		(126,778)	
	Maintenance	15,510		16,558	
	Depreciation	8,597		13,946	
	Taxes	8,171		8,215	
	Interests	16,481		19,420	
	Others	384		345	
	Total (B)		250,401		264,129
Grand Income ((A)-(B))			7,354		-5,175
Reduction-discount		-16,660		-7,397	
Miscellaneous:	Income	661		5,136	
	Loss	-1,540		-6,633	
	Total (C)		-17,539		-8,894
Net Income ((A)-(B)+(C))			-10,185		-14,069
Deficit up to previous year			-33,425		-43,610
Deficit accumulated			-43,610		-57,679

Note: /1 As of Dec. 31, 1981 and 1982

Source: CDE, Balance General, Estados Suplementarios, Dec. 1982

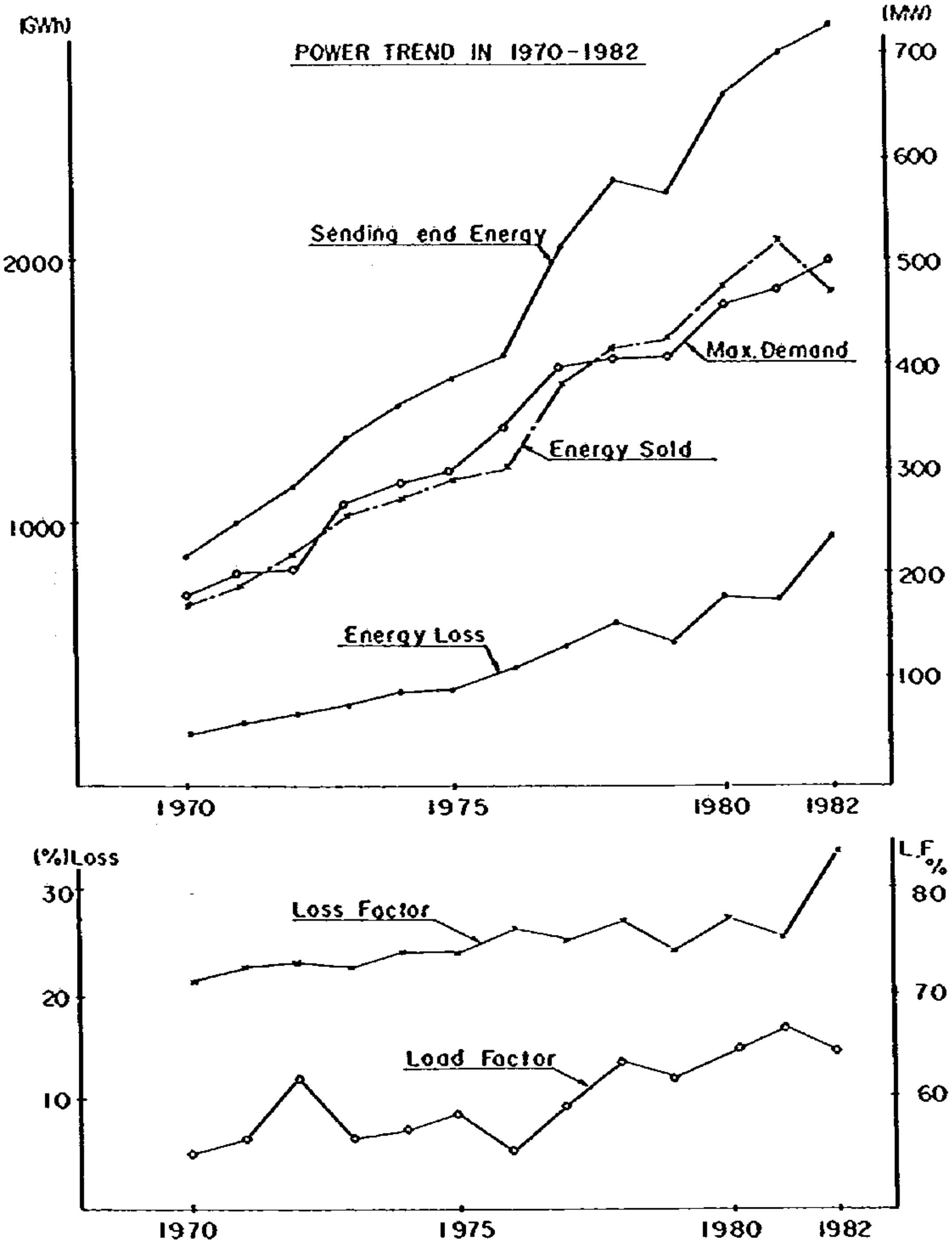
Table B-27 BALANCE SHEET OF CDE
(BALANCE FINANCIERO DE CDE)

Unit: 10^3 RD$

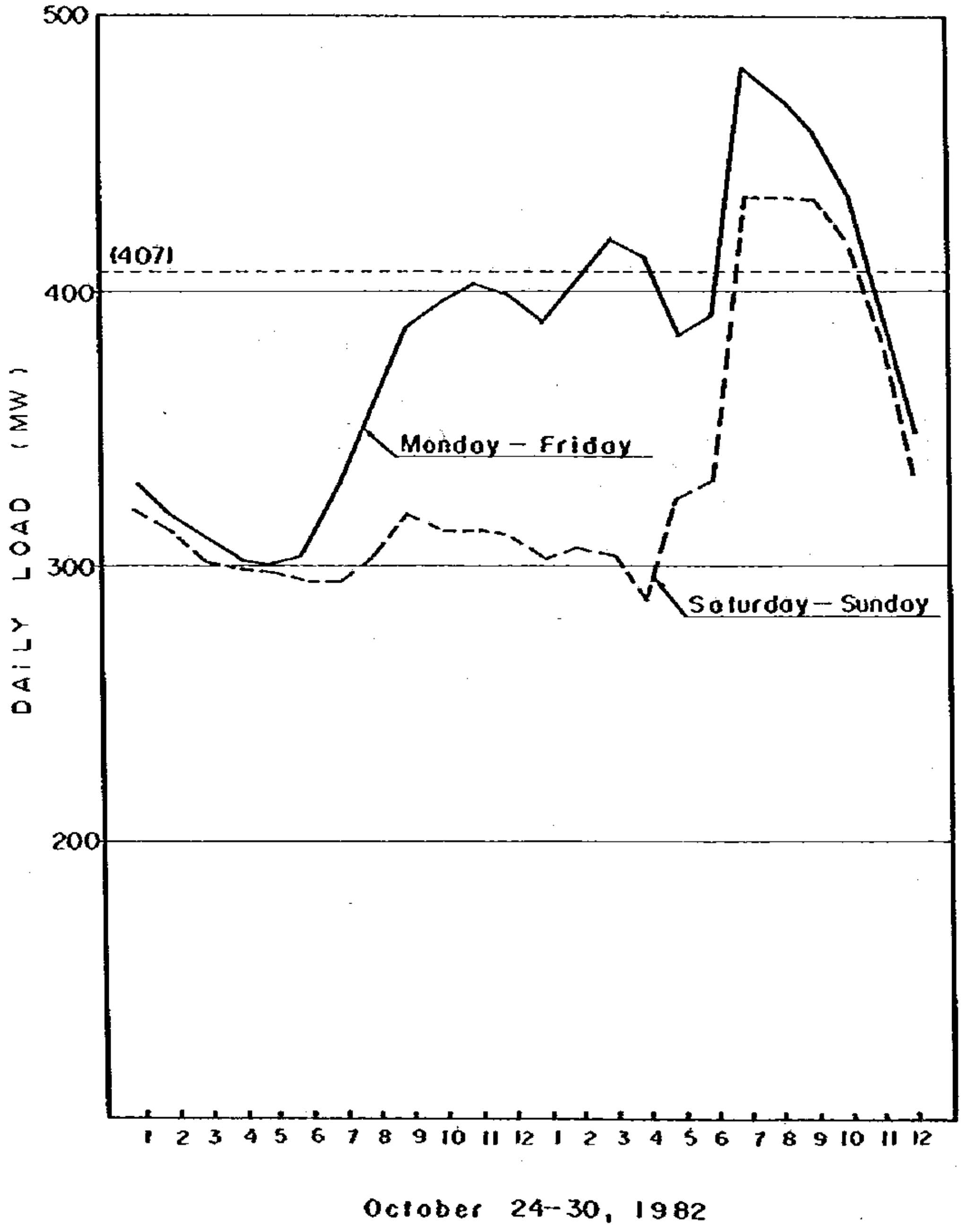
	1981	1982
ASSETS		
Fired Assets		
Electrical equip.	411,479	517,992
Other properties	698	698
Provision for depreciation	-65,462	-76,570
Fuel and materials	22,584	24,698
Investment	130	130
Current Assets		
Cash	2,472	10,111
Account receivable	56,614	58,185
Insurance	1,125	3,177
Work in progress	1,897	3,240
Total ASSETS	431,538	541,661
EQUITY		
Capital: stock	112,000	132,116
donation	15,999	15,999
Deficit: accumulated	-33,425	-43,610
others	-10,187	-14,069
Reserve for contribution	5,627	7,546
LIABILITIES		
Long-term loan: bond	4,648	5,639
loans	259,638	317,295
Account payable	36,958	73,587
Deposit for fuel	17,967	21,068
Interest accumulated	18,174	21,092
Others	4,139	4,998
Total LIABILITIES	431,538	541,661

Source: CDE, Balance General, Dec. 1982

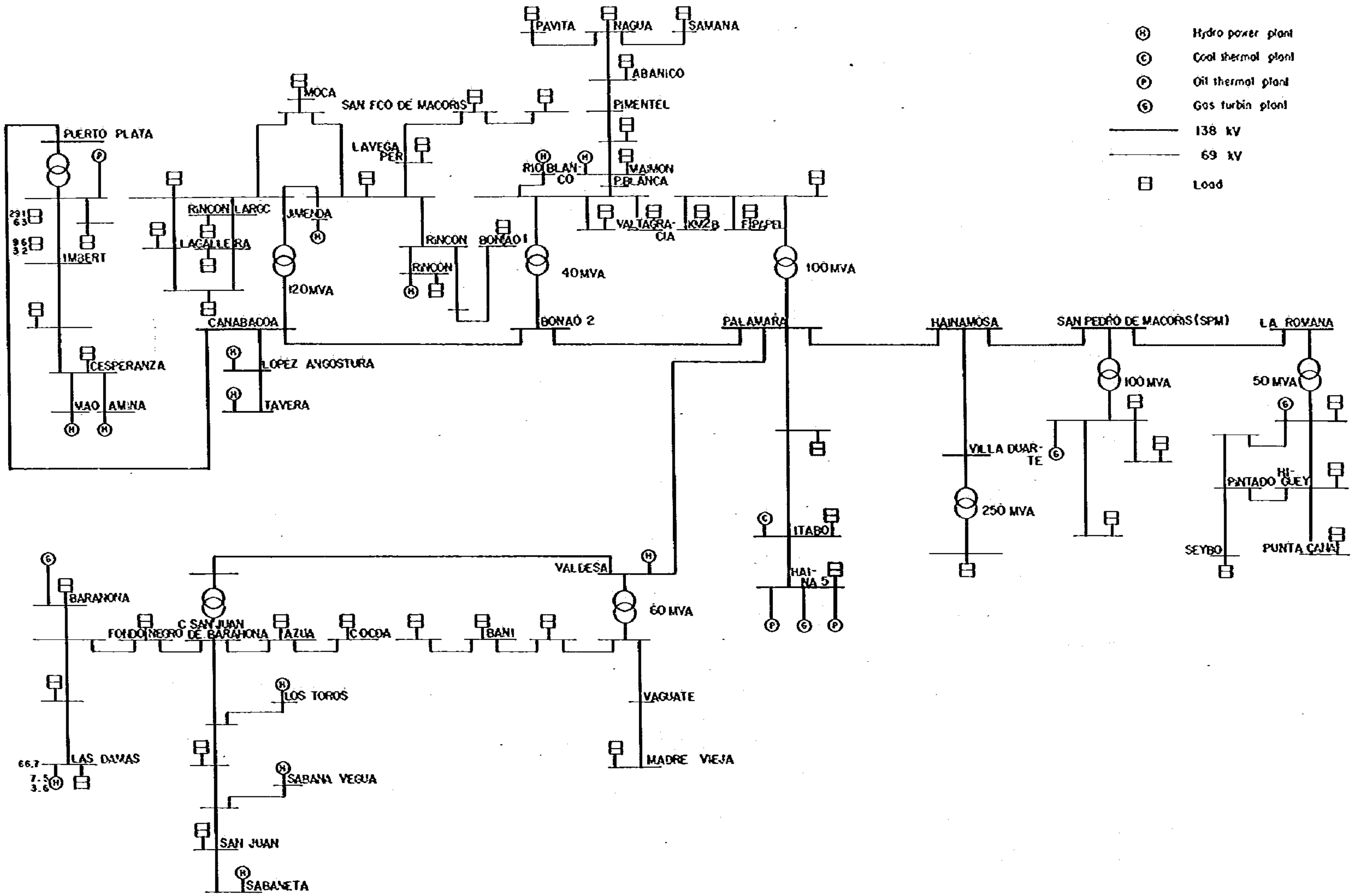
FIGURES



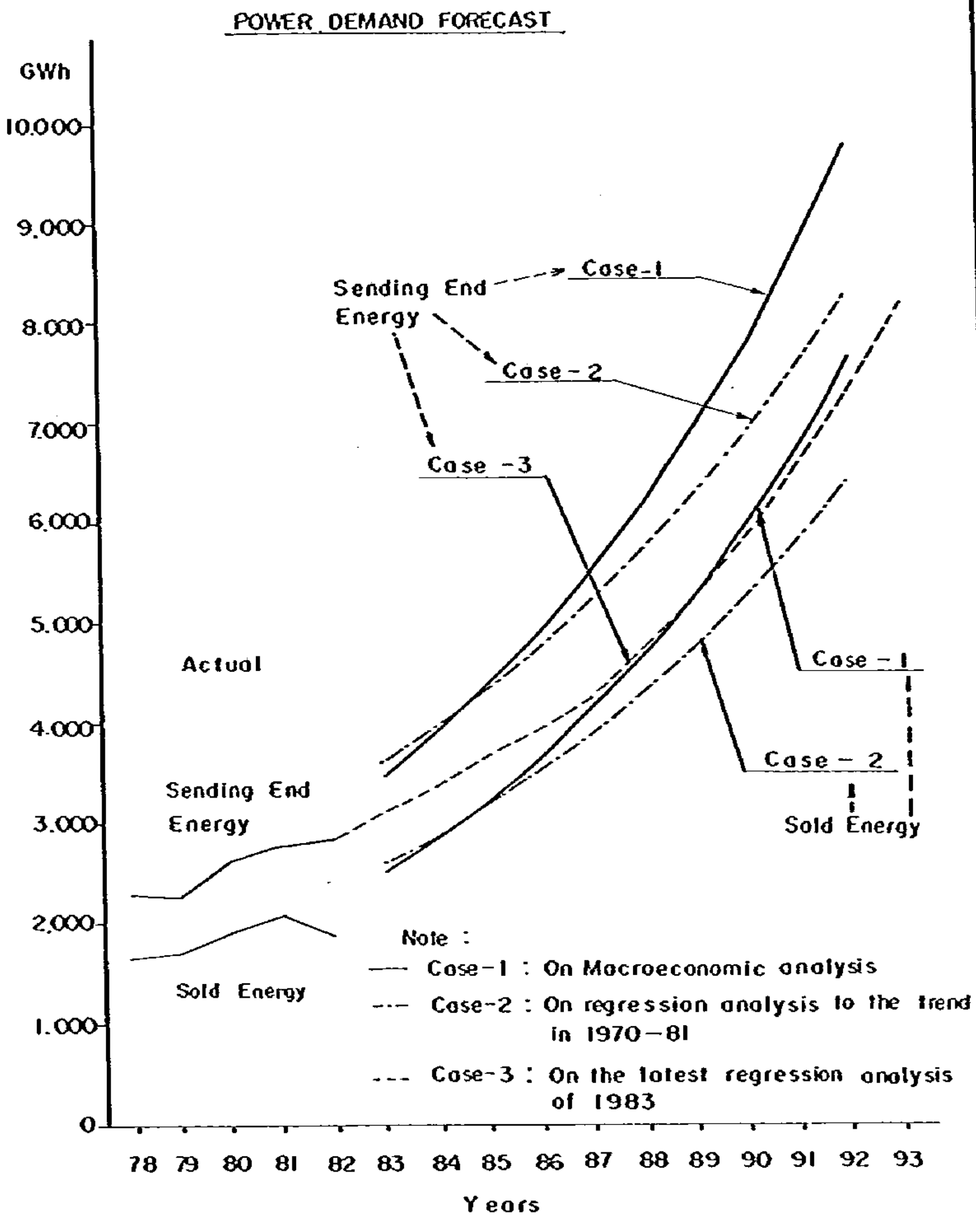
CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Power Trend in 1970 - 1982
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	B-01	*Tendencia de Energía en 1970-1982*
JAPAN INTERNATIONAL COOPERATION AGENCY		



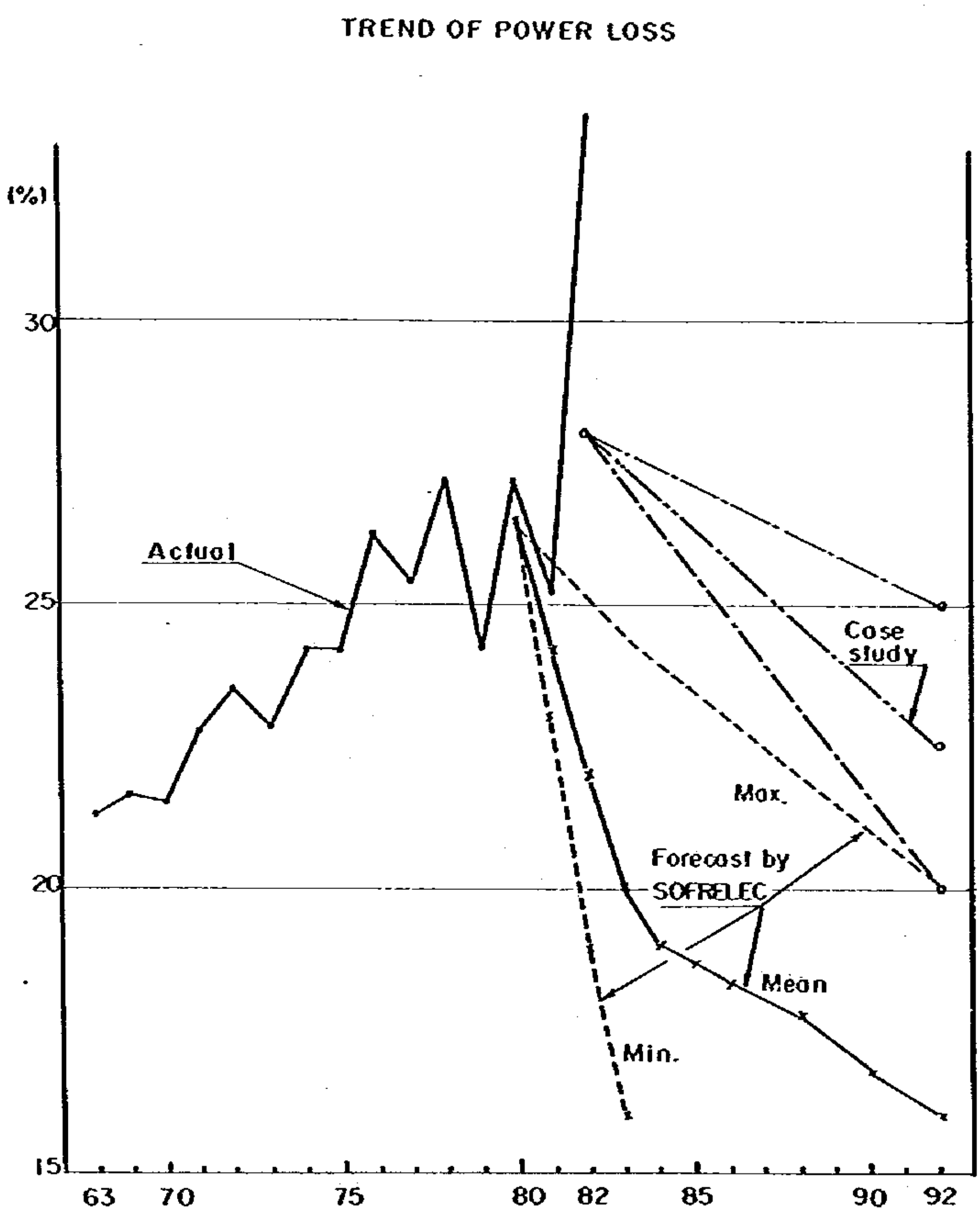
CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Typical Daily Load Curve
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	B-02	*Curva Tipica de Carga Diaria*
JAPAN INTERNATIONAL COOPERATION AGENCY		



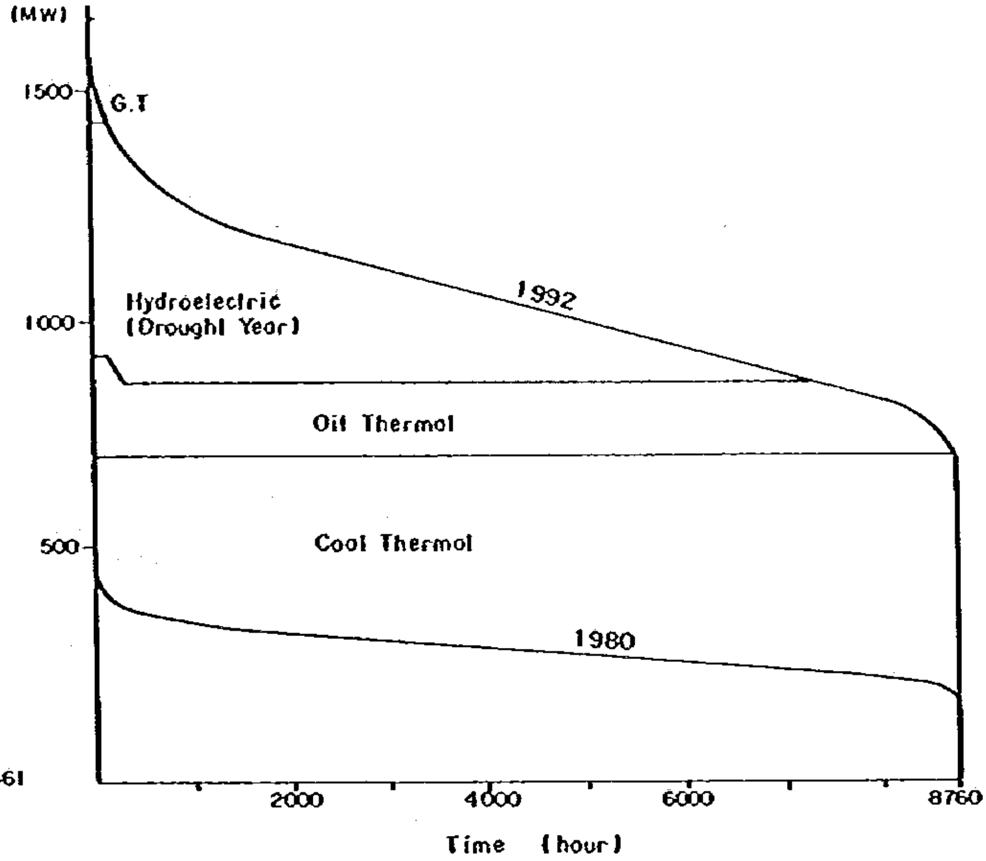
CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Present Power System
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	8-03	*Diagrama Eléctrico Actual*
JAPAN INTERNATIONAL COOPERATION AGENCY		

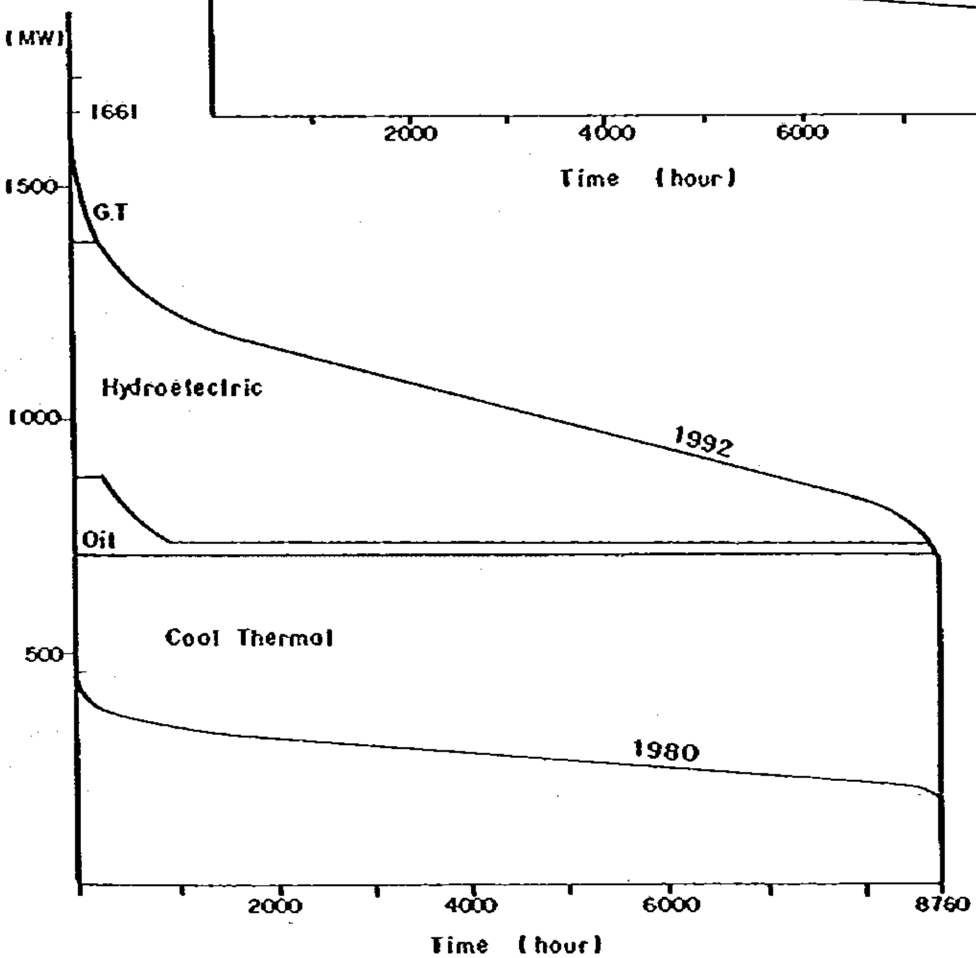


CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Power Demand Forecast by CDE - Sofrelec
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	B-04	*Proyección de Demanda por CDE - SOFRELEC*
JAPAN INTERNATIONAL COOPERATION AGENCY		

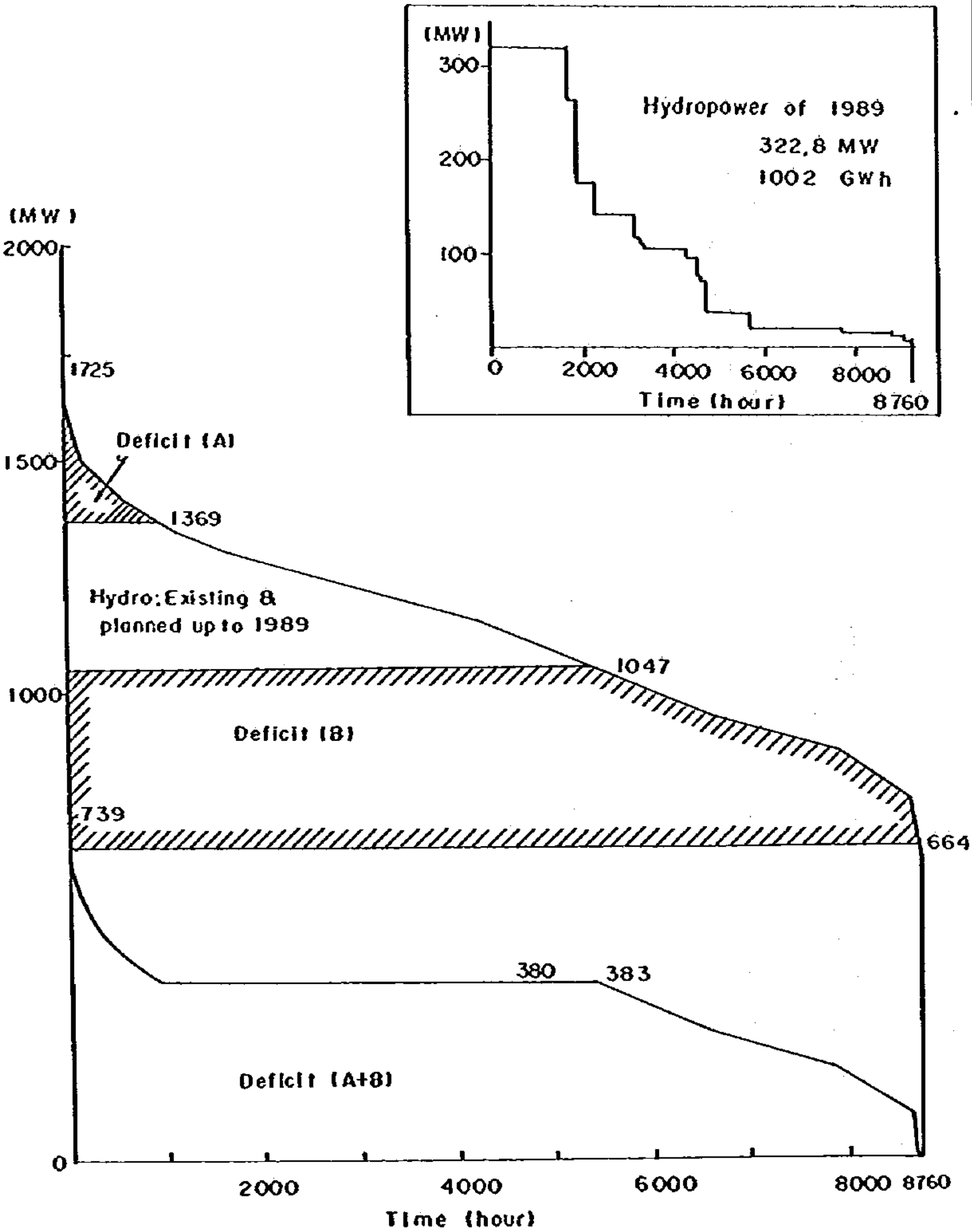


CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Trend of Power Loss
EL TORITO-LOS VEGANOS HIDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	8-05	*Tendencia de Pérdida Eléctrica*
JAPAN INTERNATIONAL COOPERATION AGENCY		

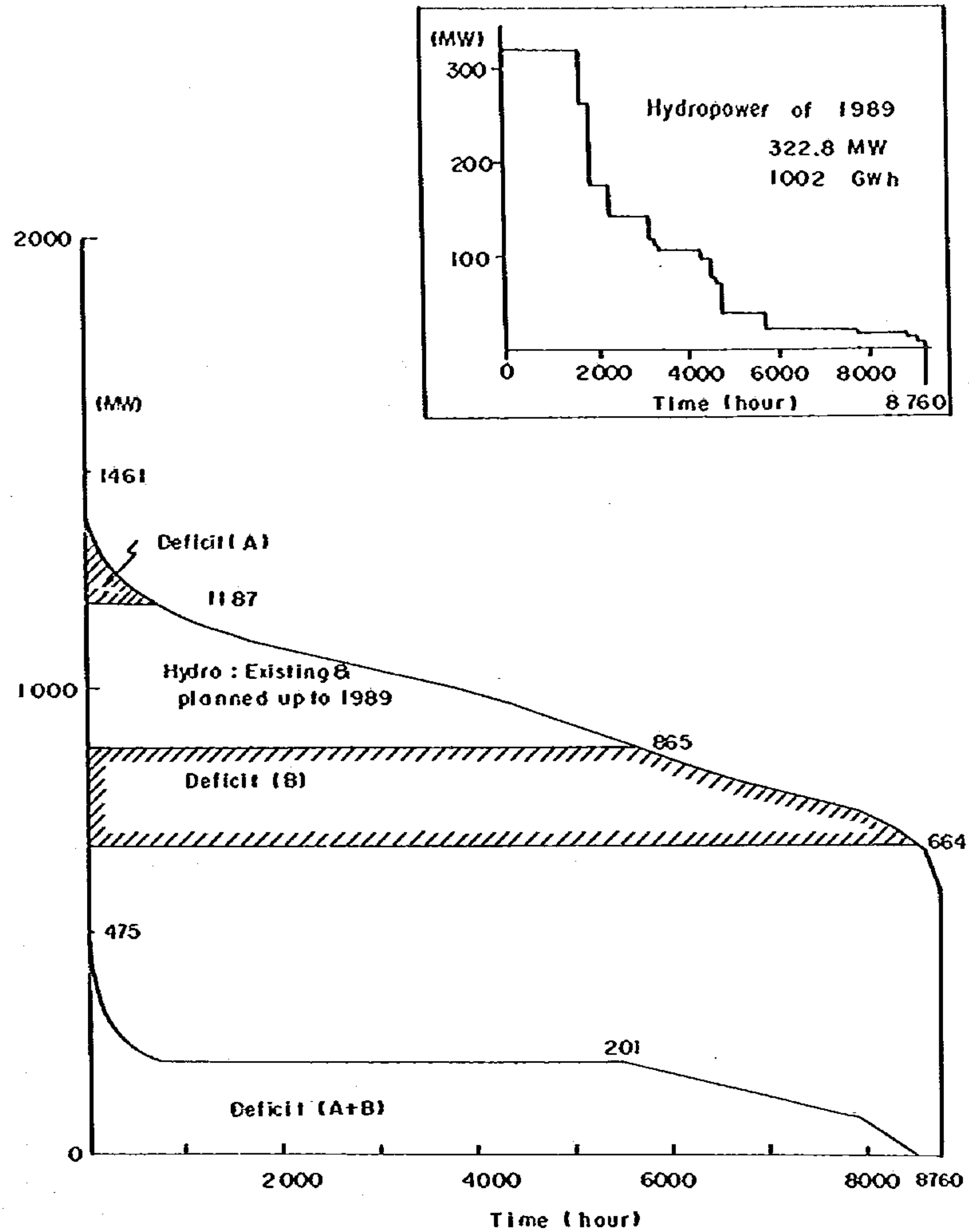




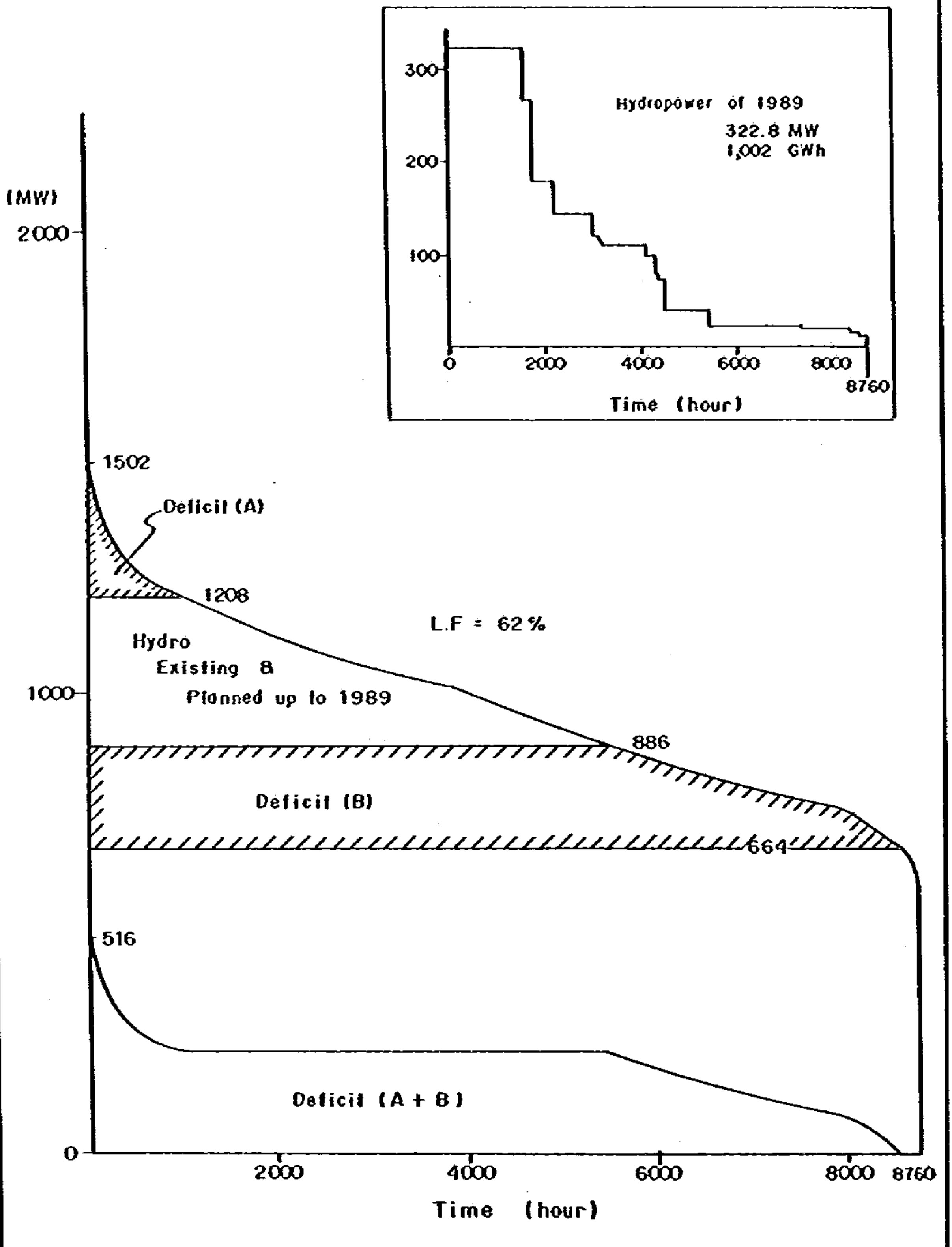
CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Load Duration Curve 1980 & 1992 and Power Supply Program 1992
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	B-06	*Curva de Duración de Carga en 1980 y 1992, y Plan de Expansión para 1992*
JAPAN INTERNATIONAL COOPERATION AGENCY		



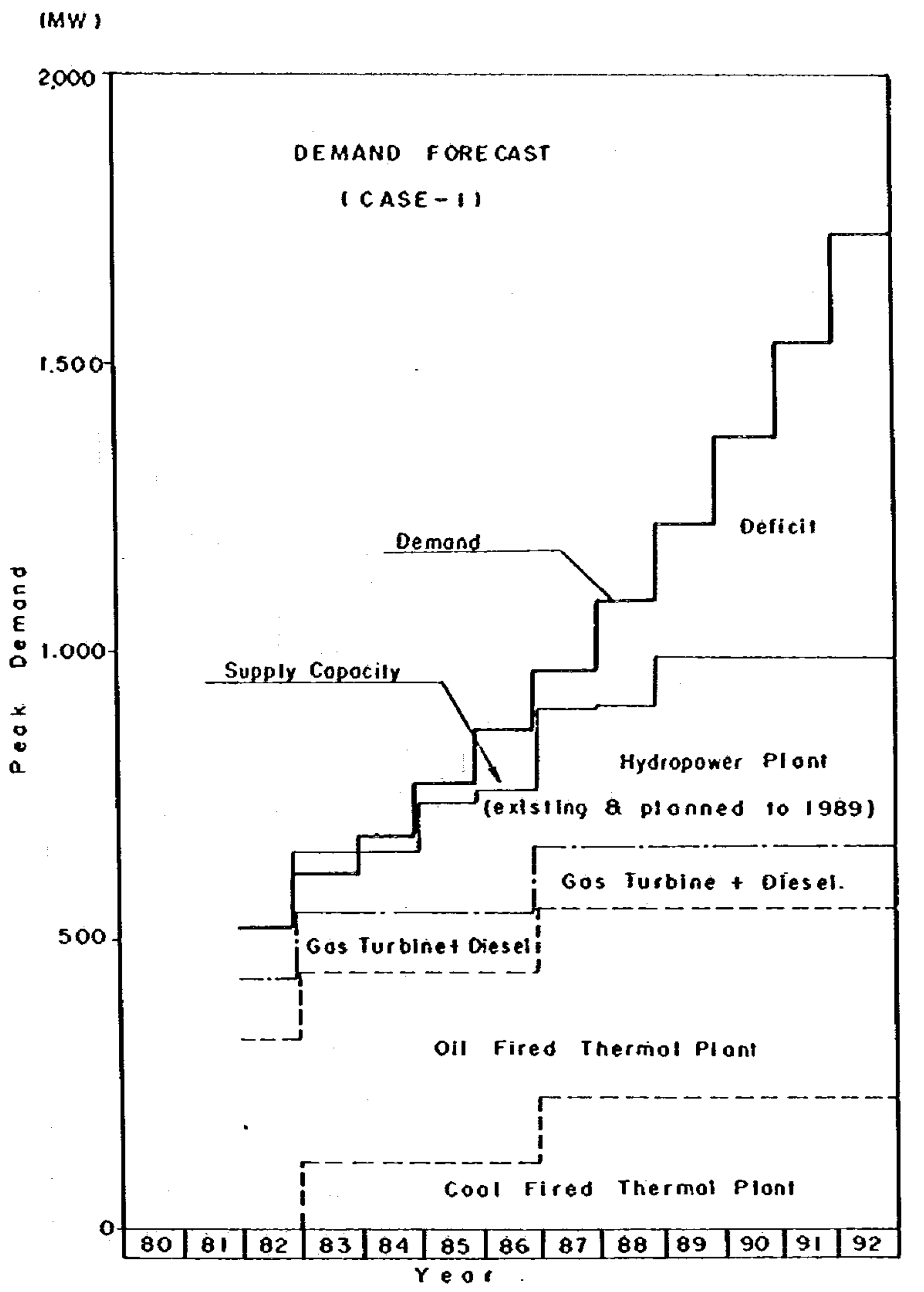
CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Forcasted Load Duration Curve (Case 1)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO LOS VEGANOS	B-07 (1)	*Curva de Duración de Carga (Caso 1)*
JAPAN INTERNATIONAL COOPERATION AGENCY		



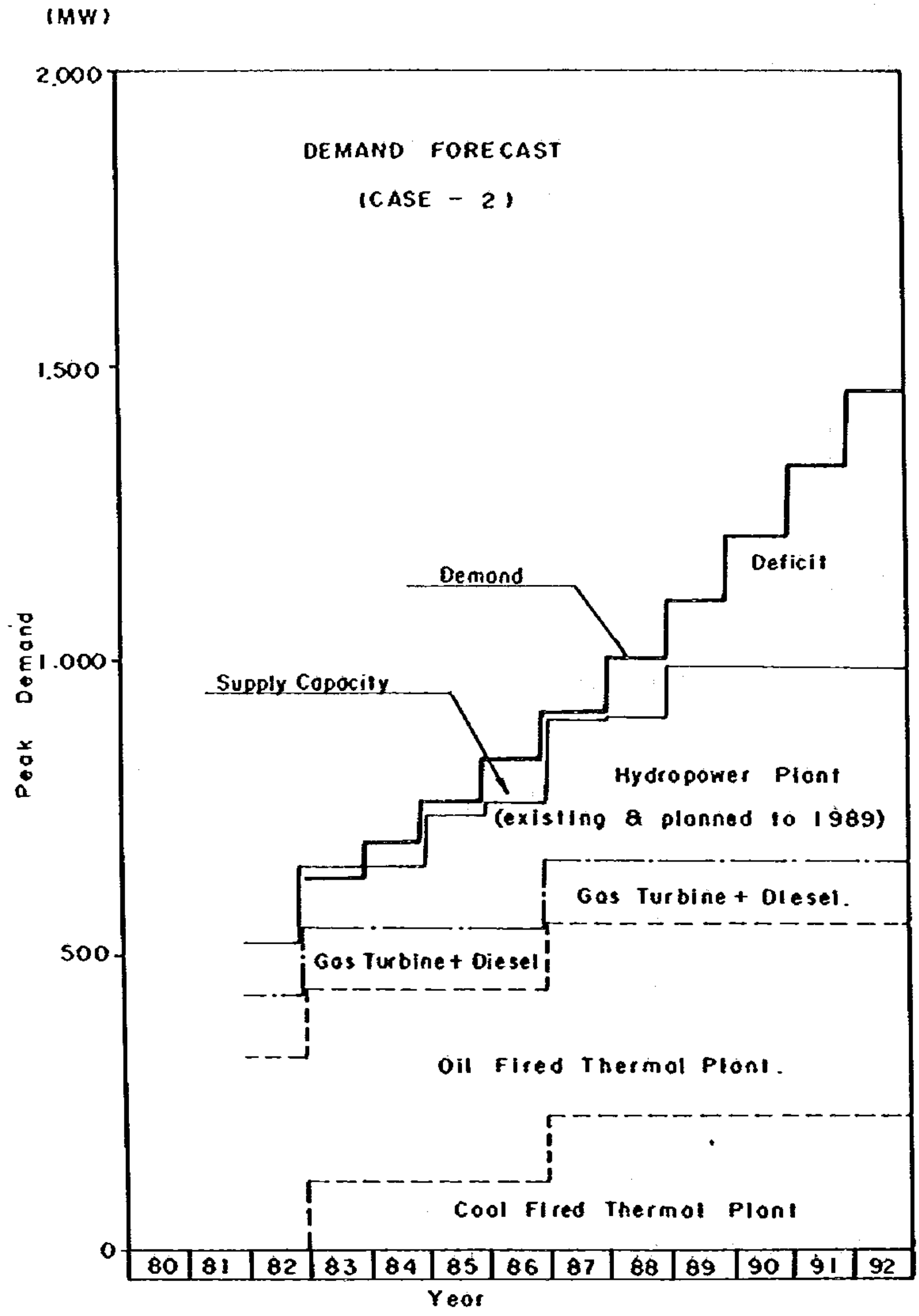
CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Forcasted Load Duration Curve (Case 2)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	B-07 (2)	*Curva de Duración de Carga (Caso 2)*
JAPAN INTERNATIONAL COOPERATION AGENCY		



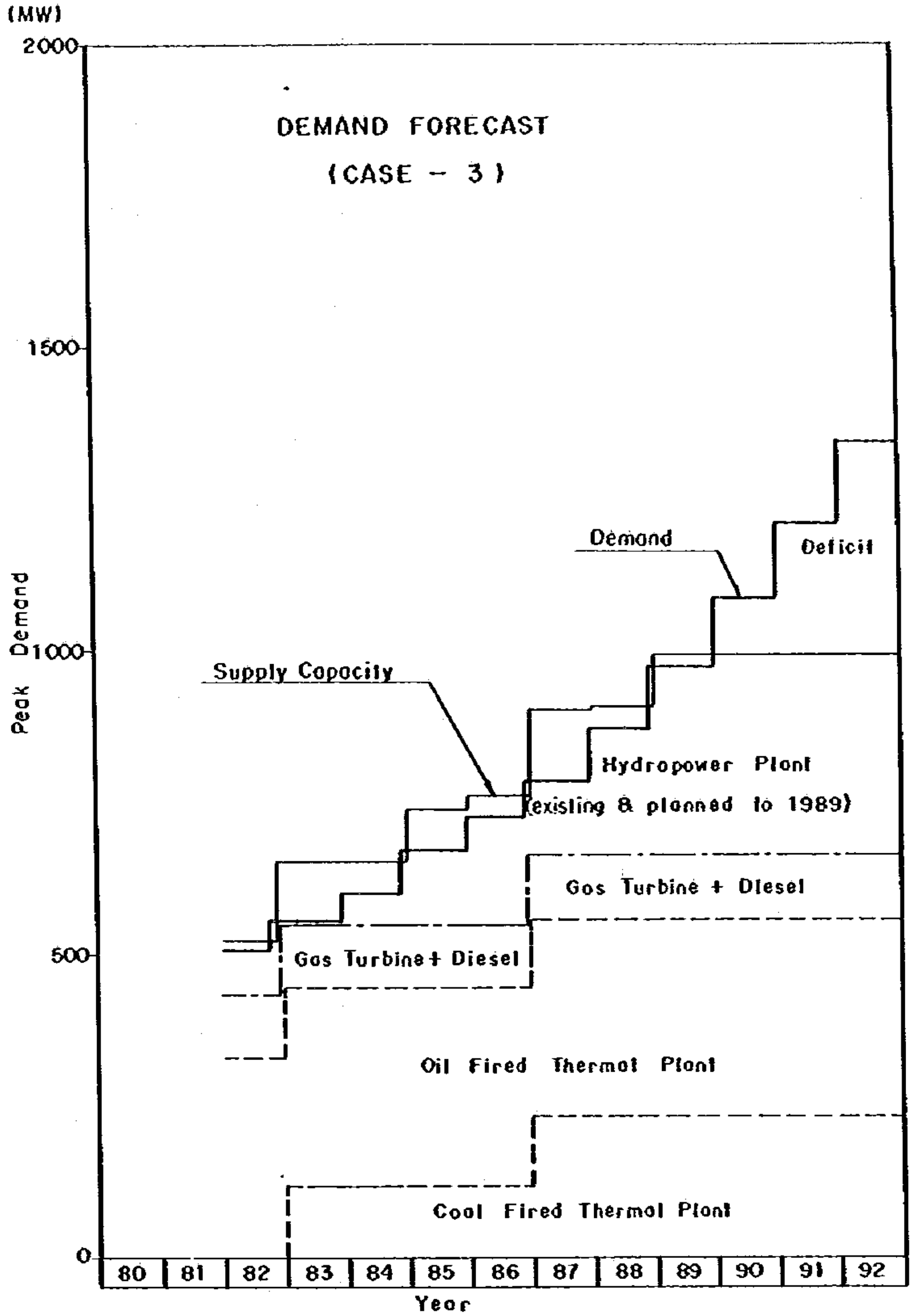
CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Forcasted Load Duration Curve (Case 3)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	8-07 (3)	Curva de Duración de Carga (Caso 3)
JAPAN INTERNATIONAL COOPERATION AGENCY		



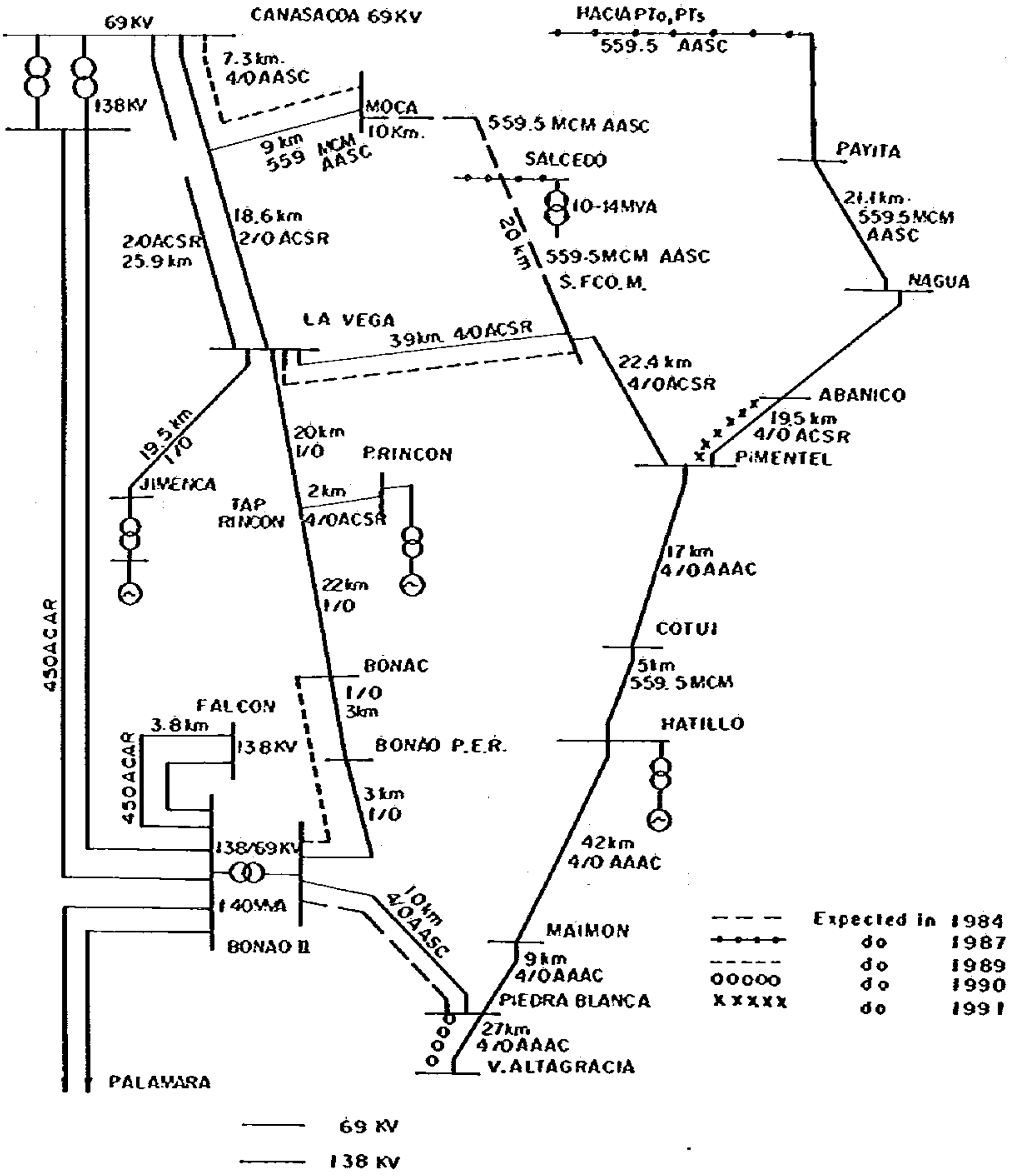
CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Peak Demand and Generating Capacity (Case I)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	B-08 (1)	*Demanda Máxima y Capacidad de Generacion (Caso I)*
JAPAN INTERNATIONAL COOPERATION AGENCY		



CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Peak Demand and Generating Capacity (Case 2)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	B-08 (2)	*Demanda Máxima y Capacidad de Generación (Caso 2)*
JAPAN INTERNATIONAL COOPERATION AGENCY		



CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	Peak Demand and Generating Capacity (Case 3)
EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS	B-08 (3)	*Demanda Máxima y Capacidad de Generación (Caso 3)*
JAPAN INTERNATIONAL COOPERATION AGENCY		



Note : Plan expected untill 1991.

CORPORACION DOMINICANA DE ELECTRICIDAD	Fig.	High Tension System Plan in North Zone (by CDE)
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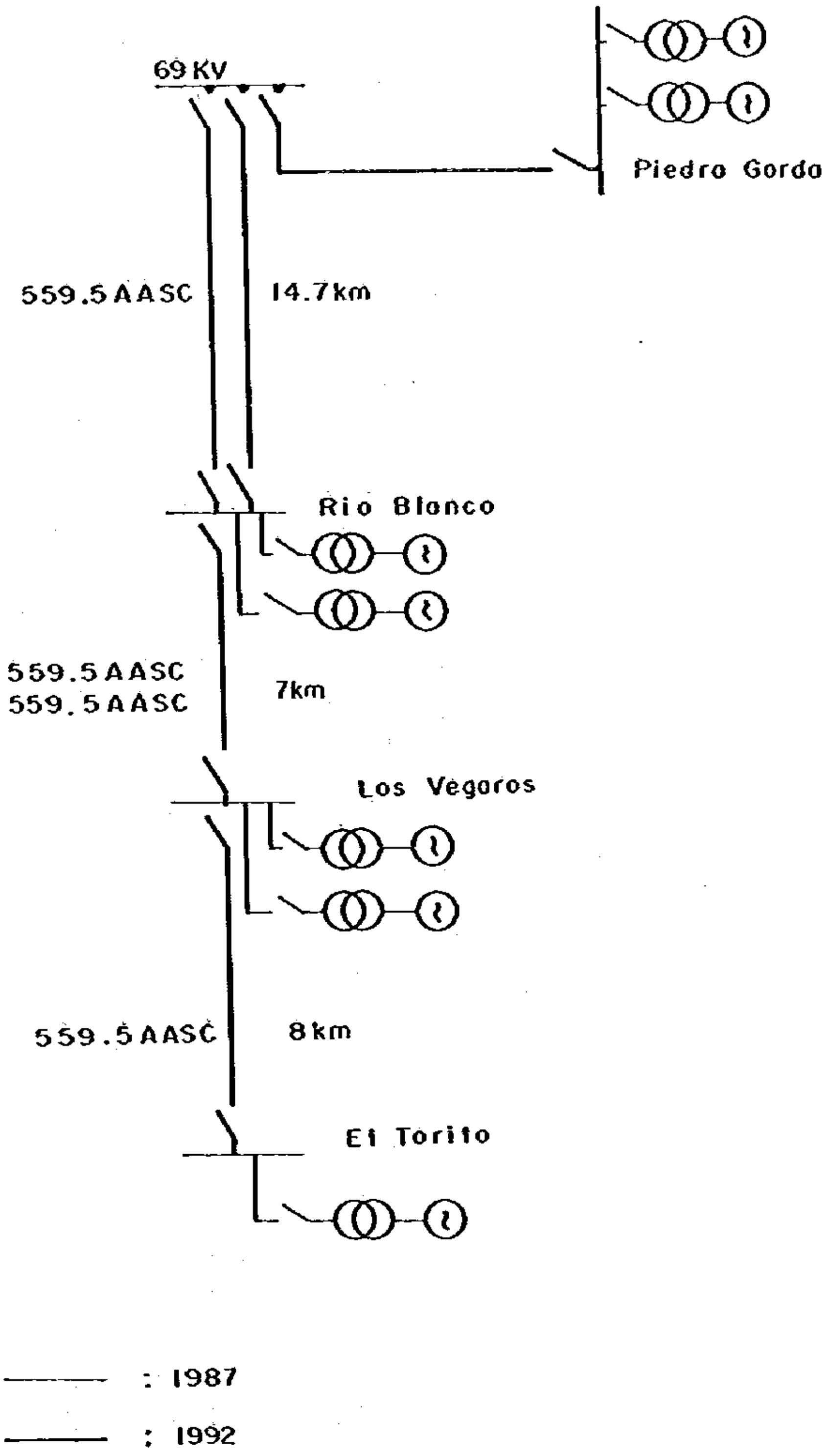
JAPAN INTERNATIONAL COOPERATION AGENCY		



CORPORACION DOMINICANA DE ELECTRICIDAD	fig.	T/L Plan of Alto Yuna (by CDE)
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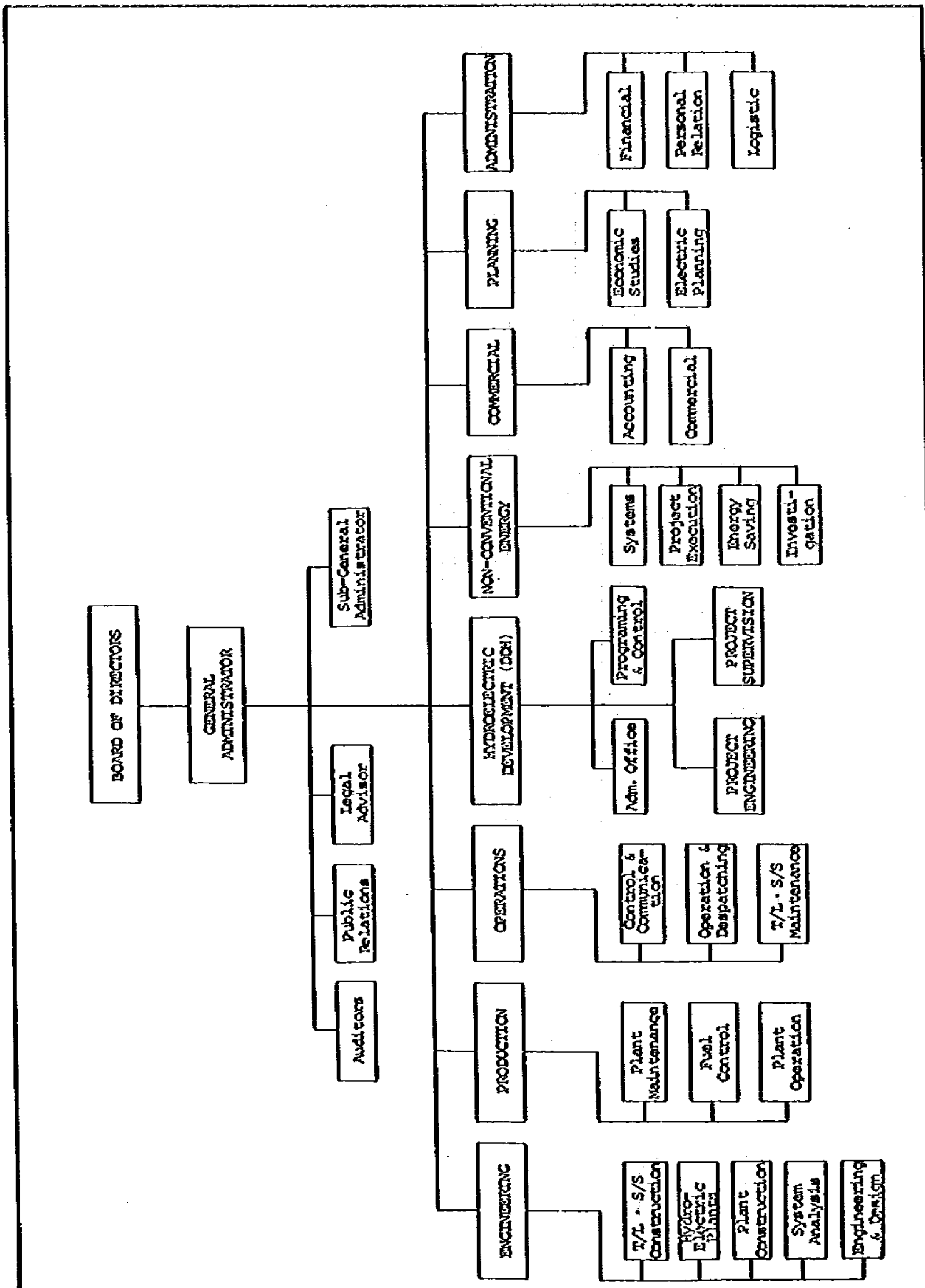
JAPAN INTERNATIONAL COOPERATION AGENCY		



CORPORACION DOMINICANA DE ELECTRICIDAD

EL TORITO-LOS VEGANOS HYDROELECTRIC COMPLEX
COMPLEJO HIDROELECTRICO EL TORITO-LOS VEGANOS

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. B-11 **Organization of CDE**

Organización de CDE

ANNEX C

ANNEX - C

METEOROLOGY AND HYDROLOGY

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C. METEOROLOGY AND HYDROLOGY

C.1 INTRODUCTION

The Yuna river is the second largest river in the Dominican Republic. It originates in the Cordillera Central and runs eastwards for about 210 km until it debouches into the Samana Bay. The river drains a total area of approximately 5,500 km^2.

The study area is located in the uppermost part of the Yuna river basin. The mainstream of the Yuna river originates in the western edge of mountains called Loma de Cerro Montoso, and it runs first in the east to west direction. After it joins with Arroyo Blanco near at El Torito at the elevation of 691 m above mean sea level, the mainstream turns its direction towards the north and flows down for about 15.5 km until it joins with the Blanco river at the elevation of 293 m above mean sea level. The average river gradient is around 1/40 in this section. (Refer to Fig.C-01 and C-02)

For the development of hydroelectric power on the mainstream of Yuna river upstream of the confluence with the Blanco river, various studies on meteorology and hydrology have been conducted in the course of this feasibility study. In view of the fact that the available meteohydrological data are rather limited in the study area, rainfall and water-level gauging stations have been newly installed at the initial stage of the study. All the existing data and the record obtained through the field investigations are extensively and intensively analyzed to define as far as possible the meteohydrological conditions in the study area. The analysis and studies have been executed jointly by CDE and JICA hydrologists.

The climatic conditions are first reviewed, with particular attention to the rainfall pattern, as described in Chapter C.2. In view of the facts that the catchment area is relatively small and that the available hydrological data are limited as explained in Chapter C.3, special attention is paid on the analysis and study of available discharge at each intake site planned for the hydropower development, as discussod in Chapter C.4. Analysis and study on flood are also executed to define design flood discharge, as described in Chapter C.5.

In view of the relatively high yield of sediment in the watershed of the upper Yuna river basin due to the erosion mainly caused by shifting cultivation, specific attention is also drawn to the study on the sediment yield in the area, as explained in Chapter C.6.

Additional study on available discharge has been made to review the analysis made in Chapter C.4. by means of simulation model analysis on the basin rainfall and discharge. The result of additional analysis for verification conducted jointly by CDE-JICA hydrologists are presented for reference in Chapter C.7.

C.2 METEOROLOGY

C.2.1 Climatic Conditions

The study area in the upper Yuna river basin has a tropical monsoon climate, commanded by the wet season and dry season. Although the distinction of the two seasons is not so clear, the wet season lasts from April to November or December. The wet season is interrupted by relatively dry months in June-July, which is generally called the mid-dry season.

As an insular country, influence of the sea is effective and predominant so that the daily sea-land breeze mitigates temperature and makes it less fluctuated throughout the year. Distribution and quantity of rainfall is also influenced by such conditions. The predominant NE trade wind, getting humid in the Atlantic Ocean, produces rainfall when it collides with the mountain ranges. The hurricanes usually attack in August-October, which characterizes rainfall in that period.

More specifically, the study area has climatic conditions as briefly explained in the subsequent paragraphs.

(1) Temperature:

Temperature has been recorded at three (3) gauging stations in and around the study area in the upper Yuna river basin; Juma Banao, Constanza and Los Botados. (Refer to Fig.C-01 and C-03.) Among these stations, Juma Bonao station has the longest recording period over 12 years and is located nearest to the study area. On the other hand, Constanza station is located in the mountain plateau of higher elevation (El. 1,215 m) and Los Botados station has a short recording period of about 2 years.

According to the record at Juma Bonao, the annual mean temperature is around 24°C. A seasonal fluctuation of the monthly mean temperature is substantially small, ranging from 22.2°C in January-February to 25.5°C in July- August, as indicated on Table C-01 and Fig. C-04. An annual fluctuation of temperature ranges from 19°C to 32°C.

(2) Relative Humidity:

Relative humidity has also been observed at three (3) gauging stations, of which Juma Bonao station has the longest recording period. (Refer to Fig. C-03) At Juma Bonao, the annual mean relative humidity is around 85%. As summarized on Table C-02, the monthly mean humidity demonstrates little seasonal variation. It ranges from 84% in March and June to 88% in December.

The records of relative humidity at Juma Bonao are referred to particularly in estimating the Dew point for analysis of probable maximum precipitation in the study area, as discussed in Chapter C.5.1.

(3) Evaporation:

The evaporation records observed at Juma Bonao in 1971-83 are also referred to. At Juma Bonao, the annual mean of evaporation is around 4 mm per day. The monthly mean evaporation falls in the range of 2.6 mm/day in December to 5.3 mm/day in June, as shown on Table C-03.

(4) Winds:

The available record of winds in and around the study area is rather limited. The record at Juma Bonao in 1979-80 has been obtained, as shown on Table C-04.

The monthly mean wind velocity is around 1.3 m/s, which the annual maximum wind velocity is about 18 m/s at Juma Bonao.

C.2.2 Rainfall

The precipitation records at the pluviometric gauging stations in and around the study area have been collected to the maximum extent. Some of the records contain hourly precipitation, while some others indicate precipitation only on a monthly basis. The recording period at each station is tabulated on Fig. C-03.

The longest precipitation records are available at Rancho Arriba (since 1939) and at Constanza (since 1931). The historical record indicates that the annual mean rainfall is about 1,300 mm at Rancho Arriba and around 1,000 mm at Constanza, as shown on Table C-05 and C-06, as well as on Fig. C-05 and C-06. It is noted, however, that the gauging stations at Rancho Arriba and Constanza are located outside the Yuna river basin and have different basin characteristics if compared with the study area.

The hourly and daily precipitation has been recorded at Los Quemados gauging station, which is located at about 4 km downstream from the confluence of the Yuna mainstream and the Blanco river. At Los Quemados, rainfall record since 1967 is available. According to the historical record, the annual mean precipitation is around 1,900 mm. The dry months are January (90 mm), June (110 mm), February (140 mm) and March (140 mm), as shown on Table C-07 and Fig. C-07.

At other rainfall gauging stations in the upper Yuna river basin, recording periods are substantially short, except for Juma Bonao gauging station (Refer to Table C-08 and Fig. C-08). The observation at these stations, including Loma del Medio, Loma Alto de Avispa, El Colorado, Cerro Montoso, Los Botatos, El Novillo, El Morroy, El Torito and La Yautia, has been executed on a monthly basis by means of totalizers installed in 1980-81. Out of these stations, automatic rainfall recorders have been newly installed at Loma del Medio, El Novillo and El Torito at the initial stage of this feasibility study, in order to obtain more accurate data on precipitation. The rainfall record at these stations are summarized on Table C-09 to C-17 and on Fig. C-09 and C-10.

A correlation of monthly rainfall among these stations has been checked to verify the relation particularly between the long-term records and the short-term records. As indicated on Table C-18 and Fig. C-11, the correlation coefficient between monthly rainfall records at Los Quemados (17 years) or Juma Bonao (13 years) and the records of other stations (3 to 4 years) varies from one place to another.

C.3 HYDROLOGICAL DATA

C.3.1 Gauging Station and Record

There are a limited number of water level gauging stations in the study area in the upper Yuna river basin. Los Quemados gauging station, installed in 1962, is located at about 4 km downstream for the confluence of the Yuna mainstream and Blanco river. The catchment area at Los Quemados is 369 km^2. Although Los Quemados gauging station was destroyed by the hurricane David in 1979 and observation was discontinued thereafter, it has the longest period (18 years) of hydrological record in the area.

The monthly mean discharge at Los Quemados gauging station ranges from 12.4 m^3/s in March to 25.1 m^3/s in December, and the annual mean discharge is about 18 m^3/s.

Since there has been no hydrological gauging station on the main stream of the Yuna river, two automatic water level gauges were installed in the course of this feasibility study at Pino de Yuna located downstream from the confluence with Arroyo Blanco, and at Los Veganos located downstream from the confluence with Arroyo Colorado. The rating curve at Pino de Yuna and Los Veganos gauging stations is prepared as shown on Table C-19 and C-20, as well as on Fig. C-12. Staff gauges were also installed by CDE at T-2 damsite on Arroyo Blanco and at the above-mentioned two water level gauging station site of Pino de Yuna and Los Veganos.

C.3.2 Discharge Measurement

Various methods are adopted to estimate daily runoff under circumstances of limited available hydrological data. They include estimate on the basis of specific discharge at the rate of catchment area, estimate by means of rainfall records, and estimate on the basis of actual discharge observation. The first and the second methods of runoff estimate are usually applicable when rainfall records over 10 years are available at an appropriate density of rainfall gauge in the catchment area. In view of the facts that the reliable rainfall records are available only in a few years, except for

Los Quemados station, the estimate of daily runoff on the basis of the ratio of catchment area and rainfall records is considered as less reliable.

Under such circumstances, discharge measurement has been conducted by two INDRHI crews in the course of this study. The proposals of discharge measurement are:

- to develop correlation between the discharge at Los Quemados gauging station and discharge at the alternative intake sites, and

- to develop rating curve at the newly installed gauging station sites.

The measurement has been made at 11 spots as follows:

Upstream Area	Downstream Area
1) R. Yuna at T-1 damsite	7) A. Caña
2) A. Blanco at T-2 damsite	8) A. Tireo
3) Pino de Yuna weir site	9) R. Blanco at confluence
4) Pino de Yuna station	10) A. Avispa
5) R. Yuna V-1 damsite	11) R. Yuna at Piedra Gorda
6) Up and downstream of A. Colorado	

In some cases, discrepancy among the data obtained by two measurement crews has been found, such as reversed order of discharge between the upstream records. Such apparently unreliable data are to be precluded from the analysis.

C.4 ANALYSIS ON AVAILABLE DISCHARGE

C.4.1 Synthetic Discharge at Los Quemados

As discussed in the foregoing Chapter, analysis on available discharge is made on the basis of a long-term observation record at Los Quemados gauging station and the correlation among the periodic discharge measurement records. (Refer to Fig. C-13)

The daily discharge records at Los Quemados gauging station (catchment area of 369 km^2) have been processed throughout the recording period of 18 years from 1962 to 1979. The monthly mean discharge ranges from 12.4m^3/s to 25.1m^3/s, and the annual mean discharge is about 18 m^3/s, as shown on Table C-21.

At a site immediately upstream of Los Quemados gauging station, water has been taken for irrigation in the Bonao valley and the volume of such a water use is to be added to the discharge record at Los Quemados, in order to estimate the natural flow at Los Quemados. In view of the facts that the daily irrigation water intake record involves frequent non-recorded period and that the volume of water intake is less than 10% of the discharge at Los Quemados, the monthly mean of irrigation water use is applied to obtain daily synthetic discharge at Los Quemados. The monthly mean of irrigation water ranges from 0.63 m^3/s to 0.80 m^3/s, as shown on Table C-22 and Fig. C-14.

On the basis of the discharge record at Los Quemados gauging station and the monthly mean irrigation water use, the synthetic discharge at Los Quemados is calculated as shown on hydrograph in Fig. C-15. The monthly mean synthetic discharge is also tabulated as shown on Table C-23. The annual mean synthetic discharge is estimated at 19.25 m^3/s. The discharge ranges from 13.96 m^3/s in March to 29.19 m^3/s in December.

C.4.2 Discharge at Each Site

On the basis of the discharge measurement records as compiled on Table C-24, a correlation between the discharge measured on the same day at each spot and at Piedra Gorda located at about 2 km upstream of Los Quemados (catchment area of 358 km^2) has been analyzed at first. By eliminating unreliable data as explained in Chapter C.3.2, the correlation coefficient is calculated (Refer to Table C-25 and Fig. C-16). The correlation is further adjusted to the discharge at Los Quemados at the rate of catchment area, as indicated on Table C-26. The appropriate rate of conversion at each site is summarized as follows:

	Discharge Ratio to Los Quemados	Ratio of Catchment Area to Los Quemados
T-1 site	0.04	0.043
T-2 site	0.04	0.039
Pino de Yuna (gauging station)	0.11	0.106
Arroyo Colorado	0.07	0.042
Confluence Colorado (V-3 site)	0.22	0.170
Arroyo Avispa	0.07	0.054

It is observed that the tributary basin of Arroyo Colorado is relatively more blessed with water in the upper Yuna river basin.

The discharge conversion ratio to Los Quemados calculated above has been checked by the average rainfall in each sub-basin, as follows:

	Ratio of Catchment Area to L.Q.	Sub-basin Rainfall Ratio to L.Q.	Weighted Conversion Ratio	Discharge Conversion Ratio Applied
T-2 site	0.039	1.28	0.050	0.04
T-4 site	0.106	1.19	0.126	0.10
V-3 site	0.170	1.22	0.207	0.22

Although the correlation coefficient of the discharge conversion ratio to Los Quemados in Table C-26 is relatively low, it is considered that the discharge conversion ratio calculated through the actual discharge measurement is applicable in estimating discharge at each site.

Available daily discharge at each intake site is estimated by applying the conversion ratio and the ratio of catchment area at Piedra Gorda to Los Quemados, in accordance with the formula as follows:

$$Q_{site} = Q_{LQ} \cdot K \cdot 358/369$$

where, Q_{site} : daily discharge at intake site
Q_{LQ} : daily discharge at Los Quemados
K : discharge conversion ratio
=358/369 ratio of catchment area at Piedra Gorda to Los Quemados

C.4.3 Available Discharge

On the basis of daily discharge estimated at each intake site, the discharge duration curve is prepared by applying the Parallel Method, as illustrated on Fig. C-17. 90% dependable discharge at the selected intake site is summarized as follows:

	Estimated 90% dependable discharge (m^3/s)
T-1 site	0.31
T-2 site	0.31
T-4 site	0.70
V-3 site	1.72
A. Colorado (intake site)	0.31

The 90% dependable discharge is adopted as a firm discharge for the run-of-river type power development plan.

On the other hand, available discharge for power generation by dam and reservoir plan is estimated by mass-curve method on the basis of the estimated daily discharge. A mass curve is a cumulative plotting of net reservoir, and is used to determine required reservoir capacity. The mass-curve at the proposed damsites is further discussed in Annex G.

C.5 FLOOD FREQUENCY STUDY

C.5.1 Rainfall Analysis

Rainfall analysis for the flood frequency study is made to determine design hyetograph on the basis of selected representative hyetograph, and estimate probable precipitation and probable maximum precipitation, as illustrated on a diagram in Fig. C-18.

The annual maximum precipitation is selected after compiling the stormy rainfall over 50 mm per day or 20 mm per hour, out of the hourly rainfall records available at 8 gauging stations. The pattern of such strong rainfall is also compiled on the hyetographs. (Refer to Table C-27 to C-29 and Fig. C-19 to C-23). As observed on the hyetographs, stormy rainfall is relatively short in duration and generally last for less than 24 hours. The maximum daily precipitation is recorded at the time of the hurricane David on August 31 - September 1, 1979, which reached 261.0 mm at Los Quemados. (Refer to Fig. C-24) The patterns of rainfall over 44.0 mm per hour (maximum hourly rainfall at Los Quemados on August 31, 1979) are also reviewed in 10 cases, and it is concluded that the stormy rainfall is represented by the hyetograph at the time of the hurricane David.

The probable maximum precipitation is estimated on the basis of the stormy rainfall at the time of the hurricane David. In the case of non-orographic rainfall, the probable maximum precipitation is estimated by means of the moisture adjustment or storm transposition. The moisture adjustment is made through 1) cyclonic adjustment method, 2) thunderstorm adjustment method, or 3) q-adjustment method. Among these methods, the cyclonic adjustment method is selected to estimate the probable maximum precipitation in the study area. The adjustment factor is calculated in accordance with the formula as follows:

P.M.P adjustment factor

$$= \frac{\text{Precipitable Water at Maximum Dew Point}}{\text{Precipitable Water at Design Dew Point}}$$

The dew point is estimated in accordance with the following formula, and relation between temperature and maximum vapor pressure.

$$e = \frac{f}{100} E$$

where, e = actual vapor pressure
f = relative humidity
E = maximum vapor pressure at temperature T

The correlation between temperature and maximum vapor pressure is shown on Table C-30, for reference. On the basis of the temperature and relative humidity recorded at Juma Bonao (Refer to Table C-01 and C-02), the monthly mean dew point is calculated as shown on Table C-31 and Fig. C-25.

The dew point of each storm recorded at Juma Bonao, as well as the maximum dew point at the station, is also tabulated as shown on Table C-32 and C-33. The maximum dew point at the station is estimated to be 27.3°C, while the design dew point is calculated at 21.3°C. (Refer to Table C-34) The precipitable water above the ground height to the 200 mb level at each dew point is calculated at 96.5 mm (3.8 inches) and 61 mm (2.4 inches), respectively, in accordance with the diagram in Fig. C-26. The adjustment factor of the probable maximum precipitation is therefore calculated at 1.58. Consequently, the probable maximum precipitation is estimated at 412 mm (=261.0 mm x 1.58).

The probable precipitation is analyzed on the basis of daily rainfall recorded at Los Quemados. The result of analysis by means of 1) moment method, 2) order-probability method, 3) Pearson Type III method, and 4) Gumbel method is shown on Table C-35 and Fig. C-27 to C-30. As seen, considerably large differences have been indicated among the probable precipitations derived from the above four methods. Aiming to select an appropriate one, the results of four methods were evaluated from an another aspect, i.e. the Creager's coefficient, C was compared with those of design floods applied in other existing and planned dams in the Republic. As shown in Fig. C-36, the results by the Gumbel method give approximately average values of the Creager's coefficients of other major dams. The

Creager's coefficient depends on the characteristics of the basin such as rainfall intensity, topography and so on. In the light of the similarity of basin characteristics, the Gumbel method was considered most appropriate. Thus, the probable precipitation is estimated by this method at 304 mm/day for the return period of 100 years and 337 mm/day for the return period of 200 years.

C.5.2 Runoff Analysis

Among various methods of flood runoff analysis, such as the storage function method, unit hydrograph method, tank model method, etc., the storage function method appears to be most appropriate to be applied in this study, since the storage function method is said to favourably fit to flood runoff analysis in Japan of which topographic condition is very similar to that of the study area.

The flood runoff analysis is executed in line with the diagram illustrated on Fig. C-18.

Under the storage function method, the basic model and its constants are assumed and flood runoff is calculated to determine reasonable runoff model. The storage volume and runoff have a basic relation as follows:

$$Se = k \cdot Qe^{P}$$

where, Se : storage volume

Qe : runoff (m^3/s)

K,p : constants

The runoff calculation of the basin or the stream section is made in accordance with the formula as follows:

$$\frac{d\,Se}{d\,t} = \frac{1}{3.6} f \cdot Rave \cdot A - Qe$$

where, Se : basin storage volume ($m^3/s.hr$)

f : coefficient of inflow

Rave: basin rainfall (mm/hr)

A : catchment area (km^2)

$Qe(t) = Q\ (t + Tl)$ direct runoff from the basin taking into account the time lag (Tl)

$$\frac{d\,Se}{d\,t} = fj \cdot Ij - Qe$$

where, Se : storage volume of stream section (m^3/s.hr)

fj : coefficient of inflow

Ij : inflow to the stream section (m^3/s)

$Qe(t) = Q\ (t + Tl)$

The constants K and p are estimated in accordance with the following formula:

$$K = 43.4 \cdot C \cdot AL^{1/3} \cdot i^{-1/3}$$

$$P = 1/3$$

where, C : reserve constant (natural basin = 0.120)

AL : stream length (km)

i : stream gradient

The time lag of the basin (Tl(B)) and stream section (Tl(S)) is estimated in accordance with the following formula:

Tl(B) : $0.047 \cdot AL - 0.56$ (catchment area over 11.9 km^2)

: 0.0 (catchment area within 11.9 km^2)

Tl(s) : time lag calculated by following flood flow velocity

$V = 3.5$ m^3/s ($i > 1/100$)

$V = 3.0$ m^3/s ($1/100 > i > 1/200$)

$V = 2.1$ m^3/s ($i < 1/200$)

The base flow (QC) is calculated at the rate of 0.04 m^3/s per km^2. Likewise, the primary inflow coefficient (f1) is presumed at 0.5 and the saturated precipitation is presumed at 100 mm, in view of the physiographic and hydrological conditions in the study area.

By dividing into the appropriate size of river basin and stream section, as illustrated on Fig. C-31, the basin and stream factors to be applied to the runoff model is calculated as summarized on Table C-36 and C-37. The flood runoff at Los Quemados is calculated as shown on Fig. C-32.

The flood runoff model developed as explained above is reviewed first by comparing the calculated and observed hydrographs. The storm records at Los Quemados, Los Veganos and Pino de Yuna are examined with respect to the rainfall and runoff, as shown on Table C-38 and Fig. C-33. Some of the records appear to be unreliable in the light of runoff coefficient, and the comparison of the calculated and observed hydrographs is made on 9 cases, as shown on Fig. C-34. The hydrographs demonstrate that the peak flood discharges are generally consistent.

On the other hand, the flood water level (flood mark) at the time of the hurricane David was traced along the upper Yuna mainstream. At a site about 100 m downstream from Pino de Yuna (catchment area of about 40 km^2), the flood water level was measured and topographic cross section was also surveyed as shown on Fig. C-35. The flood discharge is estimated at around 400 m^3/s, which is generally consistent with the value calculated through the flood runoff model. (Refer to Fig. C-32 (5).)

Through the examination as explained above, the application of storage function method and the estimate through the flood runoff model are verified to be appropriate.

On the basis of the flood runoff model, as well as the probable maximum precipitation estimated in Chapter C.5.1, the probable flood discharge and probable maximum flood (P.M.F) are calculated as summarized hereunder. (Refer to Table C-39.)

(m^3/s)

Returned Period	El Torito	Pino de Yuna	V3 Weir Site
1/20	300	310	570
1/100	420	440	820
1/200	460	490	920
P.M.F.	580	620	1,160

C.5.3 Design Flood Discharge

Design flood discharge for construction of a concrete gravity dam is, in usual case, adopted out of the probable flood for the return period of 200 years or the maximum flood discharge estimated in a climatologically similar river basin, whichever is the larger in volume. In case of construction of a fill-type dam, the design flood discharge is increased by some 20%. As for the construction of weirs, the probable flood for the return period of 100 years is taken as the design flood discharge. Consequently, the design flood discharge for spillway is determined for the dams and weirs contemplated for the project, as shown on Table C-40 and as summarized hereunder.

(m^3/s)

	El Torito	Pino de Yuna	V-3 Site
Weir	420	440	820
Concrete dam	460	-	-
Fill-type dam	560	-	-
Coffer dam	300	-	-

The design flood discharge estimated above has been checked by the specific discharge of design flood applied in other existing and planned dams in the Republic, as shown on Table C-41 and Fig. C-36. The Creager's coefficient calculated for the design flood estimated demonstrates approximately average value of those of other major existing or planned dams in the Republic. It appears, therefore, that the design flood discharge adopted for the project is an appropriate value.

C.6 STUDY ON SEDIMENT YIELD

C.6.1 Methodology

Volume of river sediment depends on such factors as rainfall, runoff, vegetation and land use, geology, land and river slope, etc. These factors affect in a complicated form, and an exact quantification of sediment is unattainable. In this study, estimate is made through 5 different methods as follows:

a) Estimate of suspended sediment by sampling

b) Estimate on the basis of land use in the catchment area

c) Survey of actual sediment in the existing reservoirs

d) Estimate through interpretation of aerial photographs

e) Estimate of empirical formula

The result of investigation, analysis and study for each method is explained in the subsequent sections.

C.6.2 Estimate by Sampling

Sampling of suspended sediment was conducted at 5 alternative dam/weir sites in April-June 1983, and samples were analyzed at INDRHI laboratory. The result of analysis is summarized on Table C-42. The volume of suspended load and discharge have correlation as shown on a rating curve in Fig. C-37, and as expressed in the following formula:

$$Qss = 0.0504\ Q^{1.2151}$$
$$Qsd = 4.3553\ Q^{1.2151}$$

where: Qss : Suspended load (kg/s)
Qsd : Suspended load (ton/day)
Q : Discharge (m^3/s)

In applying the above formula to the discharge record at Los Quemados, a trial calculation indicated that the estimate on the basis of daily mean discharge were higher by approximately 20% than the estimate on the basis of monthly mean discharge. In a simplified calculation, therefore, the suspended load is estimated at 120% of the sediment calculated on the basis of monthly mean discharge at Los Quemados.

As shown on Table C-43, total annual sediment is estimated at 83,915 tons, or 227 ton/km^2/year. It is noted, however, that sampling of sediment during the flood period was unattainable due to difficulty in access to the sites. Consequently, the above estimate appears to be less realistic in applying for design value.

C.6.3 Estimate by Land Use

The sediment yield is, in a long term, affected substantially by land use in the catchment area. Through the experimental review, a specific sediment yield is quantifiable in accordance with land use.

On the basis of vegetation and land use in the study area classified by means of aerial photographs in 1980/81 (Refer to Fig. C-38) and a standard sediment yield by land use applied by the Ministry of Agriculture and Forestry of Japan, an average sediment yield in the catchment area at the confluence with Arroyo Colorado near Los Veganos is estimated at around 1,700 m^3/km^2/year, as shown on Table C-44.

C.6.4 Sediment Survey in Existing Reservoir

A survey was conducted by the Navy Survey crew in the reservoir of Rincon dam, which was constructed in 1978 on the Jima river at a site about 17 km to the north of Bonao city. 10 cross sections were surveyed in March 1983 (Refer to Fig. C-39) to compare it with the map of the reservoir area in 1978. Consequently, it is estimated that the total volume of sediment is around 3.6 million m^3 in 5 years (1978-83). (Refer to Table C-45) This is equivalent to about 4,000 m^3/km^2/year of sediment yield in the upper Jima river basin.

It was noted through checking the original map in the Rincon reservoir area, however, that there was a discrepancy in the cross sections, and it appeared that the estimate would indicate much higher value than the actual sedimentation in the reservoir.

C.6.5 Interpretation of Aerial Photographs

A geotechnical interpretation is made on the basis of 1/20,000 scaled aerial photographs taken in 1967 (before the hurricane David in 1979) and in 1980-81 (after the hurricane David), as well as in the light of 1/5,000 and 1/20,000 scaled topographic maps. For the convenience of estimate, the catchment area upstream of the confluence of the Yuna mainstream and Arroyo Colorado near Los Veganos is divided into 5 sub-basins as follows (Refer to Fig. C-40):

Sub-basin		Approximate Catchment Area
1.	Arroyo Colorado	15 km^2
2.	Yuna river - downstream	17
3.	Arroyo Blanco	15
4.	Yuna river - upstream	16
5.	Arroyo Avispa (upstream of alternative weir site)	10
	Total:	73 km^2

Two patterns of sediment yield process are analyzed in aerial photo interpretation: i.e. 1) sediment produced by rainfall on eroded slopes and flow into river channel (V_E), and 2) sediment originally existent as river deposit and flow down when floods occur (V_T). The sediment yield in the catchment area is expressed in the following formula:

$$Vs_1,\ Vs_3,\ Vs_4,\ Vs_5 = V_E + V_T$$

$$Vs_2 = Vs_1 + Vs_3 + Vs_5 + V_E + V_T$$

where, Vs_1, Vs_2, Vs_5: sediment yield in each sub-basin

V_E = sediment originated in eroded slopes

V_T = sediment originated in river deposit

Through the sample survey in the field, a correlation between the eroded area and the mean depth of erosion is analyzed as shown on Fig. C-41. The mean erosion depth is presumed to range as follows:

Eroded Area (m^2)	Mean Erosion Depth (m)
0 - 500	1.0
500 - 1,000	1.5
1,000 - 2,000	2.0
2,000 - 4,000	2.5
4,000 - 8,000	3.5
over 8,000	5.0

On the other hand, the area of erosion is calculated in each sub-basin, by means of aerial photo interpretation. Consequently, the sediment yield from eroded slopes is estimated in accordance with the formula as follows:

$$V_E = A \cdot D \cdot K$$

where: V_E : sediment yield from eroded slopes (m^3)
A : area of eroded slopes (m^2)
D : mean erosion depth (m)
K : runoff rate of sediment, assumed at 0.8 in accordance with a standard applied by the Ministry of Construction, Japan.

The estimated sediment yield from eroded slopes in each sub-basin is shown on Table C-46.

Sediment which is originally existent as river deposit and flow down when floods occur is estimated by analysing river cross sections before and after the hurricane David in 1979. Four (4) cross sections are surveyed as shown on Fig. C-42. Further, a correlation between the river width and cross sectional area is analyzed with respect to deposition and erosion, as shown on Fig. C-43.

Fig. C-43 indicates a tendency that erosion dominates where the stream is narrow, while deposition dominates where the stream is wide. The relation between river width and debris flow indicates more clearly the tendency that the volume of erosion and deposition is in equilibrium when river width is approximately 90 m.

Volume of sediment transported through a certain river course is estimated in accordance with the equation as follows:

$$Qs = 1/2\ (Vsb + Vse)L$$

where:
- Qs : Volume of sediment transported (m^3)
- Vsb : Cross section area of sediment at the start of the stream reach (m^2)
- Vse : Cross sectional area of sediment at the end of the stream reach (m^2)
- L : Length of the stream reach (m)

In accordance with the equation and on the basis of relation between river width and debris flow in Fig. C-43, volume of sediment produced and transported from tributaries is calculated as shown on Table C-47.

A total sediment yield is obtainable from the estimated sediment from eroded slopes and sediment transported from tributaries. It is estimated that the total sediment yield in 5 sub-basins was around 2.5 million m^3 in 15 years, as shown on Table C-47. The specific sediment yield is calculated at around 2,300 m^3/km^2/year.

It is noted that the estimate of sediment yield from eroded slopes has been made by assuming a relatively high runoff rate of sediment (0.8) in this study. (The rate in highly potential sediment yield area in Japan varies in the range of 0.65 to 0.85.) In view of such conditions, it is concluded from the aerial photo interpretation that the specific sediment yield in the study area is estimated in the range of 2,000 m^3/km^2/year to 2,300 m^3/km^2/year.

C.6.6 Estimate by Experimental Formula

Among various empirical formulae to estimate sediment, a formula developed by Lane-Kalinske is applied in estimating suspended load and a formula developed by Kalinske or by Brown is applied for bed load estimate. Basic data to be applied for these formulae are determined as explained hereunder.

1) Topography:

On the basis of 1/5,000 scaled topographic map and river cross sections, a representative river section is assumed to be 10 m in riverbed width and V:H = 1:0.5 in abutment slopes. The river gradient is assumed at 1/35.

2) Gradation of Riverbed Materials:

Gradation of riverbed materials is analyzed on the basis of sample survey as shown on Table C-48 and Fig. C-44.

3) Estimate of Bed Load Transport:

Maximum particle size to be transported as bed load is estimated in each classification of discharge, as shown on Fig. C-45. The tractive force (U*) is calculated in accordance with the equation as follows:

$$U^* = \sqrt{g\,R\,I}$$

where:

- U* : tractive force
- g : acceleration of gravity (=980 cm/sec^2)
- R : hydraulic depth
- I : river gradient
- U*c : critical tractive force

The maximum particle size is estimated in accordance with six (6) experimental formulae as shown on Table C-49.

The correlation between U^*c^2 and particle size is shown on Fig. C-46.

As seen in the gradation of bed material shown in Table C-48, the percentage retained of particle size larger than 63.5 mm is only 2.7%. Then, the maximum particle size of bed material is considered to be 63.5 mm, although the sizes larger than 63.5 mm are actually contained.

Table C-49 shows the maximum grain size to be transported as bed load for respective river discharge. The grain size to be transported depends on the magnitude of river discharge as seen in Table C-49, and therefore, it is considered that the estimation of bed load transport should be made taking into consideration each grain size to be transported in accordance with the magnitude of river discharge.

However, as seen in Table C-49, the maximum grain size to be transported as bed load for the river discharge of 4.0 m^3/s, which corresponds to discharge available for the period of about 70% of a year, is 68 mm. Thus, all the bed materials consisting of maximum size of 63.5 mm are considered to be usually subject to transport constantly. In such a case, it is experimentally found that the estimation based on an assumption that bed materials uniformly consist of mean size of the particles will give a satisfactorily accurate result. Therefore, for the analysis, it is assumed that streambed material is uniformly made of a single particle size of 11.1 mm which is a mean particle size of the gradation.

These formulae are graphically shown in Fig. C-47, which gives a relationship between q_B/U^*d and $U^{*2}/(\sigma/\rho-1)gd$; where q_B is the amount of bed load per meter per second, U^* is the tractive force, d is the grain diameter, σ is the density of bed material, ρ is the density of water, and g is the acceleration of gravity.

The result of the bed load prediction is as follows where Q is the river discharge and Q_B is the bed load transport:

Q (m^3/s)	2.0	4.0	6.0	8.0	10.0	12.0
U* (cm/sec)	10.97	13.28	14.78	15.96	16.90	17.79
$U^{*2}/\{(\frac{\sigma}{\rho})-1\}g\cdot d$	0.07	0.10	0.12	0.14	0.16	0.18
q_B/U^*d						
Kalinske	0.04	0.15	0.25	0.40	0.45	0.55
Brown	0.05	0.10	0.13	0.21	0.25	0.35
Q_B (m^3/sec)						
Kalinske	$5x10^{-4}$	$2.2x10^{-3}$	$4.1x10^{-3}$	$7.1x10^{-3}$	$8.4x10^{-3}$	$1.09x10^{-2}$
Brown	$6x10^{-4}$	$1.5x10^{-3}$	$2.1x10^{-3}$	$3.7x10^{-3}$	$4.7x10^{-3}$	$6.9x10^{-3}$
Q_B (m^3/day)						
Kalinske	43	190	354	613	726	942
Brown	52	130	181	320	406	596

4) Estimate of Suspended Load Transport:

Maximum grain size to be transported as suspended load is determined by the Kresser's formula. This formula is given by

$$V^2/g\cdot d = 360$$

where V is the average flow velocity, g is the acceleration of gravity, and d is the maximum grain size to be transported in the form of suspended load.

Using the Kresser's formula, maximum size of particles to be transported as suspended load when discharge is less than 12.0 m^3/sec is estimated at 2.6 mm with regard to the V-3 site whose discharge available for the period of 10% of a year is 12.3 m^3/sec.

Taking account of the maximum particle size of 2.6 mm, the analysis of suspended load transport is made for the range of gradation between 0.074 mm and 2.38 mm.

The prediction of suspended load transport is made by using the Land-Kalinskes's formula which is given by:

$$Qs = Q\ (\sum C_B P) \quad (g/s)$$

or

$$= Q\ (\sum C_B P) \times \frac{10^{-6}}{2.65} \quad (m^3/s)$$

$$C_B = 5.55 \quad F\ (Wo)\ P^{*1.61}$$

$$P^* = \frac{1}{2}\ \frac{U^*}{Wo}\left\{\exp\ -\ (Wo/U^*)^2\right\}$$

where Q is the discharge, P is a function of Wo/U* and V/U* which is read from Fig. 48, Wo is the settling velocity of grain, U* is the tractive force, and F(Wo) is the percentage of grains whose settling velocity is Wo.

The estimate of suspended load for various values of discharge is as shown hereunder.

Q (m^3/s)	2.0	4.0	6.0	8.0	10.0	12.0
Qs (10^{-6} m^3/s)	45	118	255	460	605	765
Qs (m^3/day)	4	10	22	40	52	66

5) Bed Load and Suspended Load of V-3 Site:

Both bed load and suspended load estimated in the preceding sections are summarized as follows:

	Method of Estimation		Discharge (m^3/s)					
	Suspended Load	Bed Load	2.0	4.0	6.0	8.0	10.0	12.0
Method 1	Lane-Kalinske	Kalinske	47	200	377	655	780	1,014
Method 2	Lane-Kalinske	Brown	56	140	205	361	460	668

From this Table, relationships between discharge and sediment transport are obtained as follows:

Method 1 ; $Qs = 3.67\ Q^2 + 39.39\ Q + 29.55$

Method 2 ; $Qs = 3.38\ Q^2 + 12.45\ Q + 23.40$

where Qs is the sediment transport of both bed load and suspended load (m^3/day).

Q is the discharge (m^3/s).

Applying these formulae to the discharge - duration relationship of the V-3 site, sediment - duration relationships thereof are derived as follows:

Percent of Time(%)	10	20	30	40	50	60	70	80	90	100
Discharge (m^3/s)	12.29	8.95	7.15	5.91	5.00	4.25	3.67	3.25	2.80	2.08
Sediment (m^3/day)										
Method 1	1068	676	499	390	318	263	224	196	169	127
Method 2	686	405	285	215	170	137	114	99	85	64

Based on the sediment - duration relationship, annual yield of sediment transport of the V-3 site is calculated under the assumption that the amount of sediment between each neighboring values of duration is equal to the area of a trapezoid (See Fig. 45) as follows:

Method 1 : 36.5 days x (1.5 x 1.068 + 676 + 499 + 390 + 318 + 263 + 224 + 196 + 169 + 127 x 0.5)

= 160,600 m^3/year

or

= 2,500 m^3/km^2·year

Method 2 : 36.5 days x (1.5 x 686 + 405 + 285 + 215 + 170 + 137 + 114 + 99 + 85 + 64 x 0.5)

= 93,800 m^3/year

or

= 1,500 m^3/km^2·year

C.6.7 Sediment Yield Applied

The result of estimate by means of 5 different methods as explained hereinabove is summarized as follows:

		Specific Sediment Yield (m^3/km^2/year)
1)	Estimate by sampling	n.a
2)	Estimate by land use	1,700
3)	Survey in existing reservoir	4,000
4)	Estimate by aerial photo interpretation	2,000 - 2,300
5)	Estimate by experimental formula	1,300 - 2,300

As explained in C.6.2 and C.6.4, the estimate by sampling and survey in existing reservoir indicate less realistic figures. According to other methods, the sediment yield is estimated to be in the range of 1,300 - 2,300 m^3/km^2/year. As a design value, it is recommended to apply the specific sediment yield of 2,000 m^3/km^2/year. In view of a trap efficiency of 50%, the volume of sediment to be accumulated in the reservoir is presumed at about 1,000 m^3/km^2/year.

C.7 ESTIMATED DISCHARGE BY SIMULATION

C.7.1 Purpose of Additional Study

The available daily discharge at each intake site has been analysed in Chapter C.4 on the basis of discharge measurement at each intake site and Piedra Gorda and by applying the discharge conversion ratio. Subsequent to this hydrological analysis, daily rainfall data by the automatic recorder installed by the Project are made available up to February 1984. Discharge measurement has also been continued by INDRHI. Although, observation period of both rainfall and discharge is relatively short for executing simulation analysis on the basis of rainfall record, and more assumption is possibly contained in estimating discharge by simulation than the discharge estimated on the basis of actual discharge measurement, the simulation study is carried out to obtain hydrological information in the study area. A flow chart of the simulation analysis of low water is illustrated on Fig. C-49.

C.7.2 Basic Data for Simulation

In the additional simulation analysis of available discharge on the basis of rainfall record, the data of rainfall, evaporation and discharge measurement are utilized as follows (Refer to Table C-51):

Rainfall records of four stations at El Torito, El Novillo, Loma del Medio and Los Quemados, are used for the study. Except Los Quemados station, only short-term rainfall records from January 1983 to February 1984 are available, and they are used to determine parameters of a simulation model. Los Quemados station has long term rainfall records from July 1969 to December 1983, of which records are applied to generate long term discharge data by the said simulation model. (Refer to Table C-5-2 to C-55 and Fig. C-50 to C-53)

Rainfall records at each station are used to rebuild basin rainfall by applying areal weight; in estimating T-2 site discharge, 0.091 for El Torito and 0.909 for El Novillo; and in estimating V-3 site discharge, 0.348 for El Torito, 0.598 for El Novillo and 0.054 for Loma del Medio. (Refer to Table C-56 to C-58 and Fig.C-54 and C-55)

Discharge measurement has been conducted at the intake sites in the project area since January 1983. Through the cross check of discharge measurement records with automatic water level gauge, the records at Los Veganos intake site is considered to be the most reliable data. Consequently, the discharge records at Los Veganos site is used for the calibration of generated discharge data by a simulation model. (Refer to Table C-59 to C-61 and Fig.C-56 to C-58)

Evaporation has been observed daily at three stations, namely El Novillo, Juma Bonao, and Los Botados. The only station located within the project area is El Novillo station with similar elevation at intake sites. Consequently, the evaporation data at El Novillo are used for the study. (Refer to Table C-62)

The runoff coefficient at El Torito, Pino de Yuna and Los Veganos has been calculated as illustrated on Table C-63 and Fig.C-59. Likewise, the monthly rainfall and discharge are compared as shown on Fig.C-60.

C.7.3 Simulation Model and Its Calibration

As a simulation model to estimate available discharge for power development, the Tank Model is applied for the study. The Tank Model is the one of the selected models for low water analysis by WMO and has been widely applied to similar projects. The Tank Model is developed to represent runoff phenomena of non-linear. The model consists of usually four tanks of storage type model vessels arranged in series. Outflow from each tank represents surface runoff, intermediate runoff and base flow respectively.

After more than twenty times of trials, the parameters of the simulation model are determined as follows:

	Coefficient of holes			Hole height	
	C1 (Upper hole)	C2 (Lower hole)	C3 (Bottom hole)	H1 (Upper hole)	H2 (Lower hole)
Tank 1	0.40	0.10	0.15	40	20
Tank 2	0.05	0.05	0.10	20	10
Tank 3	-	0.01	0.10	-	5
Tank 4	-	0.001	-	-	0

Calibration of the model are carried out by comparing the hydrograph and discharge duration curve made on the basis of calculated discharge with those made on the basis of observed discharge through the period from January 1983 to February 1984. The results of calibration at Los Veganos (V-3 site) is summarized as follows:

(1) Comparison of hydrograph

Except in February 1984, the calculated peak discharge during rainy season is a little bit lower than the observed one as shown on Fig.C-61. On the other hand, the calculated base flow well coincides with the observed one through a calibration period. The calculated and observed discharge are also compared on a monthly basis as shown on Table C-64. In the light of a limited period and available data for calibration, the model can be considered to be enough to represent river runoff in the project area at this stage.

(2) Comparison of discharge duration curve

Using the hydrological data during a calibration period, two discharge duration curves are drawn on the basis of calculated discharge and observed discharge at Los Veganos (V-3), as shown on Fig.C-62. The two discharge duration curves well coincide with each other. The error of calculated discharge corresponding to each percent of time are ranging from 0% to 12.8%, or approximately 5% on an average. (Refer to Table C-65)

(3) Runoff coefficient and monthly discharge correlation

Runoff coefficient for calculated discharge and estimated discharge is estimated as follows:

Rainfall (mm)	Evaporation (mm)	Discharge 1/ (Observed) (mm)	Discharge 1/ (Calculated) (mm)	Runoff Coefficient (Observed)	Runoff Coefficient (Calculated)
2,042.6	559.9	1,482.8	1,494.1	0.726	0.731

Runoff coefficient for both observed discharge and calculated discharge is estimated at around 0.73, showing high coincidence.

Monthly discharge correlation between observed and calculated discharge is also calculated to check reliability of the analysis. The estimated correlation coefficient is 0.977, which demonstrates high reliability of the analysis. (Refer to Fig.C-63)

(4) Stability of the base flow from the tank model

As explained above, the simulation model consists of four tanks in series and the outflow from the 4th tank (last tank) represents base flow. When the long term discharge is estimated by the tank model, much care should be put on the balance between initial storage and storage at every year-end of 4th tank. It is because the average base flow can be considered to be almost equal to the runoff from the 4th tank in a long term. In case of the studied model at V-3 site, initial storage of 4th tank is 1,700 mm and its average year-end storage from 1970 to 1978 is 1,670 mm, which demonstrates a good balance. (Refer to Table C-66)

C.7.4 Daily Basin Rainfall

As noted in Chapter C.7.2, long-term daily rainfall record is only available at Los Quemados (June 1969 - December 1983), and rainfall records at El Torito, El Novillo and Loma del Medio are quite limited (January 1983 - February 1984). It is noted, however, that the rainfall pattern at the recently installed gauging stations are found to be similar to the pattern observed at Los Quemados as shown on Fig. C-64. Consequently, a long term rainfall at each sub-basin is estimated by calculating an adjustment ratio to Los Quemados on the basis of correlation analysis.

The correlation between rainfall at 3 stations and at Los Quemados is analysed as shown on Table C-67. The correlation coefficient is higher in the case of estimate by using the monthly data (Refer to Fig. C-65), and the adjustment ratio to Los Veganos is estimated as summarized hereunder.

	Adjustment Ratio to Los Quemados		
	Monthly	Annual	To Be Applied
El Torito	1.054	1.10	1.1
El Novillo	1.290	1.33	1.3
Loma del Medio	1.077	1.12	1.1

The rainfall in each sub-basin is estimated on the basis of the adjustment ratio estimated above and the areal weight calculated by the Thiessen Polygon method (Refer to Fig.C-54). The rainfall conversion ratio to Los Quemados is thus estimated as follows:

	Rainfall Conversion Ratio to Los Quemados	
T-2 site	1.3 x 0.909 + 1.1 x 0.091	= 1.28
T-4 site	1.3 x 0.455 + 1.1 x 0.545	= 1.19
V-3 site	1.3 x 0.598 + 1.1 x 0.348 + 1.1 x 0.054	= 1.22

The sub-basin rainfall is generated by applying the above conversion ratio to the long-term rainfall record at Los Quemados for the period from 1970 to 1978.

C.7.5 Available Discharge Estimated by Simulation

On the basis of the simulation model developed in Chapter C.7.3 and the daily sub-basin rainfall estimated in Chapter C.7.4, the daily discharge at Los Veganos (V-3 site) during the period for 1970 to 1978 has been calculated to estimate the dependable discharge at V-3 intake site. The discharge duration curve is prepared at V-3 site as shown on Fig. C-66, and 90% dependable discharge is estimated at 1.20 m^3/s at V-3 site.

The simulation analysis has also been executed by CDE hydrologist by further calibrating the Tank model, and 90% dependable discharge was estimated to be slightly lower or 1.00 m^3/s. On the other hand, some trial simulation in which the base flow is evaluated at slightly higher levels, 90% dependable discharge fluctuated in the range of 1.5 - 1.7 m^3/s.

At T-2 site in El Torito, the period and reliability of discharge record is too short and low to establish the Tank model for estimation of the dependable discharge. A case study is therefore made by applying the same simulation model as developed for V-3 site and the sub-basin rainfall at T-2 site, as shown on the hydrograph illustrated on Fig.C-67. Under such a condition, 90% dependable discharge is estimated at 0.28 m^3/s at T-2 site, as shown on Fig.C-68.

On the other hand, the simulation analysis was executed by CDE by further calibrating the Tank Model under such conditions. Through the analysis, 90% dependable discharge was estimated at 0.24 m^3/s at T-2 site.

The result of simulation analysis, as well as discharge estimated through discharge measurement in Chapter C.4.3, is summarized as follows:

	90% Dependable Discharge (m^3/s)		
	Discharge Measurement	Simulation CDE-JICA	Simulation CDE
T-1	0.31	-	0.23
T-2	0.31	0.28	0.24
T-1 + T-2	0.62	-	0.47
T-4	0.70	-	0.51
V-3	1.72	1.20	1.00
A. Colorado	0.31	-	0.14

The result of analysis indicates that the discharge estimated by simulation is relatively lower than the discharge estimated on the basis of discharge measurement. The estimate in Chapter C.4.3 is in no way underestimated as previously pointed out by CDE.

It should be noted that the simulation analysis is made on the basis of rainfall and discharge records available in a short period and more assumption is possibly involved in estimating discharge by simulation than in estimating it by actual discharge measurement. Taking there facts into consideration, preliminary design of the structures for power development will be prepared on the basis of the estimate through actual discharge measurement, and the result of simulation analysis will be referred to in evaluating the sensitivity of the Project feasibility.

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TABLES

Table C-01 MONTHLY MEAN TEMPERATURE AT JUMA BONAO
(TEMPERATURA PROMEDIO MENSUAL EN JUMA BONAO)

Unit: °C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1971	-	23.1	23.9	23.7	-	25.4	25.4	25.6	25.6	25.3	24.0	22.9	24.5
1972	22.3	22.2	22.5	23.2	23.0	23.8	24.5	24.3	24.1	23.9	23.0	21.6	23.2
1973	21.4	20.7	22.5	22.8	23.0	23.7	24.3	24.1	24.3	23.8	-	20.4	22.8
1974	20.4	20.8	21.9	22.4	23.8	24.4	25.3	24.8	25.0	24.6	23.6	23.9	23.4
1975	21.4	22.0	23.2	24.7	25.6	26.1	26.3	26.2	25.6	25.4	25.2	24.7	24.7
1976	23.5	21.4	22.2	23.2	24.1	24.3	24.9	25.2	25.2	25.3	25.0	22.8	22.0
1977	21.9	22.6	24.0	24.2	24.6	25.4	25.6	25.7	25.7	25.3	24.4	22.8	24.4
1978	22.3	22.3	23.8	24.0	25.1	25.6	25.5	25.6	25.5	25.3	-	-	24.5
1979	21.7	22.3	22.6	23.2	24.3	23.4	25.3	25.7	24.9	25.3	23.7	22.7	23.8
1980	22.1	22.6	23.3	24.0	25.4	26.4	26.2	26.4	26.4	26.5	24.9	23.2	24.8
1981	22.9	23.2	23.8	24.0	25.1	25.5	26.2	25.9	26.2	25.8	24.6	23.6	24.7
1982	23.3	23.2	23.9	24.8	24.7	25.5	25.9	26.2	25.9	25.6	24.1	22.3	24.6
1983	23.2	-	-	-	-	-	-	-	-	-	-	-	23.2
Mean	22.2	22.2	23.1	23.7	24.4	25.0	25.5	25.5	25.4	25.2	24.3	22.8	24.1

Table C-02 MONTHLY MEAN RELATIVE HUMIDITY AT JUMA BONAO
(HUMEDAD RELATIVA PROMEDIO MENSUAL, JUMA BONAO)

Unit: %

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1971	-	87	81	83	-	73	73	73	73	75	76	72	76.6
1972	73	78	86	85	83	84	84	86	87	90	89	93	84.8
1973	92	89	93	-	92	90	86	93	90	91	-	96	91.2
1974	-	91	-	94	90	84	85	96	-	97	-	-	91.0
1975	-	-	90	89	93	88	88	86	88	90	90	92	89.4
1976	92	93	91	91	88	88	86	89	85	88	89	91	89.3
1977	89	83	79	82	84	81	82	86	82	83	88	88	83.9
1978	84	82	82	85	84	83	86	86	85	86	-	-	84.3
1979	85	81	84	82	87	86	84	85	88	85	87	85	84.9
1980	84	81	79	81	84	80	82	82	81	82	81	87	82.0
1981	85	84	84	83	91	91	83	88	83	85	85	88	85.8
1982	85	85	75	77	84	80	82	81	85	83	85	88	82.5
1983	84	-	-	-	-	-	-	-	-	-	-	-	84.0
Mean	85.3	84.9	84.0	84.7	87.3	84.0	83.4	85.9	84.3	86.3	85.6	88.0	85.3

Note: (-) No record