REPUBLIC OF PERU

REPORT
ON
POECHOS AND CURUMUY HYDRO-POWER DEVELOPMENT PROJECTS

NOVEMBER 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

The Government of Japan, in response to the request of the Government of the Republic of Peru, agreed to conduct feasibility studies on the Poechos and Curumuy Hydro-Electric Power Projects and entrusted the studies to the Japan International Co-operation Agency (JICA).

The JICA, recognizing the importance of these electricity development projects, dispatched an 8-man survey team headed by Mr. Tsuguo Nozaki for 33 days from February 25, 1979.

The team conducted, besides field survey, studies on the technical and economic feasibilities of the Poechos and Curumuy Power Development Projects and has formulated this report.

I hope that this report will contribute to the power development of the Republic of Peru, its economic and social development as well as to the promotion of friendly and cooperative relations between Japan and the Republic of Peru.

I wish to express my sincere thanks to the officials concerned of the Peruvian Government for their kind cooperation extended to the study team.

November, 1979

Shinsaku Hogen
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President,
Japan International Cooperation Agency

Dear Mr. Shinsaku Hogen:

We submit for your attention our report on the feasibility study of the Poechos and Curumuy Hydropower Projects planned in the Piura Department of the Republic of Peru. A result of the study is described in detail in the Report, and an appendix is attatched to it for the basic data.

The survey team of eight members made a field survey assisted by Instituto de Investigaciones Energéticas y Servicios de Ingeniería Eléctrica (ELECTROPERU-INIE) during a period of 33 days from February 25 to March 29, 1979.

The team studied in Tokyo since their return to Japan and completed it in November 1979.

It is ardently hoped that the report would be useful for the electric power development in the Republic of Peru in near future.

Hearty gratitude is expressed, on this occasion of submitting the Report, to everyone who kindly rendered his valuable cooperation to the surveying activities of the team.

Yours faithfully

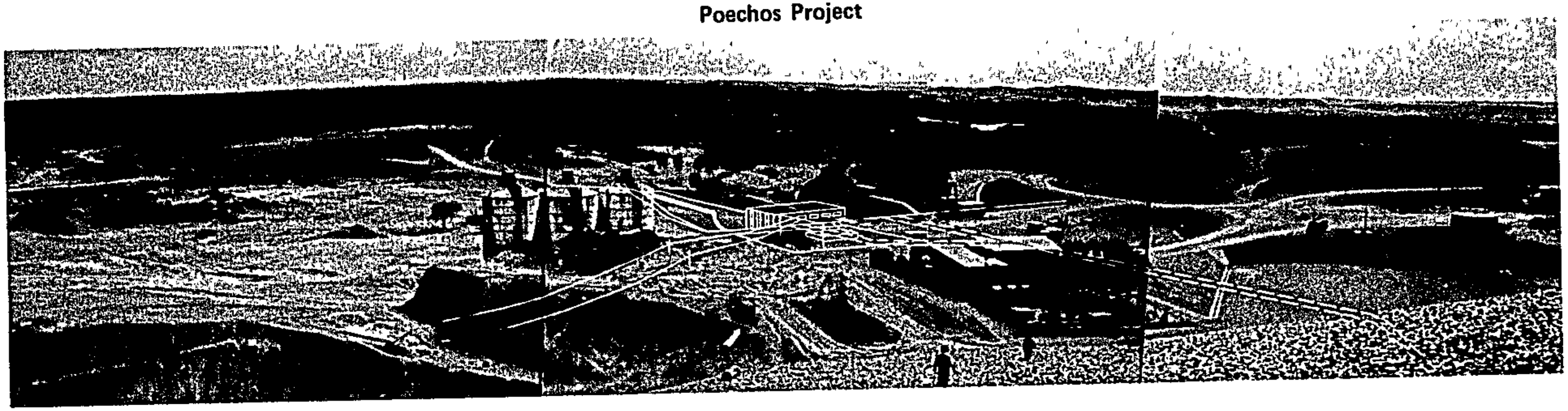
November, 1979

Survey Team for Poechos and
Curumuy Hydro-Power Development Projects

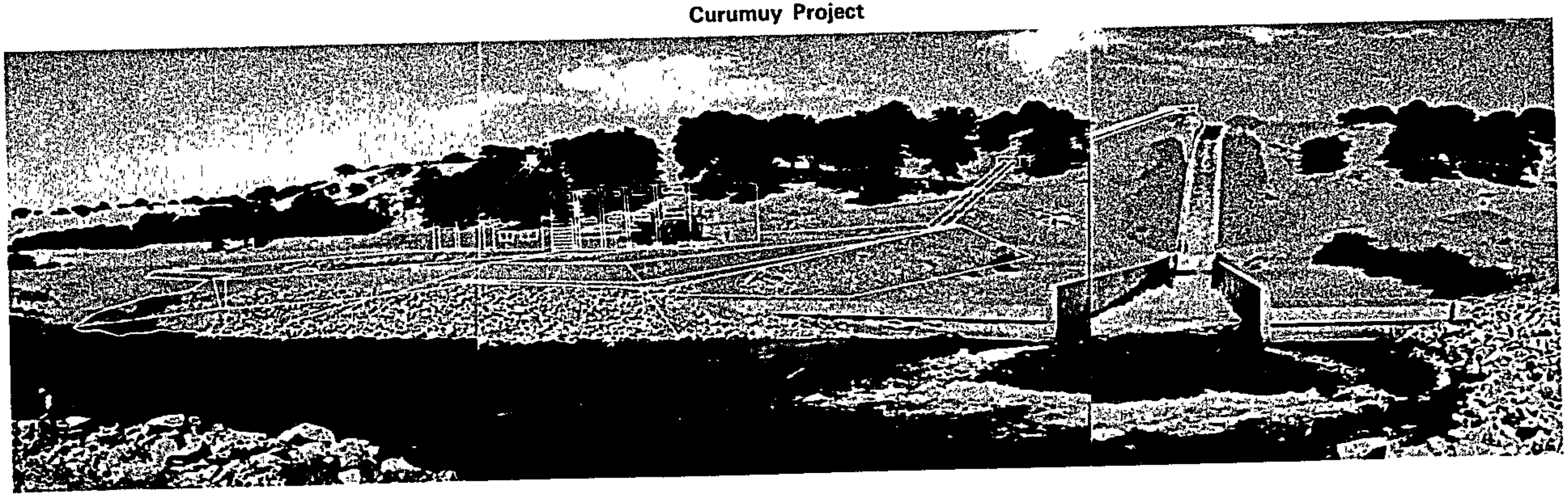
T. Nozaki

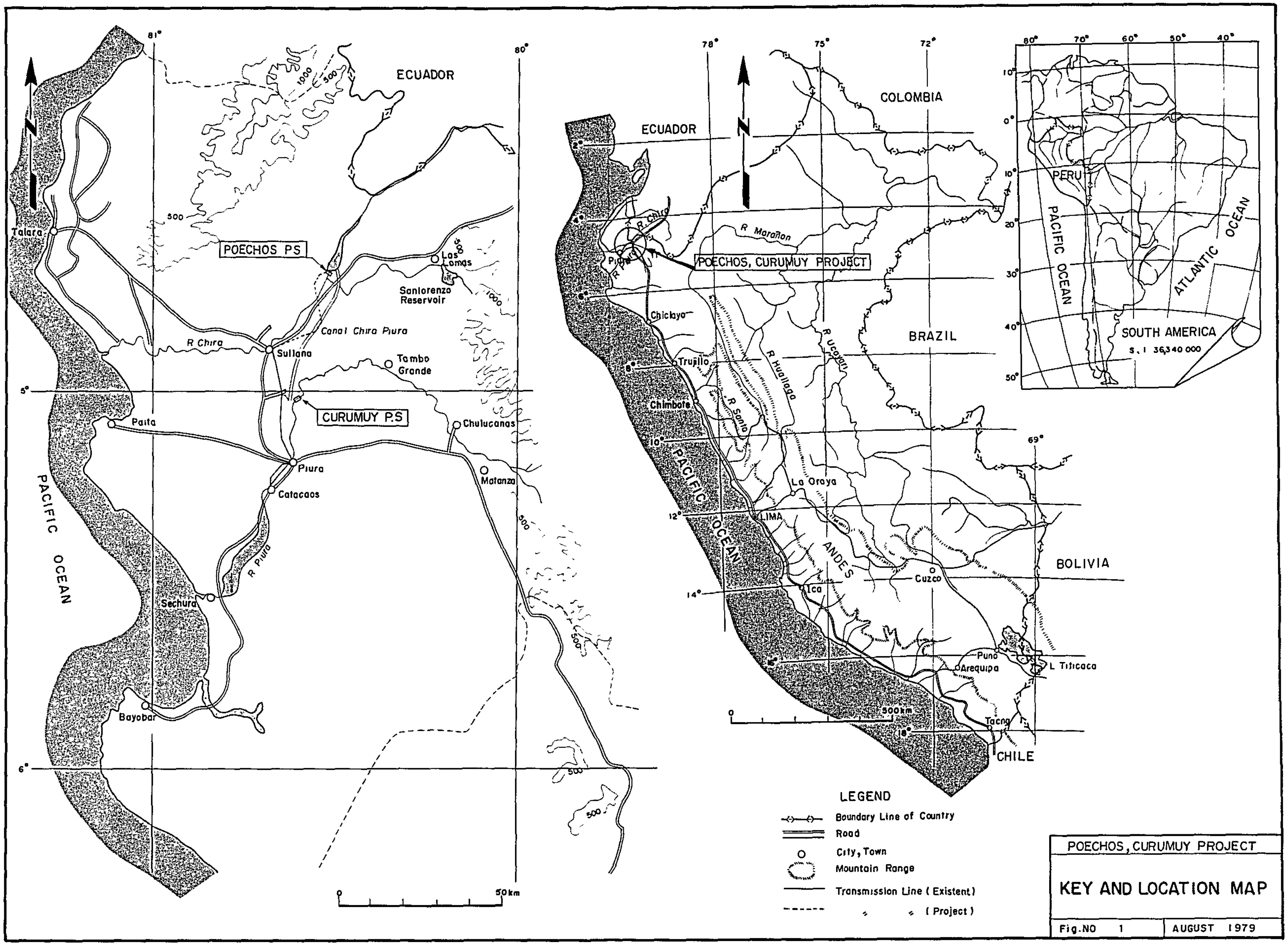
Tsuguo Nozaki, Team Leader

Poechos Project



Curumuy Project

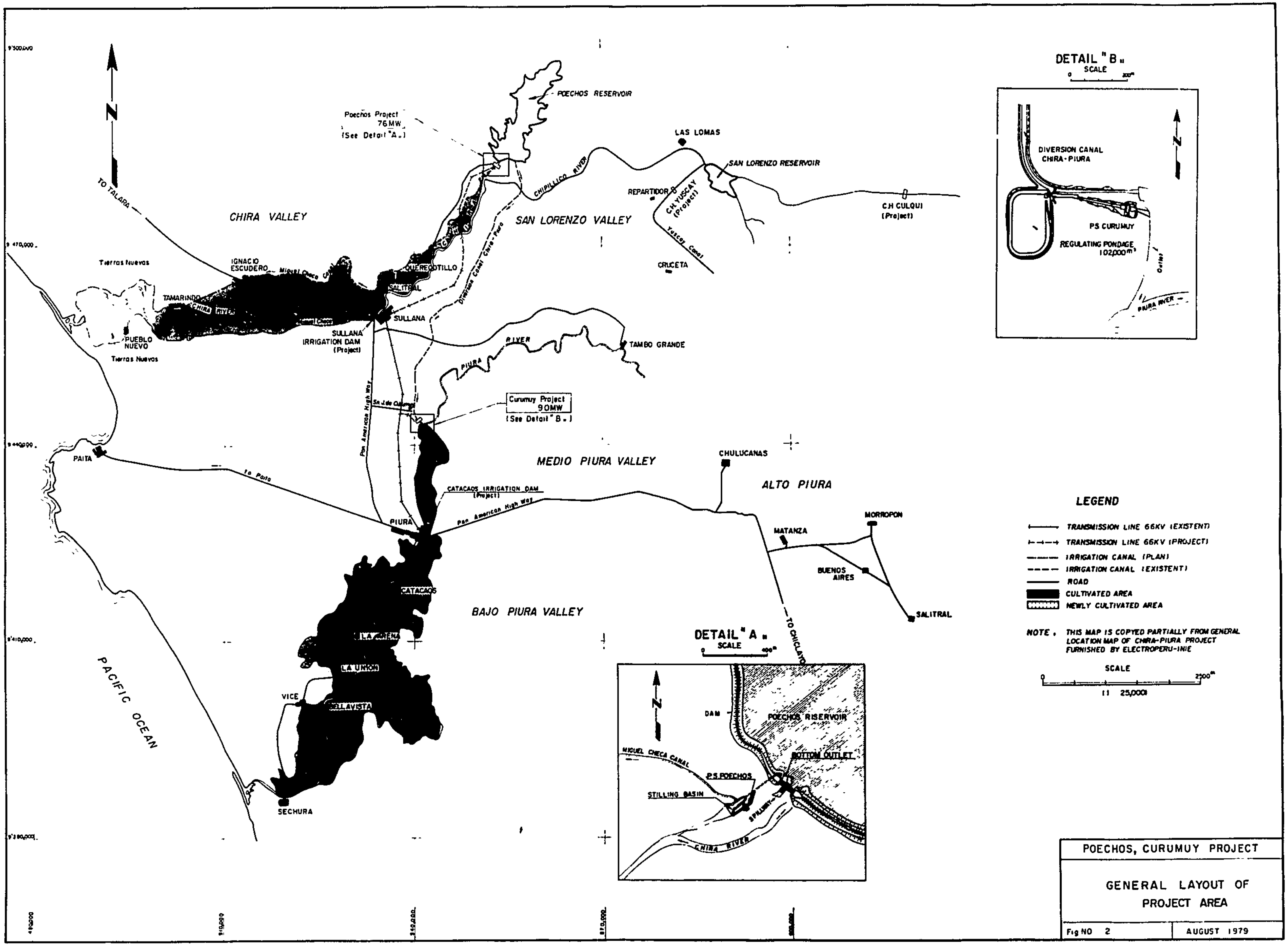




POECHOS, CURUMUY PROJECT

KEY AND LOCATION MAP

Fig.NO 1 | AUGUST 1979



POECHOS, CURUMUY PROJECT	
GENERAL LAYOUT OF PROJECT AREA	
Fig NO 2	AUGUST 1979

Principal Features of Poechos and Curumuy Project

Item	Poechos Project	Curumuy Project
Catchment Area	13,220 km^2	13,220 km^2
Dam	Poechos (Existing)	Curumuy Daily Regulating Pondage
Type	Combined Dam of Earth-fill and Concrete Gravity	Earth-fill
Height × Crest Length	48.0 m × 9.0 km	5.0 m × 308 m
Reservoir	Poechos (Existing)	Curumuy Daily Regulating Pondage
Effective Storage Capacity	830 × 10^6 m^3	102,000 m^3
Drawdown	19.0 m	4.0 m
Intake Pipe-Line (Existing)	389.6 m	150.0 m
Diversion Cannel (Existing)	-	54.0 km
Penstock		
Dia. × Length	3.2 - 2.5 m × 71.0 m	2.4 m × 320.0 m
Power Plant		
Installed Capacity	7.6 MW (2 Units)	9.0 MW (2 Units)
Max. Discharge	22.0 m^3/s/Unit	15.8 m^3/s/Unit
Effective Head	36.1 m (Standard)	38.7 m (Standard)
Annual Energy Production	51.31 × 10^6 kWh	55.20 × 10^6 kWh
Available Peak Capacity	7.6 MW	9.0 MW
Transmission Line	66 kV, 1 cct., 33.0 km	66 kV, 1 cct., 4.0 km
Construction Cost	15.3 × 10^6 US$	17.3 × 10^6 US$
Economics		
Unit Energy Cost	US$0.038/kWh	US$0.040/kWh
Benefit Cost Ratio and Annual Surplus Benefit		
Interest 10 %	1.09 (171,000 US$)	1.09 (180,000 US$)
" 8 %	1.25 (393,000 US$)	1.24 (597,000 US$)

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PART I

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PART I

CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 ANTECEDENT

In 1977, Poechos Large Dam (crest length 9 km, height 48 m, storage capacity 1.00 billion m^3) was constructed to store water for irrigation purpose on the Chira River at a point approximately 50 km north of the Piura City (population approximately 130,000) in Piura Department which is near the northern tip of the Republic of Peru. By utilizing this storage dam it will be possible to generate 7.6 MW of electric power by bifurcating the bottom outlet for irrigation and providing a turbine and a generator at the end of the pipe bifurcated. Also there is a waterway (Chira-Piura diversion canal) 54 km long completed conducting the water of Poechos Riservoir into the bed of the Piura River. At the end of the waterway there is a chute and by constructing a regulating pondage before the chute and providing a penstock, turbine and generator there, 9.0 MW of electric power can be produced.

The former is called the Poechos Hydroelectric Power Project and the later the Curumuy Hydroelectric Power Project.

At present, the power transmission system of Piura Department is not interconnected with the Central Power System centered at Lima, and as an isolated system it is meeting the demand of approximately 110 MW with expensive diesel and gas turbine power generation only. In view of this situation, it is the desire of all those concerned to construct the two hydroelectric power projects of Poechos and Curumuy in order to not only cope with future growth in demand, but also to conserve expensive diesel fuel.

Ministerio de Energia y Minas (hereafter called MEM) of the Republic of Peru and Empresa Publica de Electricidad del Peru (hereafter called ELECTROPERU) have directed Instituto de Investigaciones Energeticas y Servicios de Ingenieria Electrica (hereafter called INIE) responsible for planning and design of electric power development to investigate the two hydroelectric development projects. In the meantime Peruvian Government requested the Japanese Government to carry out a feasibility study for the projects in order to prepare a comprehensive report in order to apply for a loan from an international financing institution to finance the project costs.

In response to the request, the Japanese Government assigned the Japan International Cooperation Agency (hereafter called JICA) to conduct the study. JICA organized an engineering team of 8 specialists and dispatched it to the Republic of Peru.

The team carried out investigations of the project area and related areas with engineers of INIE from February 25 to March 29, 1979, and after returning to Japan, prepared this report during the period of April 1, 1979 to November 30, 1979 based on data collected in Peru and discussions held with MEM, ELECTROPERU and INIE.

1.2 OBJECTIVE AND SCOPE OF REPORT

The objective of this report is the feasibility study of the Poechos Hydroelectric Power Station Project planned on the right bank of the Chira River on the downstream of Poechos Dam by utilizing the bottom outlet (Salida de Fondo) constructed in the said dam which is located 50 km north of the city of Piura in Piura Department approximately 900 km north-northwest of Lima, the capital of the Republic of Peru, and the Curumuy Hydroelectric Power Station Project planned near Curumuy chute (Rapida de Curumuy) at the end of an existing canal 54 km long diverting water to the Piura River from the left bank of Poechos Dam.

The scope of the study covers the following:

(1) Load forecast (up to 1992) for the supply territory taking into consideration the location and capacity of the two power projects.

(2) Engineering feature of the Poechos Hydroelectric Power Project with particular regard to bifurcation of the existing irrigation bottom outlet, penstock, powerhouse, tailrace, connecting waterway to the existing irrigation canal, transmission line (66 kV, 1 cct, 33 km) from the power station to the existing Sullana Substation, and facilities to accommodate this line in the substation.

(3) Engineering features of the Curumuy Hydroelectric Power Project with particular regard to structures to tap the water from the existing Chira-Piura Diversion Canal, regulating pondage, head tank, penstocks, powerhouse and a transmission line (66 kV, 1 cct, 4 km) to connect into the existing transmission line (66 kV, 1 cct, 33 km) between Piura and Sullana.

(4) Engineering features of telecommunication system between the two power stations, the existing Sullana Substation and the existing Piura City Power Station.

(5) Estimation of construction costs of the two power stations and appurtenant facilities (facilities included in (2), (3) and (4) above).

(6) The economic effects of the two hydroelectric power projects.

(7) Amortization schedule for the two hydroelectric power projects.

1.3 PAST STUDIES

The Poechos and Curumuy Hydroelectric Power Projects which are the objects of the present study were first touched upon at a preliminary level in the report of 1968 on the Chira-Piura Irrigation Project Feasibility Study carried out by International Engineering Company (IECO).

Following this study, ENERGOPROJEKT made a definite study of the Chira-Piura Irrigation Project from 1971, and in that study also the potential of the Poechos and Curumuy projects were mentioned.

In 1976, Direccion General de Electricidad, MEM, produced a report "Sistema Hidroelectrico Chira-Piura, Proyecto Hidroelectricos."

Further, since 1977, INIE has been carrying out basic investigations on the two hydroelectric power projects which include geology, topography, power demand, and basic planning.

1.4 BASIC DATA

Data related to load forecasting, geological maps, topographical maps, hydrological data, and economic data necessary for the study of the Projects were obtained through INIE and also directly from Empresa de Energia de Piura S.A. (hereafter called EEPSA) and other organizations. A list of these data is given in Appendix-5.

1.5 FIELD INVESTIGATIONS AND WORK IN JAPAN

1.5.1 Field Investigations

Field investigations for the feasibility study of the two hydroelectric power projects were carried out during the 33-day period from February 25 to March 29, 1979. The Team consisted of 8 specialists who are named below engaged in his speciality.

Name	Profession	Organization	Period
Tsuguo Nozaki	Chief of Team, Civil Engineer	Electric Power Development Co., Ltd.	From Feb. 25 to Mar. 29, 1979
Hisayoshi Koganei	Coordinator	Ministry of International Trade and Industry	From Mar. 13 to Mar. 28, 1979
Mitsumasa Kato	Civil Engineer	Electric Power Development Co., Ltd.	From Feb. 25 to Mar. 29, 1979
Toshihiko Mitsuda	"	"	"
Hiroshi Asano	Geologist	"	"
Sumitaka Yoshino	Electrical Engineer	"	"
Hirofumi Sato	Economist	"	"
Hideo Ohashi	Coordinator	Japan International Cooperation Agency	From Mar. 13 to Mar. 28, 1979

1.5.2 Work in Japan

The Survey Mission, after returning to Japan, carried out feasibility studies of the Poechos and Curumuy Hydroelectric Power Projects from April 1, 1979 to November 30, 1979.

The Mission Chief, Tuguo Nozaki, visited MEM and ELECTROPERU with an interim report from October 30, 1979 to November 13, 1979, to explain and to make final adjustments of the results of studies.

Also, Ing. Julio Bustamante, Ing. Eugenio Lindo, visited to Japan staying for about a month to work together with the Survey Mission in the analisis and studies in order to reflect INIE's conception in the report on the two projects during the process of preparating the report.

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PART I

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

2.1 CONCLUSIONS

(1) In view of the locations of sites and scales of the Poechos, Curumuy Hydroelectric Power Projects, the area to be supplied the electric power generated by the two projects shall consists of 4 areas, which are the present Piura - Sullana Power System, and its surrounding areas with small power demand, such as Bajo Piura, Alto Piura and San Lorenzo.

The loads forecast for these areas for 1979, 1983 and 1992 are as shown in Table I-2-1.

Table I-2-1 Load Forecasts for Energy Supply Areas

	1979		1983		1992	
	MW	GWh	MW	GWh	MW	GWh
Piura - Sullana	24.4	117.6	31.9	159.3	71.1	397.4
Bajo Piura	1.2	2.2	1.4	2.6	2.4	4.8
Alto Piura	2.6	4.7	5.1	8.4	9.1	15.3
San Lorenzo	1.3	2.9	2.8	5.3	4.8	9.6
Total	29.5	127.4	41.2	175.6	87.4	409.1

(2) The Projects should be developed at an early date as much as possible order to supply inexpensive electric power meeting the growth in demand in the service area and to conserve expensive fuel used for the existing diesel generators.

Therefore, considering a schedule where the time required for preparating working plan, negotating a loan, and carrying out construction would be shortened to the utomost, the timing of the starts of operation of Poechos and Curumuy Power Stations were set for June 1983 and April 1983, respectively.

(3) Regarding the foundation beds for the structures of Poechos Power Station, all major structures will be built on bedrock owing to the bearing power ample enough to support the structures, and there will be no problems in proceeding with this scheme.

Regarding foundation beds for major structures of Curumuy Power Station, all of them will be built on a sand layer. Our geotechnical sarvey, which included drill boles and standard penetration tests, has found that this sand layer is relatively compact, leading to the engineering judgement that stability of the structures can be secured with a design which considers bearing capacity of the soil.

It should be noted, however, that in the stage of the Definite Design additional drill holes and standard penetration tests, peremeability tests, and grain-size analysis must be performed at the site in order to confirm bearing capacity of the soil and to study possibilities of liquefaction, and also for selection of excavation method for subsurface below the underground water level.

(4) As a result of comparison studies with alternatives of various scales, it will be suitable for the scale of Poechos Power Station to be 7,600 kW both in installed capacity and firm peak output.

The major structures in this case would be a branching pipe to be joined to the bottom outlet of Poechos Dam, a penstock of diameter from 3.4 m to 2.5 m and length of 71.0 m, a surface-type powerhouse having two 4,000-kW Kaplan turbines, and a tailrace of 102.0 m for diverting water discharged after power generation to the Rio Chira and Miguel Checa Diversion Canal.

(5) As a result of comparison studies with alternatives of various scales, it will be suitable for the scale of Curumuy Power Station to be 9,000 kW both in installed capacity and firm peak output.

The major structures of Curumuy Power Station in this case would be an upper regulating pondage of regulating capacity of 102,000 m^3, a head tank, two penstocks of inside diameter of 2.4 m and length of 160.0 m, a surface-type powerhouse having two 4,750-kW Kaplan turbines, and a tailrace of 24.0 m.

(6) The construction cost required for implementation of the Projects (excluding expenses up to the Feasibility Study) estimated as of the time of preparation of this Report is a total of US$32,632,000 for Poechos and Curumuy Power Stations combined, the breakdown being as shown in Table I-2-2.

Table I-2-2 Total Construction Cost

Unit: US$

	Foreign	Local	

Table I-2-3 (B/C), (B-C) by Heavy Oil Price and by Interest Rate

Heavy Oil Price	March 1979 Price			July 1977 Price
Interest Rate	10%	8%	6%	10%
Poechos Power Station				
Benefit-cost ratio (B/C)	1.09	1.25	1.46	1.39
Surplus benefit (B-C) US$	171,000	393,000	430,000	731,000
Curumuy Power Station				
Benefit-cost ratio (B/C)	1.09	1.24	1.46	1.37
Surplus benefit (B-C) US$	180,000	597,000	659,000	783,000

Both benefit-cost ratios (B/C) and surplus benefits (B-C) show the Poechos and Curumuy power generation schemes to be profitable compared with alternative diesel power generation indicating that these Projects are feasible.

The benefit-cost ratio (B/C) and surplus benefits when inflation is taken into consideration with the price of heavy oil (diesel fuel) escalating at an annual rate of 9% and other commodity prices at 7%, in case of an interest rate of 10%, would be shown in Table I-2-4.

Table I-2-4 (B/C), (B-C)

Considering Inflation

	Benefit-Cost Ratio B/C	Surplus Benefit B-C (US$)
Poechos Power Station	2.14	3,513,000
Curumuy Power Station	2.18	3,916,000

The energy generation costs of Poechos and Curumuy Power Stations by interest rate are shown in Table I-2-5.

Table I-2-5 Energy Generating Costs by Interest Rate

Unit: US$/kWh

Interest Rate	10%	8%	6%
Poechos Power Station	0.038	0.033	0.027
Curumuy Power Station	0.041	0.034	0.028

(8) The results of study of the amortization plan are described below.

a) Considerations of Commodity Price Escalation

The amortization plan was studied applying the commodity price escalation rates which are shown in Table I-2-6 as a result of examination comparing the World Bank's forecasts of future commodity price escalation with the actual rises in major countries since 1970.

Table I-2-6 The Commodity Price Escalation Rate

Unit: %

Forecast	Equipment	Civil Works	Personnel Costs	Operation, Maintenance	Electricity Charge
Upper Estimate	8.3	11.8	11.8	9.0	10.2
Basic Estimate	7.0	10.0	10.0	7.6	8.6
Lower Estimate	5.7	8.2	8.2	6.2	7.0

b) Total Construction Cost Considering Commodity Price Escalation

The total construction cost at 1979 values will be US$32,632,000 as indicated in (6), but when commodity price escalation is considered, the total amounts of funds required for construction are estimated to be the following:

Upper Estimate	US$42,390,000
Basic Estimate	US$40,905,000
Lower Estimate	US$39,455,000

c) Examinations of Energy Sales Price

The scope of this Project covers power generation facilities and transmission lines. Therefore, the energy sales price of delivery at a 60-kV substation will be separately estimated, because the energy sales revenue of this Project cannot be estimated based on electricity charges, included power distribution costs, for delivery to end consumers. The upper limit of the energy sales price in this case may be considered as the electricity supply costs in an alternative thermal power plant. These electricity supply costs based on March 1979 prices are US$109/kW and US$0.0264/kWh, therefore, the overall unit price of 15,640 kW of power and 100,300 MWh of annual energy production delivered at the substation will be US$0.0434/kWh.
On the other hand, the power rates for the existing diesel plants in Piura City are fixed at about US$0.035/kWh by the price control of the Peruvian

Government. This control has thrown repairs and depreciation of those plants into a financial difficulty.

The possible power rates for Poechos and Curumuy Projects are at their maximum at the level of production cost of their respective alternative thermal plants. With 8.6% as an assumed annual rate of fuel price increase, those power rates by years will be as follows:

1979	0.0434 US$/kWH
1983	0.0604 "
1992	0.1008 "
2002	0.1991 "

On making financial analyses for a 20-year period from start of operation applying the above energy sales prices, the annual average rate of return (internal rate of return) for the unamortized balance of working assets will be a high rate of 28%, but actually, this should be set at a considerably lower rate.

Annual rate of return of electric power companies are usually considered reasonable to be from 7% to 10% of unamortized balance of working assets. On setting the annual rate of return at 10%, the average energy sales price to be applied for a 20-year period from start of operation is estimated to be 0.0597US$/kWh. (Basic estimate of commodity price escalation forecast.)

And in case of the annual rate of return being 7%, the average energy sales price for a 20-year period from start of operation will be 0.0477US$/kWh in the basic estimate of commodity price escalation forecast, on which energy sales prices by year are obtained as follows:

1983	0.0377US$/kWh
1992	0.0455 "
2002	0.0622 "

The energy sales price in 1983 indicated above is found at the price level with the unexpensive energy sales price which is politically employed in the Piura City.

d) Results of Study of the Amortization Plan

Loan conditions to be enable to amortize the consturction funds solely by assigning energy sales revenue depend on energy sales prices.

The results of study of the amortization plan in cases of internal rate of return being at 10% (energy sales price; 0.0597US$/kWh) and at 7% (energy sales price; 0.0477$/kWh) are given below:

In case of 10%

Amortization plan will be able to be made without suffering deficit by setting the conditions of loan as 10% of interest pa and 10 year amortization for 25% of total construction cost and 4.5% of interest pa, more than 13 year amortization for the rest.

In case of 7%

Amortization plan can be made without deficit by setting the conditions of loan as 4.5% of interest and 20 year amortization for the total construction cost.

According to the results mentioned above, it will be desirable to loan the total construction cost subject to 4.5% of interest and 20 year amortization in order to establish the nearby same electricity charge as the actual electricity charge employed in Piura City, since it is considered undesirable that the energy sales price become higher than the acutal electricity charge in Piura City, even though the price is settled politically.

2.2 RECOMMENDATION

Based on the above conclusions it is recommended to materialize the projects as follows:

(1) Judging from the existing state of power demand and electric power generation facilities in Piura City, the projects should be carried out immediately.

Therefore it is necessary to initiate a definit design as early as possible in order to complete tender documents for bid until the end of 1980 to permit the commencement of the power stations up to the middle of 1983.

(2) It is necessary to loan the funds covering the total construction cost of the projects under the loan conditions given in the conclusions before-mentioned.

PART II

FEASIBILITY STUDY OF POECHOS AND CURUMUY HYDRO-POWER DEVELOPMENT PROJECT

CONTENTS

PART II

CHAPTER 1 LOAD FORECAST

CHAPTER 1 LOAD FORECAST

1.1 ELECTRIC POWER SITUATION IN PIURA DEPARTMENT

1.1.1 General

Piura Department is situated at the northern tip of the Republic of Peru and part of the northern end of the departament borders Ecuador. The western part of the departament is a desert area having widths of 100 to 150 km along the Pacific Ocean coast. The eastern part is the western slope and foothills area of the Andes.

Inhabited areas are the cities of Talara, Paita and Bayobar on the Pacific Ocean coast and their surrounding coastal areas, and also there is scattered population in the irrigated areas along the Chira and Piura rivers, which rise from the western slope of the Andes, and their tributaries.

The population of the departament in 1972 was approximately 855,000, of which approximately 444,000 were concentrated in the urban parts of the abovementioned inhabited areas with the remaining approximately 411,000 living in the surroundings of the urban parts and scattered in rural areas.

The power generating facilities in Piura Department amounted to approximately 108.4 MW as of 1976. Since the scale of power demand has been small and inhabited areas are scattered, practically no expansion not interconnection of transmission and distribution networks have been developed and power generation and distribution done independently at each city and each inhabited area.

Regarding the future expansion of electric power facilities of this region, it is planned for the 220-kV Lima-Chimbote Transmission Line presently under construction to be extended to Piura via Trujillo, Chiclayo and Bayobar to put the region under the National Interconnected Transmission Network by around 1990. Consequently, for the approximately 10 years until then, the electric power facilities will be operated as isolated systems as at present. The installed capacity in Piura Department in 1976 classified by public utility (ELECTROPERU, local electric power companies, and communities) and private use (private enterprises), and by hydro and thermal are shown in Table II-1-1.

Table II-1-1. Installed Capacity (kW)

	Hydro	Thermal	Total
Public utility	400	36,347	36,747
Private	0	71,636	71,636
Total	400	107,983	108,383

The number of power stations and installed capacities in 1976 of public utilities and of private use by industry type are shown in Table II-1-2 and Table II-1-3.

Table II-1-2. Number of Power Stations and Installed Capacities (kW) of public utilities

	Power Station	Installed Capacity
ELECTROPERU	16	19,139
Other Power Companies	2	17,098
Nunicipal	12	510

Table II-1-3. Number of Private Power Stations and Installed Capacities (kW)

	Power Station	Installed Capacity
Mining	15	5,129
Agriculture	4	46
Manufacturing	2	938
Petroleum	3	56,596
Fishing	8	8,509
Services	10	1,536

1.1.2 Present State of Electric Power Demand and Supply

As described in 1.1, supply of electric power in Piura Department is presently being done independently in each area, and the electric power to be produced by the Poechos and Curumuy Hydroelectric Power Projects, in view of the output and the state of the transmission networks, is to be transmitted to Piura, Sullana and their vicinities by the transmission line between Piura and Sullana which is closest to the two project sites.

The present state of electric power demand and supply of the service area of the Poechos and Curumuy Hydroelectric Power Projects will be described below.

(i) Piura-Sullana Area

This is the largest load center in the departament, and power is mainly supplied at the city of Piura, the capital of the departament, and Sullana, Catacaos, Querecotillo and their surrounding areas. Transmission lines are also most developed in this area with Piura-Sullana, 32.0 km, and Piura-Catacaos, 20.0 km, connected by 66-kV transmission lines.

The maximum power demand and energy consumption from 1960 through 1976 in this area are shown in Table II-1-4, and the breakdown of consumption by type of consumers is given in Table II-1-5.

The past growth in power demand in the Piura area was at an annual rate of 8.1% in maximum power demand and 9.0% in electric energy from 1967, when the interconnecting transmission line between Catacaos, Piura and Sullana was completed, to 1977. Seen for the 18-year period of 1960 to 1977, the annual growth rate was 14.7% in maximum power demand and 16.0% in electric energy.

The growth rate for the 18-year period was higher than for 1967 - 1977 because when interconnection of the transmission lines was started the power system consisted only of the urban area of Piura City, and than interconnection was made subsequently to the surroundings of Piura and to Sullana and Catacaos so that the demands of these districts was added. This cannot be said to have been a pure growth in demand.

Meanwhile, the power generating facilities of this area are all diesel generators which are small-scale facilities with unit capacities from 1.4 MW to 4.5 MW. All of these power gsnerating facilities are installed at Piura Power Station in Piura City. Table II-1-6 gives an outline of the power generating facilities of Piura Power Station in July 1977.

Table II-1-4. EEPSA
Energy Supplied and Maximum Power Demand
Period: 1960 - 1976

Year	Piura	Catacaos	Sullana	Querecotillo	Loss and Private Company	Energy Supplied (kWh)	Max. Power Demand (kW)
1960	5,077	-	-	-	-	5,077	1,610
1961	7,281	-	-	-	-	7,281	2,290
1962	8,375	-	-	-	-	8,375	2,500
1963	9,898	-	-	-	-	9,898	2,890
1964	11,408	-	-	-	-	11,408	3,000
1965	17,262 (*)	-	-	-	-	17,262	5,000
1966	21,357 (*)	-	2,868	-	952	25,177	6,720
1967	22,038 (*)	-	8,069	108	1,810	31,917	7,600
1968	22,998 (*)	-	7,990	391	810	32,189	8,300
1969	20,365	5,549	6,365	415	985	33,679	8,260
1970	21,459	5,412	6,457	408	1,139	34,875	8,420
1971	23,392	4,615	6,378	354	1,119	35,849	9,140
1972	24,888	3,903	7,735	419	1,352	38,297	8,920
1973	24,367	4,596	8,033	449	6,530	43,975	10,800
1974	28,242	3,878	8,221	514	7,030	47,885	9,950
1975	33,886	5,208	8,715	601	6,441	54,851	12,750
1976	44,790	4,459	10,119	741	8,479	68,588	13,850

* Includes Catacaos

Table II-1-5. Piura City
Energy Consumption by Type of Use (MWh)
Period: 1960 - 1976

Year	Street Lighting	Residential	Commercial	Other	Manu-facturing	Water Pump-up	Net Consumption	Loss	(%)	Total Consumption
1960	604	1,547	837	586	936	-	4,510	567	11.16	5,077
1961	764	1,859	971	775	2,000	-	6,459	822	11.28	7,281
1962	872	2,201	1,087	933	2,517	-	7,610	765	9.13	8,375
1963	924	2,598	1,218	1,301	2,902	-	8,943	955	9.64	9,898
1964	879	2,960	1,304	1,440	3,764	-	10,347	1,061	9.30	11,408
1965	920	3,542	1,426	1,553	5,875	-	13,316	*		
1966	1,076	4,211	1,488	1,807	7,171	-	15,753	*		
1967	1,090	4,830	1,519	1,723	6,941	-	16,103	*		
1968	1,268	5,507	1,533	1,825	6,715	-	16,848	*		
1969	1,436	6,279	1,567	2,306	6,737	-	18,325	2,040	10.01	20,365
1970	1,711	6,881	1,622	2,274	6,681	-	19,169	2,290	10.67	21,459
1971	1,723	7,586	1,779	2,434	6,988	-	20,510	2,882	12.32	23,392
1972	1,646	8,876	1,981	2,833	6,070	-	21,406	3,482	13.99	24,888
1973	1,683	9,671	2,276	2,686	8,050	-	24,366	3,479	12.49	27,845
1974	1,715	10,552	2,406	3,272	10,296	-	28,241	2,948	9.45	31,189
1975	1,841	12,943	3,074	3,422	12,585	-	33,886	2,288	6.33	36,173
1976	1,614	14,796	4,121	2,762	17,444	4,052	44,790	4,214	8.60	49,004

* No data

Table II-1-6. Piura-Sullana Area Power Supply Facilities

Generator No.	Manufacturer	Output (kW)
1	Mirrlees	1,360
2	"	1,360
3	"	1,360
4	"	2,300
5	"	2,300
6	"	4,500
7	Alco	2,500
8	"	2,500
9	"	2,500
Total		20,680

The state of operation of power generating facilities in the Piura-Sullana area during the past three years (1977 - 1979) is described below.

1977

In July of this year, 3 generators were at fault and under repair so that the available output was 14.71 MW, and the rate of operation of the total installed capacity was approximately 70 %.

1978

In November of this year one diesel generator of 2.5 MW (manufactured by General Electric) was being additionally installed, but No. 4 (2.3 MW) and No. 7 (2.5 MW) were at fault and under repair so that the available output was 15.88 MW and the rate of operation of equipment was approximately 77 %.

1979

In March of this year the diesel generator, 2.5 MW, being installed since toward the end of the previous year and two portable 1.5 MW diesel generators (Fiat) went into operation, but the No. 6 generator and two others were at fault and under repair so that for the installed capacity of 26.18 MW the available output was 16.8 MW, and the rate of operation of equipment was approximately 64 %.

The power demand at this time had grown from 16 MW in 1977 to over 20 MW in 1979 due to enlargement of the distribution network and expansion of factories.

Because of the above lack of supply capability and instability of supply, there is a restriction of supply even now with programmed outage carried out by districts.

Power supply in this area is being performed by EEPSA consisting of 51 % government capital and 49 % private capital. The energy sales of EEPSA in November 1978 and types of consumption are shown in Table II-1-7. The employees of this company comprise 7 officers, 48 staff and 101 others, a total of 156.

Demands expected to come under the power system of this Piura-Sullana area in the near future arising from equipment installation plans and system interconnection are 3.2 MW for the water supply pumping stations to Paita and Talara planned on the chira River near Sullana and 0.2 MW through connection to villages (La Huaca, Tamarindo, Amotape, Lancones) neighboring the area.

Table II-1-7. Energy Sales of EEPSA and Types of Consumption (November 1978)

Type of Consumption	Energy Sold (kWh)
Street Lighting	124,372
Residential	2,072,650
Commercial	340,338
Industrial	1,916,290
Pumping Station	574,790
Others	588,627
Total	5,617,067

(ii) Bajo Piura Area

This area is planned to be interconnected with the Piura-Sullana Power System in the very near future and the major load centers are Sechura, La Union, Vice, La Arena and Bellavista.

The existing power generating facilities amount to 1.32 MW, of which approximately 90 % is installed at Sechura. The power demand far exceeds the existing installed capacity, and very early increase in supply facilities is desired. Through the completion in 1977 of the Chira-Piura diversion waterway for irrigation, the water shortage in this area has been eliminated and rapid development of agriculture is expected, and it is through there will result a fair amount of growth in power demand.

(iii) Alto Piura Area

This area is situated to the east of the Piura-Sullana area with the principal load centers of Chulucanas, Morropon, La Matanza and Buenos Aires. The existing power generating facilities comprise 1.2 MW, of which approximately 70 % is installed at Chulucanas. This area also lacks adequate supply capability with irrigation pumps at various places being operated by diesel engines, and electrification is being called for.

(iv) San Lorenzo Area

This is an area colonized through the San Lorenzo Irrigation Project implemented approximately 20 years ago and is located about 40 km northeast of Sullana City. The community which is the center of the area is Cruceta from where the San Lorenzo area is administered.

The farmland already developed in this area amounts to 31,000 ha, with 14,000 ha which can be developed still remaining. Of the power generating equipment, there is one 0.85 MW diesel generator in the San Lorenzo administration office, by which supply is made to Cruceta for 24 hours a day and to Hualtaco, Malingas, Partidor, San Isidro, Somate-Algarrobo, Valle de los Incas and Valle Hermoso from 6:00 p.m. to 11:00 or 12:00 p.m. Communities having their own power generating equipment are Tambo Grande and Las Lomas. And there are small-scale power generating facilities for operating irrigiation gates and valves.

There is a number of plans regarding processing plants for agricultural products in this area and supply of cheap and abundant electric power is looked forward to.

1.2 LOAD FORECAST

1.2.1 Supply Area

There are four areas conceivable as major areas to be supplied electric power from the Poechos and Curumuy hydroelectric power project sites, and the power demands estimated by MEM and INIE for 1985 and the distances from the project sites are the following:

	Distance (km)	Power Demand (MW)
Piura-Sullana	4 - 30	41.0
Complejo Bayobar	120 - 150	146.0
Complejo Pesquero de Paita	70 - 100	6.5
Petroperu (Talara)	80	4.5

The Poechos and Curumuy hydroelectric power project sites are approximately 30 km and approximately 4 km distant, respectively, from the existing 66-kW Piura-Sullana Transmission Line.

Since the Piura-Sullana area are ardently nearest to the Poechos and Curumuy hydroelectric project sites and their projected output is a total of 16,600 kW, which can cope with the growth in power demand of the area for several years, it was decided that the power supply area for these Projects will be mainly the Piura-Sullana System including Bajo Piura, to which small-scale power demands of the neighboring areas of Alto Piura and San Lorenzo will be added:

1.2.2 Basic Concept of Load Forecast and Period Forecast

With regard to power demand forecast for the project area, field investigations of the demand and supply situation, types of demand, etc. have been made in the past by MEM, INIE and EEPSA to obtain a grasp of the demand and supply situation in the various load areas, and have formulated rural electrification plans for the futurer and also predictions of demands based on individual agricultural and industrial projects. In forecasting loads, a forecast was made by summing method whereby demands scheduled in the future such as rural electrification plans and individual projects were aggregated, in addition to which growth in demand of the general public was considered, and this was studied in comparison with the trend of the past demands to arrive at a final forecast.

The Survey Team checked the forecast figures based on the results of field investigations and data collected to make modifications to fit the present situation. However, because the size of demand of this supply area is small, the forecast figure can be greatly affected by demands created by policy such as rural electrification plans and implementation of individual projects. Consequently, with regard to the demands from these plans and the timing of their implementation, it was decided to adopt in principle the idea of the authorities corcerned.

The period of load forecasting was taken to be the 15 years from 1978 through 1992. The reason for selecting this period is that the scale of these Projects are small and all of the energy produced will become effective simultaneously with the start of operation, while the interconnection of the National Interconnected Transmission System with the power system of the project area is scheduled for conpletion by around 1990, and the balance of demand and supply must be secured until then as an isolated system.

1.2.3 Load Forecast

The method of forecasting power demand has been described in 1.2.2 foregoing, but since the scales of demand and types of consumption of the various supply areas differ, the growth rate in demand for the 15-year period of 1978 through 1992 was estimated by each area taking into consideration past records of demand. The results are shown in Table II-1-8.

Table II-1-8. Demand Growth Rate of Supply Power Areas

Area	Growth Rate (%)	
	Power (kW)	Energy (kWh)
Piura-Sullana	8.3	9.2
Alto Piura	9.4	8.9
Bajo Piura	5.3	6.3
San Lorenzo	10.1	9.3

Seeing these power supply areas as a whole the above growth rates correspond to 8.4 % in electric power and 9.1 % in electric energy.

According to the records of demands in the various areas in 1977, the proportions of the various areas compared with the total demand of the areas are shown in Table II-1-9.

Table II-1-9. Total Demand of the Areas and Demands of Each Area (1977)

	Demand		Proportion	
	(MW)	(MWh)	MW (%)	MWh (%)
Piura-Sullana	21.50	101.7	82.5	92.2
Alto Piura	2.36	4.2	9.1	3.8
Bajo Piura	1.08	1.9	4.1	1.7
San Lorenzo	1.13	2.5	4.3	2.3
Total	26.07	110.3	100.0	100.0

From the above table it is evident that the Piura-Sullana area occupied 82.5% of the total demand in terms of electric power and 92.2% in terms of energy production, therefore the future load forecast will be greatly affected by the trend of the demand of this area. Regarding the power system of the Piura-Sullana area as the trunk, it was assumed that interconnections with that system would be made for the other three areas in the years shown below:

Bajo Piura	1980
Alto Piura	1986
San Lorenzo	1986

As a result of making a load forecast based on the above conditions, the power demand of such of the supply areas will be as shown in Table II-1-10 and the energy production as shown in Table II-1-11. The load forecasts by community of the various supply areas are shown in Appendix-1.

For reference, the conceivable lowest demand growth rates (6% for Piura-Sullana, 7% for Alto Piura, 4% for Bajo Piura and 8% for San Lorenzo) were used to calculate conservative maximum demands, which are given by year in Fig.-3.

Table II-1-10. Estimated Maximum Power Demand of Interconnected Power System

Year	Piura - Sullana (MW)	Bajo Piura (MW)	Alto Piura (MW)	San Lorenzo (MW)	Total Interconnected Power System (MW)	
1977	21.5	(1.08)	(2.36)	(1.13)	21.5	
1978	23.0	(1.14)	(2.50)	(1.24)	23.0	
1979	24.4	(1.20)	(2.63)	(1.33)	24.4	
1980	26.0	1.26	(2.77)	(2.24)	27.3	Bajo Piura Tieup
1981	27.8	1.32	(2.86)	(2.50)	29.1	
1982	29.8	1.37	(5.10)	(2.67)	31.2	
1983	31.9	1.43	(5.11)	(2.84)	33.3	
1984	34.1	1.49	(5.22)	(3.01)	35.6	
1985	37.9	1.55	(5.33)	(3.17)	39.5	
1986	43.7	1.66	6.58	3.37	55.3	Alto Piura Tieup San Lorenzo Tieup
1987	48.4	1.77	6.80	3.55	60.5	
1988	52.2	1.87	7.05	3.76	64.8	
1989	56.9	1.99	7.30	4.06	70.2	
1990	61.6	2.11	8.59	4.28	76.5	
1991	66.4	2.23	8.87	4.51	82.0	
1992	71.1	2.36	9.15	4.79	87.4	

Note: Figures in parentheses show demands not tied to the Interconnected Power System

Table II-1-11. Estimated Energy Demand of Interconnected Power System

Year	Piura - Sullana (GWh)	Bajo Piura (GWh)	Alto Piura (GWh)	San Lorenzo (GWh)	Total Interconnected Power System (GWh)	
1977	101.7	(2.0)	(4.2)	(2.5)	101.7	
1978	108.8	(2.1)	(4.5)	(2.7)	108.8	
1979	117.6	(2.2)	(4.7)	(2.9)	117.6	
1980	125.3	2.3	(5.0)	(4.1)	127.6	Bajo Piura Tieup
1981	136.4	2.4	(5.2)	(4.6)	138.8	
1982	146.2	2.5	(8.1)	(4.9)	148.7	
1983	159.3	2.6	(8.4)	(5.3)	161.9	
1984	170.3	2.8	(8.6)	(5.7)	173.1	
1985	189.2	2.9	(8.9)	(6.1)	192.1	
1986	222.0	3.2	10.7	6.5	242.4	Alto Piura Tieup San Lorenzo Tieup
1987	250.2	3.4	11.2	6.9	271.7	
1988	269.8	3.7	11.8	7.4	292.7	
1989	279.1	3.9	12.3	8.1	323.4	
1990	323.8	4.2	14.3	8.6	350.9	
1991	354.8	4.5	14.9	9.2	383.4	
1992	379.4	4.8	15.3	9.6	409.1	

Note: Figures in parentheses show demands not tied to the Interconnected Power System.

1.3 DEMAND AND SUPPLY BALANCE

1.3.1 Basic Conditions for Examination of Demand and Supply Balance

Examination of the overall balance of demand and supply of the Catacaos-Piura-Sullana Electric Power System, Alto Piura Electric Power System, Bajo Piura Electric Power System and San Lorenzo Electric Power System with the Poechos and Curumuy Hydroelectric Power Projects in consideration was made based on the conditions below.

(1) Poechos and Curumuy Power Stations are to start operation in the middle of 1983.

(2) The Bajo Piura Electric Power System is to be interconnected in 1980, the Alto Piura Electric Power System and the San Lorenzo Electric Power System in 1986.

(3) The Olmos Project or its alternative large-scale hydroelectric power development project is to go into operation around 1990, and interconnection (220 kV) is to be made between the Central and North Power Systems about that time.

(4) In the San Lorenzo Electric Power System, Yuscay Power Station (2,500 kW) is to go into operation in 1982 and become a part of the system, subsequently to which this system is to be self-supplied until 1986 when Culqui Power Station will be put into service.

(5) The group of diesel generators 1,200 kW in the Alto Piura Electric Power System and that of diesel generators 850 kW in the San Lorenzo Electric Power System, both of which consist of many small units of old style, will be eliminated from being accounted in the Demand and Supply Balance in Interconnected Power System, due to the fact that these groups of generators are not considered suitable to be power supply resources for the large electric power systems.

The group of diesel generators of 1,200 kW furnished in Sechura, which occupy a large part of 1,322 kW of the Bajo Piura Electric Power System, will be took a count as a reserved power station for the Piura-Sullana Power System because each of them are new enough to continue operating.

(6) The Culqui Power Station Project is presently under study by INIE and is expected to go into operation in 1985 - 1986 if the project will advance well, therefore Standing on the conservative side the Project is considered to start up in 1986.

(7) Two 5-MW diesel generators are to be added in 1980 and one 5-MW diesel generator in 1981 to the Piura-Sullana Power System. (The contract has already been awarded and construction is scheduled to be started shortly.)

(8) Two units of the three 1,360-kW diesel generators of the EEPSA existing thermal power plant are to be removed in 1983 and the other in 1986 because all

Table II-1-12 Demand and Supply Balance of Interconnected Power System

Year	Max. Demand	L/F	Project	Installed Capacity			Effective Power		Guaranteed Peak Out Put		Balance	
	(MW) (1)		(MW)	Hydro (MW)	Thermal (MW)	Accum. (MW)	Annual (MW)	Accum (MW) (2)	Annual (MW)	Accum (MW) (3)	(2) - (1) (MW)	(3) - (1) (MW)
1977	21.50	54		0	0	20.68	0	16.95	0	14.11	-4.53	-7.39
1978	23.00	54	5.50	0	5.50	26.18	5.15	22.10	4.29	18 40	-0.90	-1.60
			2.50 × 1 *1		2.50		2.25		1.87			
			1.50 × 2 *1		3.00		2.00		2.42			
1979	24.40	55		0	0	26.18	0	22.10	0	18 40	-2.30	-6 00
1980	27.30	53	8.20	0	8.20	34.38	7.90	30.00	6.58	24.98	2 70	-2 32
			5.00 × 2 *1		10.00		9.80		8.17			
			1.20 *2		1.20		1.00		0 83			
			-1.50 × 2 *3		-3.00		-2.90		-2.42			
1981	29.10	54	5.00	0	5 00	39.38	4.90	34.90	4.08	29.06	5.80	-0.04
			5.00 *1		5.00		4.90		4.08			
1982	31.20	54		0	0	39.38	0	34.90	0	29.06	3.70	-2 14
1983	33.30	56	13 88	16.60	-2.72	53.26	14.20	49 10	14.60	43 66	15.80	10.36
			7.60 *4	7.60			7.60		7 60			
			9.00 *5	9.00			9.00		9.00			
			-1 36 × 2 *3		-2.72		-2 40		-2.00			
1984	35 60	56		0	0	53.26	0	49.10	0	43.66	13.50	8 06
1985	39 50	56		0	0	53.26	0	49.10	0	43.66	9.60	4.16
1986	55 30	50	26 14	27.50	-1.36	79.40	26.30	75.40	24.65	68 31	20.10	13 01
			25.00 *6	25 00			25 00		25.00			
			2 50 *7	2.50			2.50		0 65			
			-1.36 *3		-1.36		-1.20		-1.00			
1987	60.50	51		0	0	79.40	0	75.40	0	68.31	14.90	7.81
1988	64.80	52		0	0	79.40	0	75.40	0	68.31	10.60	3 51
1989	70.20	52	15.00	0	15.00	94.40	14.70	90.10	12.25	80 56	19.90	10.36
			5 00 × 3 *1		15.00		14.70		12.25			
1990	76.50	52		0	0	94.40	0	90.10	0	80 56	13.60	4.06
1991	82.00	53	7 62	0	7 62	102.02	8.00	98.10	6.66	87.22	16.10	5.22
			5.00 × 2 *1		10.00		9.80		8.16			
			-2 38 *3		-2.38		-1.80		-1 50			
1992	87.40	53		0	0	102.02	0	98.10	0	87.22	10 70	-0.18

Note : Effective Power of a diesel generator significates a maximum out put available and guaranteed peak out put is calculated as 83.3 % of the effective power. (2 months a year are taken into consideration for the inspection, repair etc.)

*1 ; Amplification of facilities of EEPSA's Piura Power Station

*2 ; Increasement of facilities by the installation of interconnected transmition line with the Bajo Piura Area.

*3 ; Elimination of facilities due to the useful service life and other reasons.

*4 ; Commencement of the operation of Poechos Power Station

*5 ; Commencement of the operation of Curumuy Power Station.

*6 ; Commencement of the operation of Culqui Power Station.

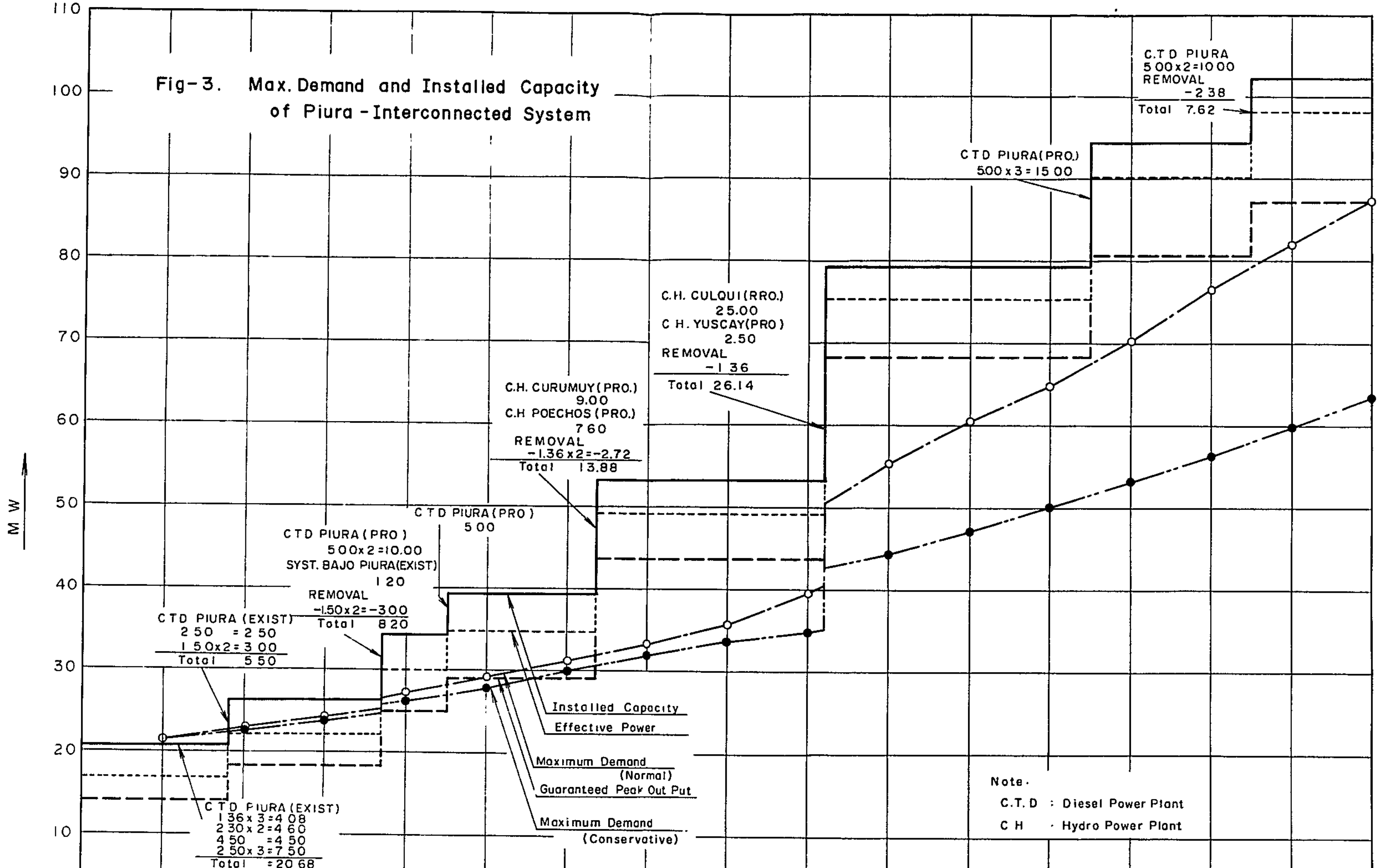
*7 ; The Yuscay Power Station (Planned to be put into operation in 1982 but is to be interconnected with the power systems of this project in 1986.)

of them will have reached their useful service life. And another unit of 2,380 kW-diesel generator also will be cut off by the same reason as mentioned above.

(9) Two units of Fiat 1,500 kW portable diesel generator, which are operating for emergency use, are to be removed in 1980.

The demand and supply balance based on the above is shown in Table II-1-12, and Fig.- 3, and from 1980 to 1990, balance of demand and supply can be secured with the Poechos and Curumuy Projects and the Culqui Hydroelectric Power Project presently under feasibility study. As for the period after 1990, it was considered that plans would be elaborated later in accordance with the situation of electric power development in Northern Peru and the state of progress transmission line interconnection with the Central System, and here it was assumed that diesel generators would be added in 1990 to meet the demand until 1992.

Fig-3. Max. Demand and Installed Capacity of Piura - Interconnected System



Year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Maximum Demand (1) (Normal) (MW)	2150	2300	2440	2730	2910	3120	3330	35.60	3950	55.30	6050	64.80	7020	7650	8200	8740
Installed Capacity (MW)	2068	2618	2618	34.38	3938	3938	5326	5326	5326	79.40	79.40	79.40	94.40	9440	102.02	10202
Effective Power (2) (MW)	1695	2210	2210	3000	3490	3490	4910	4910	4910	75.40	7540	7540	9010	9010	9810	9810
Guaranteed (3) Peak Out Put (MW)	1411	1840	1840	2498	2906	2906	4366	4366	43.66	6831	6831	6831	8056	80.56	87.22	87.22
Balance (MW) (2)-(1)	-455	-090	-230	270	580	3.70	15.80	1350	960	20.10	1490	10.60	1990	1360	1610	1070
Balance (MW) (3)-(1)	-739	-460	-600	-2.32	-004	-214	1036	806	416	1301	7.81	351	10.36	4.06	5.22	-018
Maximum Demand (Conservative) (MW)	2150	2280	2420	2630	2790	3000	3190	3370	34.90	4440	47.20	5010	5310	5630	5990	6350

1.3.2 Daily Load Curve

The daily load curve of the Piura-Sullana Power System was estimated based on past load curves, while regarding those for the other power systems the load curves investigated and prepared by INIE were used. These load curves were synthesized to prepared a daily load curve for Interconnected Piura System for 1982, 1986 and 1992.

These daily load curves are indicated in Fig.- 4 through Fig.- 8. For reference, the daily load curves of EEPSA in the past are shown in Fig.- 9.

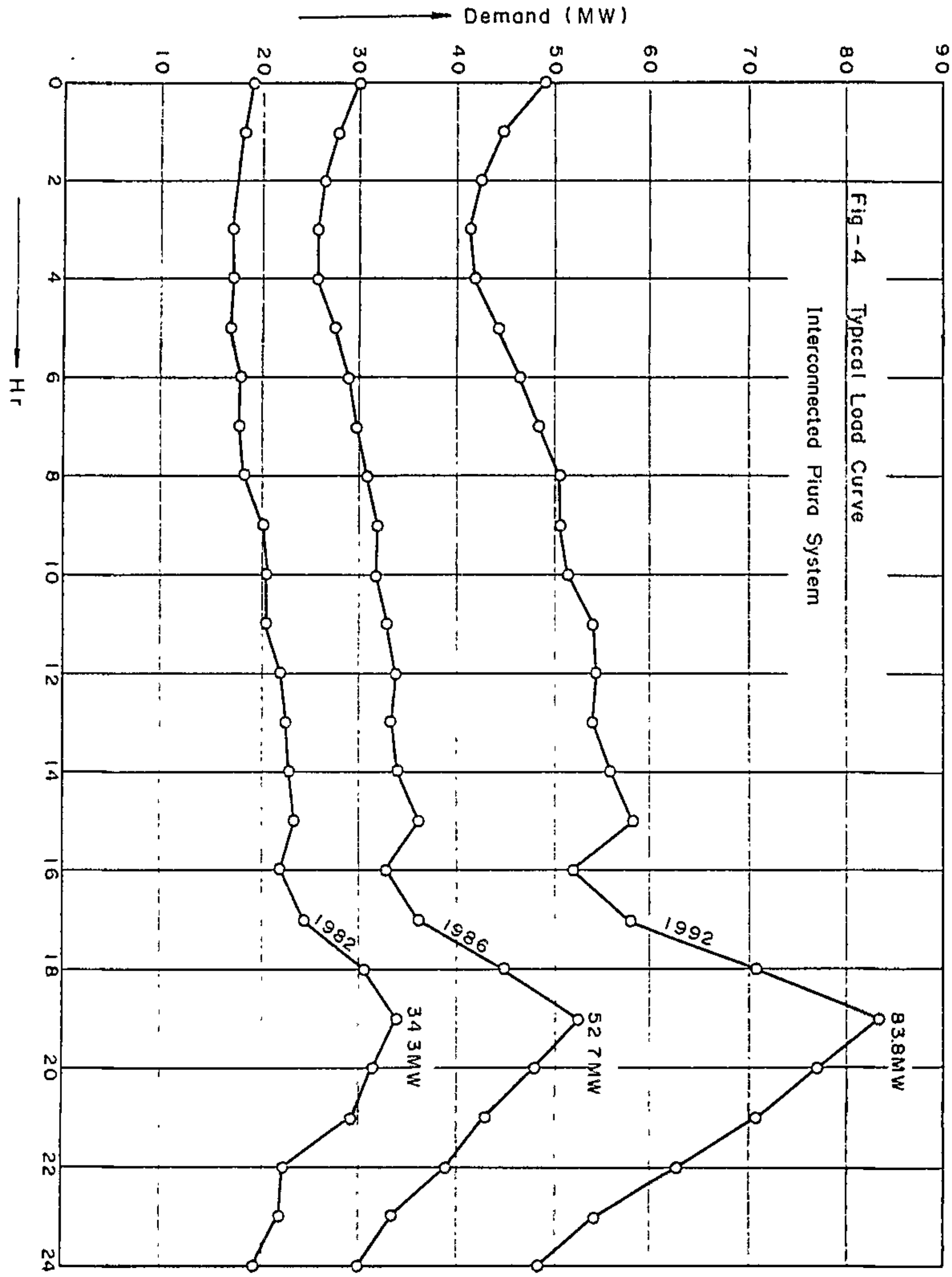


Fig - 4 Typical Load Curve
Interconnected Piura System

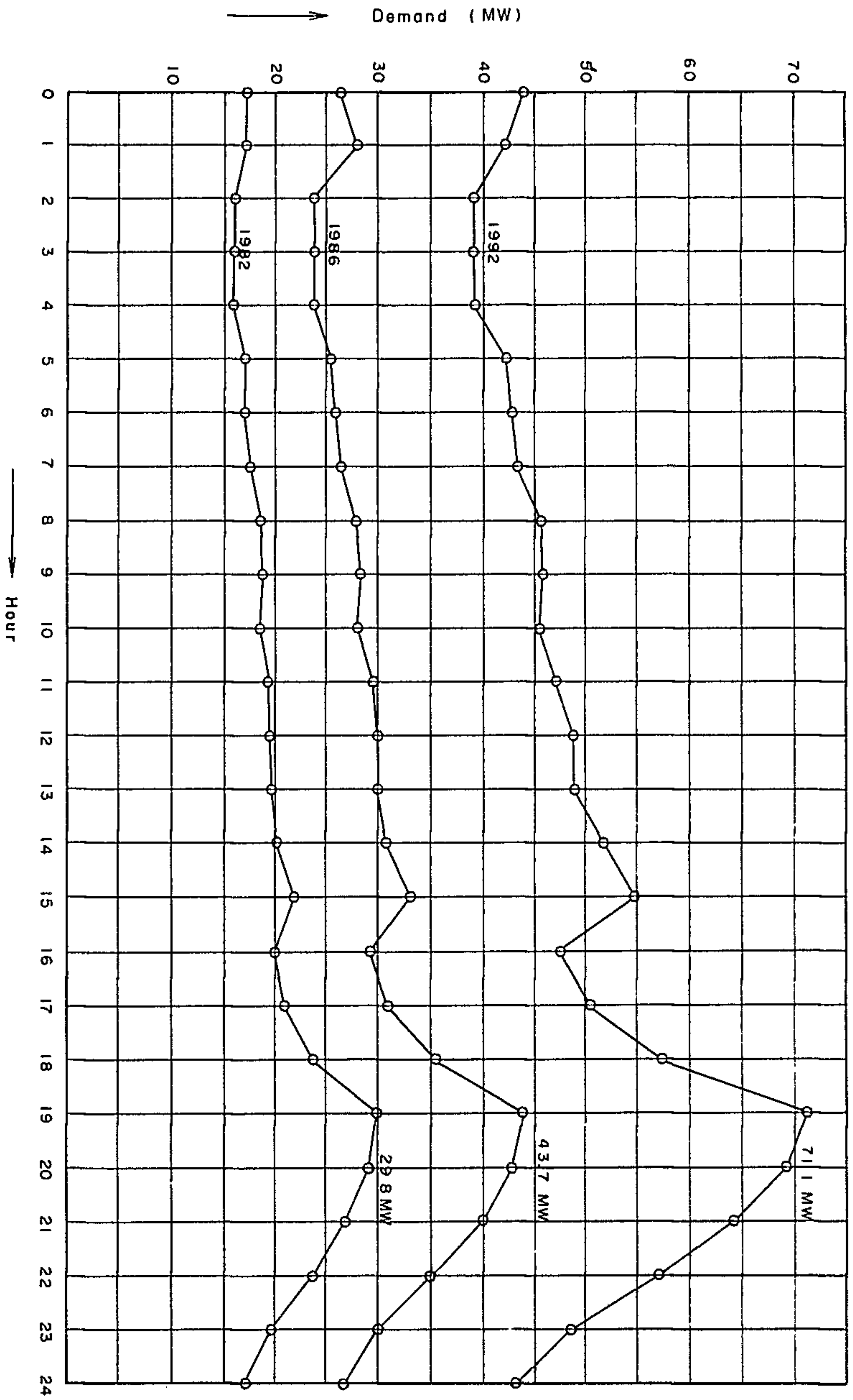


Fig-5 Tipical Load Curve Piura-Sullana System

Fig -6 Typical Load Curve : Bajo Piura

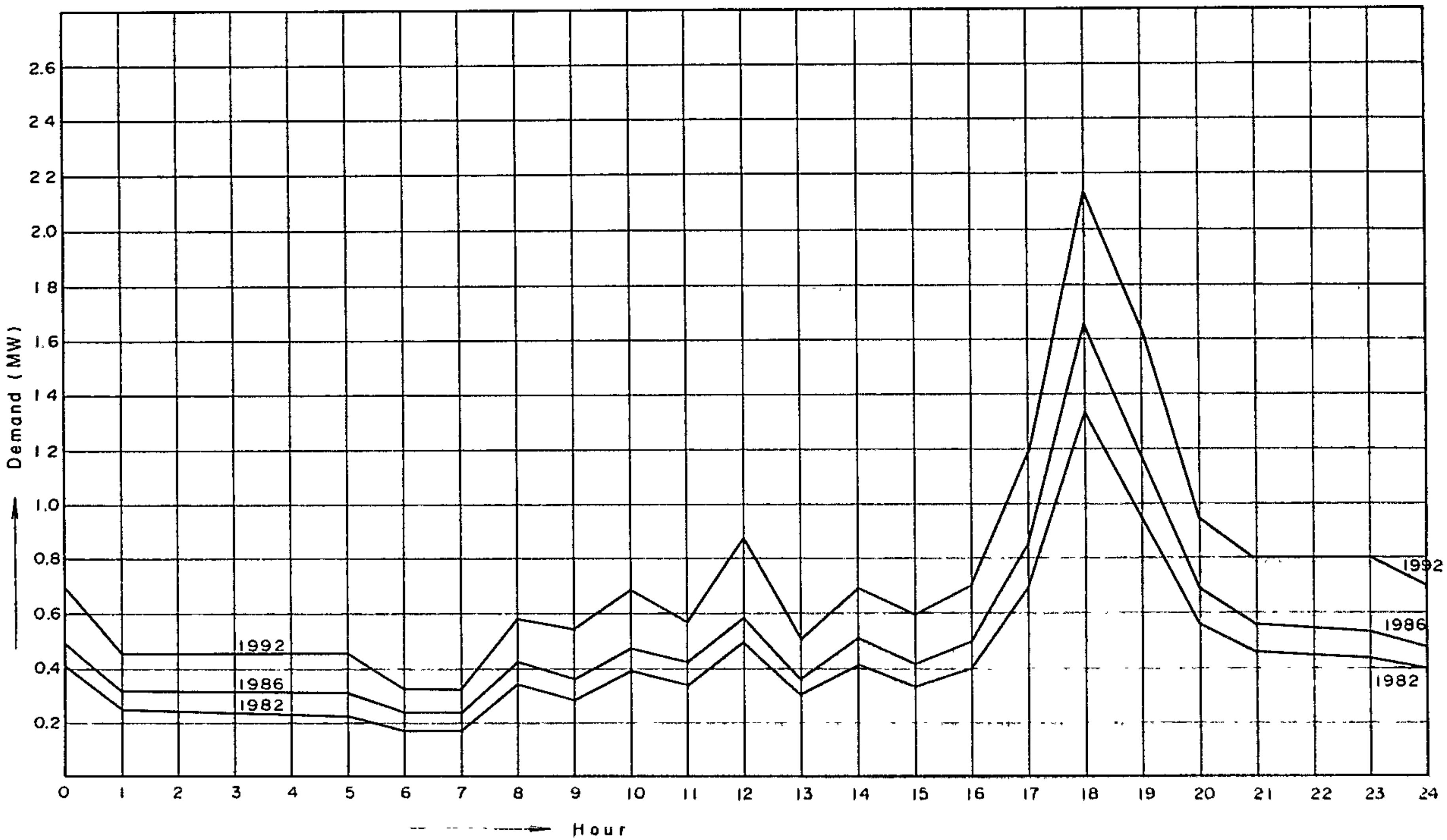


Fig - 7 Typical Load Curve - Alto Piura

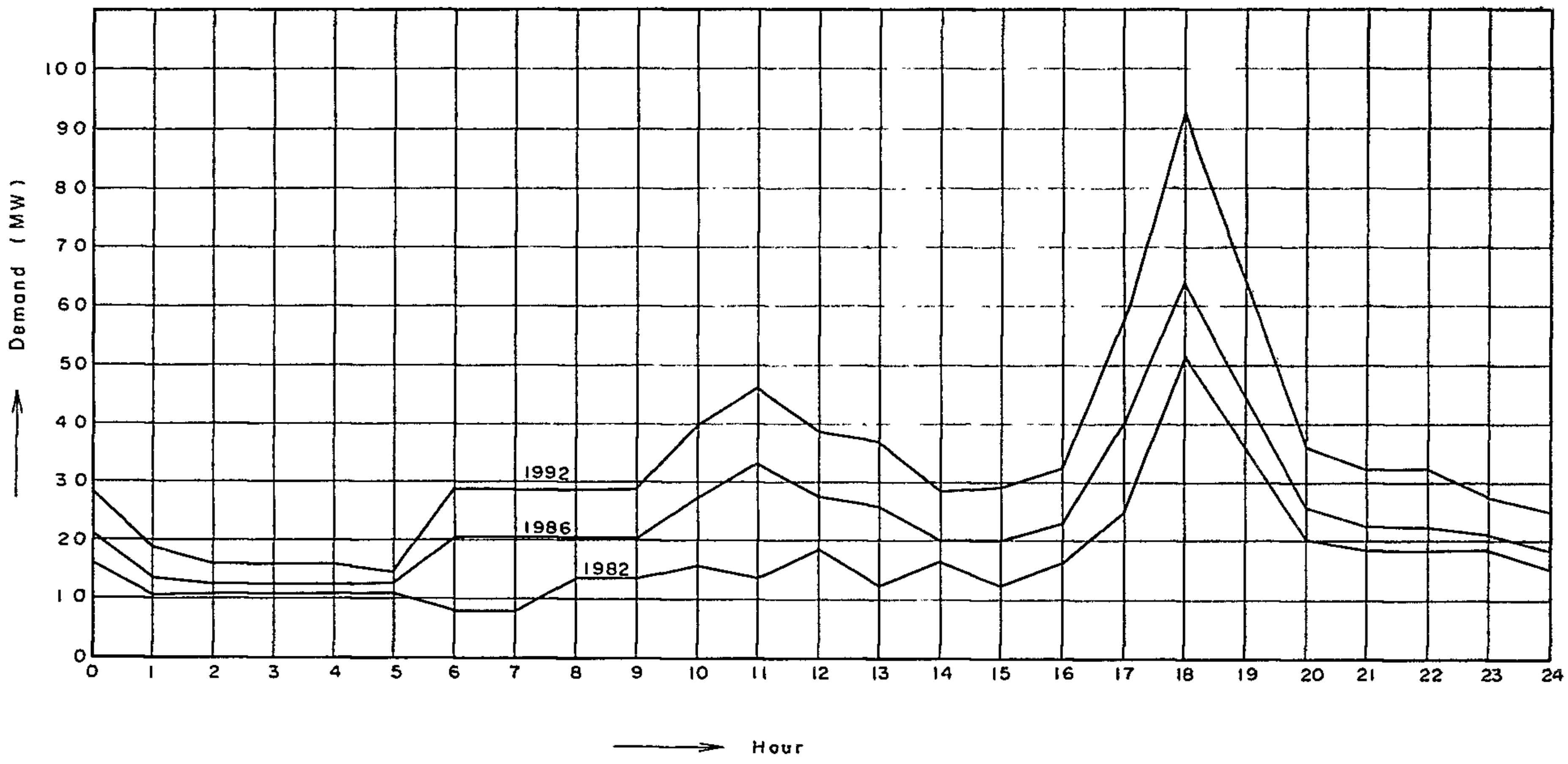


Fig.-8. Typical Load Curve : San Lorenze

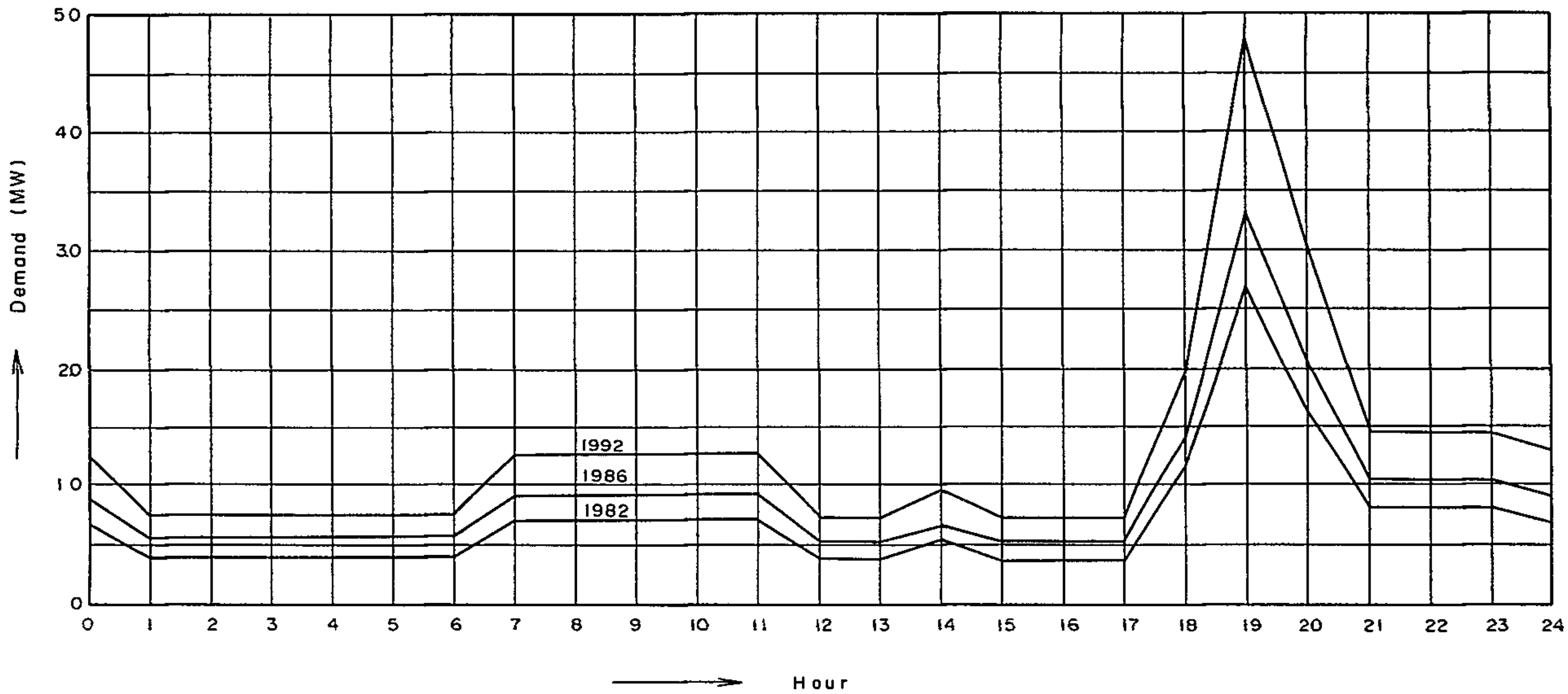
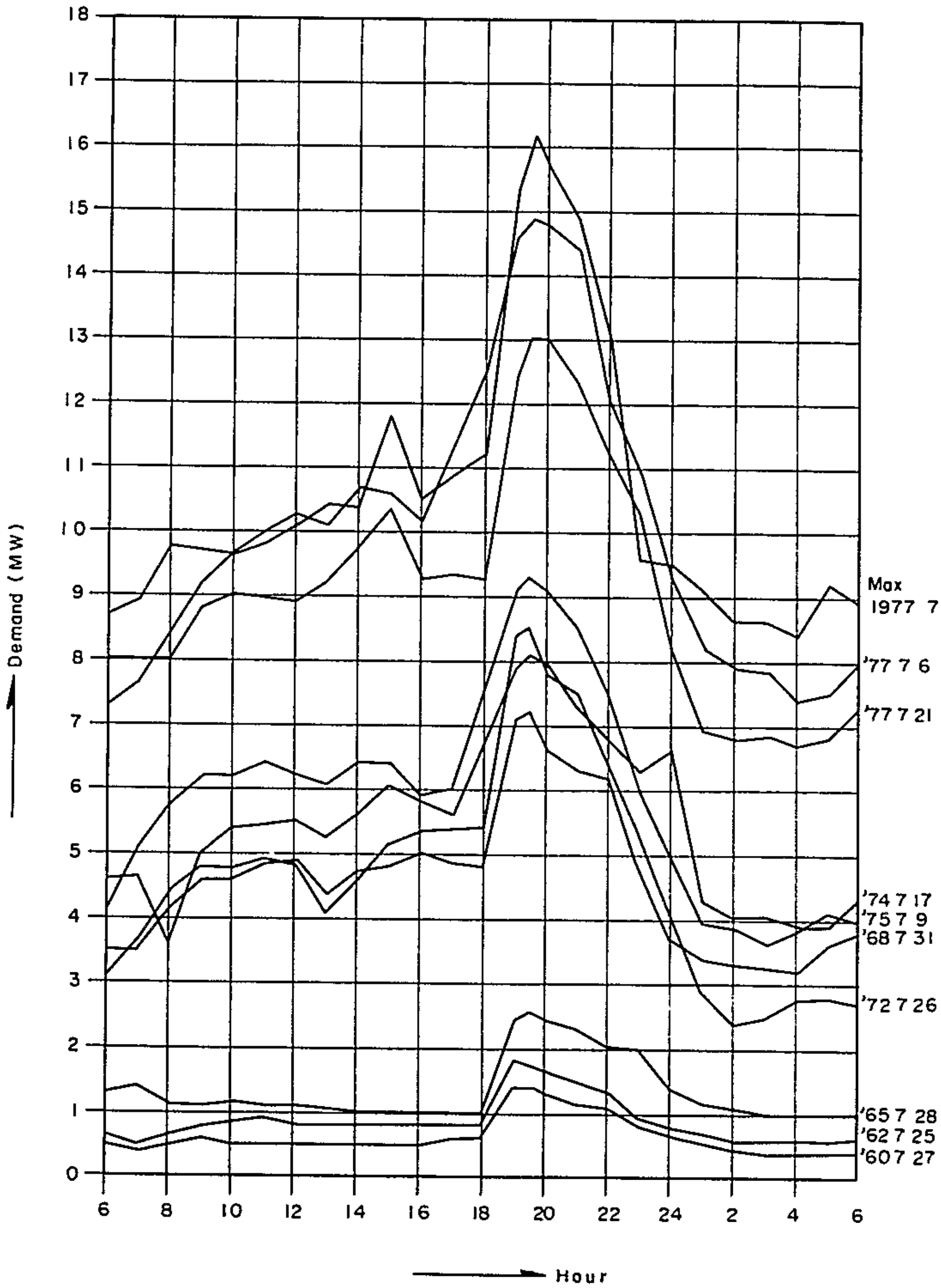


Fig-9 Daily Load Curve (1960~1977)
(EEPSA System)



CONTENTS

PART II

CHAPTER 2 DEVELOPMENT SCHEME

CHAPTER 2 DEVELOPMENT SCHEME

2.1 LOCATION AND OUTLINE OF PROJECT AREA

2.1.1 Location of Project Area

The Poechos and Curumuy Hydroelectric Power Project sites are located in Piura Departament near the northern tip of the Republic of Peru. Poechos Dam is located approximately 30 km northeast of the city of Sullana in the departament with Poechos Power Station located immediately below the Poechos dam and Curumuy Power Station approximately 40 km south of the Poechos dam and approximately 20 km north of the city of Piura.

2.1.2 Outline of Project Area

Piura Departament is located, facing the Pacific Ocean coast, at 5° south latitude and 80° west longitude, approximately 900 km north of Lima, the capital city of Peru, with the northern part of the departament bordering Ecuador.

Most of the departament is a desert consisting of dunes transported by southwest winds, and these dunes extend inland about 80 km from the sea coast. The departament is divided by the Chira River flowing through its northern part and the Piura River flowing through its southern part.

The Chira River starts from the junction of the Catamayo River and the Matara River rising from the Andes, and after flowing along the border with Ecuador for a short distance, the Chira River is joined by its tributaries such as the Quiroz River, and the Chipillico River, the then it runs by farmland in the vicinity of Sullana City to flow into the Pacific Ocean.

Similarly to the Chira River, the Piura River starts from the confluence of the Chigna River and the Huarmoco River rising from the Andes, and while flowing northward the Piura River is joined by its tributaries such as the Bigote River, the Carral del Medio River, the La Gallega River, the Charanal River and the Yapatera River, the the flow changes westward in the vicinity of Tambo Grande. Subsequently, the Piura River changes its flow southward in Curumuy, and running in farmland in the vicinity of Piura City and after passing Sechura it flows into the Pacific Ocean.

The basins of both the Chira River and the Piura River have hardly any rainfall in their downstream areas. However, there is annual precipitation of 200 to 1,000 mm in upstream areas. During the year, rainfall is concentrated in the period from January to April with this period being the rainy season and that from May to December being the dry season.

The climate of the Piura area is hot and dry, and is a typical northern coastal region climate.

Regarding the elevation and geology of the project area, the Poechos site is at an elevation of approximately 70 m, and the geology consists of Tertiary shale. The elevation of the Curumuy site is between 30 m to 70 m and the geology consists of unsolidified but compacted thick Quaternary diluvial sand deposits.

With respect to the condition of roads in the project areas, the Pan American Highway runs from Lima to Piura, and Sullana and continues beyond Talara (Talara Port). There is also a paved highway between Paita Port and Piura City. Meanwhile, to Poechos and Curumuy sites, there is a road from Piura and Sullara cities, which was built at the time of construction of the Chira-Piura Irrigation Diversion Canal, and this is asphalt-paved and has an adequate width. These roads are adequate for transportation of construction equipment and materials and there is no problem in this regard.

2.2 OUTLINE OF CHIRA-PIURA IRRIGATION PROJECT

This project was planned by the Ministry of Agriculture and is presently being implemented.

The purpose of the project is to store abundant runoff of the Chira River from January through April to supply water to its downstream area as needed, and also to divert water to the Piura River which often runs dry during dry seasons to secure irrigation water for the Piura River downstream area.

The combined irrigation area is 135,000 ha. For this purpose, two reservoirs will be provided, one on the Chira River and another on the Chipillico River, and of its tributaries. In addition, to facilitate intake of water to be discharged or diverted from the Chira River reservoir for downstream irrigation facilities, water-level regulating dams will be provided at Sullana and Piura sites.

The reservoir planned on the Chira River, namely, Poechos Reservoir, was completed in 1978, while the diversion canal to the Piura River was also completed at the same time and is in operation. Poechos Reservoir has a catchment area of 13,220 km^2 and is capable of storing 1,000 x 10^6 m^3 of water. Of this amount, the water that can be utilized for irrigation is 830 x 10^6 m^3, allowing a daily average of 26.3 m^3/sec to be supplied.

Discharge from the reservoir to the Chira River downstream area is done by a bottom outlet of 4.5 m in diameter and 415 m in length provided at the bottom of the dam. As for the diversion to the Piura River, it is carried out by an intake for diversion provided at the left bank of Poechos Dam and a diversion canal of 54 km in length and with a maximum capacity of 70 m^3/sec. San Lorenzo Dam planned on the Chipillico River and Quitoz Diversion from the Quiroz River are already in operation, and there is a plan in progress to increase the present capacity of 200 x 10^6 m^3 to 300 x 10^6 m^3.. Investigations are going on regarding Sullana Dam and Catacaos Dam scheduled to be built at the Catacaos site.

2.3 OUTLINE OF DEVELOPMENT SCHEME

2.3.1 Poechos Hydroelectric Power Project

(i) Outline of Project

This Project aims to utilize the water presently being discharged from Poechos Reservoir to the Chira River downstream area for irrigation and the potential head of the bottom outlet facilities for a maximum of power production 7,600 kW.

The power generation will be made by connecting a penstock part way along the existing bottom outlet (Salida de Fondo) to conduct water to a power-house to be located at the left side of a stilling basin at the end of the bottom outlet. The utilized water for power generation will be partly diverted through a tailrace to the Miguel Checa Irrigation canal and partly discharged to the Chira River. Poechos Reservoir will be operated between a high water level of El. 103 m and a low water level of El. 84 m and the effective storage between these levels is 830 x 10^6 m^3.

The monthly water discharged through the bottom outlet for irrigation will be a maximum 28 m^3/sec and a minimum 12 m^3/sec. Therefore, during the period in which there is high head, it will be possible to generate electricity of 7,600 kW in full base operation at Poechos Power Station with the outlet discharge for irrigation. However, as the reservoir water level approaches the minimum, it will not be possible for maximum output to be produced, in which case either the discharge must be regulated for power generation at the maximum output for a short period of time, or base operation must be done using the minimum dependable discharge. In the former case of peak operation, it will be necessary for utilized discharge to be regulated for irrigation in the downstream area. This discharge regulation will be done at Sullana Dam which the Ministry of Agriculture has scheduled for completion in 1982. In order to transmit the electric power produced by this Project to the load centers of Sullana and Piura, a transmission line of 33 km is to be constructed between Poechos Power Station and the existing Sullana Substation.

(ii) Features of Project

Power Generation Plan

Location: On the Chira River 30 km upstream from Sullana City, Piura Departament

Operation System: Base and peak-base operation using irrigation discharge from Poechos Reservoir

Capacity: 7,600 kW (3,800 kW x 2 units)

Catchment Area: Poechos Reservoir (existing, administered by the Ministry of Agriculture) 13,220 km^2.

Natural Flow:

Annual inflow (1937-1970 average), 2,280 x 10^6 m^3

Average inflow, 72.3 m^3/sec

Minimum annual inflow (1968), 850 x 10^6 m^3

Minimum annual average inflow, 27.0 m^3/sec

Storage Capacity: Poechos Reservoir

Total storage capacity, 1,000 x 10^6 m^3

Effective storage capacity, 830 x 10^6 m^3

Waterway: (existing: administered by The Ministry of Agriculture)

Bottom Outlet: Temporary diversion tunnel for construction of Poechos Dam and utilized as bottom outlet after its completion with steel lining below the dam axis.

	(Upstream Side)	(Downstream Side)
Type:	Concrete culvert	Concrete-reinforced steel pipe
Inside Diameter:	8.00 m	4.50 m
Length:	149.236 m	281.440 m
	(Total 430.676 m)	
Capacity:	314 m^3/sec	
Discharge Regulation:		
	Wheel gate	Butterfly valve
	5.5 m x 9.0 m x 1	4.5 m in dia.
		Radial gate
		3.5 m x 4.5 m x 1

Penstock

Type: Embedded penstock

Number: 1 line, bifurcated at the end

Length: Single-line part, 49 m

Double-line part, 22 m (11 m x 2)

Total 71 m

Inside Diameter: 3.20 m - 2.50 m

Weight: 114 tons

Powerhouse

Type: Outdoor

Bldg. Dimensions: 29 m x 16.4 m

Turbine Center Elevation: 58.30 m

Generator Hall Elevation: 60.80 m

Turbine

Type: Vertical-shaft Kaplan

Output: 4,000 kW

Effective Head: Max. 41.30 m, nor. 36.10 m, min. 20.90 m

Speed: 400 rpm

Available Discharge: Max. 22.00 m^3/sec/unit

Efficiency: 0.882 (at Hnor.)

Number: 2 units

Generator

Type: Ordinary

Output: 4,250 kVA

Speed: 400 rpm

Efficiency: 0.956

Voltage: 6.6 kV

Frequency: 60 Hz

Number: 2 units

Main Transformer

Type: 3-phase, oil-immersed, air-cooled

Capacity: 8,500 kVA

Voltage: 6.3/66 kV

Number: 1 unit

Tailrace

Type: Non-pressurized open concrete canal

Cross Section: Trapezoidal

Length: 102 m

Capacity: 44.2 m^3/sec

Transmission Line

Voltage: 66 kV

Number of Circuits: 1 cct.

Length: 33 km

2.3.2 Curumuy Hydroelectric Power Project

(i) Outline of Project

This Project aims to utilize the water supplied to the Piura River from Poechos Reservoir through the Chira-Piura Diversion canal and the potential head at the end of this canal for a maximum power production at 9,000 kW.

The power generation will be made by to providing an intake facility at the right side of the rectangular section part immediately upstream of the jet flow part of the diversion canal to divert the water from the canal to a head tank to be built parallel to the canal, and then to the turbine through penstocks.

The powerhouse will be located near the chute (Rapida de Curumuy), at the right-bank side of the diversion canal. During the non-irrigation season the flow of the canal will decrease and power generation to meet power demand will become impossible, so that a regulating pondage of a storage capacity of 102,000 m^3 is to be provided adjacent to the intake to store the flow from the canal and the discharge necessary for power generation is to be regulated in the pondage.

The 95% quantity of the discharge to the Chira-Piura Diversion canal according to the irrigation plan is 10^3/sec. In a 13-year period, there will be 3 months during which the discharge will be 0 m^3/sec according to the irrigation plan, but it is planned for the minimum flow necessary for power generation to be secured in those months, too.

Curumuy Power Station will cover the peak and base parts of the power system load in accordance with eventual outflow for irrigation.

(ii) Features of Project

Power Generation Plan

Location: Sullana City, Piura Departament

Operation System: Peak and base operation using flow of Chira-Piura Diversion canal.

Capacity: 9,000 kW (4,500 kW x 2 units)

Catchment Area: Poechos Reservoir, 13,220 km^2

Natural Flow: Same as Poechos Power Station

Canal (Existing: Administered by The Ministry of Agriculture)

	(Dam side)	(Canal side)
Type:	Concrete culvert	Open concrete canal

Inside Diameter:	ø2.4 m x 2	Trapezoidal, bottom width 5.00 m, height 3.58 m - 3.88 m
Length:	170.5 m	54,000 m
Capacity:	53 m^3/sec	80 m^3/sec

Intake (Intake from Chira-Piura Diversion canal)

Type: Reinforced concrete structure

Intake Capacity: Maximum 31.5 m^3/sec

Regulating Pondage

Type: Asphalt facing

High Water Level: El. 64.50 m

Low Water Level: El. 60.50 m

Available Drawdown: 4.00 m

Capacity: 102,000 m^3

Head Tank

Type: Reinforced concrete structure

Dimensions: Length 105 m

Capacity: 2,300 m^3

Penstock

Type: Exposed

Number: 2 lines

Inside Diameter: 2.4 m

Weight: 235 tons

Powerhouse

Type: Outdoor

Bldg. Dimensions: 26.8 m x 9.4 m

Turbine Center Elevation: 18.80 m

Generator Hall Elevation: 24.40 m

Turbine

Type: Vertical-shaft Kaplan

Output: 4,750 kW

Effective Head: Max. 39.70 m, nor. 38.70 m, min. 35.70 m

Speed: 514.3 rpm

Available Discharge: Max. 15.80 m^3/sec/unit

Efficiency: 0.884 (at Hnor.)

Number: 2 units

Generator

Type: Ordinary

Output: 5,050 kVA

Speed: 514.3 rpm

Efficiency: 0.956

Voltage: 6.6 kV

Frequency: 60 Hz

Number: 2 units

Main Transformer

Type: 3-phase, oil-immersed, air-cooled

Capacity: 10,100 kVA

Voltage: 6.3/66 kVA

Number: 1 unit

Tailrace

Type: Open canal

Length: 24 m

Transmission Line

Voltage: 66 kV

Number of Circuits: 1 cct ("π" connection)

Length: 4 km