MINISTERIO DE ENERGIA Y MINAS
REPUBLICA DEL PERU

YANGAS RIVER HYDRO-ELECTRIC POWER PROJECT PREFEASIBILITY REPORT

FEBRUARY 1976

JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTERIO DE ENERGIA Y MINAS
REPUBLICA DEL PERU

YANGAS RIVER HYDRO-ELECTRIC POWER PROJECT PREFEASIBILITY REPORT

FEBRUARY 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

The Government of Japan, in response to the request of the Government of Republic of Peru undertook to conduct a prefeasibility study of the Yangas Hydro-electric Power Development Project in northern Peru and entrusted the work to the Overseas Technical Cooperation Agency, the predecessor of the Japan International Cooperation Agency.

In view of the fact that Electric Power Development Company has much experience in engineering and economic studies of this nature in Peru and other foreign countries, the Agency assigned the work to the Company by awarding an engineering service contract for the prefeasibility study of the Yangas Project. The results of studies are compiled in this Report and is presented herewith.

I shall be very happy if the Report will contribute to the promotion of development of hydro-electric power projects in northern Peru and to further strengthen the bond of friendship and economic relationship between Peru and Japan.

Finally, I wish to take this opportunity to record my heartfelt gratitude to the officials of the Government of Republic of Peru for their wholehearted support extended in the execution of the studies.

February 1975

Shinsaku Hogen
President
Japan International Cooperation Agency

ELECTRIC POWER DEVELOPMENT COMPANY, LTD.
8-2, MARUNOUCHI, 1-CHOME, CHIYODA-KU, TOKYO, 100 JAPAN.

CABLE ADDRESS:
ELECTPOWER TOKYO
TELEX: J26718 EPDCTOK

LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen, President
Japan International Cooperation Agency

Dear Sir:

Submitted herewith is the report on the prefeasibility study of the Yangas River Hydro-electric Power Development Project in the Republic of Peru.

The field survey and prefeasibility study were conducted based on the engineering contract of 21 January 1974 between the Overseas Technical Cooperation Agency and Electric Power Development Company, and on the engineering contract of 26 November 1974 between the Japan International Cooperation Agency which succeeded Overseas Technical Cooperation Agency and Electric Power Development Company, respectively.

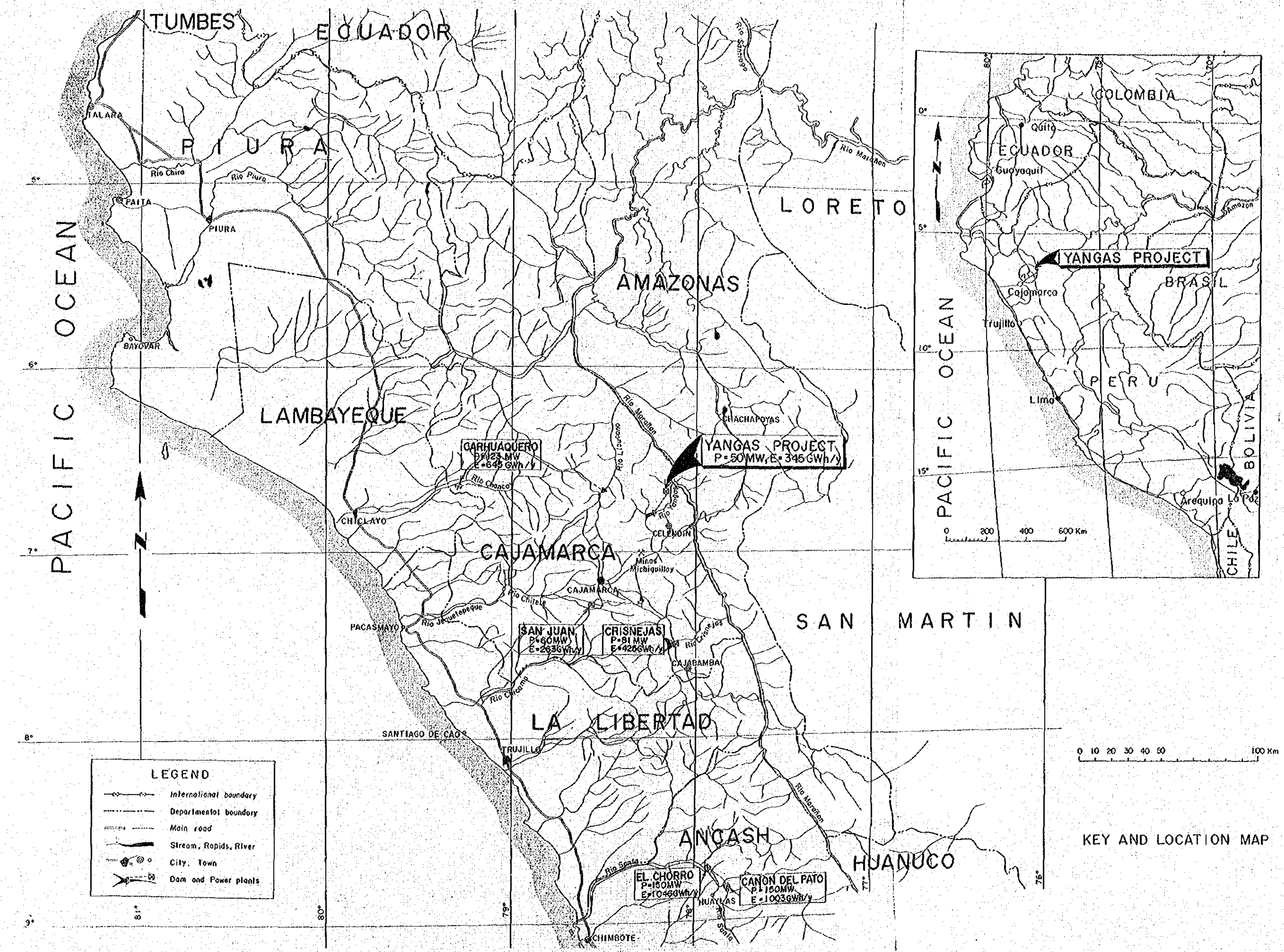
Submission of this report will constitute completion of the field survey and engineering study for the Yangas River Hydro-electric Power Development Project in a prefeasibility level in which many experts in their respective field of specialty concerned had been engaged for a period of about one year under the guidance of Chief Engineer of this company.

In closing, I would like to express my sincere gratitude for the opportunity given to cooperate in the activities of the Japan International Cooperation Agency through the investigations and study of this hydro-electric power development project.

February 1975

H. Watanabe

Hiroshi Watanabe
Chief
Japanese Survey Team for
Yangas Hydro-electric Power
Development Project



KEY AND LOCATION MAP

UNITS OF MEASURE

mm	: Milimeter
cm	: Centimeter
m	: Meter
km	: Kilometer
sq. mm	: Square milimeter
sq. cm	: Square centimeter
sq. m	: Square meter
sq. km	: Square kilometer
ha	: Hectare
cu. m	: Cubic meter
gr	: Gram
kg	: Kilogram
ton	: Metric ton
kt/yr	: Metric kiloton per year
ton/day	: Metric ton per day
ton/min	: Metric ton per minute
ℓ/min	: Liter per minute
kl	: Kilo liter
bbl	: Barrel
mmHg	: Milimeter mercury
kbbl	: Kilo barrel
m/sec.	: Meter per second
cu. m/sec.	: Cubic meter per second
cu. m/sec. -day	: Cubic meter per second - day
cu. m/sq. km/year	: Cubic meter per square kilometer per year

KW	: Kilowatt
KWH	: Kilowatt hour
MWH	: Megawatt-hour
GWH	: Gigawatt-hour
MW	: Megawatt
kV	: Kilovolt
kVA	: Kilovolt-ampere
r.p.m.	: Revolutions per minute
EL	: The height above mean sea level
°C	: Centigrade
%	: Percentage
$	: U.S. dollar
s/.	: Sole

CONTENTS

CHAPTER 1

INTRODUCTION

CHAPTER 1. INTRODUCTION

1.1 Authorization

ELECTROPERU, under the Ministerio de Energía y Minas (hereinafter referred to as MEM) of the Republic of Peru, requested the Government of Japan through the Government of the Republic of Peru by official letter, No (Ha)-6-15/12 dated February 6, 1973, for a prefeasibility study to be made of the Yangas River Hydroelectric Power Development Project (hereinafter refered to as the Yangas Project or as the Project) as the most promising for the next elctric power development scheme for the supply of electricity to the northern part of Peru where a shortage of power is anticipated from 1983 and after. In response to this request, Overseas Technical Cooperation Agency of the Government of Japan (hereinafter refered to as OTCA) dispatched to Peru a Survey Mission comprised of the engineers listed in a later part of this Chapter, under the service agreement with Electric Power Development Company (hereinafter referred to as EPDC).

The Survey Mission was occupied from February through March 1974 in field reconnaissances and gathering of necessary information and after returning to Japan and on arrival of topographic maps which were being prepared by the Instituto de Investigaciones Energéticas y Servicios Eléctricos (hereinafter referred to as INIE), a study of the Project was made and this Report has been prepared.

1.2 Purposes of Report and Scope of Study

The purposes of this Report are to select the optimum development scheme of the Yangas Project which has been recommended in the Report "Electric Power

Supply for the Michiquillay Mining Complex and its Influence Area" prepared by MOTLIMA S.A. in 1972 (hereinafter referred to as MOTLIMA Report), from technical and economical standpoint on a prefeasibility level, and to make clear the economic priority of the Project among other hydroelectric power projects in the area concerned, and making necessary recommendations on how this Project should be handled in the future.

The scope of study covered in this Report is as follows. Firstly, load forecasts were made for the period from 1975 to 1990 for (1) the existing Santa Power System centered around Chimbote, (2) industrial areas such as Trujillo and Pacasmayo etc., (3) the area centered around the Michiquillay Mines and Cajamarca, and (4) Chiclayo and the area to the north of Chiclayo. Next covered in this report are power development planning which include power facilities such as dam, waterway, powerhouse and access roads to the project area. Hydrologic study, geologic analysis, cost estimate and economic evaluation are also included. Regarding power transmission facilities, the section between the power station and Michiquillay Substation was studied.

1.3 Existing Reports

Existing reports on the Yangas Project consist of the following:

(1) The preliminary survey report made by Mr. Tuguo Nozaki, Engineer, at the time when he was technical adviser to Dirección General de Electricidad of the Republic of Peru.

(2) The survey report made by Mr. Fortunato Marin.

(3) The MOTLIMA Report.

Among these three reports cited above, the MOTLIMA Report is the newest and most detailed, explains the economic superiority of the Yangas Project in comparison with a number of development projects conceivable within the northern part of Peru, recommends to make further surveying preferentially to this Project, and giving the basis of the request for this Project made by the Government of Peru to the Government of Japan.

Besides, since the area of the dam, waterway, powerhouse, etc. proposed in the MOTLIMA Report were not covered by the existing 1/100,000-scale aerial photographical survey map described later, they have been planned on an old 1/200,000-scale map, and the necessity for relevant studies to be made including preparation of topographic maps has been pointed out in that report.

1.4 Basic Information

Basic information obtained during the period of the reconnaissance in Peru consists of the following and this Report has been prepared based on these materials.

1.4.1 Topographic Maps and Aerial Photographs

(1) Topographic Map

Scale	1:200,000
Prepared	1927, by Instituto Geográfico Militar
Scope	Covers entire project area
Note	Not well performed

(2) Aerial Photographical Map

Scale	1:100,000
Prepared	1963, by Instituto Geográfico Militar
Scope	Most part of the Project area is not covered.
Note	Well performed

(3) Aerial Photographical Map, which was newly restituted from the aerial

photographs for this Project.

Scale	1:20,000
Prepared	1974, by INIE
Scope	Covers whole area of the Project, 6 km x 30 km

(4) Aerial Photographs prepared for the above (3)

1.4.2 Information Related to Power Demand and Supply

As mentioned in 4.2 Load Forecast.

1.4.3 Hydrologic Data

The hydrologic data consist of data of nine runoff gaging stations as indicated in Chapter 6 and Appendix B (observation period 3 - 11 years), data of 17 precipitation observation stations (observation period 8 - 40 years) and data on temperature, humidity, evaporation, etc., obtained from SENAMHI, Michiquillay Copper Corporation and existing survey reports.

1.4.4 Construction Cost Data

"Guía de Materiales," 1973, Publicación Informativa-Comercial

"Anuarium 73 de la Construcción," 1973, Camara Peruana de la Construcción

1.5 Acknowledgements

Immeasurable support was received from persons in the organizations listed below in conducting field investigations, gathering information and preparing this Report and the sincerest appreciation is hereby expressed by Mission Members listed in the next section.

MEM, Pepublic of Peru

INIE ELECTROPERU, Republic of Peru

MINEROPERU, Republic of Peru

Embassy of Japan in Peru

Metal Mining Corporation, of Japan

Japan Trade Center, Lima (JETRO)

Without the cooperation of the persons concerned in the above organizations, completion of this Report would not have been possible.

1.6 Members of Survey Mission

The survey mission was comprised of six engineers of EPDC and an economist of the Ministry of International Trade and Industry, the members of which are listed below.

Chief	Hiroshi	Watanabe	Senior Civil Engineer	EPDC
Member	Hiroshi	Horie	Electrical Engineer	EPDC
Member	Katsuo	Goda	Civil Engineer	EPDC
Member	Kiyohiko	Nagatani	Geologist	EPDC
Member	Mitsuhiro	Oomori	Electrical Engineer	EPDC
Member	Koichi	Fujino	Civil Engineer	EPDC
Member	Kiyoshi	Iijima	Economist	MITI

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

2.1 Conclusions

As a result of field surveys conducted in Peru and studies made in Japan on the Yangas Project, based on past survey reports, information made available by INIE, and the aerial photographical map prepared recently by INIE, the following conclusions have been reached:

(1) From the latter half of the 1970s to the early 1980s a substantial increase in power demand is expected in the northern region of Peru due to such factors as the expansion program of the steel mill at Chimbote, the plan for construction of a new industrial center at Trujillo, the start of operations at the Michiquillay Mines and the development of petroleum-related industries. Considering this situation with regard to the Santa Power System and the surrounding area where the increase of power demand will be particularly big, it is anticipated that there will be a shortage in supply capability in 1982 even taking into account the increase of 50 MW at Cañon del Pato and supply increase of 120 MW from the Central Power System through the Lima-Chimbote Transmission Line. And further more when El Chorro of 150 MW were newly to be developed, there will be a shortage in supply capability in 1989. As a new power source to make up these shortages, it would be appropriate for a power station of load factor of around 60% to be developed in the 1980s. On the other hand, when the 1990s are entered, a peak power source of load factor of around 30% would also be considered necessary accompanying increase of load.

(2) Limestone is distributed over a wide area in the Yangas River Basin where the Project is located and due to limitations from the standpoint of

CAPITULO 2 CONCLUSIONES Y RECOMENDACIONES

2.1 Conclusiones

Después del estudio de los informes de los estudios existentes, materiales proporcionados por INIE; el plano del levantamiento aerofotogramétrico preparado recientemente por INIE; los resultados del estudio en el lugar y después del estudio detallado del proyecto de la Central Hidroeléctrica del Río Yangas en el Japón, se llegó a la siguiente conclusión:

(1) Se supone que la demanda de energía eléctrica en la parte norte del Perú aumentará considerablemente durante el período desde la última mitad del decenio de 1970 hasta principios del decenio de 1980, debido a la ampliación de industria siderúrgica en Chimbote, construcción de la nueva parque industrial en Trujillo, comienzo de la operación de las minas de Michiquillay, y desarrollo de la industria relativa a petróleo. Especialmente en la zona del Sistema de Santa y sus alrededores que gozan del considerable incremento de la demanda, el suministro de energía eléctrica quedará insuficiente para el año 1982, aún considerando la ampliación de 50 MW en la Central Eléctrica del Cañon del Pato y el suministro de 120 MW proveniente del sur (Sistema Central), mediante la línea de transmisión de Lima a Chimbote. Por otro lado, si se supone que se desarrolla y se explota la Central de El Chorro con 150 MW, también para el año 1989 se hará necesario invertir para una nueva fuente de energía eléctrica. Para satisfacer esta demanda del decenio de 1980, será conveniente la puesta en operación de una central eléctrica con factor de carga aproximado de 60%. Por otro lado al llegar al decenio de 1990, conforme al aumento de la demanda se hará necesario también considerar fuentes de energía eléctrica con factor de carga de aproximadamente 30%, para absorber la carga de pico.

(2) La cuenca del Río Yangas, en donde se ubica el presente Proyecto, tiene una distribución muy amplia de rocas calizas, y la ubicación de la represa

topography, it would be impossible for the damsite and the greater part of the headrace tunnel route to be selected avoiding this limestone area. As a result of reconnaissance of the site and geologic interpretation of aerial photographs, it is understood that the limestone bedrock occupying the greater part of the project site has been subjected to strong karstic erosion and it is considered that there exists a probability of leakage from dam and reservoir foundations when the reservoir is filled with water, and springing of large quantities of water during construction of the tunnel. In particular, watertightness of the dam and reservoir foundations is a critical matter governing the feasibility of the project and this will require thorough investigations and studies in the future, but for the purposes of this Report, the project was examined within the scope of the information presently available. The damsite and the headrace tunnel route proposed in this Report have been selected at places where there are comparatively fewer problems.

(3) Hydrologic data indispensable for establishing a power development scheme are not available in sufficient quantity for the study of the Project at the present time. Therefore, runoff of the Yangas River was calculate from runoff and precipitation data of neighboring rivers and streams. As a result of the calculation, it has been estimated that the annual average runoff at the damsite is 9.7 cu.m/sec, while the dry season average runoff during June to September is 2.7 cu.m/sec.

(4) As a result of study on the optimum scheme for hydro-electric power development on the Project based on examination of topography, geology, hydrology, economy, etc., and especially by the newly restituted 1/20,000-scaled topographical map, it was found that at the damsite (Site No. 3) proposed by MOTLIMA S.A. the reservoir capacity is greatly

y la mayoría del recorrido del canal túnel, reciben limitaciones del orden geográfico y se hace prácticamente imposible diseñar el proyecto, evitando estas zonas de rocas calizas. Como resultados del recorrido de reconocimiento en sitio de estos lugares y del estudio de reconocimiento geólogico de las fotografías aéreas, se considera que en la zona del Proyecto en la cual gran parte de los estratos del subsuelo está formada por rocas calizas, hay gran posibilidad de producirse gran cantidad de agua provenientes ya sea de infiltraciones del agua de los cimientos de la represa y del reservorio, debido a erosión del tipo Kárstico y de emanaciones de agua durante las obras de construcción de los túneles.

La impermeabilidad de la roca de los cimientos de la represa y del reservorio afecta la posibilidad de realizarse el proyecto. Por consiguiente, para la realización del presente Proyecto se debe hacer un estudio y reconocimiento muy intensivo para su selección final. Pero, por el momento, hemos efectuado estudios al respecto, de acuerdo con los datos disponibles y dentro del alcance de reconocimiento realizado y hemos seleccionado la ubicación de la represa y la ruta de recorrido de la canalización del agua, buscando la ubicación con menos problemas con respecto a estas consideraciones.

(3) Los datos hidrológicos, absolutamente necesarios para el proyecto de construcción de una Central Eléctrica, no existen en cantidad suficiente en la actualidad, en lo referente al estudio del presente Proyecto. Por esta razón se ha estimado el caudal en el punto del Proyecto, a base de los datos hidrológicos de los ríos vecinos y los datos pluviométricos. Se espera en el lugar de ubicación de la represa un caudal con un gasto promedio anual de 9.7 m^3/seg. y el caudal promedio de 2.7 m^3/seg. durante la época seca de Junio a Setiembre.

(4) Se ha confeccionado el plan óptimo como proyecto de instalación de una central hidroeléctrica en la cuenca del Río Yangas, teniendo en cuenta su topografía, geología, hidrología, y el aspecto económico. Como resultado de este estudio, se considera que la ubicación de la represa propuesta originalmente por MOTLIMA (el punto No. 3) es inadecuada desde el punto de vista de la economía y geología y por causa del menor volumen de

reduced from that which was estimated by them, while also from the aspect of geology, the site is judged unsuitable for a dam. It was found that the most suitable scheme is to construct a dam of 82 m high at the Platanal site (Site No. 1) approximately 7 km upstream from Site No. 3. As for the location of the powerhouse, the most suitable place is the Bombón site (Site No. 3) approximately 15 km downstream from the damsite providing an effective head of approximately 620 m and maximum output of 50 MW. After rough calculations of the benefits of the Project with the generating cost of a thermal power station as the index, the benefit-cost ratio (B/C) in load factor of 60% was found to be 1.09. In case of load factor of 30%, the benefit would be improved further because of the characteristics of the site and the B/C-value would become 1.33.

(5) In order to determine the priority of the Yangas Project among the other potential hydroelectric power projects in the region concerned, three other promising projects (Crisnejas, Carhuaquero, San Juan) were selected, and based on survey reports already prepared in the past and using standards identical to those for the Yangas Project, the economic evaluations for these projects were reviewed, leaving the original details of the scheme for each site unreviewed. As a result, the benefit-cost ratios of the above three projects ranged between 2.12 and 1.73, and it was generally concluded that the Yangas Project (B/C = 1.33 - 1.09) would be inferior to the other sites.

(6) As stated above, it has been found that the Yangas Project will not be as advantageous as it had generally been considered up to the present. This is because the physical features have been made clear from the newly prepared topographic map and from investigation and study, and such good

almacenamiento del agua de lo estimado originalmente, según el análisis del plan topográfico de escala de 1/20,000 preparado recientemente por INIE, y que es mucho mejor el punto del Platanal a aproximadamente 7 km aguas arriba del mismo (punto No. 1) en donde se proyecta la construcción de una represa de 82 m de altura. Por otro lado como ubicación óptima de la central se considera como la más apropiada, el lugar de Bombón a más o menos 15 km aguas abajo de la ubicación de la represa con una caída efectiva de aproximadamente 620 metros, y capacidad máxima de 50 MW.

Como resultado del estudio sencillo del aspecto económico, contando con los datos disponibles, la relación Beneficio-Costo (B/C) en que se toma como índice el costo de generación de una central térmica, resulta en valor de 1.09 para factor de carga de 60%. La relación para factor de carga de 30% resulta en valor de 1.33, la cifra poco mejor, que el caso de factor de carga de 60%, por las características propias del lugar.

(5) Con el objeto de ubicar el orden de mérito del Proyecto del Río Yangas, dentro de los otros proyectos hidroeléctricos de la zona en referencia, se han escogido otros 3 proyectos importantes (Crisnejas, Caruhuaquero, San Juan) y se revisó la evaluación económica de estos tres proyectos, utilizando los informes disponibles existentes y la misma base que en el caso de la Central de Yangas. En este caso se consideraron los proyectos de cada lugar en la misma forma como han sido presentados originalmente, para revisarse solamente la evaluación económica.

Como resultado de este estudio comparativo de la evaluación los índices Beneficio-Costo (B/C) de los tres proyectos resultaron ser de 2.12 - 1.73, indicando que si se toma en cuenta el factor económico, el proyecto de Yangas (B/C = 1.33 - 1.09) es más desfavorable, comparado con los otros.

(6) De todo lo expresado hasta el momento, se comprobó que el Proyecto Yangas no es tan favorable como se había pensado. Esto se debe a que como resultado del estudio de reconocimiento en sitio realizado en el presente estudio y del plano topográfico recientemente preparado, se ha comprobado de que no existe una buena ubicación de la represa y del canal

damsite and a relatively short waterway securing the necessary head as was previously expected do not exist.

2.2 Recommendations

Based on the foregoing conclusions the following recommendations are made:

(1) A necessity exists for a new power source to be developed as soon as possible, in the northern region of Peru.

(2) Since the Yangas Project will not prove to be as good a project as it was expected, in proceeding with this Project, prudent decision should be made carrying out more detailed investigations and studies of neighbouring hydroelectric projects and taking into consideration the progress of development of those other projects.

(3) In the future, should it become necessary to carry out this Project in step with changes in the power supply and demand situation, detailed investigations of the foundation bedrock of the limestone area should first be made to confirm whether the Project can be realized, following which more detailed surveys on topograpy should be conducted. With respect to hydrologic data, it would be desirable for detailed measurements to be started at an early date in order to accumulate as much data as possible beforehand.

comparativamente corto asegurando la caída necesaria que se había previsto originalmente, debido a la condición topográfica y geológica especial del lugar.

2.2 Recomendaciones

Conforme a las conclusiones mencionadas arriba, se hacen las siguientes recomendaciones;

(1) Es necesario hacer cuanto antes el estudio de desarrollo de nuevas fuentes de energía eléctrica en la zona norte de la República del Perú.

(2) El Proyecto Yangas no es un proyecto tan bueno como se creía originalmente y si se va a seguir adelante en este Proyecto, se deben tomar las decisiones en forma muy cuidadosa, teniendo en consideración los estudios y reconocimientos más completos de otros proyectos de generación hidroeléctrica en las vecindades del lugar y de acuerdo al estado de avance de estos otros proyectos.

(3) En el caso en que sea necesario realizarse este Proyecto según el cambio en el futuro de la relación entre la demanda y suministro de energía, primeramente se deberá efectuar los estudios detallados sobre la roca caliza de los cimientos y reconocer la factibilidad del Proyecto, y luego seguir los estudios más detallados sobre la topografía. En cuanto a los datos hidrológicos, se recomienda que se debe iniciar cuanto antes las mediciones para acumular los datos hidrológicos.

CHAPTER 3

OUTLINE OF RELATED AREA

FIGURES

TABLES

CHAPTER 3 OUTLINE OF RELATED AREA

3.1 Extent of Related Area

The nuclei of development in the northern region of the Republic of Peru are comprised of industries centered around Trujillo and Chimbote at the southern part of the coastal strip, agriculture centered around Chiclayo, chemical industries centered around Talara and Bayovar in Department of Piura, and mining in the Andes mountainlands centered around Cajamarca.

The supply of electric power in this area, except for Trujillo and Chimbote which are serviced by a single power system, depends on isolated, independent systems. The Santa Power System (180 MW) for Trujillo and Chimbote is to be interconnected in the near future with the Central Power System of Lima by a 220-KV transmission line to improve its reliability. The other areas would be supplied with electric power through interconnections made with the Santa Power System as time goes by in accordance with growths in power demand.

The Yangas Project is a scheme for power generation on the Yangas River, and is located in Celendín Province of Department of Cajamarca in the Andes Highlands. It's power generation will not only be supplied to the Michiquillay Mines near the city of Cajamarca, but will also become part of the supply capability along with other hydroelectric power stations for meeting the power demand of northern Peru. Consequently, as the extent of the related area, Department of La Libertad and the vicinity of Chimbote in Department of Ancash are contemplated besides Department of Cajamarca, while furthermore, Department of Lambayeque and Department of Piura in the north are considered as being indirectly related.

3.2 Natural Conditions

The Republic of Peru is on the Pacific Ocean side of the South American continent and is a country rather long in north-south direction situated between a point close to the equator and 18°21' south latitude, and between 68°39' and 81°20' west longitude. Based on the natural conditions, the geography of Peru may be broadly divided into three areas. These are the coastal area (Costa) along the Pacific Ocean where there is practically no rainfall throughout the year, mountain-land (Sierra) of the Andes Mountain Range located east of the Costa where high peaks of 5,000 m or more are stretching and the vast jungleland (Selva) to the east of the Andes occupying 50% of the entire national land area.

Department of Cajamarca in which the Yangas is located is in the highlands of the Sierra. And Cajamarca, the capital city of the department, is at an elevation of 2,655 m, while Celendín, the capital city of Celendín Province, is at 2,620 m. Temperatures is of Andes Highland nature with annual mean between 13° to 15°C with little fluctuation between extremes of hot and cold during the year. The period from October to April is rainy season, and unlike the Costa, there is annual rainfall of around 900 mm, but during the dry season from June to August, there is almost no rainfall.

Department of La Libertad, Department of Ancash, Department of Lambayeque and Department of Piura are located in the Costa and there is very little rainfall. However, because of less influence of the Humboldt Current (cold current), more rainfall can be expected than in the central and southern parts of the Pacific Coast area. This tendency for more rain is especially prominent in Department of Piura. Most of this area is a desert but agriculture has developed in the basins of rivers flowing down from the Andes Mountains and communities have been formed. The monthly average temperatures and rainfalls at Cajamarca, Celendín, Trujillo and Chiclayo are indicated in Tables 3-1 and 3-2.

Table 3-1 Monthly Mean Temperature at Northern Region of Peru

Unit; °C

Month / Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Cajamarca	15.3	15.3	14.8	14.7	14.8	14.4	14.4	14.7	15.1	15.2	15.1	15.4	14.9
Celendín	13.6	13.1	13.1	13.3	12.8	11.9	11.3	11.9	12.3	12.9	13.4	13.4	12.9
Trujillo	21.2	22.2	22.1	20.6	19.6	18.4	17.9	17.5	17.3	17.6	18.1	19.3	19.3
Chiclayo	24.2	25.5	25.7	23.9	22.4	20.5	19.6	19.3	19.4	19.8	20.7	22.1	21.9

Table 3-2 Monthly Average Rainfall at Northern Region of Peru

Unit; mm

Month / Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Cajamarca	83.9	88.2	113.6	102.6	34.1	7.6	6.4	11.0	32.1	80.0	75.6	85.7	720.8
Celendín	85.7	88.5	130.7	117.9	33.6	19.8	10.0	16.7	52.9	108.1	148.2	102.9	915.0
Trujillo	0.2	0.1	0.5	0.1	0.2	0.3	0.0	0.1	0.1	0.2	0.0	0.0	1.8
Chiclayo	1.2	1.0	2.5	1.8	0.1	0.0	0.1	0.1	0.3	0.8	0.6	0.4	8.9

3.3 Status Quo of Society and Economy

(1) Department of Cajamarca

Department of Cajamarca has a land area of 35,000 sq.km and a population of 920,000, and is a comparatively less developing department. As in other parts of the Sierra, the majority of the population is Indian although there is a substantial number of mestizos in the city of Cajamarca. Celendín is a relatively new town with population of about 16,000 including its urban area. The inhabitants at the Yangas site are all Indians (see Table 3-3).

Table 3-3 Population of Department of Cajamarca

Region	Population
Department of Cajamarca	920,000
Cajamarca City	62,000
Celendín Province	65,000
Celendín City	16,000

The principal industries of the department are agriculture and stock-farming, and their production in 1970 amounted to 1,380 million Soles. Mining focusing on copper in the area is very promising and although production in 1970 was only 199 million Soles (approximately 90% exported), a world scale development scheme for the Michiquillay Copper Mines, is presently going ahead between the MINEROPERU and the Japanese Michiquillay Mining Co., Ltd., and operations are scheduled to be started in 1980. The scale of ore extraction is planned to be 30,000 to 50,000 ton/day for annual production of 3,000 million Soles. This will moreover become almost entirely foreign exchange income. As for other industries, there is not much more than small-scale activity in dairy products and traditional cottage handicrafts.

The gross product of Department of Cajamarca in 1970 amounted to 160 million dollars which per capita was $176. For all of the Republic of Peru the amount was 5,200 million dollars and $399 per capita.

Since development of industry in Department of Cajamarca has been retarded, the transportation and communications systems are also poor. A road of approximately 180 km to Cajamarca from the Pan American Highway running along the sea coast is about 70% paved and will shortly become completely paved. Other roads in the department such as the one to Celendín which would be the road for transporting materials for the Yangas Project, and the road to Bambamarca all have poor surfaces and often become impassable during the rainy season. Between the cities of Lima and Cajamarca there is one aircraft flight available daily via Trujillo.

(2) Costa

(a) Inhabitants

Urban communities have been built at extremely limited parts of the desert and most of these have distinct characteristics such as Trujillo which has prospered from many years past, Chiclayo, a center of agriculture, and Chimbote, a new industrial center (see Table 3-4).

Table 3-4 Population of Coastal Region in Northern Peru in 1972

(Unit: in thousands)

Region	Total	Urban	Local
Department of Ancash	727	339	388
Chimbote City	167	159	7
Department of La Libertad	806	477	329
Trujillo City	134	127	7
Department of Lambayeque	515	377	139
Chiclayo City	156	149	7
Pacasmayo and San Pedro de Lloc' City	27	24	3
Department of Piura	855	444	441
Piura City	84	82	2
Talara City	30	30	
Republic of Peru	13,572	8,087	5,485

(b) Industry

The vicinity of Chimbote was in the past a poor agricultural village in the Santa River Basin, but a steel mill was built in 1943 and it has now become an industrial city of a population close to 200,000. This steel mill was nationalized in 1971 and now belongs to Empresa Siderúrgica del Perú (SIDERPERU). The greater parts of the city were destroyed by the earthquake which struck this area in 1970, but a recovery has been made and the present production of steel is 300,000 ton/year, while it is planned for expansion to 2,100,000 ton/year in 1980.

The city of Trujillo 130 km to the north of Chimbote is a town which has prospered from the past. A new industrial park is being constructed in the northern part of the city along the Pan American Highway, and ultimately, it is planned for this park to cover 1,740 hectares. The central industry will be related to automobiles while other mechanical processing factories are also planned.

The area covering from the northern part of Department of La Libertad to the southern part of Department of Lambayeque is an area where there is much agricultural activity utilizing water of such rivers as the Chicama, the Jequetepeque and the Chancay. The main crops are rice and sugar cane. On the Lambayeque River, Tinajones Dam for an irrigation reservoir was constructed in 1968 at a point approximately 60 km upstream from the mouth of the river. Also, an irrigation project for the Jequetepeque River is coming to realization.

Although the history of petroleum development in Peru is long, there have been no large oilfields discovered up to date. The vicinity of Talara in Department of Piura is the leading oil production area of Peru as of the present, but there has been a declining trend in production in recent years (see Table 3-5).

Table 3-5 Oil Production and Export-Import of Peru

Production	Talara and surrounding area (Including Continental Shelf)	21,748 (10^3 bbl)
	Others	840 (" ")
	Total	22,588 (" ")
Import	Crude Oil	11,074 (" ")
	Oil Products	4,450 (" ")
Export	Crude Oil	1,111 (" ")
	Oil Products	250 (" ")

However, stimulated by the successful development in neighboring Ecuador, geological surveys and trial drilling searching for oil on the Amazonas side have been under way recently, and a fair amount of production is already confirmed in the northern region. Construction of a pipeline to the Pacific Coast is necessary for petroleum transportation from the Amazonas side and laying of a line through the jungle area and across a pass in the Andes Mountain Range at an elevation of 2,400 m to reach Bayovar has been under construction. Bayovar is a desolate village at present, but will become a petroleum shipping port once the pipeline has been constructed.

A refining plant for the petroleum extracted in the neighboring area is located in Talara and its refining capacity is 64 kbbl/day, while at present, a gasoline production facility of 16.6 kbbl/day is being installed to meet the increased domestic demand. There is also a fertilizer plant being constructed in the vicinity with Japanese aid.

(c) Transportation

The Pan American Highway running along the coast line and connecting major cities is the principal means of overland transportation. This highway extends from Lima to Ecuador. Traffic is especially busy on the Chimbote - Trujillo - Pacasmayo - Chiclayo stretch and in 1970 there was traffic record of about 3,000 vehicles per day.

The ports of Peru are of relatively limited capacities. The port of Callao near Lima City is the foremost port of Peru and has the capacity to accomodate 26 ocean-going vessels. In northern Peru, Chimbote has a good natural harbor and is the best port in that part of the country. Other than these, there are substantial amounts of cargo handled at Port Salaverry having cities in the hinterland and

Port Talara, which is a petroleum base (see Table 3-6).

Table 3-6 Transportation at Port of Northern Peru in 1971

Port	Number of Vessels			Volume of Transportation (10^3 ton)
	Domestic	Foreign	Total	
Chimbote Port	151	150	301	1,198
Salaverry Port	145	107	252	880
Chicama Port	6	13	19	92
Paita Port	283	216	499	147
Eten Port	5	11	16	90
Talara Port	297	108	405	2,790

3.4 Electric Power Situation

The electric power industry in the Republic of Peru, both public and civilian, are under the jurisdiction of MEM. In 1972, ELECTROPERU was established and general power supply under national, local government and private operation, and private power generation by factories, were unified under this Corporation for a changeover to an integrated system operated by the state.

The total output of the electric power facilities in 1972 was 1,930 MW of which hydroelectric power stations comprised 1,057 MW. Private power generation facilities constituted 855 MW (see Table 3-7).

Table 3-7 Power Facilities in 1972

unit ; MW

Region	Organization		Power Generation		Total
	Public	Private	Hydro	Thermal	
Republic of Peru	1,075	855	1,057	873	1,930
Department of Cajamarca	7.1	8.0	5.3	9.9	15.1
Department of Ancash	149.7	57.2	106.5	100.4	206.9
Department of La Libertad	27.0	78.5	1.7	103.8	105.5
Department of Lambayeque	12.9	43.2	-	56.1	56.1
Department of Piura	31.9	12.0	0.5	43.5	44.0

Although there are no statistics on electric power consumption, annual energy production including losses during 1960 to 1972 showed annual growth rates of approximately 7.4% and the production in 1972 was 6,154 GWH. This amount, considered per capita, corresponds to 463 KWH/year/capita (see Table 3-8, Fig. 3-1).

Table 3-8 Energy Production in 1972

unit ; GWH

Region	Hydro	Thermal	Total
Republic of Peru	4,439	1,715	6,154
Department of Cajamarca	10.5	4.5	15.0
Department of Ancash	256.1	28.0	284.1
Department of La Libertad	-	301.2	301.2
Department of Lambayeque	-	153.6	153.6
Department of Piura	-	123.9	123.9

Consumption of electrical power energy is comparatively high in the departments in the Costa where development is more progressed among the various districts of the northern part of the country, but in Department of Cajamarca, the consumption is very small due in part to the shortage of power facilities (see Table 3-9)

Fig.3·1 Trend of Energy Production

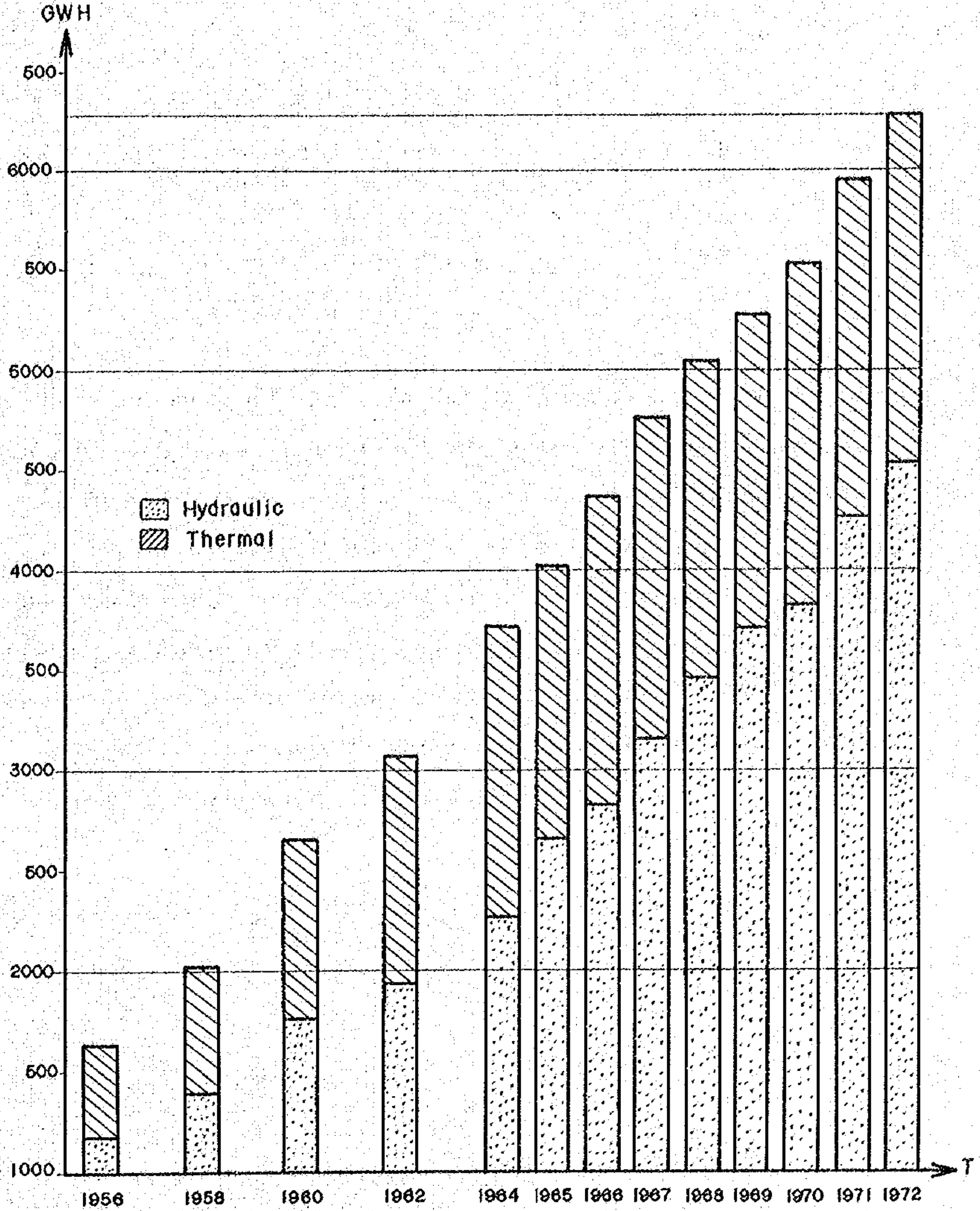


Table 3-9 Energy Consumption per capita in 1972

Region	Energy Consumption (KWH Per Capita)
Average of the country	463
Department of Cajamarca	16
Department of Ancash	390
Department of La Libertad	384
Department of Lambayeque	302
Department of Piura	145

The Republic of Peru, because of its geographic conditions and the scattered locations of its urban communities, has had only a limited electric power systems up to the present in extremely limited areas such as Lima. The majority of the cities are supplied independently with electric power chiefly through diesel generation, while factories are carrying out private power generation. Comparatively large-scale hydroelectric power development has progressed in recent years and power systems have been composed in part. It is the intention of the Peruvian Government to expand 220-kV interconnection transmission lines such as Lima-Chimbote Line throughout the country in the future.

CHAPTER 4

LOAD FORECAST AND DEMAND AND SUPPLY SCHEME

FIGURES

TABLES

CHAPTER 4 LOAD FORECAST AND DEMAND AND SUPPLY SCHEME

4.1 Area Contemplated

Various development projects are being planned in the northern part of Peru such as the industrialization schemes centered around Chimbote and Trujillo, the development of the Michiquillay Mines and of petroleum-related industries, and it is anticipated there will be rapid growth in the future in electric power demand.

The Chimbote district is the primary manufacturing area of northern Peru, and the proportion occupied by this district in the whole power demand of the northern region is fairly large. About 70% of the energy production of the existing Santa Power System is consumed in this district. The principal demand of this district is taken up by the state-owned steel mill SIDERPERU, and it may be said that the trend of power demand in the Santa Power System depends as of the present on the amount of production at this steel mill. SIDERPERU at present has established a plant expansion program and is aiming to increase its production. Besides, there are fish mill plants and a carbide plant (ENSA) in this district, while it is anticipated there will be introduction of new factories accompanying the progress in future development of the northern region.

In the northern part of Trujillo City, construction of a new industrial park comprised of various factories related to automobile manufacturing industries is being aimed for, and at present, the first-stage land levelling work has been completed. It is expected there will be an increase in power demand for this industrial city in the future.

The Cajamarca district is an area having agriculture as its central industry with lighting demand comprising the greater part of electric power demand, but since the start of operation of the Michiquillay Mines is planned in 1980, it is anticipated that there will be a considerable growth in power demand due to this mining industry and that the demand of this district will be much increased by it.

In the Pacasmayo district, development of a port accompanying the scheme of the Michiquillay Mines has been planned. There is also a cement plant of Cia. de Cemento Pacasmayo in the outskirts of the city which is at present owned half-and-half by government and private interests. The amount of cement production is presently 315 kt/yr, and the manufacturing facilities are scheduled to be doubled in 1978. There are also plans for introducing other manufacturing plants (asbestos pipe, cement pipe, etc.) into this district, although these have not yet reached the stage of materialization.

The Chiclayo district is an agricultural area centered around sugar cane and rice. There are plans for future expansion and improvement of farmland, and it will be a district in which agriculture would continue to be principal. With respect to electric power demand, it is conceivable for introduction of paper manufacturing using sugar cane bagasse as a raw material, but for the present, there are no concrete plans.

Department of Piura is a district in which there will be development in the future in many fields such as agriculture, fishing, mining and manufacturing. At present, the main industry is agriculture, particularly the cultivation of cotton for export purpose. Irrigation works are being carried out for the Chira district, and the Government is presently engaged in studies on the types of agricultural crops to be introduced in this district and schemes for processing them into finished products.

In the Paita district, with aid from countries such as the U.S.S.R. and Japan, it is being planned for equipping of fishing ports and introduction of marine products processing industries such as freezing, salting and canning. At Bayovar, there are plans for developing phosphate ores, and at present a pilot plant has been completed. The Government of Peru is now studying the terms of finance from various countries for development of this ore. There is also a plan for an oil pipe-line of 970 km crossing the Andes Mountain Range to reach Bayovar, with completion scheduled for the fiscal year of 1976. Accompaning to this schedule it is planned for construction of a port capable of accommodating oil tankers of 250,000 tons, and introduction of petrochemical plants is also being considered for the future.

Although on a small scale, petroleum is being produced in the desert area from Piura to Tumbes. A petroleum refinery is being expanded at Talara, while a fertilizer plant utilizing natural gas is being constructed with Japanese aid.

Electric power is being supplied to Piura by a private power distribution company, Empresa de Energía de Piura, and in 1973, the maximum demand and annual energy consumption were 11.2 MW and 45.6 GWH respectively.

The city of Talara is being supplied with electric power by ELECTROPERU with the maximum demand and annual energy consumption in 1973 being 9.6 MW and 66.0 GWH respectively.

Department of Tumbes is at the northernmost end of Peru and the principal industry is agriculture mainly consisting of rice and bananas. Although there are presently plans for development of agriculture and tourism, a large-scale increase in demand is not expected in the future.

The Yangas Project is close to the Michiquillay Mines, Trujillo and Chimbote which are centers of current development schemes. In case this Project should be realized, it would naturally be added to Santa Power System centered around Chimbote and Trujillo, and moreover, interconnected with

Michiquillay. As for the Chiclayo area, interconnection with the Santa Power System is conceivable in the future when it becomes necessary from the standpoints of improvement of reliability and saving of reserve capacity. Further, with respect to the two departments of Piura and Tumbes, even though there may be a possibility for demand to grow rapidly in the future, development schemes have not been finalized as yet and interconnection with the Santa Power System would be a matter for a considerably far future. In consideration of the above situation, load forecasts were made for the area mentioned below.

1. Department of Ancash
   Industrial area focusing on Chimbote and the existing Santa Power System
2. Department of La Libertad
   Industrial areas of Trujillo and Pacasmayo
3. Department of Lambayeque
   Urban communities centered around Chiclayo
4. Department of Cajamarca
   Michiquillay Mines and urban communities centered around Cajamarca

4.2 Load Forecast

The load forecast has been made using as a basis the forecast values of Informe No. 001 EM/DGE/DPE/COEPA "Análisis de Oferta y Demanda del Sistema Lambayeque-La Libertad-Ancash-Cajamarca 1975 - 1985" prepared in January 1974 by MEM, and referring to the information listed below.

1. Demanda y Oferta de Energía Eléctrica en la Región Energética Norte, June 1972 (Prepared by Cooperación Energética Peruana-Alemana para la Planificación Integral de Energía)

2. Forecast of demand accompanying expansion project for SIDERPERU (Prepared by MEM)

3. Forecast of demand accompanying to the development of Michiquillay Mines (Michiquillay Copper Corporation)

4. Avario de Estadística, 1971 and 1972 (Prepared by MEM)

5. Report on Basic Survey of Cajamarca Area Development Program, Republic of Peru (Prepared by the Metal Mining Corporation of Japan)

6. Data on actual demand and load characteristics in most recent years obtained in present field investigations.

As for the period of the load forecast it would be adequate, as a basic information for the timing and scale of the development of the Yangas Project and for the plan of expansion of the system, to estimate power balance for up to around 1985 emphasizing in the first half of the 1980s when large increases of demand are anticipated due to start of operations at the Michiquillay Mines and realization of the expansion program for SIDERPERU, the steel mill at Chimbote.

However, since the northern region is an area where there is great possibility of long-term development in the future, and as it would be desirable for a supply and demand scheme to be established for an even longer period, the period of the forecast has been selected to be from 1975 to 1990.

The results of the load forecast, indicated in Table 4-1, are generally described below. Electric power demand is governed to a large extent by the degree of progress in industrialization. The industrialization program for northern Peru has only just begun and the various schemes have large undecided aspects. Consequently, forecast values are presented here with some amount of latitude.

Figures in the load forecast which are not in parentheses are generally reasonable as forecast values for the future based on the present rate of growth in demand, the concrete natures of plans such as for plant expansion, and their certainties of realization. Maximum values of demand which could be expected in case there should be new construction and expansion of factories, and if increases in production quantitites are vigorously pushed forward in the future, are indicated in parentheses. For the later years, these values are practically the same as those estimated by MEM. As for the immediate years from now, the forecast values of MEM are reduced in accordance with the present state of progress in the industrialization program.

The load forecasts by area are given in Table 4-2 to Table 4-7

The power demand of Chimbote is greatly influenced in particular by the production plans of SIDERPERU. The maximum demand and annual energy consumption of SIDERPERU for 1973 were 48.8 MW and 184.4 GWH respectively, which comprise 89% of the maximum demand and 77% of the annual energy consumption for the Chimbote area. SIDERPERU has plans for expanding facilities in three stages, in 1975, 1978 and 1982, and at these times, therefore, it is expected there will be sudden growths in demand accompanying increases in production quantities of steel.

Fish mill factories have been practically idle from 1973 because of recent poor catches of "anchova", and it is thought the growth in power demand for fish mill in the future will also be small.

The forecast values of MEM are adopted without modification in estimating the individual loads of Chimbote, SIDERPERU, fish mill factories, etc., while demands of factories to be newly introduced in the future are considered to be from 1978 at the earliest in view of the present progress in industrial development.

According to these load forecasts, there will be rapid growth in demand up to 1980 due to the expansion program of SIDERPERU with growth in maximum power demand averaging 11% per year and growth in annual energy consumption averaging 13% per year, but after 1982, when the expansion program will have been completed, there will be a sudden drop in the growth rate.

Callejon de Huaylas is a mining district in the inland part of Department of Ancash where in 1973 maximum demand was 2.3 MW and annual energy consumption 8.9 GWH. The growth rate in demand (annual energy consumption) during the past several years has averaged about 5%. But two mining development projects of Antamina and Santa Luisa will be added in 1977 and a prominent increase in energy demand is anticipated. The figures of MEM have been adopted for this forecast.

The electric power demand of Trujillo was 14.5 MW in terms of maximum demand and 48.8 GWH in annual energy consumption. The growth rate in annual energy consumption during the past five years was approximately 10%. Land levelling work has just been completed on 50 hectares of land for the new industrial park and it is judged that conspicuous increase in demand will be from 1978 at the earliest. The central industries will be related to automobiles, and assuming there will be automobile plants, foundries, tractor and agricultural implements factories, forecast has been executed on the basis of the abovementioned information 4.2 (1).

The 138-kV power transmission line from Trujillo to Santiago de Cao is presently in the designing stage and it is thought now that completion will be in 1976 two years behind the orginal schedule. Therefore, it is estimated that the time at which the paper mill (TRUPAL) and the sugar refinery (Cartavio) at Santiago de Cao could be incorporated in the Santa Power System will be in 1977. The forecast values for these plants are estimated to be lower than those of MEM by the amounts due to the periods of delay in their incorporation into the system.

The lighting demand of the area including Pacasmayo and surrounding communities is about 1.3 to 1.5 MW and this is being met by private and local government supply capabilities (total 2.2 MW). The greater part of electric power demand in this area is made up by the requirements of a cement plant and this is presently being met with private generating facilities (effective output 7 MW), but it is scheduled for production facilities to be doubled in 1978. The demand after the expansion is estimated to be about 15 MW.

The demand due to expansion of port and harbor facilities in connection with development of the Michiquillay Mines is included in the load forecast for Pacasmayo and its surroundings. The timing of interconnection of the Pacasmayo load with the Santa Power System will be governed by whether or not the route of the Trujillo to Michiquillay transmission line will pass Pacasmayo. If things go well, interconnection with the Santa Power System will be made in 1980.

The electric power demands of the Cajamarca and Michiquillay districts will be incorporated in the Santa Power System from 1980 when operation of the Michiquillay Mines will be commenced. The load forecast for the Michiquillay Mines, including the demand of the mining town which will be born accompanying to this development of the mines, has been made assuming ore extraction of 30,000 to 50,000 ton/day in the first year and 40,000 to 60,000 ton/day from 1985.

The power demand of Cajamarca in 1973 was 1.7 MW in terms of maximum demand and 5.1 GWH in annual energy consumption. In the load forecast for this city, estimates have been made using the recent growth rate of 11% per year for the period up to 1980, while from 1981 and thereafter, it is considered that the increase in power demand will become relatively stable with the Michiquillay Mines entering production, and a growth rate of 5.5% per year has been used.

The load forecast figures for Chiclayo include, besides the load of Chiclayo, the loads of small communities surrounding Chiclayo such as Monsefu, Eten, Lambayeque, Pimentel and Ferrenafe. The present power system of Chiclayo is short of supply capability and it is anticipated that the growth rate of power demand will rise up as supply capability is secured in accordance with future progress in the industrial program.

The maximum growth rate during the past ten years of 12% has been adopted for the forecast. As a result, the maximum demand will be 35 MW in 1985 and 51 MW in 1990, and unless incorporation of new factories is vigorously pressed, demand of 78 MW at which interconnection with the Santa Power System will become advantageous will not be reached. (Note: see previously mentioned information 4.2(5)) The Chiclayo area is envisioned as an industrial area focusing on agriculture even in the future and it is inconceivable that there will be a spectacular increase in demand. For this reason, the demand of this area is not included in the total demand of the entire power system of the northern region (hereinafter referred to as Expanded Santa Power System).

4.3 Load Curves

In establishing a power supply and demand scheme, it is important to investigate the characteristics of all of the various loads in the system and to grasp the characteristics of the demand from the daily load curve through aggregation of these loads. The form of the daily load curve of the existing Santa Power System is shown in Fig. 4-1. This is the daily load curve for the entire Santa Power System prepared based on the typical individual load curves obtained from actual performances in 1973 and indicates characteristics typical of the system.

According to this, although the influence due to SIDERPERU is big in the Santa Power System, the load curve is levelled off considerably by the lighting demand during the night-time and the power demand is almost constant from 10.00 A.M to 10.00 P.M. However, with the future development of industry, the system would be expanded and it is anticipated that the shape of the load curve will become complex as various types of loads are added and lighting demand is increased.

The future load curve of the Santa Power System is estimated by obtaining the load curves of the individual loads from demand forecasts and characteristics of loads of such centers as SIDERPERU and Chimbote and making a composite from them. The weekday daily load curves for the various areas and the Expanded Santa Power System forecast for the phase of 1982 are indicated in Fig. 4-2. The reason for adopting the 1982 phase is that this will be a time corresponding to the middle of the forecast period, while the major industrialization plans which have now become concrete will all have been realized to an extent so that it is considered that subsequent increase in power demand will show a stable growth. It is further considered for this reason that this load curve will be fixed for some time because of the structure of power system, therefore this will make it convenient to estimate the entire forecast period.

The daily load curves for weekdays of factories and other consumers in the various areas are shown in Fig. 4-3 to Fig. 4-7, and it is considered there will be no substantial variation in their shapes throughout the year except for special cases such as major changes in production plans should happen.

According to the daily load curves in Fig. 4-2, the peak values of power demand come between 7.00 P.M. and 8.00 P.M., or the so-called lighting hour band. Since it cannot be thought that there would be much change over the years in the form of the daily load curve of each unit load, this characteristic is maintained in the daily load curve of the Expanded Santa Power System from 1982 and thereafter when a new power generation project is estimated to be incorporated. This is because whereas the growth in factory demand which makes up the principal part of power demand during the daytime becomes stabilized, the lighting power demands of cities such as Chimbote and Trujillo are expected to continue to increase greatly during the lighting time band, while the factory demand also during this hour band will not be small.

Consequently, by determining the power demand during 7.00 P.M. to 8.00 P.M. for all loads of the various areas, the values obtained through synthesis for the entire power system may be deemed to be the maximum power demand for the Expanded Santa Power System. The trend of variation for each period in the daily load curve of the Expanded Santa Power System is given in Fig. 4-8. As the Santa Power System is expanded to include Pacasmayo, Michiquillay, etc., as lighting demand is increased and as the increase in factory demand become stabilized, the peak demands during the daytime and the lighting hours will become prominent.

It will be necessary to secure a supply capability at all times, which can meet the increasing and becoming more complex demand. But as the hydro and thermal power stations composing the supply capability possess individually different characteristics (operating output, operating time, adaptability for load changes, etc.), it is necessary to understand well the characteristics of these supply capabilities and to let them operate to be able to fully demonstrate their features in order to carry out electric power supply in a stable and economical manner. Accordingly, in promoting future development of supply capability, it is important to study for a new power generation source, which part of the load curve (peak, base or intermediate portion) this project should be assigned to in the consideration of its role in the present supply capabilities along with the actual circumstances of the system.

4.4 Power Supply Scheme

The balance of demand and supply of the Expanded Santa Power System prepared based on the aforementioned load forecast is indicated in Table 4-8. Diesel generators of small capacities have been excluded from the supply capability in this case. Although the supply from the Central Power System through the Lima-Chimbote Transmission Line should naturally be considered, the demand and supply balance of the Expanded Santa Power System only in the northern region is studied for the time being.

According to the study, demand cannot be met beyond 1977 with the present power sources only of the Santa Power System. ELECTROPERU started expansion works (100 MW - 150 MW) of Cañon del Pato Power Station in the Santa river system in October 1974 and is scheduled to be completed in 1978. Should this power station be completed as scheduled, the supply capability in 1978 will become 223 MW, but if the expansion plan of SIDERPERU proceeds as scheduled, the generating-end demand will be 238 MW, and a shortage in supply capability will arise. Therefore, a new additional supply capacity in 1978 will be desirable. However, the shortage will not be substantial at this time, and should there be difficulty in developing a new power source timely, supply from the Central Power System through the Lima-Chimbote Transmission Line scheduled to be operated in 1978 would be one method for the moment.

In 1980, there will be a marked shortage in electric power supply caused by start of operation of the Michiquillay Mines, and from the aspect of supply stability a new additional power source is desirable to be incorporated in the Expanded Santa Power System.

Regarding the timing of incorporation of Pacasmayo into the Santa Power System, it will be governed by the route of the Trujillo-Michiquillay transmission line, of which feasibility study has not yet been completed at the present time. But as it is assumed this interconnection to be completed in 1980 at the earliest, the balance of demand and supply is considered since 1980. In the case when Pacasmayo is not interconnected with the Santa Power System, the shortage in supply capability of the Expanded Santa Power System in 1980 would be alleviated by about 9 MW and the shortage would be around 82 MW. However, it is thought that the sortage in supply capability after interconnection in case of delay of interconnection will become approximately around the values given in the table.

Table 4-9 represents the forecast of future demand transition in the sending-end power and annual sending-end energy of the Expanded Santa Power System and it is desirable from the standpoint of reliability for a supply capability to have a reserve capacity of about 10%. The Sending-end demand has been obtained by estimating transmission losses (MW) in demand-end considering maximum power demands of the various demand ends in around 1990 and adding them to demand-end values (MW).

The sending-end energy (GWH) of the Expanded Santa Power System has been estimated by calculating the loss factor for this System from the experimental formula of Puller Woodrow as shown below and calculating the annual transmission loss in energy (GWH) taking into account the transmission loss (MW) at peak load hours and adding it to the annual demand-end energy.

$$p = 0.7 f^2 + 0.3 f$$

where

p = loss factor

f = load factor

Fig. 4-9(a) and Fig. 4-9(b) indicate power supply plans for the Expanded Santa

Power System prepared based on the above method.

It is considered to be appropriate for a load forecast to be estimated on supply forcasts based on plans which have high certainties of realization as previously mentioned and adding into account reserve supply capacity. This procedure was applied in making up the forecast using the followings as preconditions:

(1) Ten percent of the supply capability of the Expanded Santa Power System is considered to be reserve capacity from the standpoint of reliability.

(2) Although it is planned to secure necessary supply capability within the Expanded Santa Power System itself insofar as possible, in case a shortage in supply capability should occur, supplementation from the Central Power System through the Lima-Chimbote Transmission Line is considered.

(3) The steam power facilities at Santiago de Cao and Pacasmayo are to be considered as reserve capacity from the standpoint of economical operation of the system.

(4) The gas turbines at Chimbote and Trujillo are to serve peak loads only in consideration of the characteristics and economics of these generators and the capacity factor is considered to be 10% as a rule.

Curve (A) in Fig. 4-9(a) indicates the changes in supply capability of the Expanded Santa Power System estimated to be necessary as prepared based on the above preconditions.

The supply capability to be secured within the System must be estimated based on how to use the Lima-Chimbote Transmission Line. Curve (A) represents the supply capability estimated to be necessary taking into account reserve capability of 10% within the Expanded Santa Power System itself, on the other hand Curve (B) shows the supply capability required within the System in case of receiving power from the Central Power System up to the limit of transmission capacity (while single-circuit, 120 MW) of the Lima-Chimbote Transmission Line assuming there will be an adequate surplus in the Central Power System. The studies of the transmission capacity (while single-circuit) of the Lima-Chimbote Transmission Line are given in Appendix A from the standpoints of steady state stability and voltage.

Since it is considered difficult that development of new power sources other than the expansion work of Cañon del Pato will be carried out in order to cope with the shortage in supply capability during 1978 to 1979 because of lack of time, it is considered unavoidable to receive power from the Central Power System through the Lima-Chimbote Transmission Line to cover a shortage of the supply capability including reserve capacity, but it would cause enormous effects during faulting of the transmission line to depend too much on this means, and lowering of reliability of the system cannot be avoided. Therefore, even though for the time being the supply capability is to be secured in accordance with Curve (B), it will be desirable to switch to a supply capability according to Curve (A) at an earliest date as soon as possible.

4.5 Anticipated New Power Sources for Development

Although as stated in the preceding section the supply capability (including reserve capacity) which must be secured within the Expanded Santa Power System itself must be considered depending on how to use the Lima-Chimbote Transmission Line, it should be endeavored to secure the supply capabilities of Figs. 4-9(a) and 4-9(b) with respect to maximum power (MW) and annual energy (GWH) through development of various new power sources such as El Chorro Power Station, Yangas Project etc., and through receiving from the Central Power System via the Lima-Chimbote Transmission Line, while adequate characteristics must be prepared for proper operation of the system taking into account the load characteristics.

Figs. 4-10(a), (b) and Figs. 4-11(a),(b) indicate the daily load curves for maximum demand hours and holidays forecast each for 1982 and 1990. In 1982, with peak portions of load met by gas turbines and Cañon del Pato Power Station allocated to the base portion, there will be a necessity for development of new power sources to supply the remaining base portion and intermediate portion of the load. The daily load factor for all of the necessary newly developed power on weekdays and at peak hours will be around 86% (annual average daily load factor will be around 60%), indicating that new power sources should have strong traits of carrying rather base load.

In 1990, the distinctions between the base, peak and intermediate portions of load will become even more prominent, and the demand at the peak portion will also be large. Therefore, it will of course be needed at this time to aim for increase in supply capability to fill the base and intermediate load requirements, but it will also be necessary for addition of a new power source to cope with the portion of peak load. Therefore, in developing hereafter new power sources to be incorporated to the Expanded Santa Power System, it will be required for a method of development of projects which have proper functions from the standpoint of operation of the power system through paying thorough considerations on load characteristics.

If Yangas Project should be developed in the early part of the 1980s, it would be appropriate to be developed as a power station supplying the intermediate load from the standpoint of carrying load, but as will be explained in Chapter 7, the economics of the project will become better if the development is made to be a power source supplying the portion of the load close to the peak. A study of this matter will be made in detail in Chapter 8.

Fig. 4-2 Daily Load Curves of Expanded Santa Power System (Maximum demand in 1982)

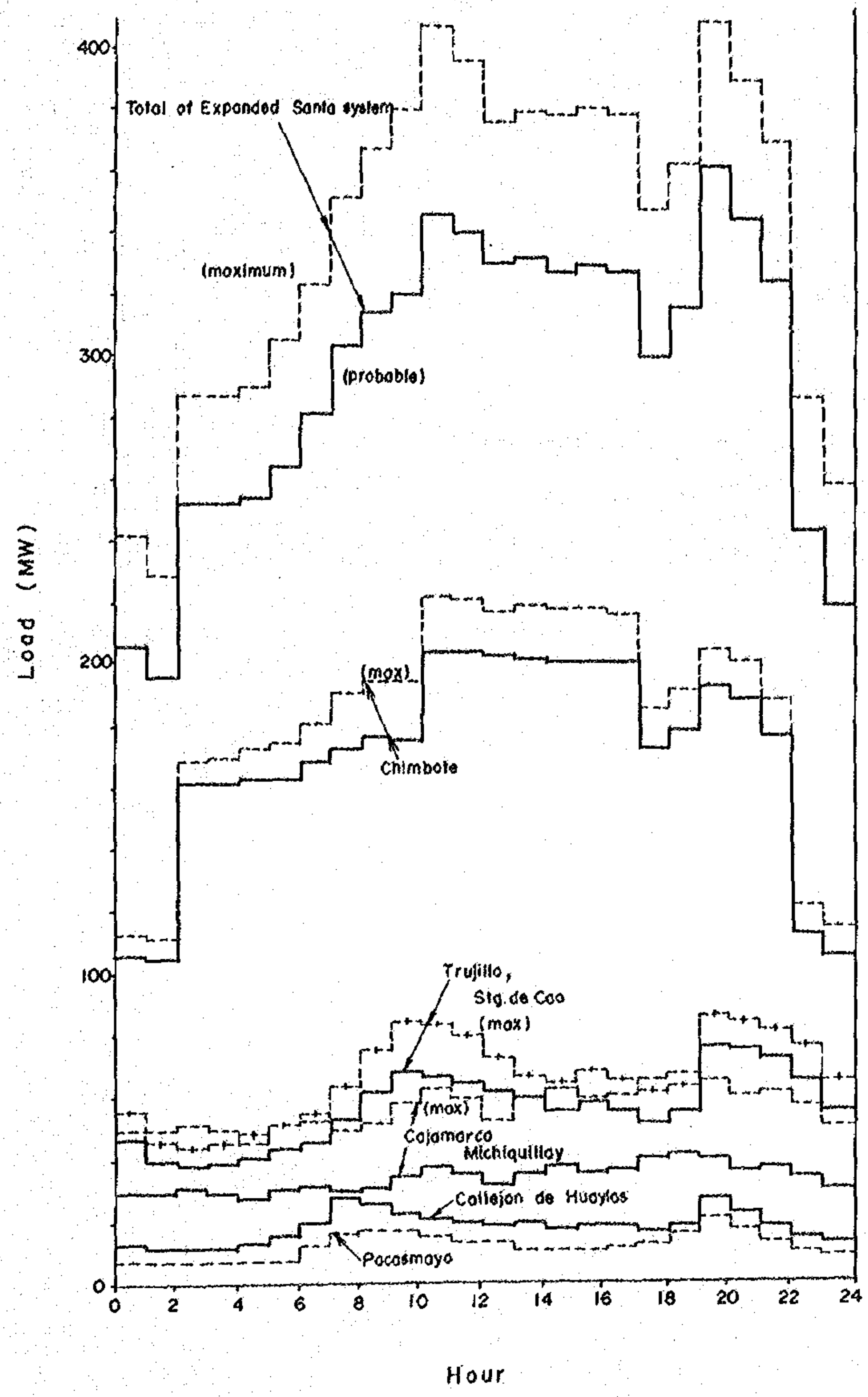


Fig. 4-1 Typical Daily Load Curves of Santa Power System (in 1973)

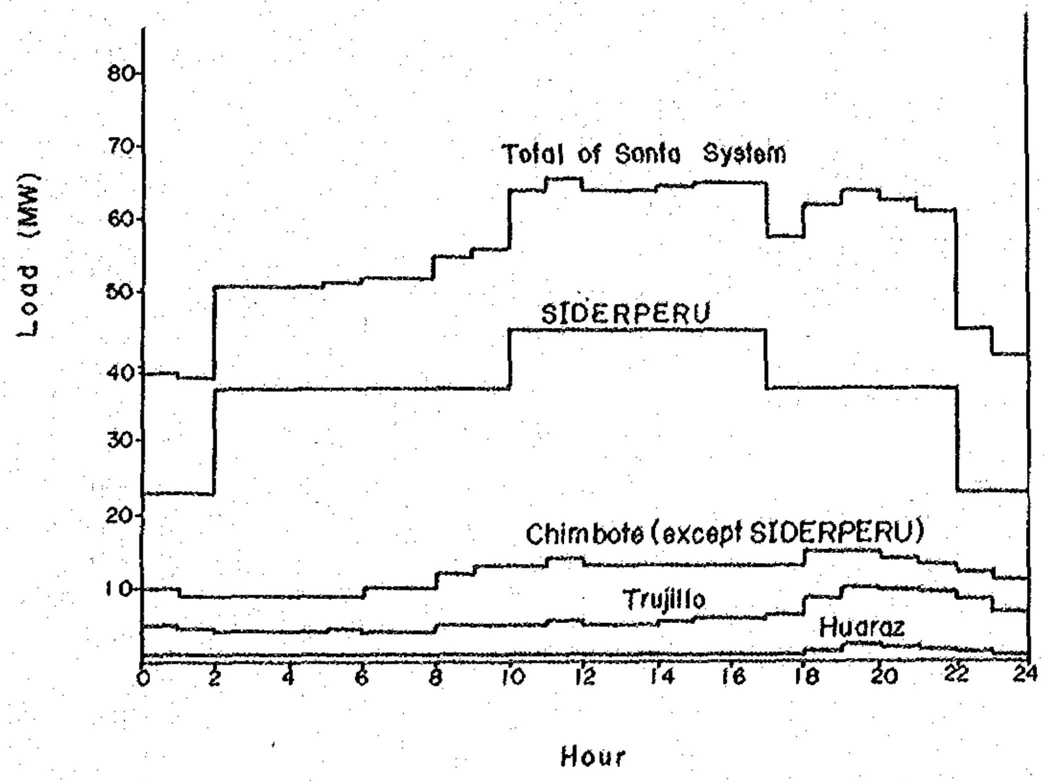


Fig. 4-3 Daily Load Curves of Chimbote Area (Maximum demand in 1982)

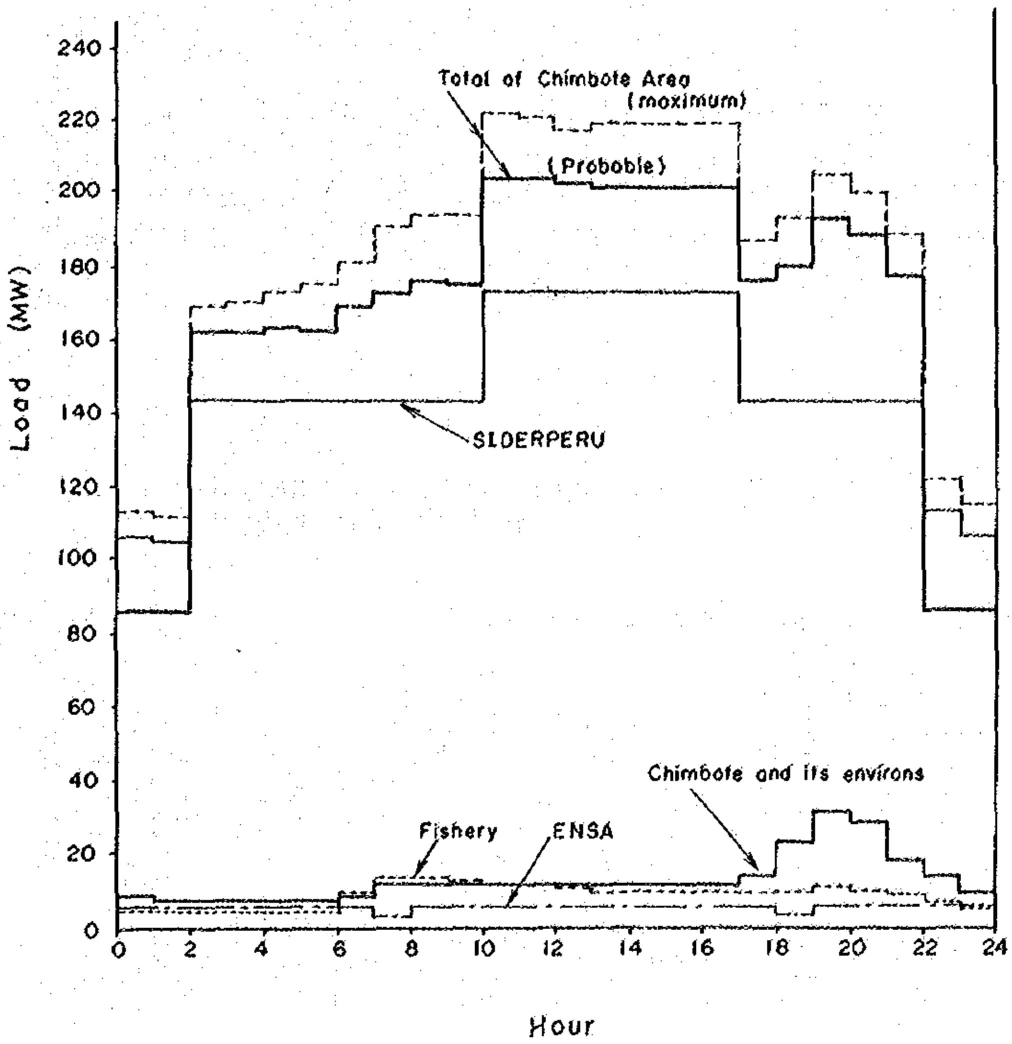


Fig. 4-4 Daily Load Curves of Callejon de Huaylas Area
(Maximum demand in 1982)

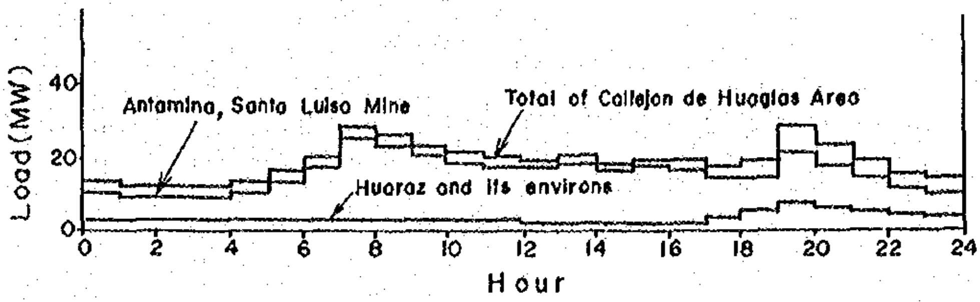


Fig. 4-5 Daily Load Curves of Trujillo and Stg. de Cao Area
(Maximum demand in 1982)

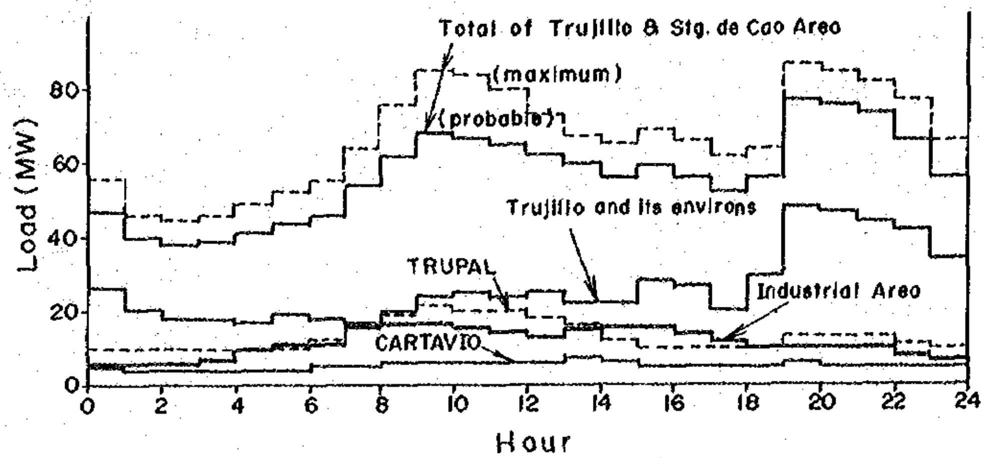


Fig. 4-6 Daily Load Curves of Pacasmayo Area
(Maximum demand in 1982)

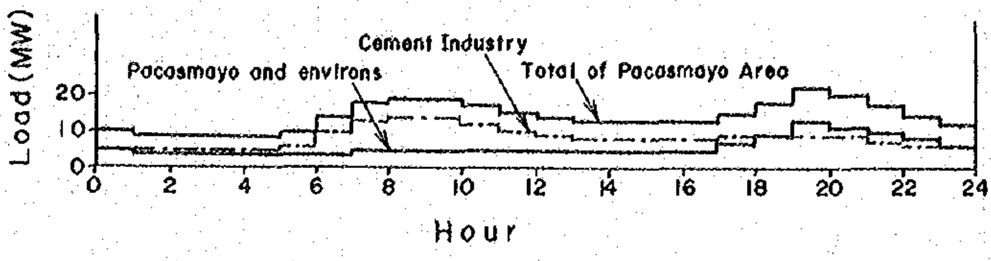


Fig. 4-7 Daily Load Curves of Cajamarca and Michiquillay Area
(Maximum demand in 1982)

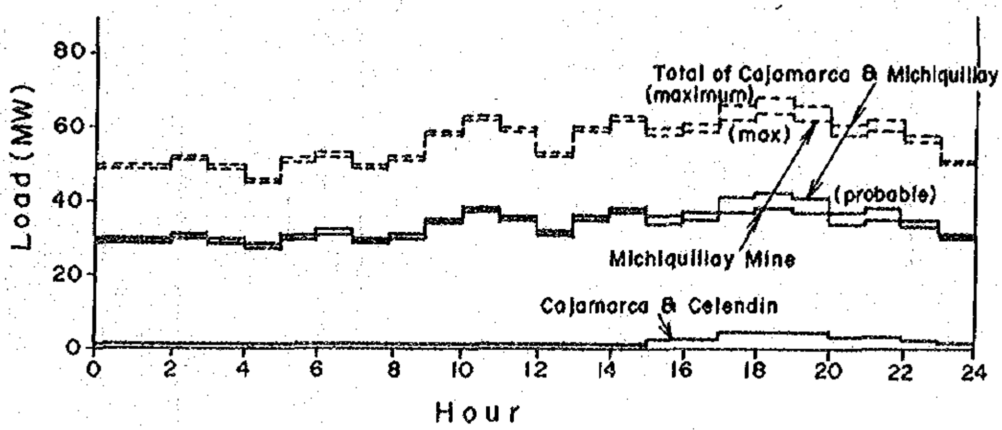


Fig. 4-8 Daily Load Curves of Santa Power System (Maximum demand)

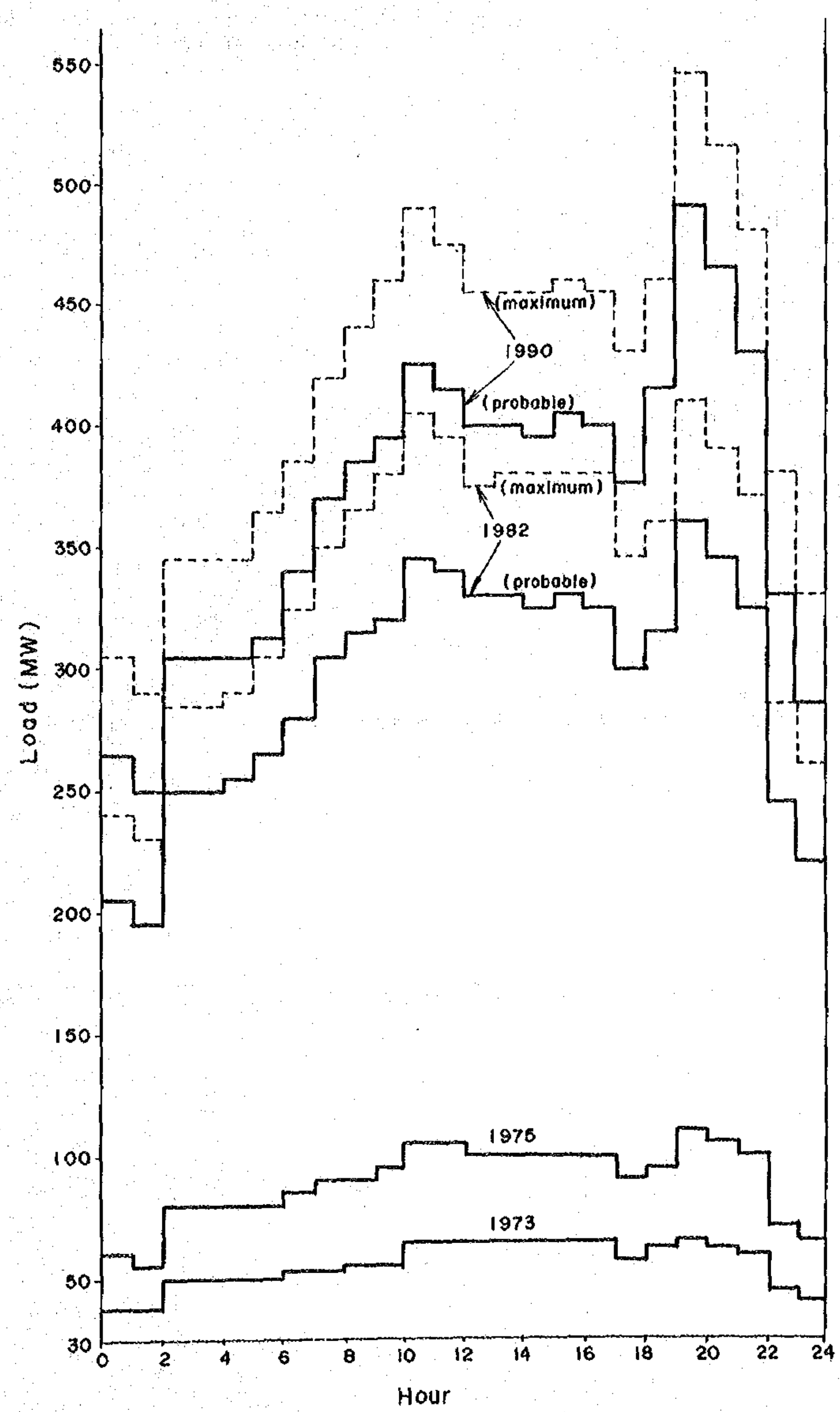


Fig. 4-9 (a) Power Demand and Required Power Supply Capacity of Expanded Santa Power System

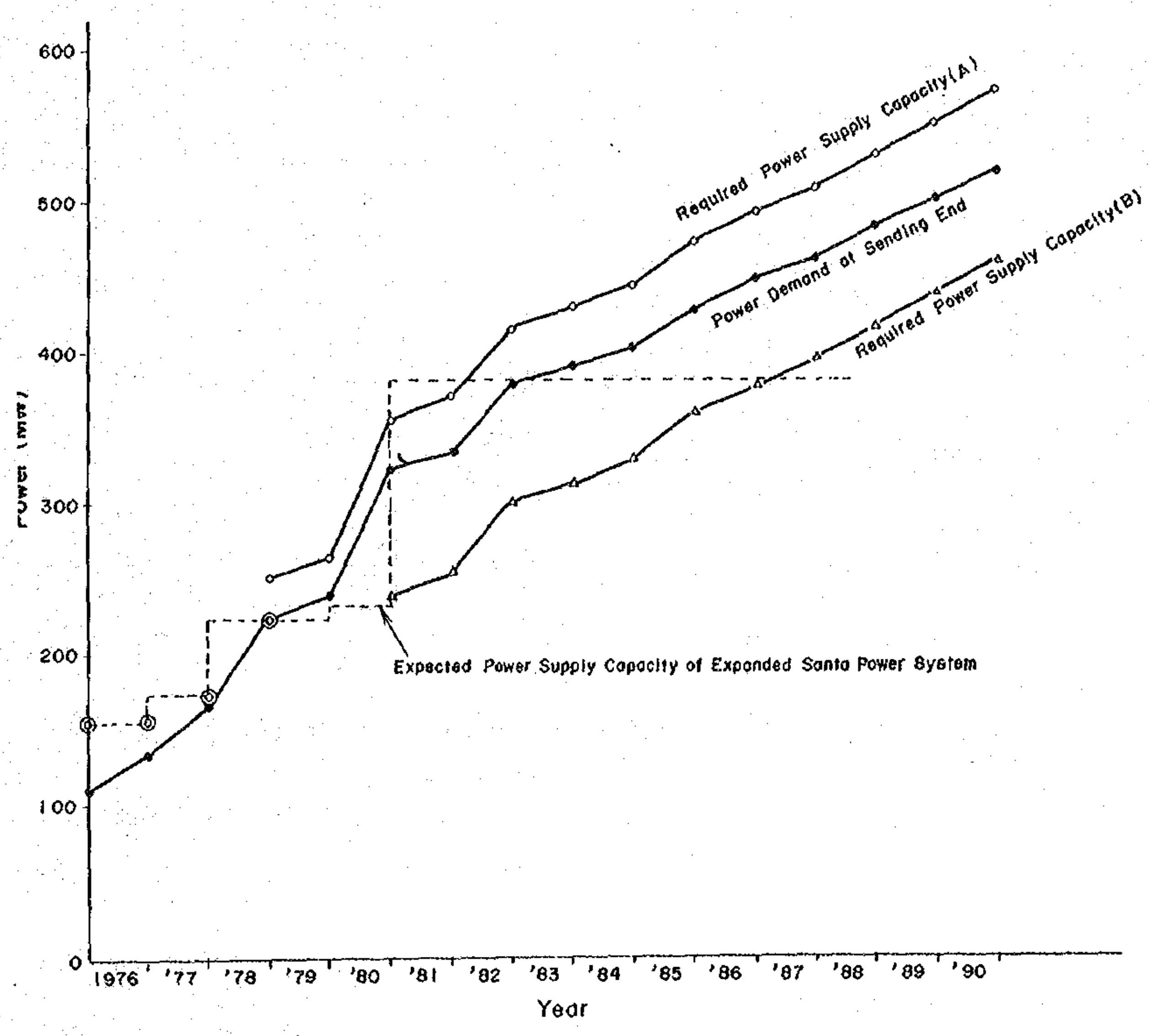


Fig. 4-9 (b) Annual Energy Demand and Power Supply Capacity of Expanded Santa Power System

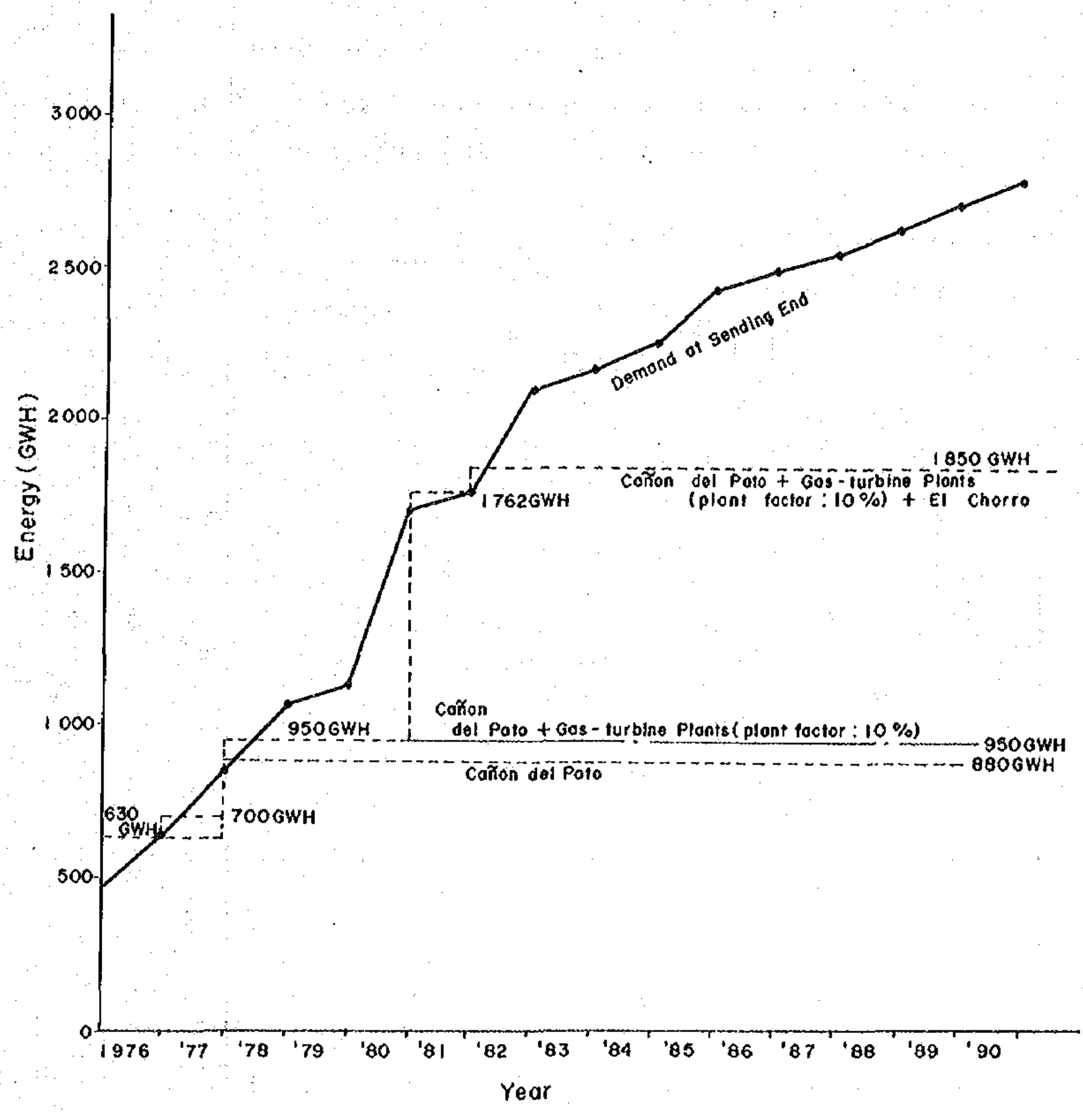


Fig. 4-10 (a) Load Duration Curve and Power Supply Capacity of Expanded Santa Power System (Maximum demand in 1982)

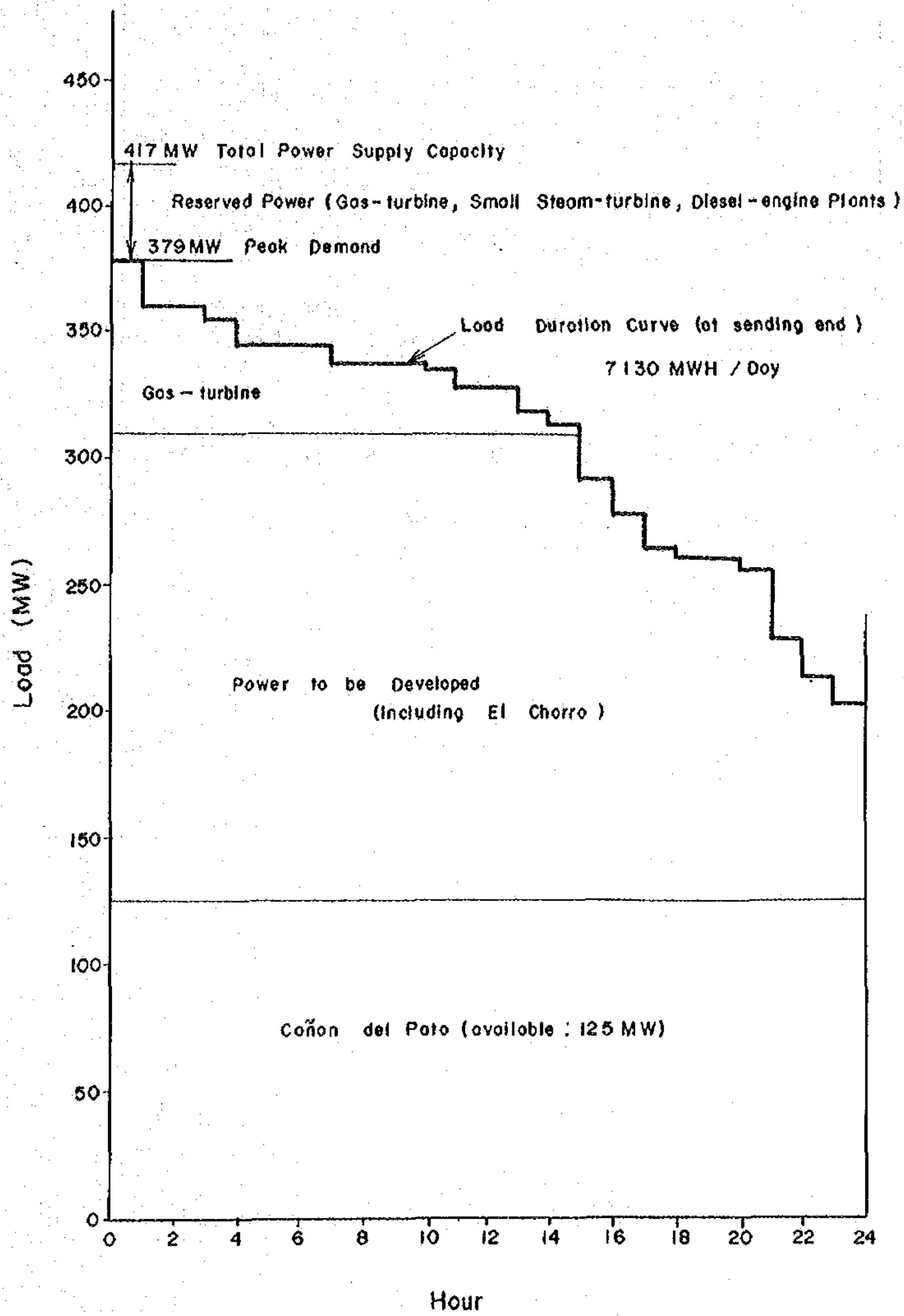


Fig. 4-10 (b) Load Duration Curve and Power Supply Capacity of Expanded Santa Power System (Holiday in 1982)

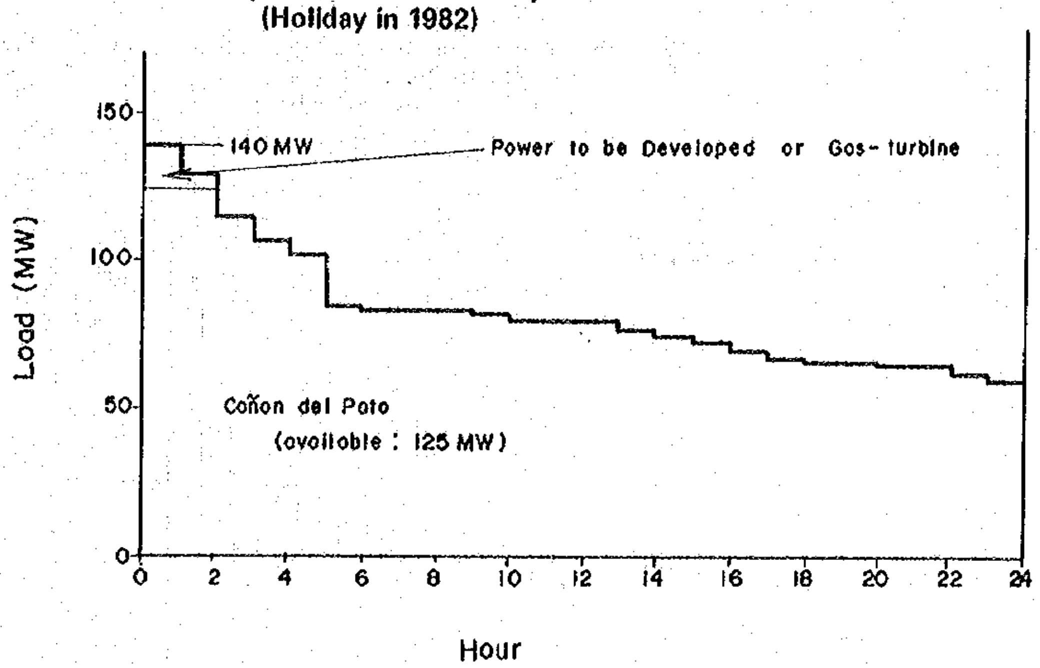


Fig. 4-11 (a) Load Duration Curve and Power Supply Capacity of Expanded Santa Power System (Maximum demand in 1990)

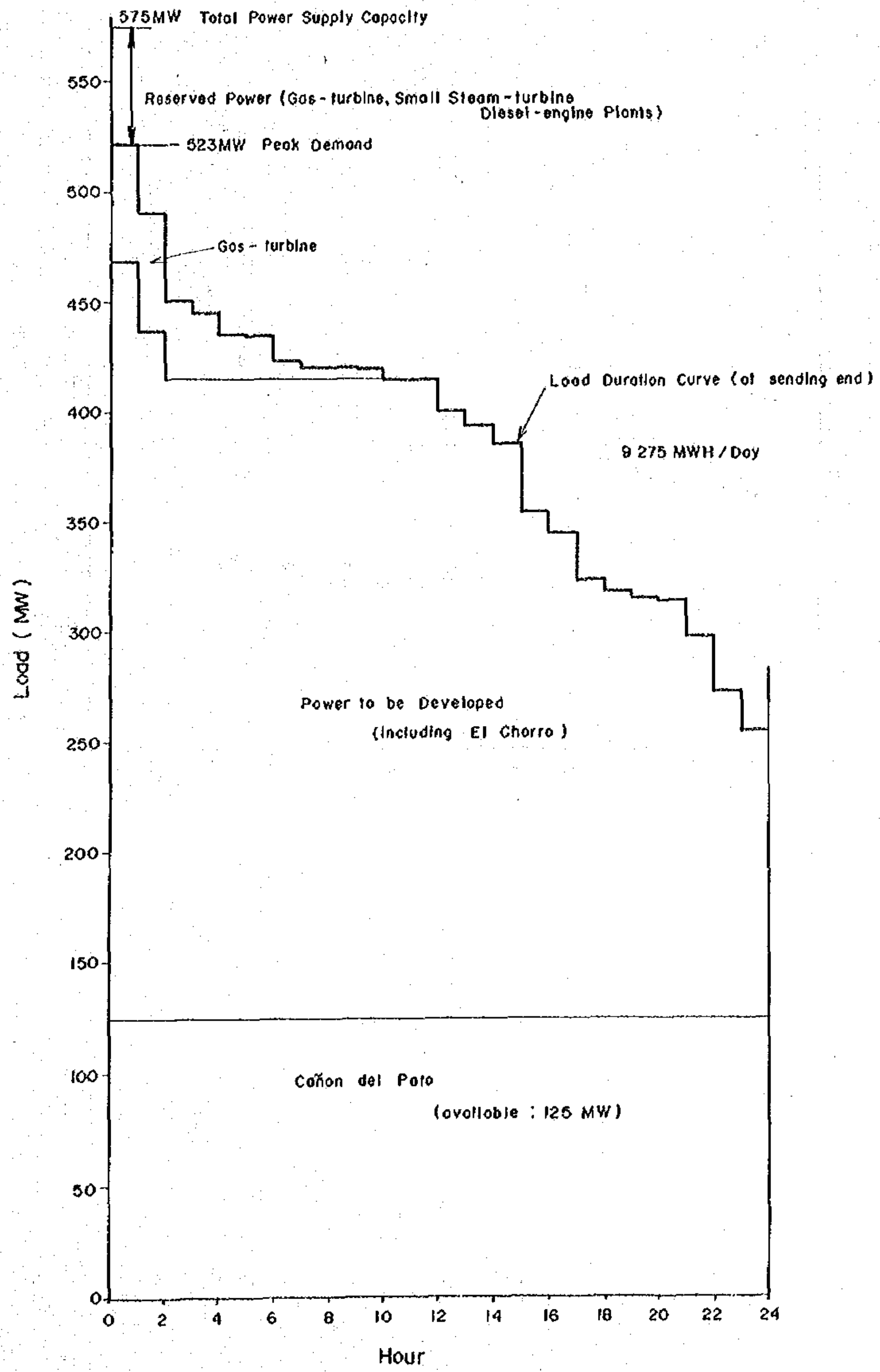


Fig. 4-11 (b) Load Duration Curve and Power Supply Capacity of Expanded Santa Power System (Holiday in 1990)

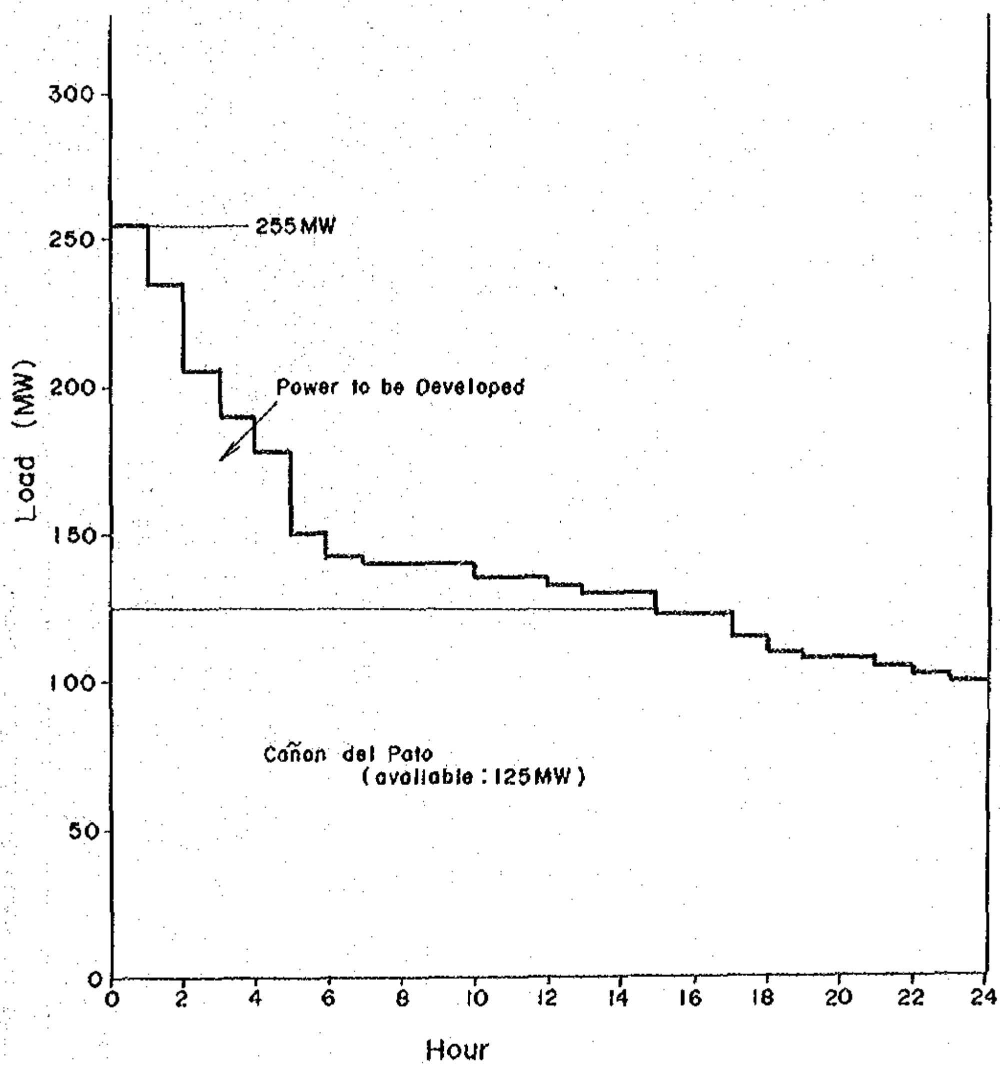


Table 4-1 Load Forecast of Northern Region (Expanded Santa Power System) - Maximum Demand (MW) and Annual Energy Consumption (GWH)

Region	Item	Unit	1972 Actual	1973 Actual	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1990
Chimbote	Maximum Demand	MW	48	55	91	111	112	(177) 163	(180) 166	(189) 171	(190) 172	(222) 204	(224) 206	(231) 211	(232) 212	(239) 219	(251) 238
	Annual Energy Consumption	GWH	188.2	241.4	369	533	542	(754) 693	(785) 722	(864) 793	(898) 828	(1169) 1099	(1221) 1151	(1268) 1189	(1307) 1229	(1352) 1273	(1450) 1366
Callejon de	Maximum Demand	MW	2.6	2.3	4	5	15	17	17	27	28	28	28	29	29	30	31
Huaylas	Annual Energy Consumption	GWH	7.8	8.9	9	9	82	92	92	160	161	162	162	163	163	165	167
Trujillo	Maximum Demand	MW	10.5	14.5	20	23	(47) 41	(59) 52	(67) 59	(73) 64	(79) 69	(87) 77	(91) 81	(95) 85	(102) 92	(113) 103	(139) 129
Stg. de Cao	Annual Energy Consumption	GWH	40.7	48.8	78	89	(255) 206	(313) 257	(350) 287	(380) 310	(412) 335	(447) 370	(462) 385	(485) 408	(516) 439	(560) 483	(661) 584
Pacasmayo	Maximum Demand	MW								17	20	22	24	26	28	32	39
	Annual Energy Consumption	GWH								87	93	102	111	118	123	133	148
Cajamarca	Maximum Demand	MW								(68) 42	(68) 42	(68) 42	(69) 43	(69) 43	(80) 55	(81) 56	(87) 57
Michiquillay	Annual Energy Consumption	GWH								(454) 290	(454) 290	(455) 291	(456) 292	(456) 292	(533) 383	(534) 384	(615) 387
Total	Maximum Demand	MW			115	139	(174) 168	(253) 232	(264) 242	(374) 320	(385) 331	(427) 373	(436) 382	(450) 394	(471) 416	(495) 440	(547) 494
	Resultant Maximum Demand	MW			108	130	(167) 161	(234) 218	(246) 229	(355) 309	(369) 322	(408) 361	(419) 372	(434) 386	(458) 411	(486) 439	(544) 492
	Annual Energy Consumption	GWH			455	630	(879) 830	(1159) 1040	(1227) 1101	(1945) 1639	(2018) 1705	(2335) 2022	(2412) 2099	(2490) 2177	(2642) 2343	(2744) 2445	(3041) 2664
	Load Factor	%			48	55	(60) 59	(57) 55	(57) 55	(62.5) 60.5	(62) 60	(65) 64	(66) 64	(65) 64	(66) 65	(64.5) 64.5	(64) 62

Note) The figures are resonable and appropriate estimates of power demand and annual energy consumption in view of the present progress of industrialization program, while the figures in parenthesis are the maximum estimates in case more vigorous industrialization is materialized. The latter for the later years is almost the same as the MEM estimate.

Table 4-2 Load Forecast of Chimbote Distruct

Load	Item	Unit	1972 Actual	1973 Actual	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1990
Chimbote and surrounding cities	Maximum Demand	MW	24.4	21.7	10	12	15	17	20	23	27	31	35	39	43	52	69
	Annual Energy Consumption	GWH	40.9	38.4	39	46	54	64	74	86	100	115	134	149	164	198	264
Fish Mill	Maximum Demand	MW			13	13	13	14	14	14	14	14	14	15	15	15	16
Industry	Annual Energy Consumption	GWH			27	28	28	29	29	30	31	31	35	35	36	37	38
SIDERPERU	Maximum Demand	MW	44.4	48.8	70	89	89	139	140	143	143	173	174	176	176	178	178
	Annual Energy Consumption	GWH	125.4	184.4	281	435	435	574	591	648	666	920	947	969	990	995	1014
ENSA	Maximum Demand	MW	5.3	4.2	5	5	5	5	5	6	6	6	6	6	6	7	7
	Annual Energy Consumption	GWH	19.8	15.7	19	21	22	23	25	26	28	30	32	33	36	40	47
Other	Maximum Demand	MW	0.6	0.6	1	1	1	(16) 1	(16) 1	(20) 1	(20) 1	(20) 1	(20) 1	(22) 1	(22) 1	(22) 1	(22) 1
	Annual Energy Consumption	GWH	2.1	2.9	3	3	3	(65) 3	(65) 3	(74) 3	(74) 3	(74) 3	(74) 3	(82) 3	(82) 3	(82) 3	(87) 3
Total	Maximum Demand	MW	48	55	91	111	112	(177) 163	(180) 166	(189) 171	(190) 172	(222) 204	(224) 206	(231) 211	(232) 212	(239) 219	(251) 238
	Annual Energy Consumption	GWH	188.2	241.4	369	533	542	(754) 693	(785) 722	(864) 793	(898) 828	(1169) 1099	(1221) 1151	(1268) 1199	(1307) 1229	(1352) 1273	(1450) 1366
	Load Factor	%	45	50	46	55	55	(49) 49	(50) 50	(52) 53	(54) 55	(60) 61	(62) 64	(63) 64	(64) 66	(65) 66	(66) 66

Note) Same as Table 4-1.

Table 4-3 Load Forecast of callejon de Huaylas

Load	Item	Unit	1972 (Actual)	1973 (Actual)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1990
Huaylas and surrounding cities	Maximum Demand	MW	2.6	2.3	3	4	5	5	6	6	6	7	7	8	8	9	10
	Annual Energy Consumption	GWH	7.8	8.9	9	9	9	10	10	11	12	13	13	14	14	16	18
Antamina and Santa Luisa Mines	Maximum Demand	MW					12	14	14	25	25	25	25	25	25	25	25
	Annual Energy Consumption	GWH					73	82	82	149	149	149	149	149	149	149	149
Total	Maximum Demand	MW	2.6	2.3	3	4	15	17	17	27	27	28	28	29	29	30	31
	Annual Energy Consumption	GWH	7.8	8.9	9	9	82	92	92	160	161	162	162	163	163	165	167
	Load Factor	%	3.4	4.4	34	26	62	62	62	68	68	66	66	64	64	63	61

Table 4-4 Load Forecast of Trujillo and Stg. de Cao District

Load	Item	Unit	1972 (Actual)	1973 (Actual)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1990
Trujillo and surrounding cities	Maximum Demand	MW	10.5	14.5	20	23	26	30	34	38	43	48	51	55	60	71	92
	Annual Energy Consumption	GWH	40.7	48.8	78	89	102	116	131	148	168	189	199	216	235	279	360
Trujillo Industrial Area	Maximum Demand	MW						11	14	14	14	17	17	17	20	20	25
	Annual Energy Consumption	GWH						32	41	41	41	49	49	49	60	60	80
Stg. de Cao Paper Factory (TRUPAL)	Maximum Demand	MW					(27) 15	(30) 18	(32) 18	(35) 19	(37) 20	(38) 21	(39) 22	(40) 23	(40) 23	(40) 23	(40) 23
	Annual Energy Consumption	GWH					(122) 73	(133) 77	(144) 81	(156) 86	(167) 90	(171) 94	(175) 98	(180) 103	(181) 104	(181) 104	(181) 104
Stg. de Cao Paper Factory (CARTAVIO)	Maximum Demand	MW					6	6	6	7	7	7	7	8	8	8	8
	Annual Energy Consumption	GWH					31	32	34	35	36	38	39	40	40	40	40
Total	Maximum Demand	MW			20	23	(47) 41	(59) 52	(67) 59	(73) 64	(79) 69	(87) 77	(91) 81	(95) 85	(102) 92	(113) 103	(137) 129
	Annual Energy Consumption	GWH			78	89	(255) 206	(313) 257	(350) 287	(380) 310	(412) 335	(447) 370	(462) 385	(485) 408	(516) 439	(560) 483	(661) 584
	Load Factor	%			45	44	(62) 57	(61) 56	(60) 56	(59) 55	(60) 55	(59) 55	(58) 54	(58) 55	(58) 54	(57) 54	(54) 52

Note) Same as Table 4-1.

Table 4-5 Load Forecast of Pacasmayo District

Load	Item	Unit	1972 (Actual)	1973 (Actual)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1990
Pacasmayo and surrounding cities	Maximum Demand	MW			2	2	6	7	8	9	11	13	14	16	18	28	29
	Annual Energy Consumption	GWH			7	11	25	30	35	40	45	52	58	65	70	80	95
Pacasmayo Cement Factory	Maximum Demand	MW			7	7	7	8	10	12	13	14	15	15	15	15	15
	Annual Energy Consumption	GWH			30	30	30	39	44	47	48	50	53	53	53	53	53
Total	Maximum Demand	MW	8	8.8	7	9	11	12	15	17	20	22	24	26	28	32	39
	Annual Energy Consumption	GWH			37	41	55	69	79	87	93	102	111	118	123	133	148
	Load Factor	%			47	52	57	66	60	58	53	53	53	52	50	47	43

Table 4-6 Load Forecast of Cajamarca and Michiquillay Mines

Load	Item	Unit	1972 (Actual)	1973 (Actual)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1990
Cajamarca Celendín	Maximum Demand	MW	1.3	1.7	2.4	2.7	3	3	3	4	4	4	5	5	5	6	7
	Annual Energy Consumption	GWH	4.6	5.1	7	8	9	10	11	13	13	14	15	15	17	18	21
Michiquillay Mines	Maximum Demand	MW								(64) 38	(64) 38	(64) 38	(64) 38	(64) 38	(75) 50	(75) 50	(80) 50
	Annual Energy Consumption	GWH								(441) 277	(441) 277	(441) 277	(441) 277	(441) 277	(516) 366	(516) 366	(594) 366
Total	Maximum Demand	MW	1.3	1.7	2.4	2.7	3	3	3	(68) 42	(68) 42	(68) 42	(69) 43	(69) 43	(80) 55	(81) 56	(87) 57
	Annual Energy Consumption	GWH	4.6	5.1	7	8	9	10	11	(454) 290	(454) 290	(455) 291	(456) 292	(456) 292	(533) 383	(534) 384	(615) 387
	Load Factor	%	40	34	33	34	34	38	42	79	79	79	79	78	80	80	79

Note) Same as Table 4-1

Table 4-7 Load Forecast of Chiclayo District

Load	Item	Unit	1972 (Actual)	1973 (Actual)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1990
Chiclayo and surrounding cities	Maximum Demand	MW	9.4		12	14	15	16	18	20	23	25	28	31	35	41	51
	Annual Energy Consumption	GWH			59	66	73	79	86	93	102	110	120	132	140	170	200
	Load Factor	%			56	54	56	56	55	53	51	50	49	49	47	47	45

Table 4-8 Demand and Supply Balance of Expanded Santa Power System

Item \ Year	1972 (Actual)	1973 (Actual)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1990
Supply Capability	155	155	155	155	173	223	223	232	382	382	382	382	382	382	382
Cañon del Pato	75	75	75	75	75	125	125	125	125	125	125	125	125	125	125
Chimbote Gas Turbine	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Trujillo Gas Turbine	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Stg. de Cao Thermal (TRUPAL)	(12.5)	(12.5)	(12.5)	(12.5)	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
Stg. de Cao Thermal (Cartavio)	(6.2)	(6.2)	(6.2)	(6.2)	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2	6.2
Pacasmayo Diesel	(8.6)	(8.6)	(8.6)	(8.6)	(8.6)	(8.6)	(8.6)	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
El Chorro									150	150	150	150	150	150	150
Power Demand (Demand End)	54	71	108	130	(167) 161	(234) 218	(246) 229	(355) 309	(369) 322	(408) 361	(419) 372	(434) 386	(458) 411	(486) 439	(544) 492
Chimbote	48	55	91	111	112	(177) 163	(180) 166	(189) 171	(190) 172	(222) 204	(224) 206	(231) 211	(232) 212	(239) 219	(251) 228
Callejon de Huaylas	2.6	2.3	4	5	15	17	17	27	28	28	28	29	29	30	31
Trujillo, Stg. de Cao	* 10.5	* 14.5	* 20	* 23	(47) 41	(59) 52	(67) 59	(73) 64	(79) 69	(87) 77	(91) 81	(95) 85	(102) 92	(113) 103	(139) 129
Pracasmayo								17	20	22	24	26	28	32	39
Cajamarca, Michiquillay								(68) 42	(68) 42	(68) 42	(69) 43	(69) 43	(80) 55	(81) 56	(87) 57
Transmission Loss			3	4	(5) 5	(10) 8	(11) 9	(20) 14	(20) 15	(24) 18	(24) 18	(26) 19	(30) 21	(33) 25	(41) 31
Power Demand (Sending End)			111	134	(172) 166	(244) 226	(257) 238	(375) 323	(389) 337	(432) 379	(443) 390	(460) 405	(488) 432	(519) 464	(585) 523
Surplus Supply Capability			44	21	(1) 7	(−21) −3	(−34) −15	(−143) −91	(−7) 45	(−50) 3	(−61) −8	(−78) −23	(106) −50	(−137) −82	(−203) −141

* For Trujillo only

Table 4-9 Power Demand and Annual Energy at Sending-End of Expanded Santa Power System

Item	Unit	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1987	1990
Maximum Demand (Demand End)	MW	108	130	(167) 161	(234) 218	(246) 229	(355) 309	(369) 322	(408) 361	(419) 372	(434) 386	(458) 411	(486) 439	(544) 492
Transmission Loss	MW	3	4	(5) 5	(10) 8	(11) 9	(20) 14	(20) 15	(24) 18	(24) 18	(26) 19	(30) 21	(33) 25	(41) 31
Power Demand at Sending End	MW	111	134	(172) 166	(244) 226	(257) 238	(375) 323	(389) 337	(432) 379	(443) 390	(460) 405	(438) 432	(519) 464	(585) 523
Load Factor	%	48	55	(60) 59	(57) 55	(57) 55	(62.5) 60.5	(62) 60	(65) 64	(66) 64	(65) 64	(66) 65	(64.5) 64.5	(64) 62
Loss Coefficient	-	0.31	0.38	(0.43) 0.42	(0.40) 0.38	(0.40) 0.38	(0.47) 0.45	(0.45) 0.43	(0.49) 0.48	(0.50) 0.48	(0.49) 0.48	(0.50) 0.49	(0.49) 0.49	(0.48) 0.45
Annual Energy Consumption (Demand-End)	GWH	455	630	(879) 830	(1159) 1040	(1227) 1101	(1945) 1639	(2018) 1705	(2335) 2022	(2412) 2099	(2490) 2177	(2642) 2343	(2744) 2445	(3041) 2664
Annual Energy Loss	GWH	8	13	(19) 18	(35) 27	(39) 30	(82) 55	(79) 57	(103) 76	(105) 76	(112) 80	(131) 90	(142) 107	(172) 122
Annual Energy at Sending-End	GWH	463	643	(898) 848	(1194) 1067	(1266) 1131	(2027) 1694	(2097) 1762	(2438) 2098	(2517) 2175	(2602) 2257	(2773) 2433	(2886) 2552	(3213) 2786

Note) Same as Table 4-1