REPUBLIC OF PERU

FEASIBILITY REPORT ON MICHIQUILLAY TRANSMISSION PROJECT

SEPTEMBER, 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

P R E F A C E

The Government of Japan, in response to the request of the Government of the Republic of Peru, undertook to make a survey for formulation of a plan of the electric power supply to the Michiquillay Mine and its surrounding area in Northern Peru and entrusted the work to the Japan International Cooperation Agency.

The Agency, being fully cognizant of the importance of this investigation for the Republic of Peru in the light of the social and economic status on the development of the Michiquillay Mine and electrification of the surrounding area organized a survey team headed by Mr. Takeshi Yamazaki, Senior Engineer of Operation and Maintenance Department, Electric Power Development Co., Ltd., comprising six experts, and sent the team to Peru for the period from November 12, 1974 to January 10, 1975 to carry out the investigation.

The team made a report back in Japan in conformity with the outcome of the survey performed and the analysis of data collected, and have now completed this report for submission.

If this Michiquillay Transmission Project would be realized for supply of electric power to the Michiquillay Mine, one of the greatest copper mines in the world in quantity of potential reserves and to its surrounding area, development of the project area as well as improvement in the welfare of the populations there would be accelerated.

It is most grateful if this report could serve the benefits of the Republic of Peru and contribute to materialization of the Michiquillay Transmission Project.

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

September, 1975

Shinsaku Hogen
President
Japan International Cooperation Agency

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LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency

Dear Sir:

Submitted herewith is a report on the feasibility study of the "Michiquillay Transmission Project" comprising the electric power sector of the infrastructure which is to be the basis for development of the Michiquillay Mine located in Departamento de Cajamarca, the Republic of Peru.

In October 1974, at the request of the Japan International Cooperation Agency, the survey team of six experts from the Japan International Cooperation Agency and Electric Power Development Co., Ltd. was organized for the purpose of conducting a survey of the above mentioned Project.

The survey team visited Peru for a period of 60 days from November 12, 1974 to January 10, 1975 and engaged in collection of data required for preparation of a plan, in discussions with agencies concerned, and in field reconnaissances of the project area.

Upon returning to Japan, based on the results of field investigations and data collected, the survey team proceeded with a series of studies on electric power demand and supply of related areas, power transmission and transforming schemes, power system analysis and economic evaluation, and have now prepared this report.

It is our sincere hope that the report will be of great help to the realization of the power transmission project at an early date for development of the Michiquillay Mine and greater progress in regional development and economic growth of the Cajamarca district.

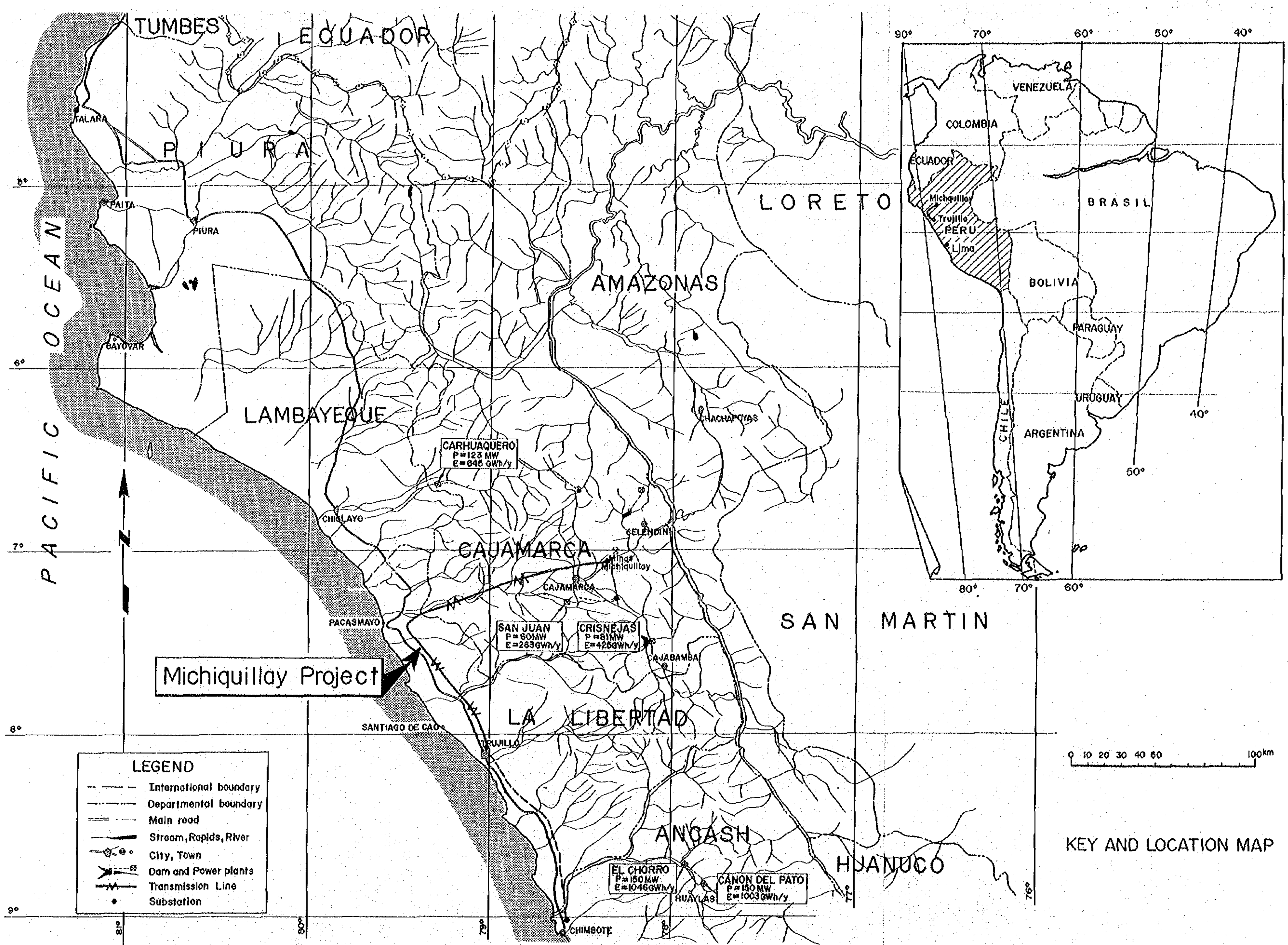
I would like to take this opportunity to express our heartfelt gratitude for the valuable cooperation that Ministerio de Energia y Minas, Empresa Minero del Peru, Electricidad del Peru and government agencies concerned of the Republic of Peru, the Japanese Embassy in Lima, and the various companies concerned in Peru extended to the team in expediting the preparation of this report.

September, 1975

Respectfully yours,

T. Yamazaki

Takeshi Yamazaki
Chief
Japanese Survey Team for
Michiquillay Power Transmission
and Transforming Project



KEY AND LOCATION MAP

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

MEM :	Ministerio de Energía y Minas
MINEROPERU :	Emplesa Mineria del Perú
ELECTROPERU :	Electricidad del Perú
PETROPERU :	Petoroleos Peru
EPCHAP :	Empresa Publica de Comercialización de la Harina y Aceite de Pescade
COFIDE :	Corporación Financiera de Desarrollo
SIDERPERU :	Empresa Siderurgica de Perú
SENAMHI :	Servicio Nacional de Meteorología E Hidrología
EE.EE.AA :	Empresas Electricas Asociadas
kw :	kilowatt
MW :	10^3 kilowatt
kWh :	kilowatt hour
MWh :	10^3 kilowatt hour
GWh :	10^6 kwh
S/· :	Soles
km :	kilometer
B/C :	Benefit-Cost ratio
mills/kWh :	10^{-3} US$/kWh

1 US$ = 300 Yen , 1 US$ = 43.38 Soles

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CHAPTER I

BACKGROUND AND PURPOSE OF SURVEY

CHAPTER I. BACKGROUND AND PURPOSE OF SURVEY

1-1 Background

The mountainous area of the South American Continent stretching north-south for 5,600 km along the Pacific Ocean coast is a copper-producing area which is the so-called "Andes Copper Belt." The Michiquillay Mine located near the city of Cajamarca in the northern part of the Republic of Peru is situated in part of this Copper Belt, and with the acquisition of mining rights by MINEROPERU in 1970, preparations for development of the mine by Peru and Japan have been ongoing since then. This mine, until its reversion to Peru, had been owned by the American mining company ASARCO. According to preliminary studies by that company, the concentration of copper is 0.72 % with confirmed reserves of 570 million tons. On the other hand, a joint technical survey mission of the Japanese non-ferrous metal industry (Kaneko Mission) conducted field surveys in 1971, and an average copper concentration of 0.75 % and reserves of 412 million tons have been confirmed to date.

Development of the Michiquillay Mine is to be undertaken by the two parties consisting of the Government of Peru and Michiquillay Mining Co., Ltd., a private enterprise on the Japanese side (participating companies: Mitsui Mining and Smelting Co., Ltd., Nippon Mining Co., Ltd., Mitsubishi Metal Co., Ltd., Sumitomo Metal Mining Co., Ltd., The Dowa Mining Co., Ltd., Furukawa Co., Ltd., Nittetsu Ming Co., Ltd.), and the Government of Japan, in response to the request of the Government of Peru, has promised economical and technical cooperation in connection with development of the mine. As a part of this cooperation, the Japanese Government dispatched to Peru a survey mission on the infrastructure related to the mine in June 1973 (Mera Mission). The present Survey Mission was dispatched for the purpose of investigations related to the electric power development department out of the proposals made by the Mera Mission.

The essentials of the proposals submitted to the Japanese Government by the Mera Mission are described below.

(1) Mining City Development

Basic planning and basic designing of a mining community to be built accompanying development of the Michiquillay Mine should be done with Japa Japanese technical cooperation. Furthermore, it would be desirable to include in the technical cooperation detail design of parts to be utilized by the population other than that of the mining enterprise. Regarding construction cost, it is proposed that financial cooperation should be given regarding costs of public facilities and improvement of housing land (approximately 5 million US dollers) estimated to be utilized by the population (approximately one third of the whole) other than that of the mining enterprise.

(2) Water Resources Development

The water supply plan for the Michiquillay Mine should be contemplated as a part of the Jequetepeque River Comprehensive Development Project presently being carried out with West German technical aid, and if a feasibility study were to be completed within the 1973 fiscal year, it is thought that aid on a government level would be forthcoming from West Germany. However, in case there should be difficulties about financial cooperation from West Germany, cooperation from Japan should then be considered.

(3) Electric Power Development

It would be desirable for a feasibility study on a transmission line between Trujillo and Michiquillay to be carried out in 1974-1975 with Japanese technical aid. Also, it would be desirable for a prefeasibility study to be made as early as possible with Japanese technical aid on hydroelectric power development of the Yangas River which is thought to be relatively economical.

(4) Road Development

It would be desirable for financial cooperation to be given for the total cost of 51.8 million Soles (approximately 1.3 million US dollars) of definite design and construction of Abra Gavilan - Cajamarca, Cajamarca - Namora, Santa Margarita Entrance - Mine Entrance, and Cajamarca Bypass, those roads which should be built by 1975 out of six roads in the Cajamarca district suggested to be improved and paved. Financial cooperation should be considered for the remaining two roads (E-I Sector and Baños del Inca - Santa Margarita Entrance).

(5) Port and Harbor Development

As soon as an outlook has been gained to an extent on the production scale of the Michiquillay Mine and the possibility of smelting and refining, it would be desirable for technical aid to be provided in 1975 for a feasibility study and detail design and planning regarding the port of Pacasmayo and for financial cooperation to be provided regarding the construction cost (approximately 16 million US dollars total cost according to this survey).

The above proposals and the financial and technical cooperation schedules may be summarized as follows:

Table 1-1 Study and Investment Schedule Suggested by Mera Mission

Year	Nature of activity	Study cost (US$ thousands)	Total investment Cost (US$ thousands)	Total investment Foreign currency (US$ thousands)
1974	Power: Preliminary study at Yangas	110		
	Roads: Paving, Abra Gavilan - Cajamarca		100	50
	, Paving, Cajamarca - Namora		600	200
	, New construction, Cajamarca bypass		300	100
	Sub-total	110	1,000	350
1974-75	City: Basic design & construction planning	1,800		
	Power: Feasibility study of Trujillo-Michiquillay transmission line	300		
	Roads: Paving & re-alignment from approach to Santa Margarita to approach to the mine		400	200
	Sub-total	2,100	400	200
1975-76	Power: Construction planning for Trujillo-Michiquillay transmission line	1,000		
	Roads: Paving, Baños del Inca-approach to Santa Margarita		400	200
	Harbor: Feasibility study for Pacasmayo harbor, preparation of master plan & detailed design	600		
	Sub-total	1,600	400	200
1976-79	City: Construction (Housing site preparation; public facilities)		5,000	1,000
1977	Harbor: Construction of Pacasmayo harbor		15,600	12,000
1977-79	Power: Construction of Trujillo-Michiquillay transmission line		13,700	9,100
1979	Roads: New construction, E-I		200	100
	Sub-total		34,500	22,200
	Total	3,810	36,300	22,950

1-2 Objectives and Survey Area

The Central Power System (total installed capacity 936 MW) centered around Lima, the capital of Peru, and the Santa Power System (total installed capacity 182 MW) in northern Peru will be interconnected in 1978 by the 220 kV, single-circuit, 400 km Lima-Chimbote Interconnecting Transmission Line scheduled to be constructed with a Yen loan from the Japanese Government. Through this interconnection, it is aimed for the abundant and cheap hydroelectric power of the Central Power System and the Santa Power System to be supplied to the city of Chimbote which is the industrial district of northern Peru and to other load areas of northern Peru including the Michiquillay Mine.

This Project has the objective of establishing a power transmission scheme for power supply to Michiquillay predicated on completion of the Lima-Chimbote Transmission Line, and completion of the Chimbote-Trujillo Transmission Line (to be stepped up from 138 kV to 220 kV to when the Lima-Chimbote Interconnecting Transmission Line is completed) now in the process of bidding, to result in interconnection of the Central Power System and the Santa Power System by a 220 kV transmission line as far as Trujillo.

The survey Mission carried out field investigations on the four departments of Ancash, la Libertad, Cajamarca and Lambayeque in northern Peru as the survey area and with the following concrete objectives:

(1) Preparation of basic power transmission and transmission and transforming scheme based on "Survey for Regional Development Planning in Cajamarca of Peru" by the Metallic Minerals Exploration Agency of Japan in December 1973.

(2) Coordination with the basic power transmission and transforming scheme along the Pacific Ocean coast of ELECTROPERU.

(3) Establishment of a plan for power transmission to the surrounding areas.

(4) Examination of the supply capabilities of existing and projected power supply facilities for power supply to the Michiquillay Mine from the Central Power System and the Santa Power System.

(5) Carrying out of field reconnaissances for the studies of (1) to (4) above, collection of data, and exchange of opinions with Peruvian Government agencies concerned.

1-3 Composition of Survey Mission

The work assignments and organizations belonged to of the members of the Survey Mission at the time of dispatchment are given below.

Chief	Takeshi YAMAZAKI, Overall Direction Operation & Maintenance Department, EPDC	
Member	Masashi MIKUNI, Thermal Power Planning Thermal Power Department, EPDC	
Member	Hiroshi KAGAMI, Load Forecasting Foreign Activities Department, EPDC	
Member	Kikufumi NAGASAKA, Power Transmitting and Transforming Planning Transmission & Substation Section, Operation & Maintenance Department, EPDC	
Member	Kinya SATO, Power System Planning Electrical System Engineering Office, Operation & Maintenance Department, EPDC	
Member	Michio KANDA, Economic Analysis Industrial Survey Department, Japan International Cooperation Agency (JICA)	

1-4 Period of Field Survey

Field investigations were made dividing the Mission into three teams which engaged in necessary data collection and field reconnaissances in Peru for the periods indicated below.

Takeshi Yamazaki, Hiroshi Kagami and Kikufumi Nagasaka for the period of November 13, 1974 to January 8, 1975.

Masashi Mikuni and Kinya Sato for the period of November 13 to December 10, 1974.

Michio Kanda for the period of November 13 to December 2, 1974.

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2. CONCLUSIONS AND RECOMMENDATIONS

The Michiquillay Mine is a huge copper mine boasting one of the largest reserves in the world and the influence of its development on Peru's economic progress and on improvement of the international balance of payments as well as on the regional development of the Cajamarca district which is a relatively underdeveloped part of the country will be extremely great. Accompanying the development of the mine, the economic activity of the surrounding area will be greatly increased and the productivities of stock-farming, forestry and agriculture of the area will be markedly improved. This Report is on the technical and economic studies of the method of supplying electric power as the electric power sector of building the infrastructure accompanying development of the mine. It will be possible to supply cheap, abundant electric power from the Central Power System and the Santa Power System and at the same time it is thought this will serve to improve the living conditions of the population of the area and contribute to stabilization of social welfare.

2-1 Conclusions

2-1-1 Electric Power Supply from Region Central and Santa Power System to Michiquillay Mine and Surrounding Area

(1) Load Forecast

It is forecast that the electric power demand of the Central Power System at the beginning of 1982 when the Michiquillay Mine starts operation will be 1,801 MW and that of the Santa Power System 370 MW, while in 1985 these will be 2,170 MW (annual growth rate of 8.7%) and 413 MW (annual growth rate of 9.6%) respectively.

The power demand of the Michiquillay Mine is forecast to be 40 MW in 1982 at the time of start of its operation and 65 MW from 1987 and after, the percentages occupied in the power demand being 1.9% and 2.2% respectively.

(2) Power Demand and Supply Balance

In 1978, the Lima-Chimbote Interconnecting Transmission Line will be completed to connect the Central and Santa power systems so that consumption of the surplus power of Mantaro Hydroelectric Power Station (684 MW) can be expected, but with growth in power demand it is expected that the power demand and supply balance will become tight in 1980.

CAPITULO 2. CONCLUSIONES Y RECOMENDACIONES

Las Minas de Michiquillay es un yacimiento gigante de cobre, cuya reserva es uno de los mayores del mundo y la influencia de su explotación en la economía de la República del Perú, en la mejora del balance de pagos internacionales y en el desarrollo regional de la zona de Cajamarca que actualmente se encuentra relativamente subdesarrollada será de suma de importancia.

Se espera que conforme se desarrolla la explotación de las Minas de cobre, aumentará enormemente la actividad económica de la región aledaña, incrementándose la producibilidad de la industria ganadera, forestal y agricola de la región.

El presente informe consiste en el estudio técnico económico del sistema de abastecimiento de la energía eléctrica que forma parte de la organización de la infraestructura correspondiente al sector de la energía eléctrica, resultándo la conclusión de que existe la posibilidad del suministro de energía suficiente y económica, del Sistema Eléctrico Central y del Sistema Eléctrico del Santa y que al mismo tiempo puede fomentar ampliamente la elevación del nivel de vida y la estabilidad de la población aledaña a la región vinculada al proyecto.

2-1 Conclusiones

2-1-1 Capacidad de Suministro de Energía desde los Sistemas Eléctricos de la Zona Central y del Sistema Eléctrico de Santa hacia las Minas de Michiquillay y Sus Zonas Aledañas

(1) Estimación de la Demanda de la Energía

La demanda de energía de los Sistemas Eléctrucis de la Zone Central a principios del año 1982, en que se inicie las operaciones de las Minas de Michiquillay se estima que llegará a 1,801 MW, mientras la demanda del Sistema del Santa será de 370 MW; y para el año 1985, se estima que llegará a 2,170 MW con el tasa anual de crecimiento de 8.7% y de 413 MW en el Sistema Eléctrico del Santa, con una tasa de crecimiento de 9.6%.

La demanda de energía de las Minas de Michiquillay en el período inicial de 1982 se estima en 40 MW como máximo y que a partir del año 1987 será de 65 MW ocupando una proporción dentro de la demanda general de 1.9% y de 2.2% respectivamente.

(2) Balance de la Demanda y el Suministro de la Energía

En el año 1978, quedará concluída la Línea de Transmisión Lima-Chimbote de Interconexión de los Sistemas Eléctricos de la Zona Central y del Santa y se puede esperar el aprovechamiento de la energía sobrante proveniente de la Central del Mantaro (684MW), pero conforme crece la

However, if Sheque Hydroelectric Power Station (585 MW) were to be completed in 1981, a new surplus supply capacity will be produced in the Central Power System. Furthermore, in the Santa Power System, El Chorro Hydroelectric Power Station (160 MW) is scheduled to start operation in 1982, and for the power demand of 2, 102 MW and 12, 652 GWh of the interconnected system in 1982, the firm output will be 2, 232 MW and the firm energy 12, 285 GWh, and the required supply capability will be available through the year by using secondary energy (1, 990 GWh) of Mantaro Hydroelectric Power Station provided that overhaul of thermal power plants is conducted during the rainy season.

2-1-2 Power Supply to Michiquillay Mine and Related Area, and System Interconnection

(1) Power Supply to Michiquillay Mine

The three methods below are conceivable for supply of electric power to the Michiquillay Mine:

a) Supplying of power by constructing a thermal power generating facility at the site.

b) Supplying of power by constructing a coastal thermal power station at Trujillo and relevant transmission line.

c) Supplying of power by constructing a transmission line and relying on the supply capability of power generation facilities existing and planned to be built in the future in the Central and Santa Power Systems.

As a result of technical and economic studies on the three methods of supply listed above, Alternative b), the case of building a coastal thermal power station, would have a merit of US$1, 043 thousand annually compared with Alternative a), while Alternative c), in case it is assumed that power is received at Trujillo at the current nationally unified wholesale rate of ELECTROPERU (14.7 mills/kWh in case of application to the Michiquillay Mine) for a power sales rate of 22.2 mills/kWh at the Michiquillay Mine, there would be a merit of US$1, 700 thousand annually compared with Alternative a).

Therefore, as the source for power supply to the Michiquillay Mine and its surrounding area, the electric power of the Central and Santa Power Systems is to be relied on, and it is economically appropriate for this power to be supplied to the Michiquillay Mine and its surrounding area through a transmission line via Trujillo Norte Substation.

demanda, se estima que alrededor del año 1980, se llegará a balancear la oferta y la demanda de la energía.

Sin embargo hacia el año 1981 se concluirá la Central Hidroeléctrica de Sheque de 585 MW, y nuevamente se producirá energía sobrante en el Sistema Eléctrico de la Zona Central.

Por otro lado, en el Sistema Eléctrico del Santa, se programa la puesta en operación de la Central El Chorro (160 MW) en el año de 1982 y se tendrá en el mismo año 1982, una potencia asegurada de suministro de 2,232 MW y una energía asegurada de 12,285 GWh (energía primaria en el sistema hidráulico), ante la demanda de potencia de 2,102 MW y de energía de 12,652 GWh, y el suministro asegurado de potencia y energía será disponible por año, si se usará la energía secundaria (1,990 GWh) de la Central Hidroeléctrica de Mantaro siempre que la desmontaje de las plantas termicas se efecturará durante estación de lluvia.

2-1-2 Suministro de Energía e Interconexión de Sistemas, a las Minas de Michiquillay y las Zonas de Su Influencia

(1) Suministro de energía a las Minas de Michiquillay para el suministro de energía a las Minas de Michiquillay se pueden considerar los tres casos siguientes.

a) Instalación de Centrales Termoeléctricas en la zona, para el suministro de energía.

b) Instalación de Central Termoeléctrica en el litoral de la zona de Trujillo, con su respectiva línea de transmisión para el suministro de energía.

c) Construcción de líneas de transmisión para el suministro de la energía procedente del sistema eléctrico existente de la Zona Central y del Sistema del Santa y desde los sistemas de generación programados en el futuro.

Como resultado del estudio técnico económico comparativo de los tres sistemas de suministro arriba descritos, se llegó a la conclusión de que el caso de la construcción de la Central térmica en el litoral del plan b) resulta con ventajas económicas de 1,043 mil dólares US por año, comparado con el Plan a); mientras que en el caso del Plan c) puede tener una ventaja del orden de 1,700 mil dólares US comparado con el mismo plan a), siempre que se le aplique la misma tarifa existente de ELECTRO-PERU para la venta al por mayor dentro de la República (en el caso de las Minas de Michiquillay será de 14.7 US$ mills/kWh), y utilizando a Trujillo como punto a recepción y el monto de la venta de energía a las Minas de Michiquillay en 22.2 US$ mills/kWh.

Por esta razón se cree que es económicamente más conveniente de que para el suministro de la energía eléctrica a la zona de las Minas de

Further, in the case of Alternative c), since the power costs of the Central and Santa Power Systems are unknown, it was unavoidable to use a current nationally unified power rate which is thought to be slightly higher than the pertinant cost, assuming that Trujillo Norte Substation would be the point of delivery.

Due attention should be given to the fact that the nationally unified wholesale rate of Alternative c) is approximately equal to the generating cost of 13.6 mills /kWh of the 220 kV system in case of receiving power from the Central and Santa Power Systems at Trujillo Norte Substation on start of operation of the Michiquillay Mine in 1982.

With regard to the transmission line route for this Project, in consideration of the future electric power program such as power supply to the Pacasmayo district and interconnection with Region Norte, the route from Trujillo Norte Substation via Pacasmayo to Michiquillay Substation will be technically and economically superior. As for voltage and number of circuits, these were studied from an overall aspect based on the load forecast and considering transmission capacity, transmission loss and the future system scheme, and as a result a 220 kV, 1-cct, steel tower transmission line which is economically advantageous was selected.

As the greater part of the power demand at Michiquillay Substation is composed of the load of the mine, the substation site will be provided adjacent to the mine area. The capacity of the substation was selected to be 80 MVA in consideration of the loads of the mine and its surrounding communities.

As a method of power supply to the Michiquillay Mine, it is further conceivable to construct a diesel plant at Pacasmayo for independent supply, but this must be decided in view of the outlook for hydro and thermal power generating facilities presently planned for development and the trends in electric power demand.

Further, in selection of the transmission line route for this Project, the relation with the planned Alto Chicama Coal-burning Thermal Power Development Project (ultimate capacity 480 MW) was also examined, but viewed from the scale of Alto Chicama Thermal Power Station, it would be appropriate for it to be directly interconnected with Trujillo Norte Substation.

(2) Power Supply to Cajamarca City

Power supply to the city of Cajamarca is presently being carried out with small-scale hydroelectric and diesel power generating facilities, but from 1982 when Michiquillay Substation would be completed, it would be economically advantageous to supply power by a transmission line from this substation. For the voltage of this transmission line, 33 kV would be optimum in view of the transmission distance and the size of the load, and power demands up to around 1994 can be satisfied.

Michiquillay se emplee como fuente, la energía generada por los sistemas de la Zona Central de la República y por Sistema del Santa, por medio de una línea de transmisión y a través de la Subestación Trujillo Norte.

Se debe notar que el costo normalizado de la tarifa de venta al por mayor de energía eléctrica, para el año de 1982, en que entre en operación las Minas de Michiquillay, se ha tomado como un valor similar al costo de generación de 13.6 US$ mills/kWh, para el caso en que se reciba la energía del Sistema Eléctrico Central y del Sistema Eléctrico del Santa en la Subestación de Trujillo Norte por un sistema de 220 kV.

Respecto a la ruta de la línea de transmissión del presente proyecto, es más ventajoso hacerla pasar por la zona de Pacasmayo, después de recibir la energía en la Subestación de transformación de Trujillo Norte, si se considera el suministro de energía a la zona de Pacasmayo y la interconexión con la región norte, tanto desde el punto de vista técnico como económico.

En cuanto a la tensión y el número de circuitos de la presente línea se determinó en una línea de un circuito de 220 kV del tipo aéreo soportado por torres de acero después de hacer un estudio desde el punto de vista integral en base a la estimación de la demanda; la capacidad de la línea; la pérdida de transmisión y planes de interconexión futura.

La mayoría de la demanda de energía de la Subestación de transformación de Michiquillay es la carga de las propias Minas, y se ubicará en un terreno colindante a las Minas, debido a la ventaja de construirse lo más cercano posible a las instalaciones mineras.

La capacidad de esta Subestación se determinó en 80 MVA teniendo en consideración la demanda de las Minas y de las poblaciones colindantes.

Como otro método para el suministro de energía a las Minas de Michiquillay, se puede considerar la instalación de una planta Diesel en Pacasmayo y una línea independiente de transmisión, pero esta decisión debe hacerse después de estudiarse los planes de desarrollo de los sistemas de generación hidraulicas y térmicas, y el proceso del crecimiento de la demanda de la energía.

Para la selección de la ruta de la línea de transmisión del presente proyecto se ha estudiado también su vinculación en el proyecto de desarrollo del Plan de construcción de la Central Térmica a carbón del Alto Chicama (potencia máxima de salida de 480 MW), pero se vió que es más conveniente la interconexión directa a la Subestación de Trujillo Norte, tomando en consideración la magnitud de la Central de Alto Chicama.

(2) Suministro de Energía a la Ciudad de Cajamarca

La ciudad de Cajamarca se encuentra servida actualmente por una pequeña planta hidroeléctrica y una planta térmica Diesel, pero a partir del año de 1982 en que se concluya la Subestación de Michiquillay será más económico el suministro desde la misma Subestación.

As the power transforming facilities at Cajamarca, a transformer of 5 MVA capacity is to be installed initially, with extensions to be made successively in steps in accordance with the increase in power demand at Cajamarca.

(3) Power Supply to Celendin City

In the city of Celendin, power supply is being made by means of small-scale diesel generating facilities in order to satisfy a demand of less than 100 kW, mainly compressing lighting load. Judging from the size of the power demand, in case of power supply from Michiquillay Substation the power cost would be high and therefore uneconomical, and the diesel power generating facilities at Celendin should be maintained for the time being and expanded thereafter. However, when the power demand of Celendin reaches a level of 0.8 MW or higher, there will be a merit produced in power supply through construction of transmission line from Michiquillay Substation and the time for this will be around 1990.

(4) Power Supply to Pacasmayo City

The Pacasmayo district is composed of the communities of Pacasmayo, San Pedro de Lloc, Chepen and Guadalupe, which are being supplied by small-scale diesel plants, and the maximum demand is a total of about 2.0 MW.

There is a cement factory of Cia. de Cemento Pacasmayo S. A. in operation in the outskirts of Pacasmayo City, which has an independent power generation capability (7 MW), and there is a plan for extension of 18 MW of generating facilities in 1977 for the purpose of expansion of production.

The power demand of the communities including Pacasmayo in 1982 when the Michiquillay transmission line is completed is forecast to be 13 MW, but as the loads are scatteredly situated, secondary power transmission and transforming facilities and 220 kV substation at Pacasmayo will require a large amount of funds, and will not be economical from the aspect of power costs.

The size of the load which would produce a merit in power supply would be approximately 48 MW, and the time when this demand including the load of the cement factory is reached would be around 1987, and since this would coincide with the time for renewal of the existing privately-owned power generating facilities of the cement factory at Pacasmayo, a substation should be provided at Pacasmayo between 1985 and 1987.

La tensión de transmisión de esta línea será conveniente determinarlo en 33 kV, teniendo en consideración la distancia y la magnitud de la demanda de energía, y en esta forma podrá responder a la demanda hasta el año 1994 aproximadamente.

La instalación del sistema de transformación de la Subestación de Cajamarca será un transformador de 5 MVA de capacidad y será ampliada en forma escalonada conforme aumenta la demanda de energía de la Ciudad de Cajamarca.

(3) Suministro de energía a la ciudad de Celendín

La ciudad de Celendín se encuentra actualmente servida por una pequeña planta de generación Diesel, con una demanda total de menos de 100 kW, siendo la mayoría de ellos cargas del tipo de alumbrado. Desde el punto de vista de la magnitud de la demanda, el costo de energía será muy elevado si se suministra la energía por medio de la Subestación de Michiquillay; y se debe mejorar y ampliar las instalaciones de la planta Diesel existente.

Sin embargo, si la demanda de la ciudad de Celendín llegase a 0.8 MW, aparecerá la ventaja de la transmisión y suministro de energía desde la Subestación de transformación de Michiquillay y se estima que esto sucederá aproximadamente en el año 1990.

(4) Suministro de Energía a la ciudad de Pacasmayo

La región de Pacasmayo está compuesta por las ciudades de Pacasmayo, San Pedro de Lloc, Chepen, Guadalupe que cuenta cada uno con plantas Diesel independientes de pequeña capacidad y la demanda total máxima es de 2.0 MW aproximadamente.

En los suburbios de la ciudad de Pacasmayo, existe la planta de Cemento de la Cía de Cemento Pacasmayo que cuenta con su planta propia de generación (7 MW) y tiene un plan de ampliación para instalar una planta de generación de 18 MW para responder a la demanda para aumentar la producción para el año 1977.

La demanda total de la zona de Pacasmayo, incluyendo la propia ciudad de Pacasmayo y las ciudades vecinas en el año 1982 se estima en 13 MW, pero la demanda de energía se encuentra dispersada y requiere de mucha inversión para la instalación de líneas secundarias de transmisión; y la construcción de la Subestación en Pacasmayo para el suministro de energía no resulta conveniente desde el punto de vista económico del costo.

La magnitud de la demanda que produce ventajas económicas para el suministro, es del orden de 48 MW, pero esta demanda se estima se alcanzará recién en el año 1987, incluyendo la necesidad de la fábrica de cemento, pero esta época coincidirá con el período de reposición de los

(5) Interconnection with Chiclayo District

With respect to the time of interconnection of the Chiclayo district with the Santa Power System, economy of the interconnection will be greatly influenced by the size of the power demand of the district and new power development plans in the surrounding area. The present power demand of the city of Chiclayo is 9 MW. Including the power demand of the surrounding area, it is forecast that the time at which there would be a merit produced by the interconnection would be around 1997 when the load will reach 78 MW. It has been considered that the interconnection would be made if development of a new hydroelectric power source (Carhuaquero Hydroelectric Power Station, 123 MW) were to be carried out prior to 1997.

(6) Interconnection between New Hydroelectric Power Sources and Michiquillay Substation

There are plans for new hydroelectric power development projects such as Yangas (50 MW), San Juan (60 MW) and Crisnejas (81 MW) in the area around Michiquillay Substation. It would be technically and economically advantageous for these hydroelectric power sources to be interconnected to the Santa System via Michiquillay Substation judging from their presently projected development scales and geographical conditions. The transforming facilities at Michiquillay have been given considerations to make possible interconnections with these hydroelectric power sources in the future.

2-1-3 Outline of Facilities and Construction Cost of the Project

The Project is to construct a transmission line of a 240 km, 220 kV, 1 cct from Trujillo Norte Substation passing by Pacasmayo to reach Michiquillay, Michiquillay Substation (80 MVA), and further, construction of a 30 km, 33 kV transmission line from Michiquillay Substation to the city of Cajamarca. The total construction cost of these power transmission and transforming facilities including the amount of interest during construction is estimated to be US$24,010 thousand of which US$14,350 thousand would be required in foreign currency and US$9,660 thousand in domestic currency. (Amounts used for the construction cost and economic evaluation are based on commodity prices and wages as of April 1975 and escalations up to the time of start of construction are not considered.)

equipos existentes de la planta generación de la fábrica de cemento, por lo que se decidió programar la instalación de la Subestación de Pacasmayo entre el año 1985 y 1987.

(5) Interconexión con la zona de Chiclayo

El tiempo propicio para la interconexión entre los Sistemas Eléctricos de la Zona de Chiclayo y el Sistema Eléctrico del Santa depende mucho de la magnitud de la demanda de energía de la Zona de Chiclayo y los planes de desarrollo de nuevas fuentes de energía en sus alrededores, que influirán enormemente en el aspecto económico de la interconexión.

La demanda total actual de la ciudad de Chiclayo es de 9 MW. Se estima que esta demanda total, incluyendo la demanda de las ciudades aledañas, alcanzará el valor de 78 MW en que se aparece la ventaja de la interconexión, recién en el año 1997.

Se programó la interconexión en esta época, en el caso en que el desarrollo de nuevas fuentes energéticas hidráulicas (Central Hidráulica de Carhuaquero de 123 MW) se realice antes del año 1997.

(6) Interconexión entre las nuevas fuentes hidráulicas y la Subestación de Michiquillay

En los alrededores de la Subestación de Michiquillay existen los planes de desarrollo de las nuevas fuentes energéticas hidráulicas de las Centrales Yangas (50 MW), San Juan (60 MW), Crisnejas (81 MW) etc.

Estas nuevas fuentes hidráulicas son técnica y económicamente ventajosas operar en interconexión con el Sistema Eléctrico del Santa, a través de la Subestación de Michiquillay, si se toma en consideración la magnitud, y consideraciones geográficas de estas nuevas fuentes. Las instalaciones de la Subestación de Michiquillay se proyectó teniendo en cuenta los espacios necesarios para realizar estas interconexiones.

2-1-3 Descripción de las instalaciones del presente proyecto y consideraciones del costo

El presente proyecto consiste, en resumen en la construcción de una línea de transmisión de un circuito de 220 kV, de 240 km de longitud, que saliendo de la Subestación de Trujillo Norte, llega hasta Michiquillay, pasando por la Zona de Pacasmayo; la construcción de una Subestación y de una línea de transmisión de 30 km desde la Subestación de Michiquillay, para el suministro de energía la ciudad de Cajamarca.

El costo total de estas instalaciones de transmisión se estima en 24,010 mil dólares U.S., incluyendo costo de los intereses durante la construcción, de los cuales 14,350 mil dólares U.S. serán necesidades en moneda extranjera, mientras 9,660 mil dólares U.S., serán necesidades en moneda nacional (la estimación para el cálculo de los costos se realizó teniendo en cuenta los costos de materiales y de manos de obra para abril del año 1975, y no se ha considerado los factores de reajuste necesarios hasta la fecha de iniciación de las obras).

Outline of Michiquillay Power Transmission and Transforming Facilities

(1) Transmission Facilities

Trujillo - Pacasmayo - Michiquillay

Voltage 220 kV, 1 cct, 240 km

Michiquillay - Cajamarca

Voltage 33 kV, 1 cct, 30 km

(2) Transforming Facilities

Trujillo Norte Substation

220 kV switching equipment

Michiquillay Substation

220 kV, 33 kV switching equipment

Transformer, 80 MVA

Cajamarca Substation

33 kV, 13.8 kV switching equipment

Transformer, 5 MVA

(3) Telecommunications Facilities

Power line carrier telecommunications equipment for load dispatching and maintenance

VHF radio telecommunications equipment for transmission line maintenance

Construction Cost for Michiquillay Power Transmission and Transforming Facilities

Unit: US$$10^3$

	Foreign Currency	Domestic Currency	Total
220 kV transmission and transforming facilities (including telecommunications facilities)	13,600	9,260	22,860
33 kV transmission and transforming facilities	750	400	1,150
Total	14,350	9,660	24,010

Resumen del Proyecto de Instalación de Sistema de Transmisión de Michiquillay

(1) Instalaciones de Transmisión de Energía

Trujillo - Pacasmayo - Michiquillay

Voltaje 220 kV, 1 circuito, 240 km

Michiquillay - Cajamarca

Voltaje 33 kV, 1 circuito, 30 km

(2) Instalaciones de Transformación

Subestación de Trujillo

Instalación de Interrupción de 220 kV

Subestación de Michiquillay

Instalación de Interrupción de 220 kV y de 33 kV

Transformador de 80 MVA

Subestación de Cajamarca

Instalación de Interrupción de 33 kV y de 13.8 kV

Transformador de 5 MVA

(3) Instalaciónes de Comunicaciones

Instalaciones de comunicaciones de onda portadora sobre línea de transmisión de potencia, para el servicio de seguridad y mantenimiento.

Instalaciones de comunicaciones de radio, para el servicio de mantenimiento de la línea de transmisión.

Costos para la instalación de transmisión para el proyecto de Michiquillay

Unidad: 10^3 dólares U.S.

	Moneda Extranjera	Moneda Nacional	Total
Instalación de transmisión y transformación de 220 kV (incluyendo comunicaciones)	13,600	9,260	22,860
Instalación de transmisión y transformación de 33 kV	750	400	1,150
Total	14,350	9,660	24,010

2-1-4 Economic Evaluation of Project

Since the energy demand of the Michiquillay Mine comprises more than 95% of the whole, the economic evaluation of the Project was made based on the power demand of the Michiquillay Mine only. The method of evaluation was to take the discount rate at 10%, the generating cost of an on-site diesel generating plant as benefit (B) the generating cost of a thermal plant at Michiquillay including transmission and transforming costs between Trujillo and Michiquillay as cost (C) and evaluating by the benefit-cost (B/C) method.

a) The annual average benefit (B) of the Project over its service life would be US$10,628 thousand while the cost (C) would be US$9,585 thousand so that B/C would be 1.11 and B - C US$1,043 thousand.

b) Since a substation will be constructed at Pacasmayo in 1987, if the construction cost of the transmission line between Trujillo and Pacasmayo were to be allocated in accordance with the sizes of energy demands at Pacasmayo Substation and the Michiquillay Mine, B/C would then be 1.15.

The above evaluation is based on the generating cost of a thermal power generating facility using bunker C oil at the current price in Peru. In case of comparison of generating cost at Trujillo Norte Substation through supply from hydroelectric power sources such as Sheque, El Chorro and Yuncan and generating cost of the on-site diesel at the international market price for bunker C oil, B/C would be 1.60.

2-2 Recommendations

(1) Viewed from technical and economic standpoints, the power transmission and transforming facilities of the Project should be constructed to enable receiving of power from power generating facilities of the Central Power System and the Santa Power System either existing or to be built in future, and the route of the transmission line should start from Trujillo Norte Substation, and go along the Pan American Highway to pass by Pacasmayo from where it will go to the Michiquillay Mine.

(2) In order to complete this power transmission and transforming project for power supply to the Michiquillay Mine and the city of Cajamarca

2-1-4 Evaluación Económica del Proyecto

La evaluación económica del proyecto se hizo sólo a base de la demanda de las Minas de Michiquillay, debido a que esta ocupa el 95% de la demanda total.

Para la evaluación económica se consideró una tasa de descuento de 10%, tomando el costo de generación de la planta Diesel instalada en el lugar como Beneficio. (B), y tomando como costo (C) el costo total que comprende la instalación de una central térmica en la ciudad de Trujillo; la construcción de una línea de transmisión entre Trujillo y Michiquillay, incluyendo los costos de transmisión y de transformación, evaluándose por medio del método de Beneficio - Costó (B/C).

El resultado de esta evaluación es la siguiente:

a) El Beneficio (B) promedio anual del proyecto durante todo el tiempo de su vida es de 10,628 mil dólares U.S., mientras que el costo (C) es de 9,585 mil dólares US por lo que la relación B/C será de 1.11 y la diferencia B - C será de 1,043 mil dólares US.

b) Para el año 1987 se construirá la Subestación de Pacasmayo y si se reubica el costo de construcción de la línea de transmisión de acuerdo a la demanda de energía de la Subestación de Pacasmayo y la demanda de energía de las Minas de Michiquillay, el valor de la relación B/C será de 1.15.

Esta evaluación se hizo a base de costo de producción de energía utilizando el petróleo C, de acuerdo a su costo actual en el Perú, pero después que se realice la interconexión de la línea de transmisión, será posible el aprovechamiento de las Centrales Hidráulicas de Sheque, El Chorro y Yuncan, y si se calcula el costo de producción en la Subestación de Michiquillay comparando estos costos de generación hidráulica con los costos de generación térmica en planta, utilizando el precio internacional del petróleo C, el valor de la proporción B/C llegará a 1.60.

2-2 Recomendaciones

(1) El plan de Transmisión y Transformación del presente proyecto debe llevarse a la práctica, desde el punto de vista técnico y económico, para poder recibir la energía proveniente del Sistema Eléctrico del Centro y del Sistema Eléctrico del Santa tanto procedente de las instalaciones existentes como de los de desarrollo futuro, y la ruta de su recorrido debe seleccionarse desde la Subestación de Trujillo Norte, a lo largo de la Carretera Panamericana Norte, hasta Pacasmayo y luego hasta las Minas de Michiquillay.

(2) Para poder concluir el proyecto de transmisión y transformación para iniciar el suministro de energía a las Minas Michiquillay y a la ciudad de Cajamarca a comienzos del año 1982 en que se programa la operación

by the beginning of 1982 when the mine is scheduled to commence operation, it would be necessary to carry out a definite study from 1977 to 1978 and to start construction work in 1979.

(3) The electric power for the Michiquillay Mine will be supplied by the Santa Power System to be interconnected with the Central Power System by the Lima-Chimbote Interconnecting Transmission Line in 1978, and for this power supply to be made it will be necessary for addition of Unit No. 4 to Unit No. 7 (unit capacity 114 MW) of Mantaro Hydroelectric Power Station, Sheque Hydroelectric Power Station (585 MW) to be constructed, and development of El' Chorro Hydroelectric Power Station (160 MW) and Yuncan Hydroelectric Power Station (160 MW) to proceed as planned.

(4) While watching the progress in the electric power development projects mentioned in (3) above and the trends in power demand, construction of a diesel plant at Pacasmayo and moved-up construction of Alto Chicama Thermal Power Station as sources for supplying power to the Michiquillay Mine should be decided by the end of 1978 when a definite study for this Project will be completed, thus providing definite assurance of power supply to Michiquillay.

(5) Since the greater part of the load at Michiquillay Substation will be the load of the Michiquillay Mine, the substation has been planned adjacent to the Mine property. Therefore, in land reclamation of the site for the substation, it would be technically and economically advantageous to perform this reclamation at the same time that the Mine will develop its site. In this case, the plottage for the substation including the space for future expansion and access road for hauling in large-sized transforming equipment should be developed under discussion with the Mine.

(6) Selection of Transmission Line Route

In selecting the route of the transmission line in the vicinities of Pacasmayo and Michiquillay, route selection and design should be done in consideration of lead-in at Pacasmayo Substation, future interconnection with Chiclayo in the north, and in the case of Michiquillay, future interconnections with projects such as Yangas and San Juan.

de las Minas de Michiquillay, se debe realizar los estudios definitivos entre los años 1977 y 1978 e iniciar los trabajos de construcción en el año de 1979.

(3) La potencia para las Minas de Michiquillay será suministrada desde el Sistema Eléctrico del Santa que será interconectada al Sistema Eléctrico de la Zona Central, mediante la construcción de la línea de transmisión de Lima - Chimbote; y para este suministro de energía es necesario llevar a cabo las ampliaciones programadas de los equipos Nº 4 al Nº 7 de la Central Hidroeléctrica del Mantaro (capacidad unitaria de 114 MW) y el desarrollo de nuevas fuentes como la Central de Sheque (585 MW); Central Hidroeléctrica de El Chorro (160 MW) y la Central Hidroeléctrica de Yuncan (160 MW) etc.

(4) Mientras se vigila el desenvolvimiento de los nuevos planes de desarrollo descritos en el párrafo precedente (3) y la transición de la demanda de energía, se debe asegurar el suministro de energía a las Minas de Michiquillay tomando las decisiones necesarias para los planes como la construcción de la planta Diesel de Pacasmayo; y adelantar la construcción de la Central Térmica de Alto Chicama dentro del Sistema Eléctrico del Santa; etc., para antes del año 1978 en que se termine los estudios definitivos del presente proyecto, con el objeto de aclarar la seguridad del suministro de energía a las Minas de Michiquillay.

(5) Preparación de los terrenos para la construcción de la Subestación de de Michiquillay.

La Subestación de Michiquillay será construida muy próxima a las Minas, dentro de terrenos montañosos, debido a que la mayoría de la demanda es la carga propia de la minería.

Por esta razón la preparación del terreno para la construcción de la Subestación debe realizarse al mismo tiempo en que se prepara los terrenos para la construcción de las instalaciones mineras desde el punto de vista de las consideraciones técnicas y económicas.

En este caso se debe llevar a cabo las conversaciones necesarias con las autoridades de las Minas de Michiquillay con el objeto de obtener un terreno suficiente para las ampliaciones futuras y el acceso para el transporte de equipos grandes como transformadores de alta capacidad.

(6) Selección de la ruta de la línea de transmisión

La ruta de la línea de transmisión en las cercanías de Pacasmayo y cerca de Michiquillay, se debe diseñar teniendo en consideración la entrada a la Subestación de Pacasmayo, la interconexión futura con Chiclayo en el norte y la interconexión futura con los proyectos de Yangas, San Juan etc.

CHAPTER 3

PRESENT STATE OF DEVELOPMENT OF PROJECT AREA

CHAPTER 3. PRESENT STATE OF DEVELOPMENT OF PROJECT AREA

3-1 Economic Structure

3-1-1 Recent State of Peruvian Economy

(1) Gross Domestic Product

The economy of Peru in 1974 showed favorable development to be an exception in the global economic crisis which engulfed all of the developed countries. In effect, in terms of gross domestic product, there was a growth of 6.3 % over the previous year compared with a rate of 5.6 % for 1973.

The growth rates by category in the gross domestic product when compared with the Five-Year Plan of Peru (1971 - 1975) are indicated below.

Unit: %

	1971-1975 5-year plan target growth rate,	1973 Increase over previous year,	1974 Increase over previous year,
Agriculture	4.2	2.4	1.2
Fishing	4.8	-22.6	51.8
Mining	5.7	0.7	4.2
Manufacturing	12.4	7.5	8.0
Construction,	6.6	8.5	20.2
Other		-	-
Total	7.5	5.6	6.3

Source: EL COMERCIO, 1° DE ENERO DE 1975

(2) Investment

Investment in 1974 showed a growth of 24.7 % over 1973 and the amount invested reached 53,900 million soles. The GDP ratio due to this investment increased to 17.9 % compared with 12.9 % in 1968. The comparison with the target values of Peru's Five-Year Development Plan is as follows:

Unit: $S/10^6$

	1973	1974
Public Sector		
5-Year Plan (1971-1975)	28,530	33,751
Actual investment	14,210	19,943
Ratio (%)	49.8	59.1
Private Sector		
5-Year Plan (1971-1975)	20,240	23,377
Actual investment	29,023	33,957
Ratio (%)	143.4	145.3
Total		
5-Year Plan (1971-1975)	48,770	57,128
Actual investment	43,233	53,900
Ratio (%)	88.6	94.3

(3) Consumer Commodity Price Index and Other

The consumer commodity price index showed an increase of 17.5 %. The Peruvian Government, in order to avoid economic retrogression, has adopted a policy of setting prices for food, petroleum, etc. at low levels compared with international prices, with the differences borne by the state treasury. The unemployment rate in the capital area of Lima decreased from 7.3 % in 1973 to 6.5 % in 1974.

3-1-2 Economy of Project Area

The economy of northern Peru is sustained by mineral products such as copper, zinc and lead, agricultural products such as cotton, sugar and maize, marine products chiefly consisting of fish meal and fish oil, and the production activities of SIDERPERU, the only steelworks in Peru. The production of pig iron by SIDERPERU in 1974 reached 400 thousand tons to supply 60 % of the domestic demand. Much is expected on industrialization in the north from 1977 when an oil pipeline as long as 825 km from San Jose de Saramuro in Departamento de Loreto to Bayovar on the Pacific Ocean coast is completed.

Construction of an automobile parts and assembly plant at Trujillo is scheduled and in 1974 a rolling mill costing 120 million soles, was completed and went into operation.

Agriculture

As a general feature of this region, the export agriculture (sugar, cotton) seen in the coastal area has a relatively well-developed infrastruc ture and utilize more modern production means. In effect, the cultivated land in the coastal area is only 36 % of the total cultivated land in the north but accounts for 72 % of the production amount. Of this, 56 % is export-oriented agriculture. On the other hand, agriculture in the Andes mountain area is practically all subsistence agriculture practiced by Indio and the great part of the agricultural products are consumed domestically.

Table 3-1 Cropped Area, Production and Ratio on National Basis of Principal Agricultural Products (1971)

	Northern Region (A)		Entire Peru (B)		Ratio A/B	
	Cropped area. (10^3 ha)	Production (10^3 ton)	Cropped area (10^3 ha)	Production (10^3 ton)	Cropped area (%)	Production (%)
Rice	102	482	147	591	69.4	81.5
Barley	38	26	183	159	20.8	16.4
Wheat	53	42	139	122	38.1	34.4
Maize	142	138	373	616	38.1	22.4
Potato	36	262	320	1,968	11.3	13.3
Cotton	59	85	137	232	43.1	36.6
Cane	122	7,201	154	8,778	79.2	82.0
Alfalfa	16	671	135	6,346	11.9	10.6
Banana	35	207	137	919	25.5	22.5
Coffee	32	16	136	71	23.5	22.5
Other	241	-	804	-	29.9	-
Total	876	-	2,665	-	32.9	-

Note: Total agricultural production in 1971 of entire Peru is 39,000 million Soles

Mining, Petroleum

The mining industry is the most promising in Peru, and is slessed with abundant resources such minerals as copper, iron, zinc and lead have been confirmed centered in the mountainous area. In particular, development of the Michiquillay Mine has the largest scale of the development projects planned by MINEROPERU, and there is a possibility for it to become one of the largest in the world.

The production of mines in northern Peru accounted for 10 % of total production in 1972 as shown in Table 3-2.

Table 3-2 Production of Principal Mineral Products (1972)

Minerals	Northern region		Entire Peru		Ratio A/B (%)
	Production (10^3 ton)	Value(A) (10^6 s/.)	Production (10^3 ton)	Value(B) (10^6 s/.)	
Copper	11	306	204	5,841	5.2
Zinc	17	107	397	3,392	3.2
Lead	13	86	184	1,506	5.7
Iron ore	0	0	9,414	2,787	0
Silver (ton)	137	215	1,291	2,076	10.4
Petroleum (10^6 barrel)	14	1,190	22	1,921	61.9
Total	-	1,904	-	17,523	10.9

Data source: Anuario de la Mineria del Peru 1972, and data on petroleum for 1971.

Production of petroleum in Peru was started in 1925 and production in excess of domestic consumption continued until 1961, but from 1961, production could not keep up with the growth in domestic demand and in 1971 the production was only 22 million barrels against consumption of 36 million barrels. During this time, most of the petroleum was produced in Departamento de Talara in nothern Peru with a part of the remainder extracted in the eastern Montana. Production in the Talara district indicated a peak of 21 million barrels in 1964, but since then there has been a declining treno and in 1971 the production was only 14 million barrels. On the other hand, production at Zocala in the eastern Montaña showed steady growth since 1965 and reached 10 million barrels in 1970 but subsequently there has been a trend of decrease.

Meanwhile, stimulated by the great success achieved in petroleum development in Ecuador which lies contiguous to Peru, the Peruvian Government entered full-scale into development of the Upper Amazon (northeastern Peru) from 1970, and in 1971 to 1972, more than 10 wells were test-driven and 11 thousand barrels per day were successfully produced.

The investment for petroleum development in the Upper Amazon region amounted to 27 million US dollers by the end of 1974, and by a pipeline (length 825 km, diameter 36 in) crossing the Andos Mountain Range to be completed around the middle of 1976, petroleum will be pumped to the port of Bayovar on the Pacific Ocean coast. It is estimated that the quantity of oil piped will be 250 thousand barrels per day in 1976 and 1,000 thousand barrels per day in 1980, but at the present point in time a definite production schedule has not yet been established.

Further, in the Talara district, 20 million ft^3 of natural gas (reserves, 761,500 million ft^3) is presently being produced accompanying petroleum production, and of this amount 7 million ft^3 is being utilized as energy for petroleum production and maintaining pressures of oil wells. The remaining natural gas is scheduled to be used for fertilizer production at Talara Fertilizer Plant now under construction with technical and economic aid from Japan.

The principal veins of coal in Peru lie in Departamento de la Libertad (Chicama River basin), Departamento de Ancash (Santa River basin) and in the vicinity of Lima (Oyon-Checras) and the reserves are estimated to be 2,363 million tons. However, under present circumstances, since accurate data are lacking, the physical and chemical properties of the coal and the quantity which can be profitably mined are unknown. It is noted that at the Santa River vein in northern Peru an annual average of 100 thousand tons of anthracite coal was mined from 1940 to 1960 although there had been a declining trend from 1958 and the mine was closed by the great earthquake centered around Chimbote which occurred in 1971.

Fishing

Until 1971, Peru was the leading fishing country in the world accounting for one sixth of production of the entire world. An overwhelmingly large part (98 %) of the catch consisted of anchovy used for manufacture of fish meal and fish oil which were important sources of foreign exchange accounting for 30 % of total exports. However, because of the abnormally poor catches of anchovy for the three years from 1971 until very recently, the majority of the fish meal and fish oil plants (37 plants) in northern Peru were closed down. The anchovy catch began to increase again from 1974 and 4 million tons are now expected contrasted to catches of approximately 10 million tons in peak years.

The fishing catches of northern Peru and comparisons with the national total are given in Table 3-3.

Furthermore, in order to raise the nation's level of protein consumption, the Peruvian Government has set forth a policy of expanding production of food fish and at Paita and Samancos (Chimbote) in northern Peru it is about to construct large factories for canning, freezing and smoking.

Table 3-3 Haul of Anchovy and Fish Meal Production

Unit: 10^3 ton

	1968			1970			1972		
	Northern region	Entire Peru	Ratio (%)	Northern region	Entire Peru	Ratio (%)	Northern region	Entire Peru	Ratio (%)
Haul of Anchovy	4,847	10,263	47.2	4,391	12,277	35.7	979	4,446	22.0
Fish meal	881	1,922	45.8	797	2,253	35.4	219	894	24.5
Export	-	2,083	-	716	1,873	38.2	478	1,524	31.4
Internal consumption	-	47	-	-	33	-	-	68	-
Increase and decrease in stock	-	-208	-	-	347	-	-	-656	-
Stock	-	392	-	-	654	-	-	128	-
Fish oil	-	292	-	-	311	-	-	-	-
Export	-	323	-	-	200	-	-	300	-

Table 3-4 Investment Scheme of Fishery at Northern Region

Project	Cold store (10^3 ton)	Export (10^3 ton)	Internal consumption (10^3 ton)	Fishing boat No. of boat	Capacity (ton)	Total investment (10^6 US$)
Paita	42	17	25	15	1,800	25.8
Samancos	25	20	5	5	2,000	16.4

Data source: EPCHAP

Manufacturing

Of the total public investment scheduled during the period of the Five-Year Plan for National Development (1971-1975), 25.1 % is for manufacturing and it is being attempted to raise the ratio of manufacturing to GDP from the 20.9 % of 1970 to 26.9 % in 1975. Government investment in northern Peru is planned to be 1.3 thousand million Soles for the state-owned SIDERPERU Steelworks (1974 pig iron production, 400 thousand tons) at Chimbote and 1.6 thousand million Soles for the fertilizer plant at Talara. Furthermore, with the target for start of operation in 1977, a newsprint factory using bagasse as base material is planned to be constructed at Trujillo. An investment of 2.2 thousand million Soles is required for construction of this plant of which COFIDE will invest 0.6 thousand million Soles with the balance made up by foreign loans. The production of the plant will be 110 thousand tons annually which is a quantity sufficient to meet the demand of the domestic market. Furthermore, various factories centered around the automobile-related industry are scheduled to be built at Trujillo and it is expected that it will show rapid development as an industrial city. Besides the above, plans for a petro-chemical complex are also being considered for Bayovar which will become the shipping port for petroleum produced in the Upper Amazon Basin, but a concrete stage has not yet been reached.

Agriculture, mining and petroleum, fishing and manufacturing in northern Peru have been described in the foregoing. The labor force by industry in this region is shown in Table 3-5.

Table 3-5 Labor Population Devided into Regions(1970)

Regions		Agri-culture	Mining	Manu-facture	Con-struction	Com-mercial	Service	Others	Total
Northern	Population (10^3 persons)	680	15	155	28	94	190	36	1,199
	Ratio (%)	(57)	(1)	(13)	(2)	(8)	(16)	(3)	(100)
Central	Population (10^3 persons)	483	48	333	71	264	511	71	1,782
	Ratio (%)	(27)	(3)	(19)	(4)	(15)	(24)	(4)	(100)
Southern	Population (10^3 persons)	635	17	119	26	94	177	29	1,097
	Ratio (%)	(58)	(2)	(11)	(2)	(9)	(16)	(3)	(100)
Amazon	Population (10^3 persons)	114	1	15	3	16	36	5	191
	Ratio (%)	(60)	(1)	(8)	(2)	(9)	(19)	(3)	(100)
Entire Peru	Population (10^3 persons)	1,912	81	623	128	470	913	142	4,269
	Ratio (%)	(45)	(2)	(15)	(3)	(11)	(21)	(3)	(100)

3-2 Present State of Electricity Industry

Permits and approvals in connection with construction and management of electric power facilities are being given by the Electricity Bureau of the Ministerio de Energia y Minas for both public and privately-owned electric power. Until 1972, supply of electric power to the public was undertaken by Servicios Electricos Nacionales (SEN), regional corporations (Santa Corporation, etc.), municipalities and private campanies, but the Peruvian Government, with the aim of changing to a state-owned integrated system unifying all of these systems, initiated ELECTROPERU in October 1972 unifying SEN, Mantaro Corporation, Santa Corporation, Tacna Corporation, etc. Power supply to the public thereafter became the responsibility chiefly of ELECTROPERU and it is planned for municipally-run and privately-run power supply organizations to be successively absorbed into ELECTROPERU.

Power supply by ELECTROPERU is done by wholesale to companies for distribution, by direct supply to large customers such as factories, and in some regional municipalities, supply by means of small-scale in independent systems.

The geographical division of Peru for the electric power industry is made up of four regions as shown in Fig. 3-1. Locations of the major po power stations are indicated in Fig. 3-2.

The electric power tariffs in Peru are set individually in the form of approval by the Minister of Energia y Minas for the rates petitioned by an electric power enterprise. The Peruvian Government, through Ministerio de Energia y Minas Ordinance No. 1385 EM/DGE dated December 30, 1974, decided that country-wide unified tariffs would be applied to electric power supplied to the public and industrial customers and this was put into effect from January 15, 1975. The tariffs of electric power sold by ELECTROPERU to electric power enterprises and industrial customers are made up of three parts as indicated in Table 3-6.

RTable 3-6 Tariffs of Electric Power Sold by ELECTROPERU

Clases	No. 100	No. 200	No. 300	Reference
Demand charge	100 s/. /kW	90 s/. /kW	80 s/. /kW	Based on maximum monthly demand
Energy charge	0.6 s/. /kWh	0.55 s/. /kWh	0.5 s/. /kWh	
Reactive power energy charge	0.3 s/. /kVarh	0.28 s/. /kVarh	0.25 s/. /kVarh	More than 60% of effective energy
Minimum charge	100 s/. /kWx0.6	90 x/. /kWx0.6	80 s/. /kWx0.6	Based on contract power

Notes: (1) No. 100 for cases of receiving voltage of 13.8 kV and maximum power demand of 50 kW or more.

(2) No. 200 for cases of receiving voltages from 13.8 kV to 60 kV and maximum power demand of 50 kW or more.

(3) No. 300 for cases of receiving voltages exceeding 60 kV and maximum power demand of 50 kW of more.)

Furthermore, for public electric power enterprises with maximum power demand of 30,000 kW or less, a discount of 25 % is given. By industrial customer is meant a customer as stipulated in "Ley General de Industria."

3-2-1 Central Electric Power System

In October 1973, the First Stage Project of Mantaro Hydroelectric Power Station, 342 MW, was completed and through a 220-kV transmission line of total length of 765 km which was completed at the same time, interconnection with the power system of EE.EE.AA. (total installed capacity, 584 MW) was made possible. This interconnection was the first step in structuring of a nation-wide interconnected system, and further, it is

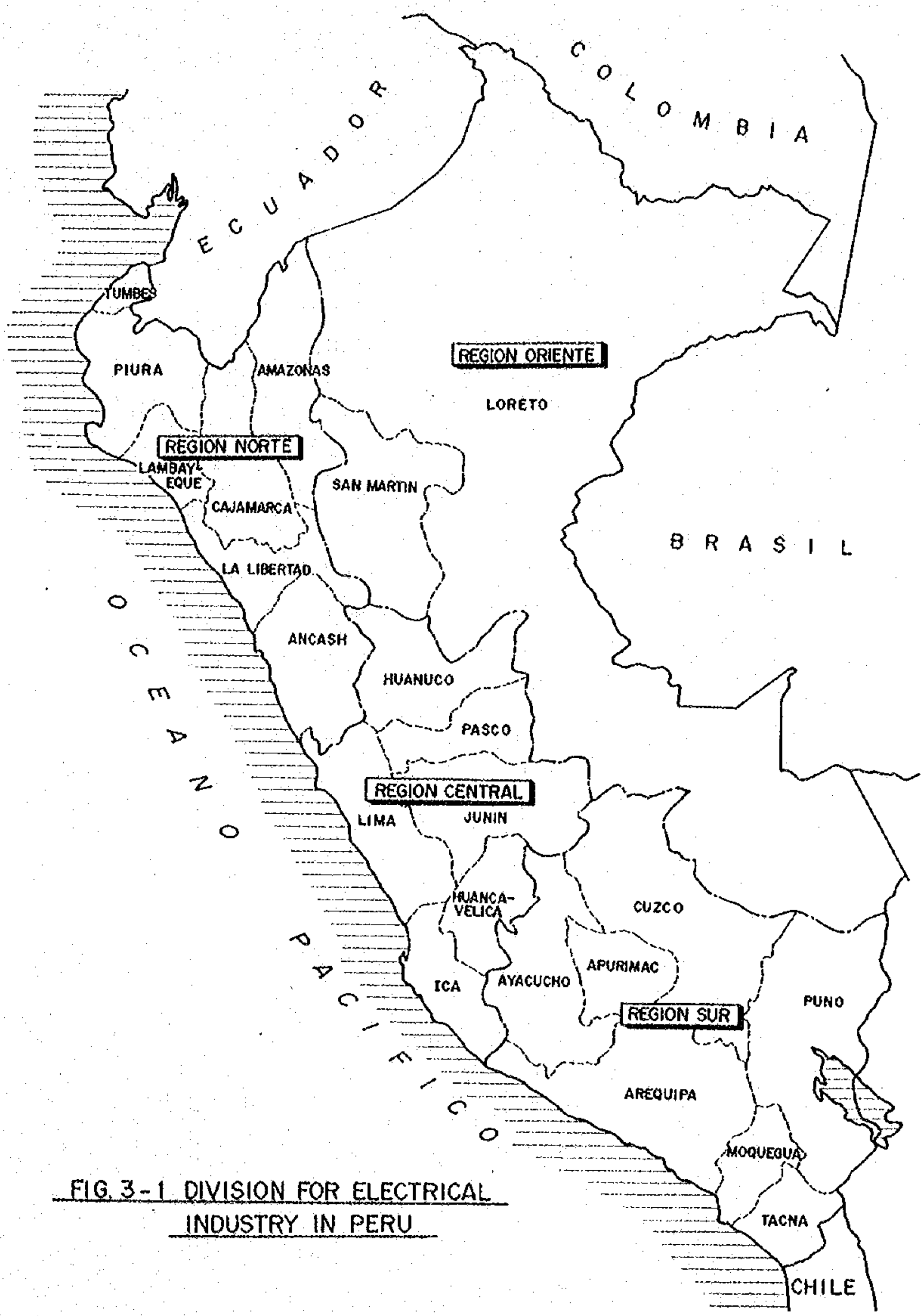
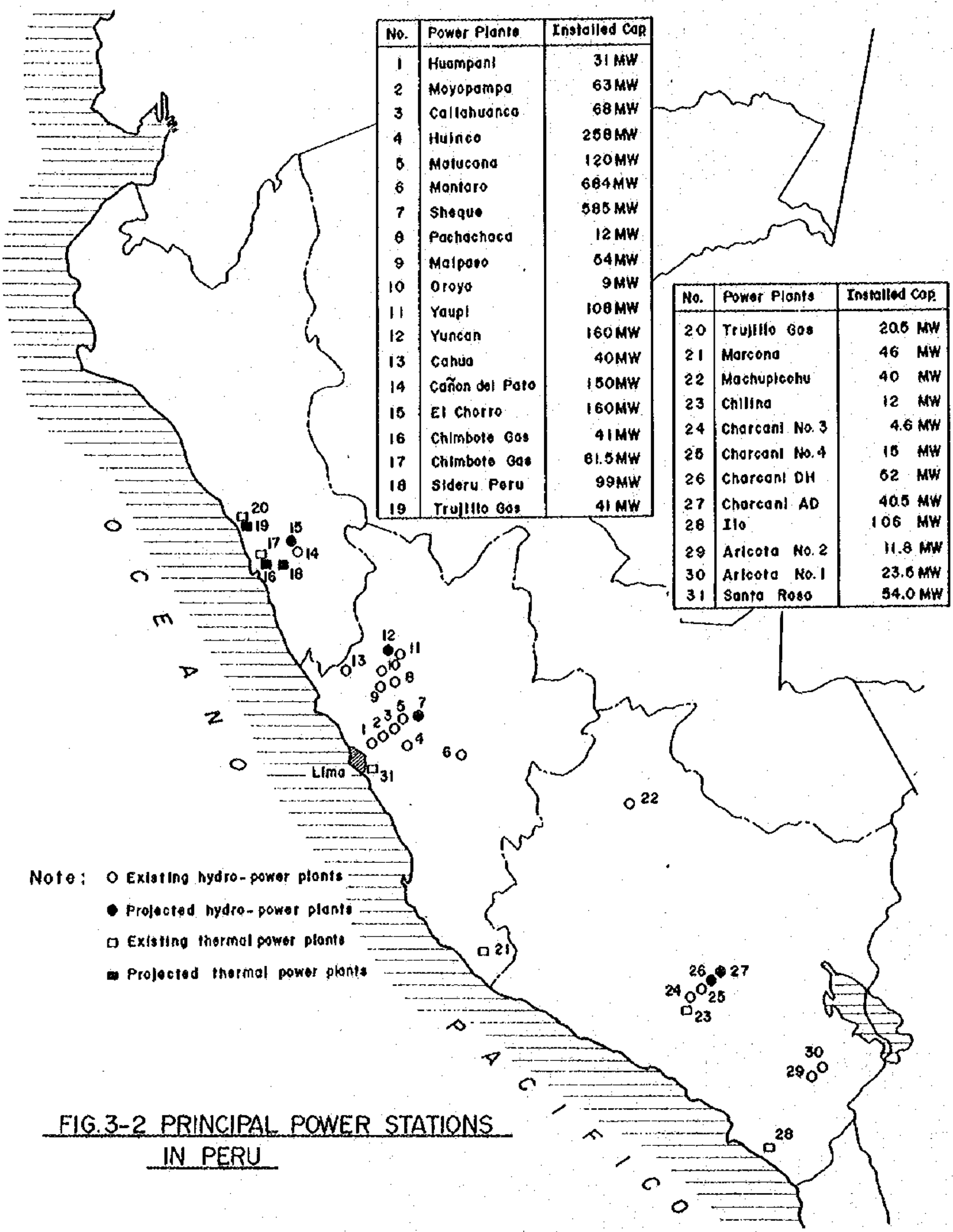


FIG. 3-1 DIVISION FOR ELECTRICAL INDUSTRY IN PERU



No.	Power Plants	Installed Cap.
1	Huampani	31 MW
2	Moyopampa	63 MW
3	Callahuanca	68 MW
4	Huinco	258 MW
5	Matucana	120 MW
6	Mantaro	684 MW
7	Sheque	585 MW
8	Pachachaca	12 MW
9	Malpaso	54 MW
10	Oroya	9 MW
11	Yaupi	108 MW
12	Yuncan	160 MW
13	Cahua	40 MW
14	Cañon del Pato	150 MW
15	El Chorro	160 MW
16	Chimbote Gas	41 MW
17	Chimbote Gas	61.5 MW
18	Sideru Peru	99 MW
19	Trujillo Gas	41 MW

No.	Power Plants	Installed Cap.
20	Trujillo Gas	20.5 MW
21	Marcona	46 MW
22	Machupicchu	40 MW
23	Chilina	12 MW
24	Charcani No. 3	4.6 MW
25	Charcani No. 4	15 MW
26	Charcani DH	62 MW
27	Charcani AD	40.5 MW
28	Ilo	106 MW
29	Aricota No. 2	11.8 MW
30	Aricota No. 1	23.6 MW
31	Santa Rosa	54.0 MW

FIG. 3-2 PRINCIPAL POWER STATIONS IN PERU

scheduled for the CENTROMIN Power System (total installed capacity, 183.5 MW) to be brought into the interconnected system in 1976, and for the Cahua Power System (installed capacity, 40 MW) and the Santa Power System (total installed capacity, 182 MW) in 1978.

In operation of the interconnected system between EE.EE.AA. and Mantaro Hydroelectric Power Station it is expected that the amount of power exchange will become larger with increased demand. The power exchange contract of January 1974 is for 100 MW, but when the Mantaro Second Stage Project (114 MW x 4 units) is completed, the supply of power to EE.EE.AA. is scheduled to become 270 MW.

Power supply to the city of Pisco has also become possible as a result of completion of this interconnected system.

The service area of the Central Power System centered around Lima has 30 % of the total population of Peru with 60 % of the manufacturing production of the entire country, while power consumption is approximately 70 % of the entire country's consumption.

With completion of Mantaro Hydroelectric Power Station the total installed capacity of the interconnected system will be 936 MW, and compared with the total demand of 525 MW of the interconnected system in 1974, there would appear to be a considerable surplus in the supply capability. However, it is thought power demand will continue to grow at a rate close to 10 % as the interconnected system is expanded and the power distribution network is expanded and put in shape, and the development of a large-scale hydroelectric power source to follow Mantaro is looked forward to. The large-scale hydro considered promising in the Central Power System is the Sheque Hydroelectric Development Project.

This Sheque Hydroelectric Project (installed capacity, 585 MW) would consist of diverting an average of 22.8 m^3/sec of water from the Amazon River basin by the existing Marcapomacocha Diversion Tunnel to the intake site of the existing Huinco Hydroelectric Power Station for generation of a maximum output of 585 MW, at the same time adding one 60 MW generator at the existing Huinco Hydroelectric Power Station, which combined with increased generation downstream will produce 2,985,000 MWh. Preparation of a Final Study for this Sheque Hydroelectric Power Station was contracted between ELECTROPERU and Motor-Columbus in October 1974 as a first step toward realization and it is expected that the First Stage Project will be completed at the end of 1980. It might be noted that work for the Sheque Hydroelectric Project is planned to be divided into two stages.

A diagram of the existing electric power system of Region Central is given in Fig. 3-3.

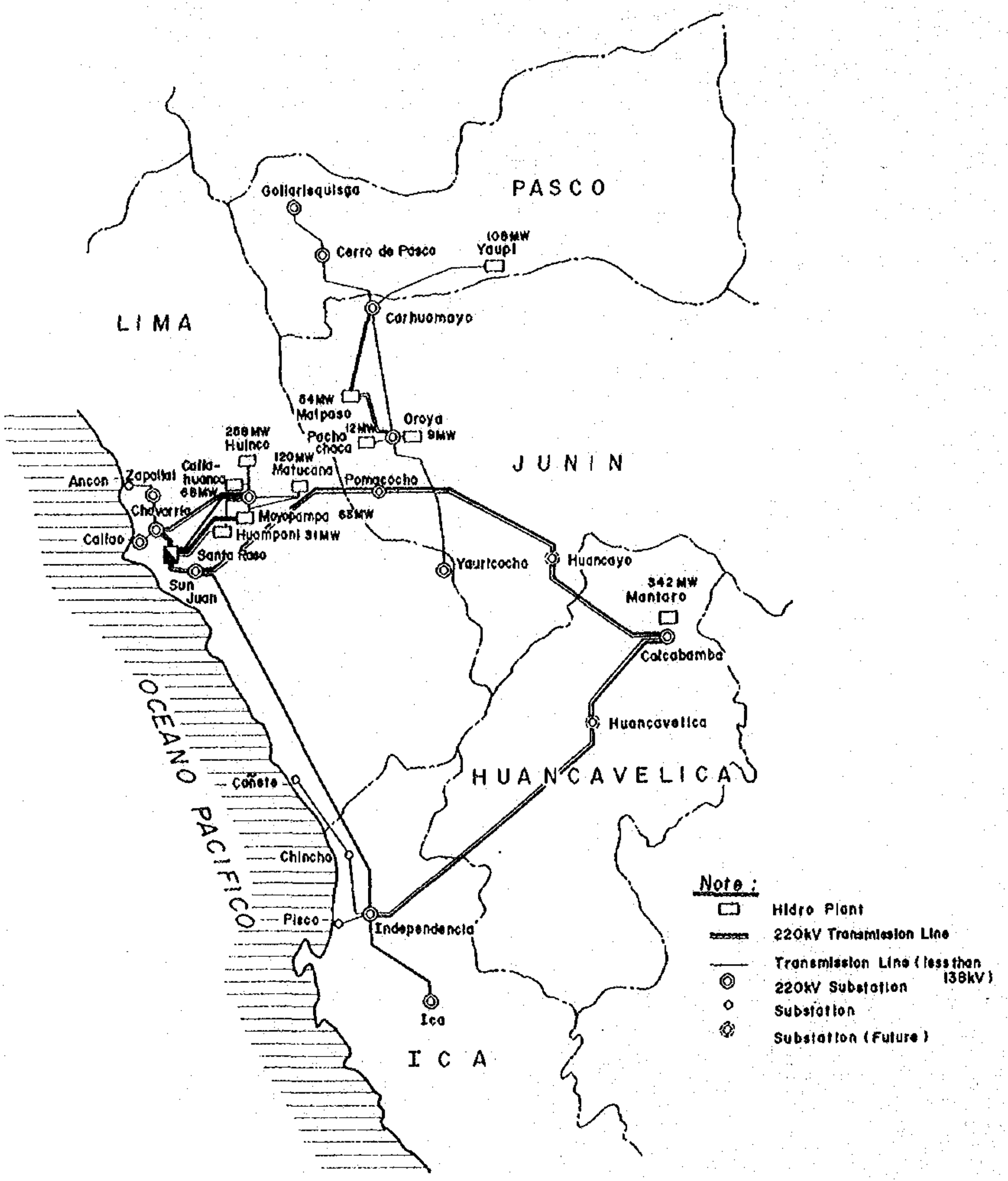


Fig. 3-3 EXISTING POWER SYSTEM IN CENTRAL REGION (1974)

3-2-2 Present State of Electric Power System of Region Norte

In Region Norte (the project area) are the Santa System centered around Chimbote and the power systems of the Santiago de Cao, Pacasmayo, Cajamarca and Chiclayo districts, but there are no interconnecting lines between them and each is an independent system. A diagram of the existing power systems of Region Norte is given in Fig. 3-4.

(1) Santa Power System

The Santa System is a 138 kV, 66 kV power system centered around Chimbote, the largest industrial area of northern Peru, and supplies electric power from Cañon del Pato Hydroelectric Power Station of ELECTRO-PERU to the cities of Chimbote and Trujillo and to the Huaylas district. A state-owned steelworks (SIDERPERU), fish meal factories, and a carbide factory are at Chimbote.

As power generation facilities, there are the Cañon del Pato Hydroelectric Power Station, 100 MW (25 MW x 4 units) at the upstream part of the Rio Santa, and for peaks and emergencies, gas turbines at Chimbote, 61.5 MW (20.5 MW x 3 units) and Trujillo, 20.5 MW.

It should be added that there is a high volume of sand and gravel in the water at Cañon del Pato Power Station to cause heavy abrasion of turbine runners and nozzles so that there is frequent stoppage of one unit of generators for maintenance. Therefore, the dependable output is taken to be 75 MW.

The 138 kV transmission lines are two circuits, 93 km, between Cañon del Pato and Chimbote, and one circuit, 139 km, between Chimbote and Trujillo.

The Santa Power System is to be interconnected with the Central Power System by a 220 kV transmission line in 1978.

(2) Santiago de Cao District

Scattered private power generation facilities for agriculture and manufacturing exist between Trujillo and Pacasmayo. The major power facilities are steam or diesel generators among which are the 12.5 MW of a paper mill (TRUPAL) at Santiago de Cao, the 4.6 MW of a sugar refinery at Cartavio, the 14 MW of the Casa Grande Agricultural Cooperative and the 4 MW of the Laredo Agricultural Cooperative. The paper mill and sugar refinery are interconnected by a 34.5 kV transmission line, but the others are independent systems.

Further, a double-circuit, 138 kV transmission line is to be built between Trujillo and Santiago de Cao in 1976 for interconnection with the Santa Power System.

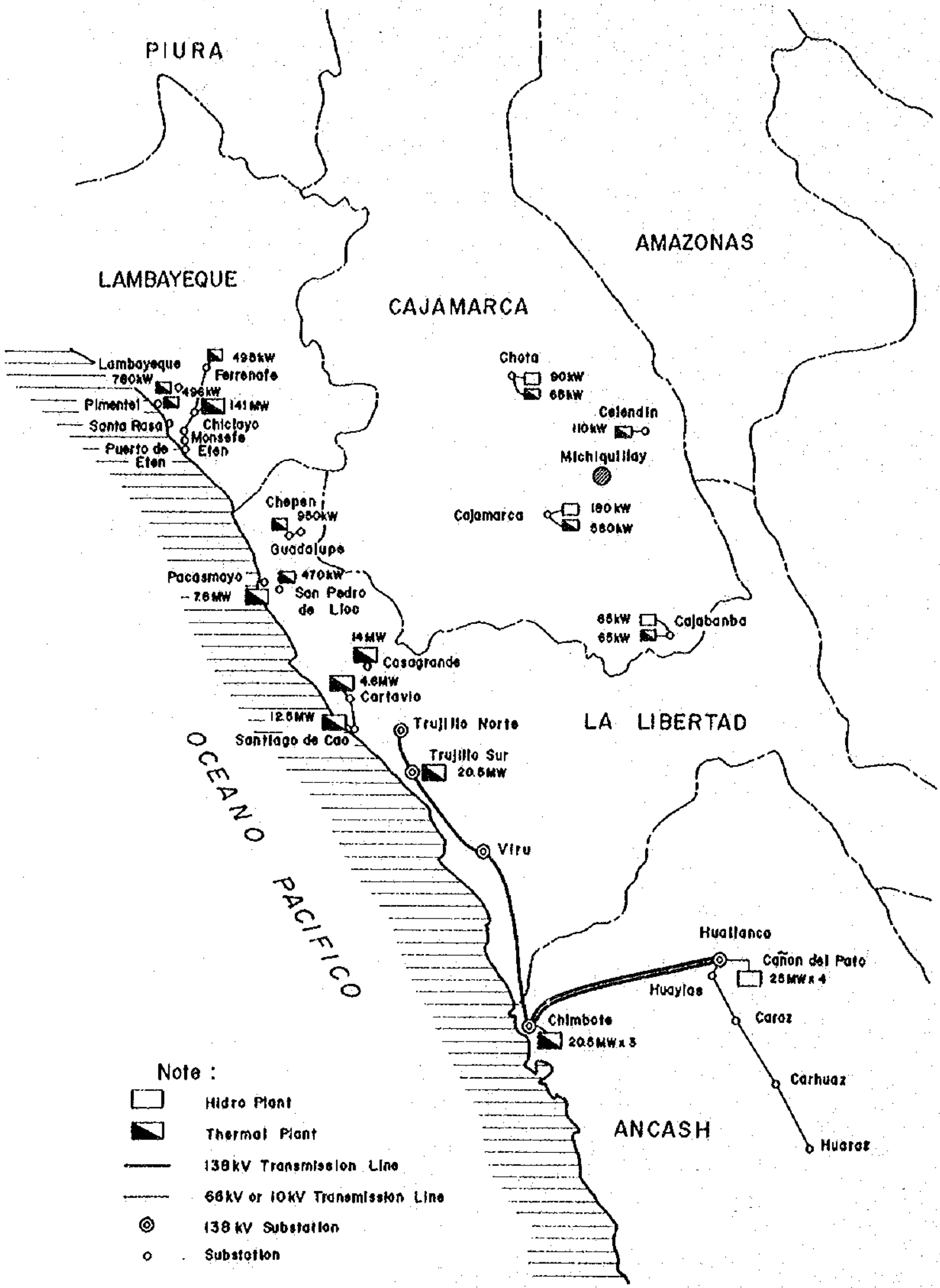


Fig. 3-4 EXISTING POWER SYSTEM IN NORTHERU REGION (1974)

(3) Pacasmayo District

At Pacasmayo, Electrica San Andres S.A. is supplying electric power to the city by means of an 800 kW diesel generator. There is a c cement plant in the suburbs which has 7 MW of steam and diesel, and as there is a plan to expand the plant from daily production of 1,000 tons to 3,000 tons in 1977, construction of an 18-MW thermal power plant is projected.

As for the area surrounding Pacasmayo, there are diesel generators of 740 kW at San Pedro de Lloc and 950 kW at Chepen and Guadalupe supplying power to their respective districts.

(4) Cajamarca District

This district is centered around agriculture and most of the power demand of the city of Cajamarca is for lighting. A hydroelectric power station and diesel power station are supplying power to the city by 13.8 kV lines. The power generation facilities have a capacity of 3,760 kW.

Besides the above, there are towns such as Celendin, Cajabamba and Choto, each having an independent system.

(5) Chiclayo District

This district is centered around Chiclayo and is an agricultural district with sugar cane and rice as the main crops. Electric power is supplied by a 10 kV distribution line from a theremal power station at Chiclayo to the city of Chiclayo and the towns of Monsefu, Eten, Puerto de Eten and Ferrenafe. Power generation facilities consist of 141 MW of steam and diesel at Chiclayo Power Station (of which 3 MW are under repair) and 495 kW of diesel at Ferrenafe.

Also, the towns of Lambayeque, Pimentel, Santa Rosa and San Jose have individual diesel plants for power supply and very soon will be interconnected with Chiclayo by a 10 kV districution line.

Furthermore, the Peruvian Government has plans for interconnection in the future with the Santa System by a 220 kV transmission line.

3-3 Present State of Development of Michiquillay Mine

The Michiquillay Mine which was discovered in 1957 by a peruvian later went through many changes in circumstances and was nationalized by the decree of 1970 abrogating mining concessions and the mining rights held till then by ASARCO were reverted to the Peruvian Government. Later, it was agreed between Michiquillay Mining Co., Ltd. and MINERO-PERU for joint development of the mine and a comprehensive development plan (F.R.) is now being prepared.

(1) Mine Development Plan

Geological surveys, basic extraction plans, appurtenant civil facilities (waste disposal, water supply dam, river diversion, roads, and foundations for civil and building work), ore dressing studies, and preparation of topographical maps have been completed, and at present a joint operation of engineers from MINEROPERU and Michiquillay Mining is going on in Peru to finalize an ore dressing plan (pilot plant). Meanwhile, studies and work in Japan on quantity of reserves, concentration calculations, ore extraction plans, basic flow sheet on ore dressing, mechanical equipment calculations, civil work cost calculations of appurtenant facilities, obtainment of estimates from various manufacturers, selection of optimum scale, etc. have more or less been completed, and at present these are being put together.

(2) Infrastructure Build-up Plan

In July 1973, International Development Center of Japan, commissioned by the Metallic Minerals Exploration Agency of Japan, carried out a basic survey of the infrastructure of the Cajamarca district (Mera Mission), prepared basic plans on mining community development, water re resources development, electric power development, and port and harbor development, and recommended further necessary surveys to the two governments of Peru and Japan. Responding to this, a survey mission on electric power which carried out the investigations described in this Report was dispatched in November 1974 following which a survey mission on road development was dispatched to Peru in March 1975. It is planned for survey missions on port and harbor development, mining community development and water resources development to be dispatched in succession.

In order to start operation in 1982, build-up of the infrastructure will be indispensable, and a construction period of 5 years will be required for this purpose.

Development of the mine will be by open-cut, and from 1982, 40 thousand ton per day of ore will be handled. Copper concentrates produced will be piped 240 km to the port of Pacasmayo scheduled to be newly constructed where it will be dehydrated, dried, and shipped out. The ore reserves in terms of copper ore of concentration of 0.75 % or higher are seen to be 412 million tons and at the rate of 40 thousand ton per day, the mine life will be approximately 30 years.

The total development cost is expected to be increased from the 284 million US dollars originally estimated to more than approximately 400 million US dollars due to the abrupt rises in commodity prices since the oil crisis. Therefore, it has become necessary from the standpoint of the economics to enlarge the mining scale, and ore handling at a rate of 70 thousand ton per day from 1987 is being considered.

Comparison of Dimensions for Development of the Michiquillay Mine

Dimensions		Japanese Mission	ASARCO
Quantity of ore (10^6 ton)		412	519
Handling of ore (10^3 ton/day)		30	36
Average grady of ore for 13 years (%)		Cu 0.823	0.80
Total average grade of ore (%)		0.75	0.72
Intial strip sand and soil (10^6 ton)		60	143
Copper ore mining ratio (%)		87.7	87
Copper concentrate (%)		Cu 30	29
Annual production of copper (ton)		75,800	95,600
Total development cost			
Mining	(US$ 10^6)	240	338
Infrastructure	(")	44	
Total	(")	284	338

As a note, operation of a pilot plant to establish the grade of ore was started in September 1974 and the results being extremely good the outlook for development of the mine is very bright.

CHAPTER 4

LOAD FORECAST

CHAPTER 4. LOAD FORECAST

4-1 Basic Considerations

Approximately 95 % of electric energy supplied through the Michiquillay power transmitting and transforming facilities will be consumed by the Michiquillay Mine. Consequently, the objectives of the load forecast required for technical and economic evaluations of the Project would be considerably achived if the accurate value of power demand to arise from Michiquillay Mine were to be obtained. However, it is necessary to examine whether the existing and proposed generating facilities will have capability enough to supply power to the Michiqullay Mine, therefore, load forecasts of the Central and Santa Power Systems will be required.

Regarding the Central Power System and the Santa Power System, there are the load forecasts made in 1974 by the Direccion de Electricidad del Ministerio de Energia y Minas, while further, for the Santa Power System, a detailed load forecast was made in the "Report on Prefeasibility Study of Yangas Hydroelectric Power Development Project" submitted to the Government of Peru by a Japanese Government Survey Mission in February 1975. These forecasts are of the so-called "analytical method" where load forecasts are made by areas and then summed up.

With the values from the above as bases, the Survey Mission made some modifications based on the data obtained as a result of field investigations of the load forecast for the Central Power System and the Santa Power System.

These results (load forecasts by the analytical method) were cross-checked by macroscopic load forecasts in order to confirm its appropriateness.

4-2 Power Demand of Michiquillay Mine and Surrounding Area

4-2-1 Power Demand of Michiquillay Mine

The Power demand of the Michiqullay Mine including the power supply required for the mining community of approximately 40,000 persons to be built accompanying development of the mine is forecasted to be maximum power of 40 MW assuming mining scale of 40,000 ton per day, and 65 MW from 1987 when the mining scale will become 70,000 ton per day. The maximum power and energy by year would be indicated below.

Of the Michiquillay Mine demand, a power demand to be kept in mind is the load of approximately 15.2 MW of synchronous motors. This demand is mainly composed of electric motors for running ore crushing mills and its high load-factor operation (LF = 0.84) is expected.

Table 4-1 Demand at Michiquillay Mine

Classification		1982	1983	1984	1985	1986	1987
Mining:	Max. demand (MW)	1.8	1.8	1.8	1.8	1.8	2.9
	Energy (GWh)	10.5	10.5	10.5	10.5	10.5	17.1
Concentrate:							
	Max. demand (MW)	28.3	28.3	28.3	28.3	28.3	46.0
	Energy (GWh)	197.8	197.8	197.8	197.8	197.8	321.4
Mining city and others:							
	Max. demand (MW)	10.2	10.2	10.2	10.2	10.2	16.1
	Energy (GWh)	70.4	70.4	70.4	70.4	70.4	114.2
Total:	Max. demand (MW)	40.0	40.0	40.0	40.0	40.0	65.0
	Energy (GWh)	278.7	278.7	278.7	278.7	278.7	452.7

Note: 1/ Constant in and after of 1987

4-2-2 Power Demand of Surrounding Area of Michiquillay Mine

The power demand of the Department of Cajamarca in which the Michiquillay Mine is located is small on the actual demand at Cajamarca, the capital city of the said Department having a population of approximately 50,000, being less than 2,000 kW in October 1974. The data for communities having power generation facilities are indicated in Table 4-2.

Table 4-2 Actual Demand of Cajamarca in October 1974

Cities	Urban population (10^3 persons)	Effective installed capacity (kW)	Max. demand (kW)	Generation (MWh)	L.f (%)	No. of customers	kWh per customers	Reference
Cajamarca	49.8	3,760	1,740	509.2	40.6	4,484	114	Diesel, Hydro
San Marcos	2.1	75	46	8.1	27.4	448	18	Hydro
Cajabamba	5.8	125	-	4.6	-	399	12	Diesel, Hydro
Celendin	8.0	189	75	11.3	20.9	792	14	Diesel
Bambamarca	5.0	63	21	5.9	39.0	132	47	Hydro
Chota	6.1	195	99	23.9	33.5	732	33	Diesel, Hydro
Santa Cruz	2.8	217	63	8.8	19.4	243	36	Diesel,
Cascas	2.5	145	79	15.4	27.1	405	38	Hydro
Niepos	0.8	26	7	2.5	49.6	81	31	Hydro
Contumaza	2.6	155	51	10.4	28.3	334	32	Hydro

The cities which are located within 30 km from Michiquillay Substation to be constructed adjacent to the Michiquillay Mine and hence can be considered to receive power supply are Cajamarca and Celendin. In view of the present urban population and the number of customers it is estimated that potential demand will be 1.5 to 2 times the present demand. The results of load forecasts for Cajamarca and Celendin are given in Table 4-3.

Table 4-3 Demand of Cajamarca and Celendin

Location \ Year	1976	1978	1980	1982	1985	1990	Increase (%)
Cajamarca:							
Max. demand (MW)	2.1	2.7	3.3	4.0	5.0	6.5	8.4
Energy requirement (GWh)	7.1	8.9	10.6	12.3	14.6	18.3	7.0
Celendin							
Max. demand (MW)	0.2	0.3	0.4	0.5	0.6	0.9	11.2
Energy requirement (GWh)	0.9	1.1	1.4	1.7	2.0	2.9	8.7
Total Total							
Max. demand (MW)	2.3	3.0	3.7	4.5	5.6	7.4	8.7
Energy requirement (GWh)	8.0	10.0	12.0	14.0	16.6	21.2	7.2

Source: Prefeasibility Report on Yangas Hydro Power Project, prepared by JICA

Increases in demand arising from regional development around Cajamarca and Celendin are expected to come from the light industries such as lumbering, flour mills and ceramics, but there are no concrete plans established at the moment.

4-3 Power Demands of Santa Power System and Chiclayo Power System

The existing Santa Power System has a structure centered around Cañon del Pato Hydroelectric Power Station (100 MW) located on the Santa River, with gas turbines (total capacity 82 MW) installed at Chimbote Sub-Station and Trujillo Substation, 138 kV transmission lines connecting these power sources, and power receiving substations located at Chimbote and Trujillo.

The maximum power demand of this Santa Power System in 1974 was 82 MW of which 60 % was consumed by SIDERPERU located in the city of Chimbote.

The actual power generation performances of the Santa Power System in the most recent years are indicated in Table 4-4. It should be noted that a great earthquake occurred in May 1970 centered around Chimbote and Cañon del Pato Hydroelectric Power Station was forced to be stopped for a long period due to restoration work. As a result, power generation in 1970 fell to approximately 50 % compared with 1969. This long-term outage of Cañon del Pato Hydroelectric Power Station, proving to be a great obstacle to restoration work in the disaster area centered around Chimbote, caused the Peruvian Government to install three 20.5 MW gas turbine units at Chimbote and one gas turbine unit of the same capacity at Trujillo in 1971 and 1972 respectively in order to be able to quickly cope with such unforeseen emergencies.

Table 4-4 Actual Demand in Santa Power System

Year	Cañon del Pato (GWh)	Chimbote Gas turbine (GWh)	Trujillo Gas turbine (GWh)	Total generated energy (GWh)	Total generated energy (MW)	L. F (%)	Energy demand at customer: SIDER-PERU (GWh)	Energy demand at customer: Residential and others (GWh)	Energy demand at customer: Total (GWh)	Loss factor (%)
1968	210.2	-	-	210.2	51.5	46.6	76.6	119.4	196.0	6.8
1969	218.1	-	-	218.1	51.0	48.8	84.9	121.0	205.9	5.6
1970	113.4	-	-	118.2	53.0	25.5	37.5	72.2	109.7	7.2
1971	245.0	5.4	-	250.3	60.0	47.6	117.6	106.7	224.3	10.4
1972	247.0	16.5	3.4	263.7	57.0	52.8	125.4	111.4	236.8	10.2
1973	321.0	12.4	2.4	335.8	71.0	54.0	184.4	119.2	303.6	9.6
Increase (%)	8.8	-	-	9.8	6.6		20.1	0.0	9.0	-

Chiclayo located approximately 100 km from Pacasmayo by the Pan American Highway is the second major city of northern Peru next to the largest city of Trujillo and has a population of approximately 200,000. The electricity industry of Chiclayo is a private enterprise, Cía. de Servicios Electricas S.A., which as of October 1974 had a total installed capacity of 14.1 MW and was generating a maximum of 9.0 MW. The power generation performances and the energy consumptions since 1968 are shown in Table 4-5.

Table 4-5 Actual Demand in Chiclayo City

Year	Generated energy (GWh)	Max. demand (MW)	L. f (%)	Energy demand at customer end (GWh)	Loss factor (%)	Reference
1968	26.4	5.5	54.8	-	-	
1969	28.4	5.9	54.9	-	-	
1970	30.0	6.3	54.3	-	-	Energy sold in 1973: s/.56,977x10^3
1971	32.5	6.8	54.6	-	-	
1972	35.1	7.3	54.9	-	-	
1973	36.3	7.9	52.5	29.9	17.6	
Increase (%)	6.6	7.5	-	-	-	

Cia. de Servicios Electricas S.A. has been proceeding with plans for extension of a 2.5 MW diesel generating facility scheduled for completion in March 1975 in order to meet increasing power demand.

Regarding the power demands of the Santa Power System and the Michiquillay project area in 1976, the forecast figures by MEM and the forecast figures by the Yangas Hydroelectric Power Development Project Survey Mission are correspondingly indicated in Tables 4-6 and 4-7. Further, the detailed forecast figures for each year from 1976 to 1990 are shown in Tables A-2-1 and A-2-2. The present Survey Mission has adopted the same figures as the Yangas Survey Mission except for the load of SIDERPERU which has been revised based on the latest capital investment plans for SIDERPERU obtained by the present Survey Mission.

Table 4-6 Power Demand in Santa and Other Systems

Unit: MW

Item \ Year	1976	1978	1980	1985	1990	Increase (%)
Sistema Santa	2/ (-) 139	(357) 253	(413) 279	(580) 350	(627) 415	(7.1) 8.1
Pacasmayo	(-) 2	(21) 7	(23) 9	(46) 18	(64) 29	(9.8) 21.0
Lambayeque (Chiclayo)	(-) 14	(-) 16	(95) 20	(113) 35	(142) 51	(4.1) 9.7
Cajamarca Celendin	2	3	4	5	7	9.4
Michiquillay 1/	-	-	-	1/ (50) 40	(57) 65	(-) -
Total	(-) 157	(378) 279	(531) 312	(789) 448	(890) 567	(9.5) 9.6

Note : 1/ Michiquillay mine will be put in operation in 1982.
2/ Figures in parenthesis indicate the demand estimated by MEM.

Table 4-7 Energy Demand in Santa and Other Systems

Unit: GWh

Items \ Year	1976	1978	1980	1985	1990	Increase (%)
Sistema Santa	2/ (-) 631	(1,348) 1,128	(1,855) 1,340	(2,533) 1,926	(2,937) 2,213	(7.7) 9.4
Pacasmayo	(-) 11	(103) 30	(115) 40	(188) 70	(267) 95	(8.6) 16.6
Lambayeque (Chiclayo)	(-) 66	(-) 79	(487) 93	(564) 140	(680) 200	(3.4) 8.2
Cajamarca Celendin	8	10	13	17	21	7.1
Michiquillay 1/				(287) 278	(323) 452	(-) -
Total	(-) 716	(1,451) 1,247	(2,457) 1,486	(3,572) 2,431	(4,207) 2,981	(10.1) 10.7

Note : 1/ Michiquillay mine will be put in operation in 1982.
2/ Figures in parenthesis indicate the demand estimated by MEM.

4-4 Power Demand of Central Power System

The power systems comprising the interconnected power grid of Region Central will be, from 1976 on, the four of the existing Mantaro Power System, the EE.EE.AA. Power System, the CENTROMIN Power System and the Marcona Power System. Further, in 1978, with completion of the Lima-Chimbote Interconnecting Transmission Line, the existing Paramonga Power System will become interconnected with the Central Power System. As a result, power systems in Region Central which will not have been interconnected with the Central Power System after 1978 will be less than 10 % of total installed capacity.

The total installed capacity of the five power systems in 1974, including the Paramonga Power System, was 1,207 MW, and the maximum power demand was 745 MW (assumed). In the Central Power System, the power demand of EE.EE.AA. occupies 70 % and that of CENTROMIN 18 %. The actual past data of these two power systems are shown in Table 4-8.

Table 4-8 Actual Data of EE, EE, AA and Centromin

Year	EE, EE, AA Max. Demand (MW)	EE, EE, AA Generated Energy (GWh)	Centromin Max. Demand (MW)	Centromin Generated Energy (GWh)	Remarks
1968	338	1,733	123	951	
1969	353	1,842	126	920	
1970	391	1,994	127	924	No available data on
1971	425	2,204	129	876	Centromin for 1973
1972	444	2,345	130	973	
1973	485	2,555	-	-	
Increase(%)	7.6	8.1	-	-	

CENTROMIN is pushing ahead with a plan for annual production of 118,000 tons of electrolytic copper by 1980 through new development of the Toromocho Mine and further development of the existing mines at Cobriza and Casapalca. Since it is expected that power demand will be doubled, if the demand for this plan is added to the demand of existing mines, development of the Yuncan Hydroelectric Power Project (160 MW) as the power source to meet this demand is presently being pushed.

There is a plan for construction of Peru's second steelworks at Nazca located 400 km south of Lima and the Peruvian Government is proceeding with various preparations aiming at start of operation in 1980. Iron ore is planned to be supplied from the nearby Marcona Mine.

The results of load forecast for the Central Power System from 1976 compared in terms of the MEM forecast figures and the Survey Mission's forecast figures including corrections considering the power generation performance of EE.AA.AA. for 1973 obtained by the Survey Mission are indicated in Tables 4-9 and 4-10. Detailed forecast figures for each year from 1976 to 1990 are given in Tables A-2-1 and A-2-2.

Table 4-9 Power Demand in Interconnected Central Power System

Unit: MW

Item \ Year	1976	1978	1980	1985	1990	Increase (%)
Sector Lima	(623) 600	(789) 714	(958) 850	(1,366) 1,313	(1,940) 2,030	(8.5) 9.1
S. Paramonga-Huacho	-	62	66	69	80	-
S. Pisco	16	17	17	20	23	2.6
S. Ica	8	9	10	14	19	6.4
S. Nazca	-	-	16	72	107	-
S. Marcona Mining	115	115	115	115	126	0.7
S. Huancavelica	-	20	36	43	49	7.8
S. Centromin	209	289	392	439	485	6.2
S. Tarma	17	20	27	35	40	6.3
S. Huancayo	-	14	17	23	32	7.8
S. Otros	6	15	20	27	39	-
Estimated new demand	-	-	-	-	75	-
Total	(994) 971	(1,350) 1,275	(1,674) 1,566	(2,223) 2,170	(3,015) 3,105	(8.3) 8.7

Note : Figures in parenthesis indicate the maximum demand estimated by MEM.

Table 4-10 Energy Demand in Interconnected Central Power System

Unit: GWh

Item \ Year	1976	1978	1980	1985	1990	Increase (%)
Sector Lima	(3,274) 3,153	(4,148) 3,752	(4,941) 4,467	(7,213) 6,901	(10,414) 10,669	(8.5) 9.1
S. Paramonga-Huacho	-	312	334	350	410	2.3
S. Pisco	39	53	61	73	86	5.8
S. Ica	36	43	51	71	94	7.1
S. Nazca	-	-	56	403	635	-
S. Marcona Mining	638	638	638	638	704	0.7
S. Huancavelica	-	170	215	253	288	4.5
S. Centromin	1,517	2,107	2,877	3,221	3,556	6.3
S. Tarma	91	104	135	181	205	6.0
S. Huancayo	-	40	49	74	107	9.0
S. Otros	30	63	79	109	138	-
Estimated new demand	-	-	-	-	416	-
Total	(5,625) 5,504	(7,678) 7,282	(9,436) 8,962	(12,586) 12,274	(17,053) 17,308	(8.2) 8.5

Note: Figures in parenthesis indicate the energy demand estimated by MEM.

4-5 Load Forecast by Macroscopic Method

It is a well-known fact that there is a very close correlation between income per capita and electric power consumption per capita. In Fig. 4-1, the correlations between gross domestic product per capita and electric energy consumption per capita of various countries in the world are shown taken from the 1973 United Nations Statistical Yearbook.

The electric energy consumption per capita and the gross domestic product per capita of Peru are roughly at an average level for the world, and it should be permissible to consider that the average growth in electric energy consumption of the world is traced in accordance with the growth in GDP per capita (which may be considered as income per capita).

In application of load forecast by macroscopic method to the the Central Power System and the Region Norte Power System of Peru, there is a necessity for the trend of GDP to be forecast into the future. The target growth rate in GDP of Peru for the Five-Year Plan from 1971 through 1975 is 7.5 % annually, while the actual rates were 5.6 % in 1973 and 6.3 % in 1974. It is difficult to make a long-range forecast of GDP in view of the structure of the Peruvian economy, because the economic development program chiefly based on mineral resources has a close relation with trends in the world economy and is easily affected by international market prices.

Consequently, the load forecast was made by obtaining the figures of the power demand of entire Peru in the cases of GDP growing at annual rates of 8 %, 6 % and 4 % up to 1990, and assuming that the ratios of the power demands of the Central Power System and the Santa Power System to the power demand of the entire country would remain unchanged in the future. The results are given in Table 4-11.

Evaluating the load forecast made with the analytical method by the results of the forecast by the macroscopic method, it is thought difficult for growth in power demand up to 1980 to be realized unless there is a GDP growth rate of around 7 %. The results of long-range forecasts up to 1990 by the macroscopic method coincide well with the case of GDP growth rate of 6 %. It should be noted that the results of load forecast for the Santa Power System made by the analytical method are at the upper limits of the results of forecast by the macroscopic method and it is thought these are largely influenced by the expansion plans of SIDER-PERU and the power demand of the Michiquillay Mine.

Table 4-11 Comparison of Load Forecast between Macro and Analytical Method

Unit: 10^6 kWh

Year	1980	1985	1990
I. Load forecast by macro method			
(1) Growth rate of GDP: 4 %			
Santa system	1,072	1,447	1,958
Central system	6,525	8,803	11,914
Total	7,597	10,250	13,872
(2) Growth rate of GDP: 6 %			
Santa system	1,217	1,867	2,834
Central system	7,404	11,359	17,273
Total	8,621	13,226	20,107
(3) Growth rate of GDP: 8 %			
Santa system	1,444	2,100	3,994
Central system	8,784	12,779	24,298
Total	10,228	14,879	28,292
II. Load forecast by analytical method			
(1) Load forecast by mission			
Santa system	1,353	2,291	2,781
Central system	8,962	12,274	17,308
Total	10,315	14,565	20,089
(2) Load forecast by MEM			
Santa system	1,855	3,008	3,527
Central system	9,436	12,586	17,053
Total	11,291	15,594	20,580

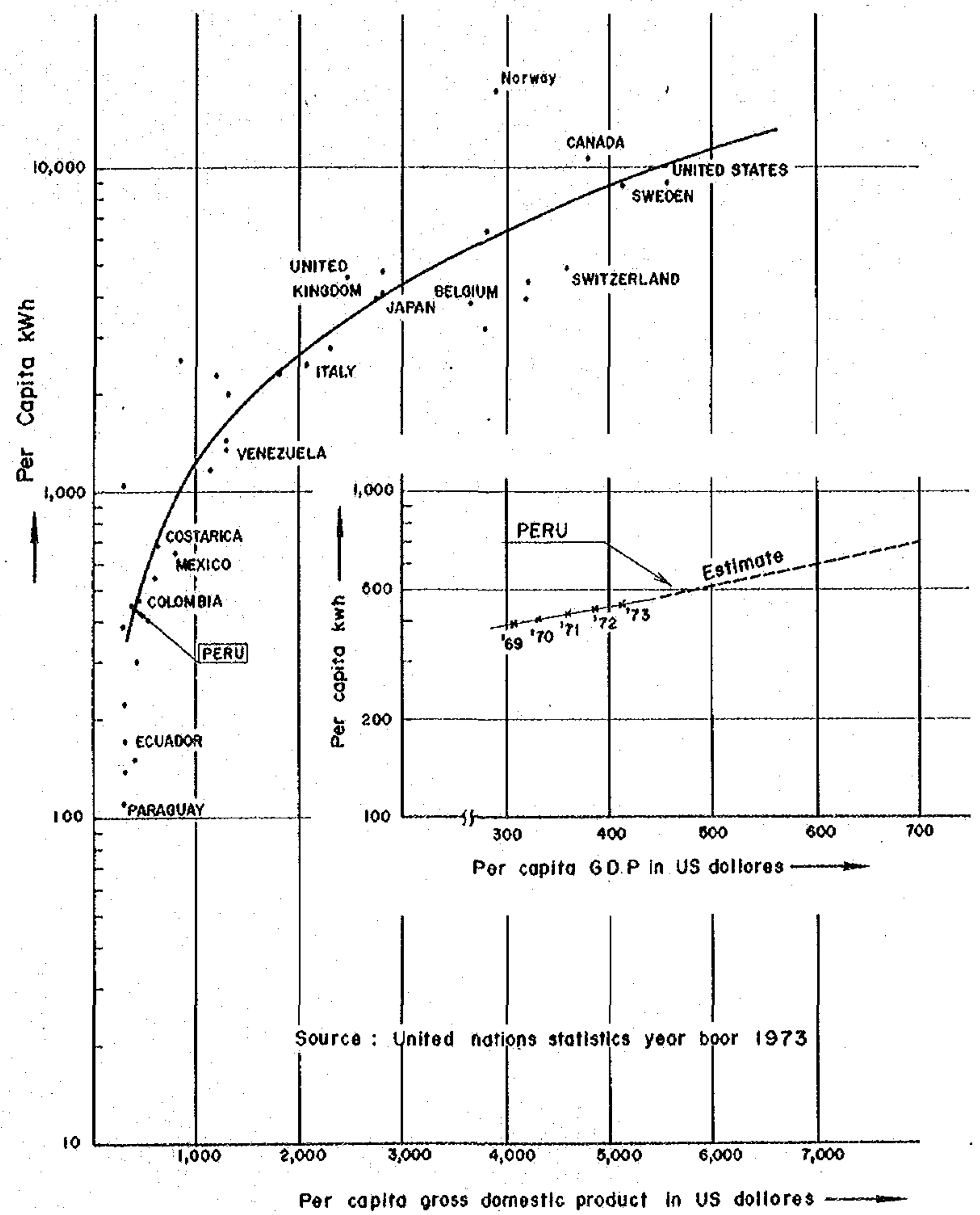


Fig. 4-1 RELATION BETWEEN PER CAPITA KWH AND GROSS DOMESTIC PRODUCT

4-6 Power Demand and Supply Balance and Power Transmitted from Central Power System to Santa Power System

In the examination of power demand and supply balance, since the Central Power System and the Santa Power System are to be interconnected in 1978 by the Lima-Chimbote Interconnecting Transmission Line, besides studying the power demand and supply balance of the entire interconnected system, the surplus capacity of the Central Power System to supply the Santa Power System through the Lima-Chimbote Interconnecting Transmission Line was also considered.

4-6-1 Electric Power Development Plans

Regarding electric power development plans, construction schedules thought to be the most reasonable at the present time were studied based on existing reports, and it was assumed the following power sources would become interconnected with the power systems by 1985.

Central Power System

Mantaro Hydro,	No. 4 Unit	114 MW	Oct. 1976
	No. 5 Unit	"	Mar. 1977
	No. 6 Unit	"	Jul. 1977
	No. 7 Unit	"	Dec. 1977
Lima Thermal,		125 MW	1978
Sheque Hydro,	Stage I	292.5 MW	1981
Huinco Hydro,	Extension	60 MW	1981
Sheque Hydro,	Stage II	292.5 MW	1983
Yuncan Hydro		160 MW	1984
Sub-total		1,386 MW	

Santa Power System

Gas turbine	82 MW	1976
Canon del Pato, Extension	50 MW	1978
SIDERPERU Thermal	99 MW	1978
El Chorro Hydro	160 MW	1982
Sub-total	391 MW	

4-6-2 Power Demand and Supply Balance

As power demand, the demand forecast by the analytical method was adopted, while the dependable supply capability throughout the year was considered as the supply capability to meet the power demand. Regarding the supply capabilities of power stations to be incorporated in the power systems according to electric power development plans, existing reports were used as bases, but modifications were made for the Yuncan Hydroelectric Project and the El Chorro Hydroelectric Project which will be subject to changes in their installed capacities. Further, although unit capacity for the Alto Chicama Coal-burning Thermal Power Station Project is planned to be 120 MW, viewed from the standpoints of the system capacity of the Santa Power System and the transmission capacity of the Lima-Chimbote Interconnecting Transmission Line, a unit capacity of around 60 MW for the first-stage project should be more reasonable.

The supply capabilities of the Central and Santa Power Systems are indicated in Table 4-12.

Table 4-12 Supply Capability in the Central and Santa Power Systems up to 1985

Name of power plants	Installed capacity (MW)	Dependable power (MW)	Dependable energy (GWh)	Remarks
1. Central power system				
a) Existing power plants				
EE, EE, AA				
Huinco	258	240	875	
Matucana	120	90	745	
Callahuanca	68	60	505	
Moyopampa	63	63	460	
Huampani	31	27	190	
Santa Rosa	54	48	47	Gas turbines
sub-total	594	528	2,822	
Centromin				
Pachachaca	12	4.5	38	
Malpaso	54.5	43	200	
Yaupi	108	86.4	680	
La Oroya	9	7	47	
sub-total	183.5	140.9	965	
Cahua	40	40	175	HIDROANDINA
Marcona	47	42	245	Marcona Mining Co.
Mantaro	342	342	2,990	ELECTROPERU
Total	1,206.5	1,092.9	7,197	

b) Under construction or planning				
Sheque	585	585	1,792	
Huinco	60	0	1,193	after compleation of Sheque 2nd stage
Mantaro	456	342	70	
Lima thermal	125	113	766	
Yuncan	160	160	910	
Sub-total	1,386	1,200	4,731	
Total	2,592.5	2,272.9	11,928	
2. Santa power system				
a) Existing power plants				
Cañon del Pato	100	75	630	
Chimbote Gas turbine	61.5	61.5	54	
Trujillo Gas turbine	20.5	20.5	18	
Sub-total	182	157	702	
b) Under construction or planning				
Cañon del Pato	50	50	25	Additional 2 unit
Chimbote Gas turbine	41	41	36	20.5 MW x 2 unit
Trujillo Gas turbine	41	41	36	ditto
El Chorro	160	120	1,046	
SIDERPERU	99	66	605	
Sub-total	391	318	1,748	
Total	573	475	2,450	

As shown in Fig. 4-2, the Michiquillay Mine will come into operation in 1982, and for this, it is essential that the Sheque Hydroelectric Power Station, on which Motor Columbus are presently preparing a definite study, will be completed in 1981, the preceding year of the operation start. At present, the expansion of a tunnel to become the headrace of Sheque Power Station is being carried out taking advantage of the rainy season when diversion from the Amazon River system is unnecessary, and it is expected that operation can be started in time in 1981.

Mantaro Power Station located on the Mantaro River of the Amazon River system will have a final installed capacity of 684 MW (besides reserve of 114 MW x 1 unit) and the secondary electric energy of the Power Station will reach 1,990 GWh. It will be possible for this energy to be effectively used through combined operation with existing and future thermal power stations. The energy shortage of the Central and Santa Power Systems indicated in Table 4-14 will be covered by this secondary electric energy.

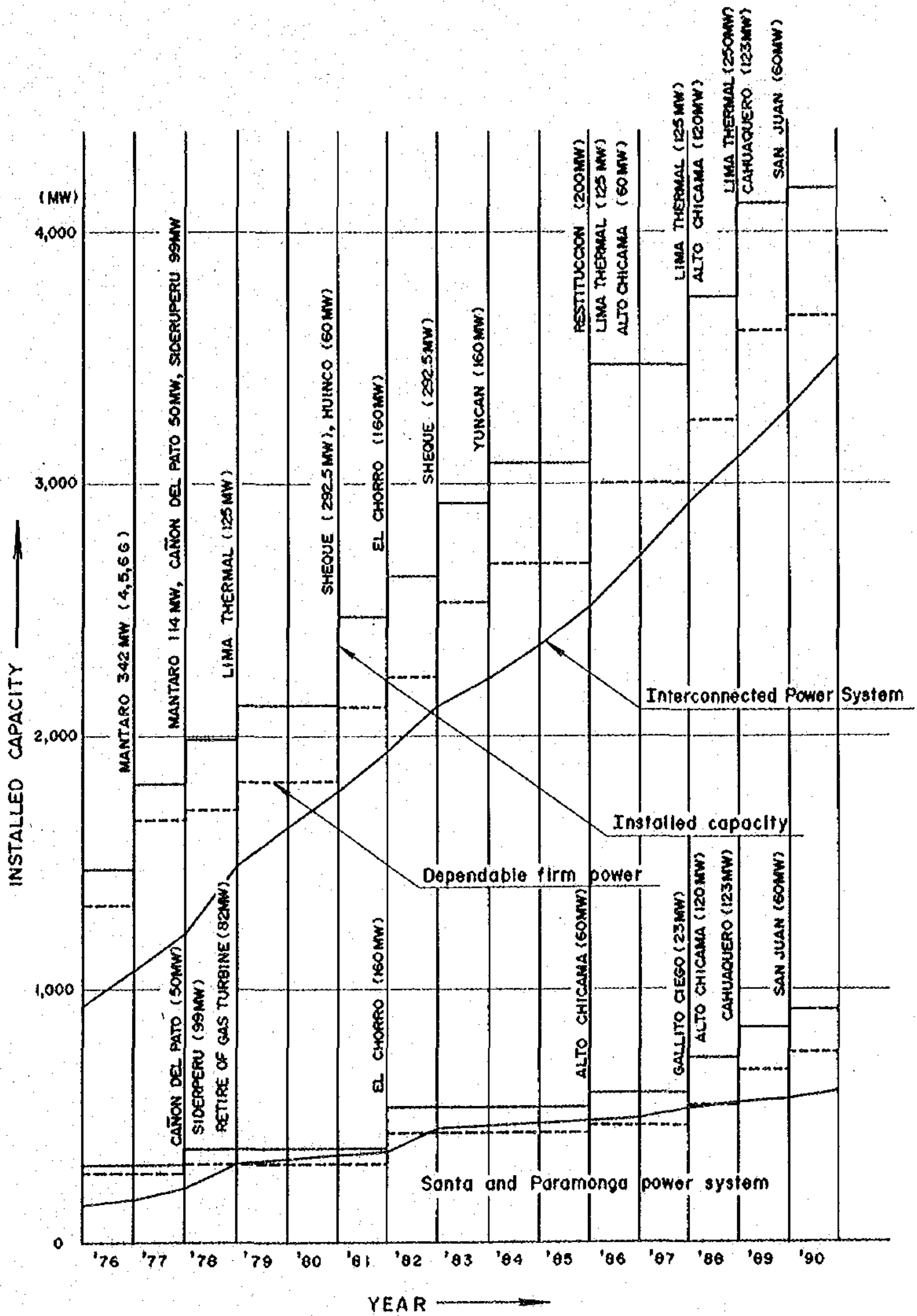


Fig. 4-2 INTERCONNECTED POWER SYSTEM

Power generating facilities to be added to the Santa Power System in the near future are the four gas turbines of unit capacity of 20.5 MW each to be installed at Chimbote and Trujillo and the three steam turbines utilizing waste heat of unit capacity of 33 MW each to be installed at SIDERPERU.

As for El Chorro Hydroelectric Power Station, preparation of a final design will be started in September 1975, while at present, excavations of side adits for geological survey are going on and it is thought there is ample possibility for start-up to be made in 1982. The supply capability of the Santa Power System is indicated in Table 4-12.

It should be noted that supply capabilities planned for 1985 and after are all based on reports of prefeasibility study level. Consequently, it can be predicted that the future development scales and the timings of incorporation into the systems may be altered.

Table 4-13 Power flow from Central System to Northern System

Year	Central Power System			Power flow to Northern power system (MW)	Santa & Paramonga System			
	Peak demand (MW)	Dependable firm power (MW)	Surplus power (MW)		Peak demand (MW)	Dependable firm (MW)	Surplus Power with gas. turb. (MW)	Surplus Power without gas turb. (MW)
1976	897	1,053	156	-	139	239	100	18
1977	1,010	1,393	383	-	168	239	71	-12
1978	1,167	1,393	226	84	315	313	- 2	-84
1979	1,312	1,506	194	96	327	313	-14	-96
1980	1,445	1,506	61	61	345	313	-32	-114
1981	1,575	1,799	224	126	357	313	-44	126
1982	1,664	1,799	135	87	438	433	- 5	-87
1983	1,771	2,091	320	93	444	433	-11	-93
1984	1,886	2,251	365	102	453	433	-20	-102
1985	2,019	2,251	232	131	482	433	-49	-131
1986	2,221	2,543	322	88	493	487	- 6	-88
1987	2,382	2,543	161	129	534	487	-47	-129
1988	2,547	2,656	109	16	552	618	66	-16
1989	2,721	2,881	160	0	573	741	168	86
1990	2,910	2,881	-29	-29	596	801	205	123

Note : Maximum transmission capacity will be 150 MW at Chavarria Substation.

4-6-3 Surplus Capability of Supply from Central Power System to Santa Power System

In case the gas turbines of the Santa Power System are considered as reserve capacity, based on the above-described power demand and supply balance, the power transmission from the Central Power System to the Santa Power System, as shown in Fig. 4-3, will be 84 MW in 1978 at the time of interconnection, 87 MW in 1982, and 131 MW in 1985.

Viewed from the energy balance, an energy shortage will be 949 million in kWh in 1980, but if the gas turbines are used and Lima Thermal Power Station is operated in a suitable combination so that the secondary energy of Mantaro Power Station can be utilized, it is thought a shortage of energy can be avoided. The demand and supply balances of the Central and Santa Power Systems are given in Tables A-2-5 and A-2-6.

Table 4-14 Energy Balance between Central and Santa System

Year	Central Power System			Power flow to Northern power system (GWh)	Santa & Paramonga System			Surplus energy(A)+(B) (GWh)
	Energy demand (GWh)	Dependable energy (GWh)	Surplus energy(A) (GWh)		Energy demand (GWh)	Dependable energy (GWh)	Surplus energy(B) (GWh)	
1976	5,504	7,022	1,518	-	631	774	143	-
1977	6,356	7,092	736	-	830	774	-56	-
1978	6,970	7,092	122	15	1,450	1,507	57	179
1979	7,854	7,859	5	5	1,522	1,507	-15	- 10
1980	8,628	7,859	- 769	0	1,687	1,507	-180	-949
1981	9,287	9,732	445	336	1,771	1,507	-264	181
1982	9,932	9,732	- 200	- 200	2,350	2,553	203	3
1983	10,533	10,844	311	0	2,421	2,553	132	443
1984	11,166	11,754	588	27	2,508	2,553	45	633
1985	11,924	11,754	- 170	0	2,641	2,553	-88	258
1986	12,995	13,415	420	0	2,689	2,921	232	652
1987	13,957	13,415	- 542	0	2,928	2,921	- 7	-549
1988	14,880	14,182	- 698	- 559	3,013	3,572	559	-138
1989	15,849	15,715	- 134	- 134	3,097	4,248	1,151	1,017
1990	16,898	15,715	-1,183	-1,183	3,191	4,809	1,618	435

Note: (1) Transmission line loss more than 138 kV does not considered in the energy demand

(2) Secondary energy of Mantaro Hydro Power Station is to be 1990 GWh, which will be going to become effective energy by combination operation of the thermal power plants.

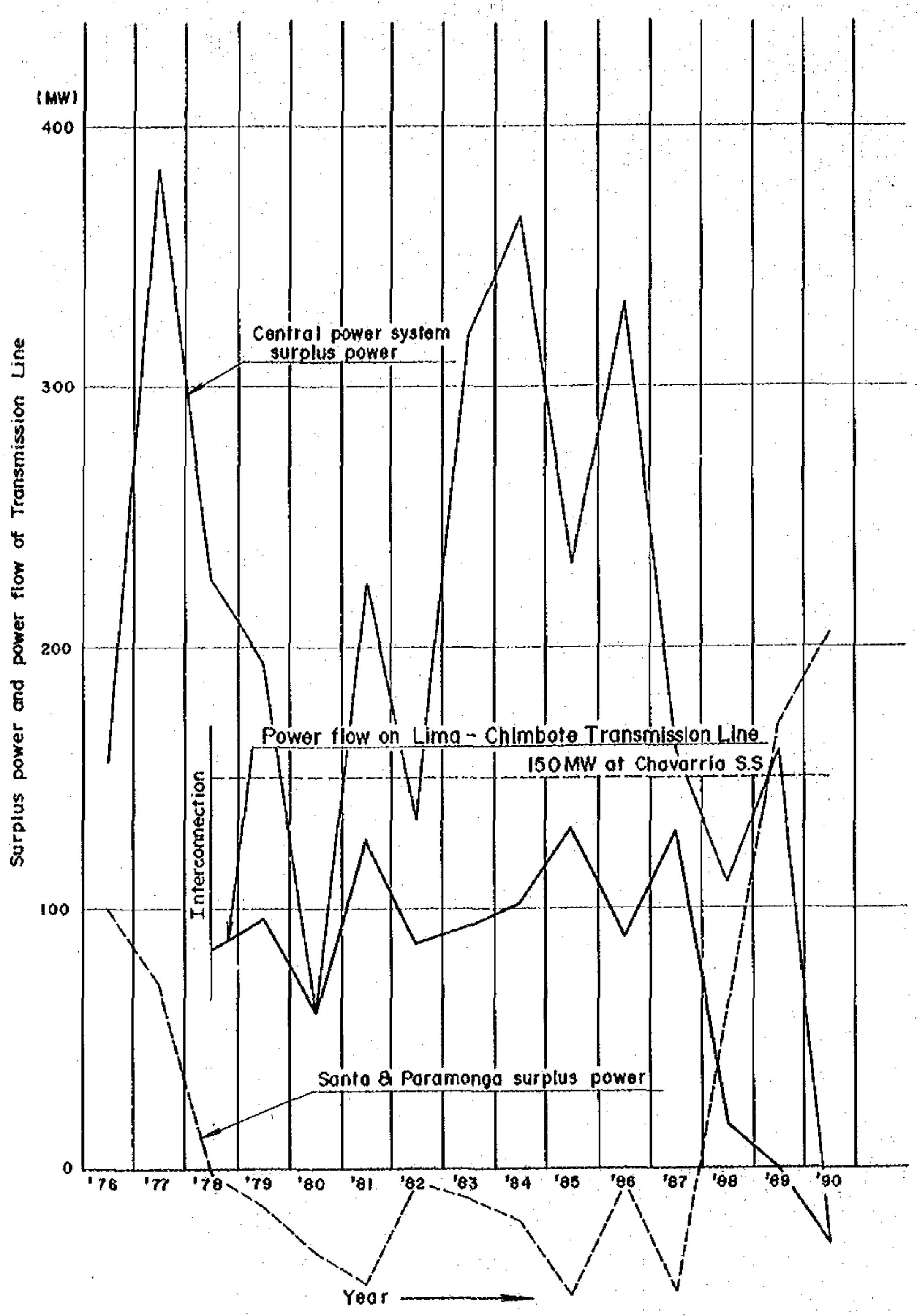
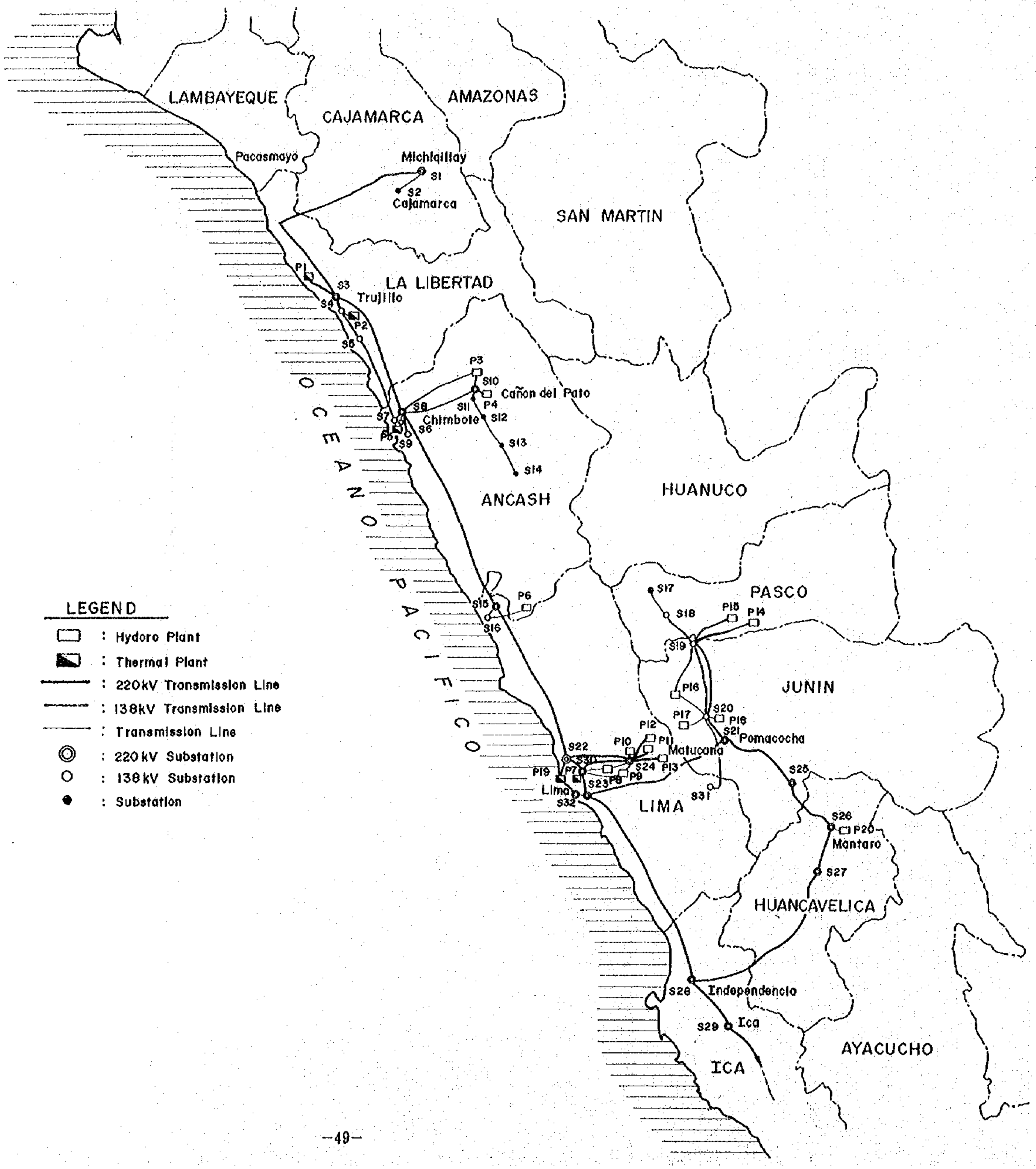


Fig. 4-3 POWER FLOW OF LIMA-CHIMBOTE TRANSMISSION LINE



POWER PLANT

No.	Power Plants	Installed Cap.(MW)	
P 1	Santiago de Cao	12.5	(T)
P 2	Trujillo	41	(T)
P 3	El Chorro	160	(H)
P 4	Cañon del Pato	150	(H)
P 5	Chimbote	130	(T)
P 6	Cahua	40	(H)
P 7	Santa Rosa	54	(H)
P 8	Huampani	31	(H)
P 9	Moyo Pampa	63	(H)
P 10	Callahuanca	68	(H)
P 11	Huinco	325	(H)
P 12	Sheque	585	(H)
P 13	Matucana	120	(H)
P 14	Yaupi	108	(H)
P 15	Yuncon	160	(H)
P 16	Malpaso	54	(H)
P 17	Pachachaca	12	(H)
P 18	Oroya	9	(H)
P 19	Lima	125	(T)
P 20	Mantaro	798	(H)

SUB-STATION

No.	Sub-Station
S 1	Michiquillay
S 2	Cajamarca
S 3	Trujillo Norte
S 4	Trujillo Sur
S 5	Viru
S 6	Chimbote Norte
S 7	Chimbote No. 2
S 8	Chimbote No. 1
S 9	Chimbote Sur
S 10	Huallanca
S 11	Huaylas
S 12	Caraz
S 13	Carhuaz
S 14	Huaraz
S 15	Paramonga Nueva
S 16	Paramonga
S 17	Gollarisquisga
S 18	Cerro de Pasco
S 19	Carhuamayo
S 20	Oroya
S 21	Pomacocha
S 22	Chavarria
S 23	San Juan
S 24	Callahuanca
S 25	Huancayo
S 26	Colcabamba
S 27	Huancavelica
S 28	Independencia
S 29	Ica
S 30	Santa Rosa
S 31	Yauricocha
S 32	Balnearios

Note : (T) Thermal Power Plant
(H) Hydro Power Plant

Fig.4-4 INTERCONNECTED ELECTRIC POWER SYSTEM IN PERU (IN 1985)

CHAPTER 5

POWER SUPPLY PLAN

CHAPTER 5. POWER SUPPLY PLAN

5-1 Preconditions

The following preconditions were considered in preparation of this plan for supplying power to the Michiquillay Mine and related areas.

(1) An optimum plan is to be prepared based on the electric power development plan of "A Survey for Regional Development Planning in Cajamarca of Peru" (prepared in December 1973) submitted by the survey mission of the Metal Mining Agency of Japan, carrying out field reconnaissances and making comprehensive studies and evaluations of both technical and economic aspects.

(2) Coordination is to be aimed with long-range electric power development plans formulated in Peru on the area and its surroundings.

(3) The load forecast is to be made up to 1990 and the power transmission facilities are to be adequate for stable supply to meet the demand forecast.

(4) It is to be assumed that Trujillo Norte Substation will have been stepped up to 220 kV and interconnected with the Central Power System by the end of 1981 when this Project is to be completed.

5-2 Power Supply Plan

5-2-1 Power Supply to Michiquillay Mine

The power demand of the Michiquillay Mine including the surrounding communities shown in Table A-2-1 will be 44 MW in 1982 at the time of commencement of operation of the mine and 72 MW in 1990, with 90 % of the power being the load of the mine.

As the method of supplying this electric power, it is conceivable that a diesel power station is constructed at the site, or that supply is made by a transmission line from Trujillo Norte Substation of the Santa System.

(1) Power Supply by Diesel Power Plant at Site

Since the Michiquillay Mine is situated at an elevation of around 3,600 m, the decrease in output of a diesel generating facility would be approximately 30%.

It is not economical for large unit capacities to be adopted for generating equipment, because reserve facilities will be required due to periodical inspections.

Taking the above into overall consideration, the scale of the generating facilities including reserve facilities required to meet the power demand of 44 MW at the start of operation of the mine would be six 11.5-MW units.

To meet increases in power demand, it would be effective to add generators in stages.

(2) Power Supply through Transmission Line

1) Transmission Line Route

As the route for the transmission line between Trujillo Norte Substation and Michiquillay, either a route from Trujillo through Pacasmayo to Michiquillay, "Alternative A", or a route from Trujillo to Michiquillay passing along the Chicama River, "Alternative B",' can be considered.

These two routes are as shown in Fig. 6-1 and Fig. A-6-1 to Fig. A-6-3, and except for the matter of length, Route A is clearly better than Route B in geographical conditions considered from the standpoints of construction work and maintenance and operation of the transmission line.

As the result of an overall examination including factors such as the long-range electric power plan for northern Peru and, needless to say, economy, Route A is of more advantage as described in 5-3-1.

2) Transmission Voltage and Number of Circuits

Since one third of the load at the Michiquillay Mine will be accounted for by the use of synchronous motors, the transmission capacity will be determined by steady-state stability. In order to satisfy this transmission capacity, the transmission line will be required to be 138 kV, 2 cct, or 220 kV, 1 cct.

In case a 138 kV, 2 cct transmission line is adopted, a 220 kV/138 kV interconnecting transformer would be required at Trujillo Norte Substation. Furthermore, the transmission line construction cost will be higher than for a 220 kV, 1 cct transmission line, and therefore, a 220 kV, 1 cct transmission line would be economically more advantageous.

On the other hand, when faulting is considered, a single-circuit transmission line will be inferior to a double-circuit line with respect to supply dependability. However, clearance of transmission line faults can generally be done in a short period of time, while by leaving the power generating equipment used for construction of the Michiquillay Mine as an emergency power source, this problem can be coped with, and in the future, the dependability can be improved through interconnection with new power sources developed in the area surrounding Michiquillay. Further, since the transmission line route via Pacasmayo is more advantageous as previously stated, and considering that it will become an interconnecting transmission line for Region Norte, the study was continued based on 220 kV and a single circuit.

5-2-2 Power Supply to Cajamarca City

Power supply to the city of Cajamarca is being carried out through a hydrolectric power station (installed capacity 720 kW) on the Chonta River approximately 14 km northeast of the city and a diesel power station (installed capacity 4,897 kW) in the city. The greater part of the diesel generating equipment was installed newly in 1972.

When Michiquillay Substation comes into operation in 1982 it will become possible to supply power to Cajamarca City by a transmission line from that substation. In case of power supply by transmission line from Michiquillay Substation to Camajarca, it would be desirable that part of the generating facilities in the city should be left as emergency equipment, and that the remainder be diverted to other districts for power generation.

5-2-3 Power Supply to Celendin

Power supply to Celendin is being carried out on a time basis at night by a diesel power station (installed capacity 187 kW) in the city, and all of the load is lighting load. A maximum supply of 100 kW was recorded in the past, but due to a decrease in output, the supply at present is down to approximately 60 kW. It will be possible to supply power by transmission line from Michiquillay Substation when the substation starts operation.

5-2-4 Power Supply to Pacasmayo District

The Pacasmayo district is subdivided into the three communities of Pacasmayo, San Pedro de Lloc, and Chepen and Guadalupe, each independently being supplied with electric power. The maximum demand is 2 MW with practically all of it being lighting load.

A cement factory of Cía. de Cemento Pacasmayo is located outside of Pacasmayo and is in operation with daily production of 1,000 tons of cement. Electric power is being supplied by privately-owned generating facilities (oil-burning thermal and diesel totalling 7 MW). This plant has plans for extension of 18 MW in generating capacity to triple production to 3,000 tons per day around 1977.

There is also a power generation plan for 23 MW at the Gallito Ciego site on the Jequetepeque River including an irrigation project, but the time of its construction is yet undecided.

In the case the Michiquillay Transmission Line is completed, it will be possible to supply the Pacasmayo district from the Santa Power System by constructing a substation in the district, but since the district has scattered loads of the cement factory and the three communities, a large investment will be required in order to supply the power. Consequently, in case of supplying power to this district from the Santa Power System, the timing of extension or renewal of the power generating facilities of the cement factory which accounts for the greater part of the load and the trend in demand will be an important factor in determining the merit of supplying the power.

5-3 Evaluation of Electric Power Supply Plan

In making an evaluation of electric power supply to the Michiquillay Mine and its neighboring communities, there are three alternatives as follows:

- A1) The hidroelectric power plants projected to be newly constructed (including transmission and transforming facilities for the Michiquillay Mine)
- A2) A coastal steam power plant supposed to be constructed at Trujillo and considered as the standard thermal power plant (including transmission and transforming facilities for the Michiquillay Mine)
- A3) An on-site diesel plant which would be naturally necessary without the above-mentioned transmission and transforming facilities between Trujillo and Michiquillay.

As above mentioned, it is expected to depend on either A1 or A2 of these three alternatives for power supply from the Central Power System and the Santa Power System through transmission and transforming facilities.

In case of A1, it can be thought possible to apply the nationally unified electricity tariff referred to in the Chapter 3, 3-2 to the 220 kV bus of Trujillo Norte Substation. This is because applying this unified tariff to the power demand of the Michiquillay Mine results in obtaining the figure of 14.7 mills/kWh, roughly equal to the generating cost of A1 as indicated in appendix A-8. Therefore, this figure of 14.7 mills/kWh is considered here as the generating cost of A1.

On the other hand, the generating cost of A2 is calculated to be 15.8 mills/kWh, explicitly higher than 14.7 mills/kWh of power supply by A1. So, if the generating cost of A2 were to be cheaper than that of A3, it is needless to say that it would be economically favorable to supply power to the Michiquillay Mine by A1, of which the generating cost would be the cheapest of the three alteratives.

In this sense, it is enough to make an economic comparison between A2 and A3. For this, the generating cost of A2 with transmission and transforming cost, being considered as power cost (C) and the generating cost of A3 as benefit (B), were compared at their present valve.

The following are the conditions for this economic evaluation such as the service life and the facilities' expense rate of the transmission and transforming facilities, the standard thermal plant, and the alternative on-site diesel power plant, and also the discount rate and the fuel price for diesel power plant and the generating cost of the thermal power plant.

(1) Service Life

		Residual Value
Transmission facilities (steel tower line)	30 years	10 %
Transmission facilities (wood pole line)	20 years	10 %
Standard thermal generating facility (steam)	25 years	10 %
Alternative generating facility (diesel)	20 years	10 %
Transforming facility	30 years	10 %
Telecommunications facility	10 years	0 %

(2) Interest Rate per Annum

10 % (both domestic and foreign currencies)

(3) Fixed Cost Ratio

(Unit: %)

	Interest & Depreciation	Operation & Maintenance	Total
Transmission facility (steel tower line)	10.55	2.50	13.05
Transmission facility (wood pole line)	11.57	2.50	14.07
Transforming facility	10.55	3.00	13.55
Telecommunications facility	16.27	-	16.27

(4) Fuel Price

The currently adopted prices in Peru and international market prices were considered, and with the price at the port of Salavery as a basis, prices were calculated for various locations adding the respective fuel transportation costs.

The fuel prices are indicated in Table 5-1.

Table 5-1 Fuel Price in 1973

Location	Present price in Peru		International market price		Reference
	US$/kl	US$/ton	US$/kl	US$/ton	
Salavery	16.37	17.23	50.00	52.63	Bunker C.
Trujillo, Pocasmayo	20.31	21.38	53.94	56.78	9.700 kcal/l
Chiclayo	23.70	24.95	57.33	60.35	10.200 kcal/kg
Cajamarca	26.69	28.09	60.32	63.49	
Michiquillay	27.63	29.13	61.30	64.53	
Celendin	31.99	33.67	65.62	69.07	

Note: Present fuel price in Peru was adopted for economic evaluation

(5) Standard Thermal Power Generating Cost

The generating cost at the transmitting end at Trujillo assuming a steam generating facility is indicated below.

Fuel price	Generating cost (mills/kWh)
Present fuel price in Peru	16.45
International market price	15.14

The conditions for calculation of the generating cost were the following:

Installed capacity	125 MW x 2 unit
Construction cost	117.530 10^3US$
Unit construction cost	470 US$/kW
Fixed cost	13.74 %
Thermal efficiency	36.5 %
Station service use	6.0 %
Plant factor	70.0 %

5-3-1 Evaluation of Power Supply to Michiquillay Mine

(1) Evaluation of Transmission Line Route

As for routes of the transmission line, there are two alternatives of A and B as stated previously. The construction costs of the two routes are shown in Table 5-2 with Route A being approximately US$ 1 million more costly compared with Route B.

Table 5-2 Comparison of Construction Cost

(Unit: 10^3US$)

	Route A	Route B
Voltage and No. of cct.	220 kV, 1 cct	220 kV, 1 cct
Length of transmission line	240 km	180 km
Construction cost		
a) Transmission line	15,140	14,074
b) Transforming facilities		
Trujillo	1,296	1,296
Michiquillay	5,672	5,672
c) Telecommunication facilities	774	774
Total	22,882	21,816

However, the long-range electric power program of the Peruvian Government calls for interconnection with Region Norte by trunk transmission lines, and in case Alternative B directly connecting from Trujillo to Michiquillay were to be adopted, a necessity would arise to newly construct a transmission line between Trujillo and Pacasmayo. Approximately US$5 million is estimated as the construction cost of this new transmission line, and if extension to Pacasmayo is additionally considered, the construction cost of Alternative B would be approximately US$ 4 million higher than that of Alternative A.

Notwithstanding, the economic superiority or inferiority of the two alternatives, A and B, will be governed by the timing of interconnection to Region Norte and the time it will become necessary to newly construct Pacasmayo Substation. The case in which Alternative A is economically more advantageous comes under the condition that interconnection with Region Norte or construction of Pacasmayo Substation would be realized within 18 years from completion of the Route A transmission line, in effect, before the year 2000.

As will be described in 5-3-4, it would be most effective for Pacasmayo Substation to be provided around 1985 to 1987, while as described in A-5-1, interconnection with Region Norte around 1995 would be economical.

Consequently, the route of the transmission line to Michiquillay should be Route A which passes via Pacasmayo.

(2) Evaluation of Power Supply by Transmission Line and Alternative Facility

With Route A for the transmission line, a comparison of the power costs of the transmission line and alternative diesel generating facilities at the site will be as indicated in Table 5-3 showing that it would be more economical for power to be supplied by the transmission line, and it should be adopted.

Table 5-3 Comparison of Generating Cost at Michiquillay

(Unit: mills/kWh)

	Diesel plants at Michiqullay (B)	Supply through Interconnected transmission line (C)	(B)/(C)	(B)-(C)
Present fuel price in Peru	27.83	25.10	(1.11)	2.73
International market fuel price	35.74	34.03	(1.05)	1.71

Note: LF = 70 %

Conditions Used in Economic Evaluation (Present worth in 1975)

- Interconnecting Line

1) Transmission Line (Route A)

Section: Trujillo - Michiquillay

Length : 240 km

Voltage and number of circuits : 220 kV, 1 cct

Construction cost : US$15,140 thousand

2) Transforming Facilities

Trujillo : Lead-out facilities, 1 cct

Michiquillay : Lead-out facilities, 1 cct

Transformer, 80 MVA, 220 kV/33 kV

Construction cost : US$6,968 thousand

3) Telecommunication Facilities, 1 set

Construction cost : US$774 thousand

On-site Diesel Plant

Installed effective capacity : 50 MW

Equipment : 11.5 MW x 6 units (1 unit reserve)

Construction cost : US$32,790 thousand

Unit construction cost per kW : US$656/kW

Fixed cost ratio : 15.52%

5-3-2 Evaluation of Power Supply to Cajamarca City

The results of comparisons of power costs at the city of Cajamarca in both cases of supply by transmission line from Cajamarca and of supply by alternative diesel power generation will be as shown in Table 5-4.

For the power cost in case of supply by transmission line, it was considered that the transmitting and transforming facilities up to Michiquillay were existing, and the standard thermal power generating cost, the transmission loss up to Michiquillay and the expenses of the Cajamarca transmission and transforming facilities were taken into account.

As a result the power cost in case of supply through transmission line would be approximately one half that of the case of the alternative facilities. Therefore, power supply should be made through transmission line.

The maximum demand at Cajamarca until the time of start-up of Michiquillay Substation is forecast to be 3.7 MW while the effective capacity of the existing generating facilities of the city is thought to be more or less equivalent. Therefore, it is desirable for these facilities to be well-maintained and operated without a hitch.

Table 5-4 Comparison of Generating Cost at Cajamarca

(Unit: mills/kWh)

	Diesel plants at Cajamarca (B)	Supply through interconnected transmission line (C)	(B)/(C)	(B)-(C)
Present fuel price in Peru	53.85	27.77	1.94	26.08
International market fuel price	61.75	37.03	1.67	24.72

-Note: LF = 35 %

Conditions Used in Economic Evaluation (Present Worth in 1975)

- Transmission and Transforming Facilities

1) Transmission Line

Section : Michiquillay - Cajamarca

Length : 30 km

Voltage and number of circuits : 33 kV, 1 cct (80 mm^2 ACSR)

Construction cost : US$346 thousand

2) Transforming Facilities

Transformer : 5 MVA, 33 kV/13.8 kV

Construction cost : US$774 thousand

- On-site Diesel Plant (Alternative Facility)

Installed effective capacity : 7.5 MW

Equipment : 2,875 kW x 3 units (1 unit reserve)

Construction cost : US$4,445 thousand

Unit construction cost per kW: US$592/kW

Fixed cost ratio: 16.00 %

5-3-3 Evaluation of Power Supply to Celendin

A comparison of power costs for Celendin is given in Table 5-3. The power cost of supply by transmission line will be comparatively higher and this will be economically disadvantageous. Therefore, power supply for the time being should be by upkeep and expansion of diesel generating facilities.

However, when the power demand of Celendin increases to 0.8 MW or more, power supply through transmission line will be economical. According to the load forecast, this arises around 1990.

If, in the future, power supply is to be made through transmission line, a transmission voltage of 33 kV is recommended. In case 13.8 kV were to be adopted, the limit of transmission capacity would be 1 MW from the aspect of voltage drop. The initial investment amount will be slightly larger in case of 33 kV, but when installation costs accompanying increase in power demand are considered, it would be more advantageous to provide facilities having ample supply capability from the beginning.

Table 5-5 Comparison of Generating Cost at Celandin

(Unit: mills/kwh)

	Diesel plants at Celendin (B)	Supply through intercinnected transmission line (C)	(B)/(C)	(B)-(C)
Present fuel price in Peru	63.28	66.30	0.95	-3.20
International market fuel price	71.18	75.33	0.94	-4.15

Note: LF = 35 %

Conditions Used in Economic Evaluation (Present Worth in 1975)

- Transmission and Transforming Facilities

1) Transmission Line

Section : Michiquillay - Celendin

Length : 30 km

Voltage and number of circuits : 33 kV, 1 cct (32 mm^2 ACSR)

Construction cost : US$313 thousand

2) Transforming Facilities

Transformer : 500 kVA, 33 kV/13.8 kV

Construction cost : US$507 thousand

On-site Diesel Plant (Alternative Facility)

Effective capacity : 600 kW

Equipment : 250 kW x 3 units (1 unit reserve)

Construction cost : US$352 thousand

Unit construction cost per kW : US$587/kW

Fixed cost ratio: 20.39 %

5-3-4 Evaluation of Power Supply to Pacasmayo District

With the power demand of the cement factory and the three communities of the Pacasmayo district in 1982 when the Michiquillay power transmission and transforming facilities will be completed, as shown in Table 5-6, power supply from the Santa Power System will not be economical, since it will require a large amount of capital investment in transforming facilities and secondary-side supply facilities. However, if the power demand were to rise to 48 MW or more, there would be economic merit and the year will be 1987 when this level will be reached.

The cement factory has a load of 7 MW and power is being supplied by exclusive power generation facilities. These power facilities were constructed in 1966 and the limits of service life will be reached around 1985 to 1987.

The cement factory also has a plan for extension of 18 MW in power generating facilities around 1977 and since there is a time delay of 5 years until completion of the Michiquillay transmission and transforming facilities.

Therefore, constructing a new substation at Pacasmayo around 1985 to 1987 when the old power generating facilities of the cement factory will need to be replaced, power supply from the Santa Power System to the cement factory and the three Pacasmayo district communities together would be the most effective from the aspect of effectively utilizing existing facilities, and this is also considered to be the most economical. In this case, the cost of new construction of the substation and secondary-side supply facilities would be approximately US$8,300 thousand.

The new power sources of 18 MW to be added at the cement factory in 1977 can be utilized effectively as reserve capacity for the Santa Power System and the cement factory.

Conditions Used in Economic Evaluation (Present worth in 1975)

- Transmission and Transforming Facilities

1) Transmission Line

Transmission cost : Case of fuel at current price in Peru, 0.97 mills/kWh

Case of fuel at international market price, 1.00 mills/kWh

Note : Transmission cost between Trujillo and Pacasmayo, and cost of outgoing facilities at Trujillo.

2) Transforming Facilities

Pacasmayo : Lead-out facilities, 2 cct

Transformer, 60 MVA x 1 unit,

220 kV/66 kV/33 kV

Construction cost, US$4,830 thousand

Note : Transformer capacity to correspond to 1990 power demand.

- Pacasmayo Cement Factory Supply Facilities

Transmission line : 66 kV, 1 cct

Length : 10 km

Transforming facilities : 30 MVA

Construction cost : US$1,151 thousand

- Three Pacasmayo Communities Supply Facilities

Transmission line : 33 kV, 1 cct

Length : 35 km

Transforming facilities : 10 MVA, 3 locations

Construction cost : US$2,367 thousand

- On-site Diesel Plant

Installed effective capacity : 5 MW class unit, 10 units (1 unit reserve)

Construction cost : US$22,596 thousand/unit

Unit construction cost per kW : US$452/kW

Fixed cost ratio: 16.93 %

Table 5-6 Comparison of Generating Cost at Pacasmayo

(Unit: mills/kwh

	Diesel plants at Pacasmayo (B)	Supply through the substation newly installed in 1982 (C)	(B)/(C)	(B)-(C)
Present fuel price in Peru	22.68	24.43	0.93	-1.75
International market fuel price	30.58	33.13	0.92	-2.55

Note: LF = 50 %

CHAPTER 6

PRELIMINARY DESIGN

CHAPTER 6. PRELIMINARY DESIGN

6-1 Preliminary Design of Transmission Line

6-1-1 220 kV Transmission Line

(1) Basic Principle of Preliminary Design

In order to carry out economical power supply to the Michiquillay Mine and related areas, it was considered that this power supply would be done by a transmission line from Trujillo Norte Substation of the Santa Power System which is to be interconnected with the Central Power System, and being based on the load forecast and taking into account supply dependability, economy and the future system plan of northern Peru, etc., a single circuit with voltage of 220 kV and a transmission line route passing through Pacasmayo were selected.

(2) Outline of Preliminary Design

1) Transmission Line Route

The transmission line route of this Project is to have its starting point at Trujillo Norte Substation passing along the Pacific Ocean coast to Pacasmayo and then along the Jequetepeque River to cross the Andes Mountain Range to reach Michiquillay Substation to be newly constructed, and is 240 km in length.

The section of approximately 100 km along the Pacific Ocean coast from Trujillo to Pacasmayo is a desert area and a great part of this route will run along the Pan American Highway. As this whole area is exposed to salt contamination due to a constant wind from the sea, and in order to lessen the salt contamination, the route was selected to lie inland.

The section along the Jequetepeque River from Pacasmayo to San Pablo is lower in elevation, and the topography is featured with numerous ups and downs. The section from San Pablo passing north of the city of Cajamarca to reach Michiquillay Substation is higher in elevation, and is a plateau area with a gently-sloped topography. These sections of the route were selected to be along roads to facilitate construction and maintenance.

Furthermore, the route in the vicinity of Pacasmayo was selected taking into consideration possible construction of a new substation in the future.

The outline of this transmission line is given in Fig. 6-1.

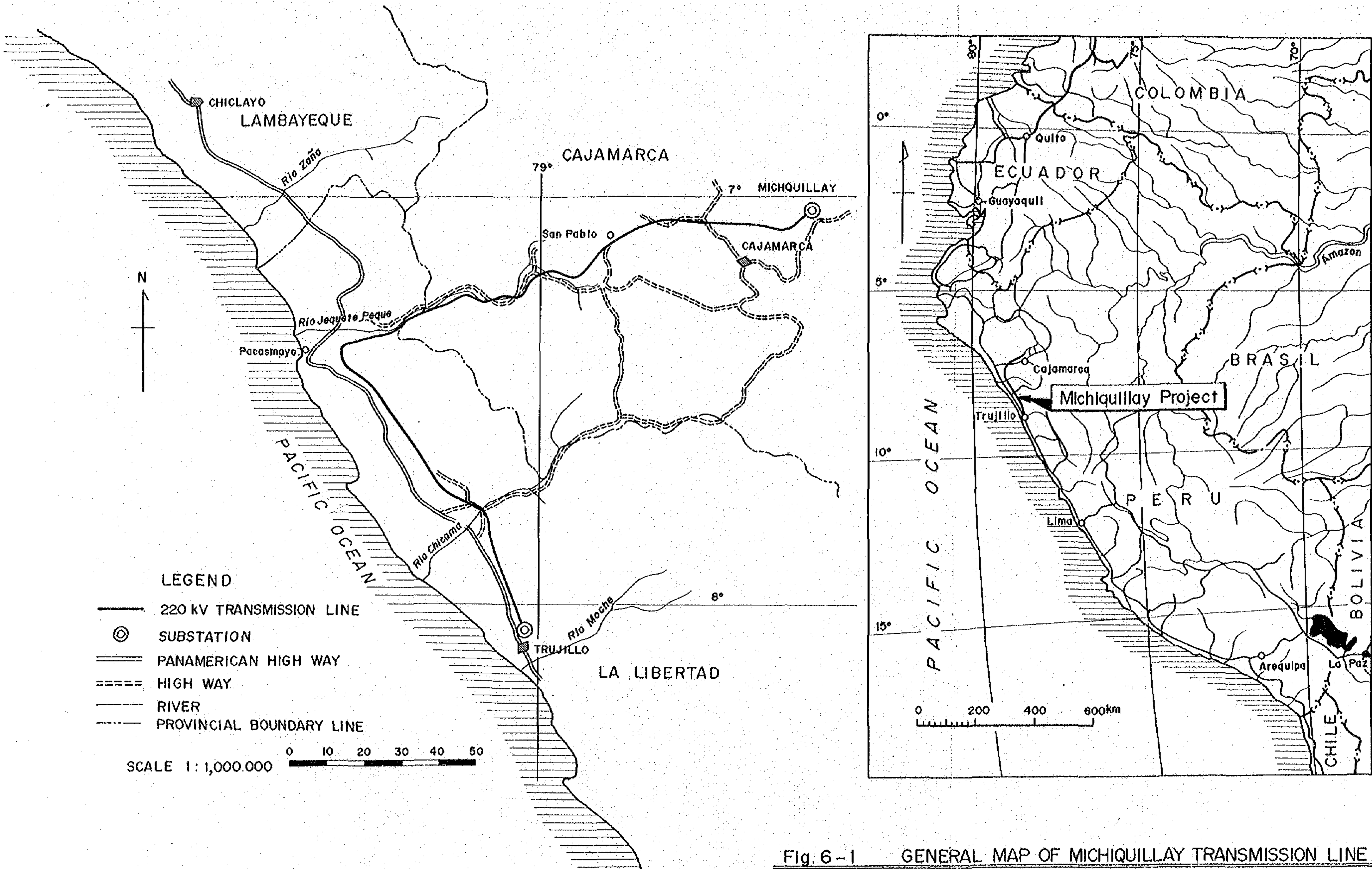


Fig. 6-1 GENERAL MAP OF MICHIQUILLAY TRANSMISSION LINE PROJECT

2) Meteorology

The design of a transmission line is greatly influenced by meteorological conditions. Study of the meteorological conditions was carried out obtaining observation data from SENAMHI and the Michiquillay Mine, while the design conditions for existing transmission lines were used for reference. The locations of the meteorological observatories from which data were obtained are indicated in Fig. 6-2.

In order to produce an economical design for the transmission line, its route was divided into 4 zones below according to the conditions of its surroundings, and the meteorological conditions of each zone were established.

Zone 1 : Elevation below 1,000 m, seacoast area, salt-contaminated area

Zone 2 : Elevation below 1,000 m, ordinary mountain area

Zone 3 : Elevation 1,000 m to 3,000 m, mountain area, high elevation area

Zone 4 : Elevation 3,000 m to 3,800 m, mountain area, high elevation area

a) Precipitation

The seacoast area through which this transmission line will pass can be said to have no precipitation at all. It is the high elevation areas where precipitation can be observed, and according to meteorological statistics on these areas the greatest precipitation is at Porcon with an annual average of about 1,260 mm and a monthly maximum of about 250 mm. The monthly average precipitation at related locations are shown in Fig. 6-3.

b) Temperature

According to statistical data on temperatures, both the maximum and minimum have been observed at Michiquillay, the maximum recorded 32.5°C and the minimum -6°C, and only in Zone 4, the minimum temperature falls below zero centigrade. The temperatures at related locations are shown in Fig. 6-4.

c) Wind Speed and Wind Pressure Load

There are no typhoons striking this area at all and it may be said that the conditions with regard to wind speed are relatively mild. It is estimated that the maximum wind speed (ten-minute average) is 35 m/sec at Michiquillay.

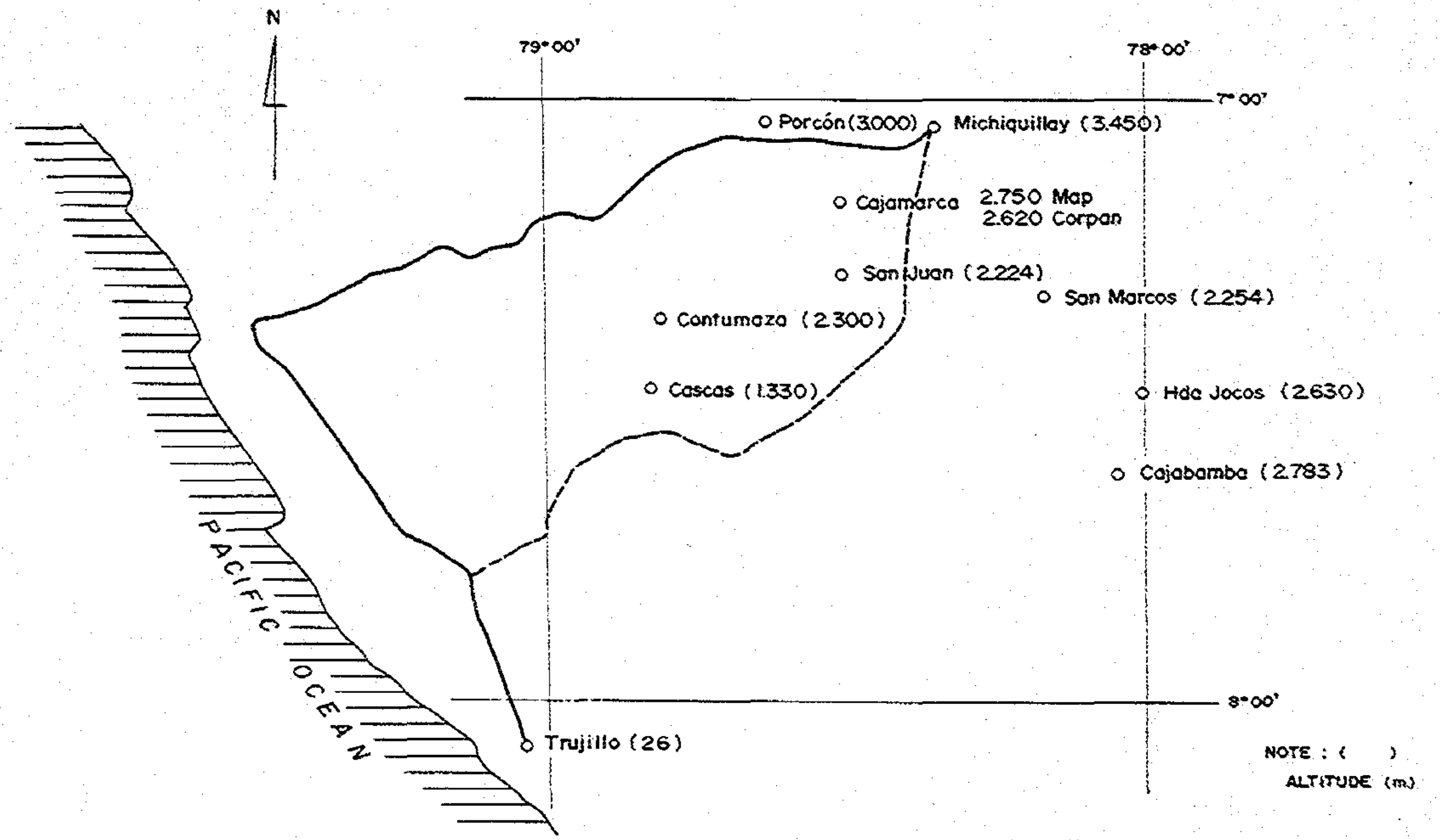


Fig.6-2 LOCATION MAP OF METEOROLOGICAL OBSERVATORY

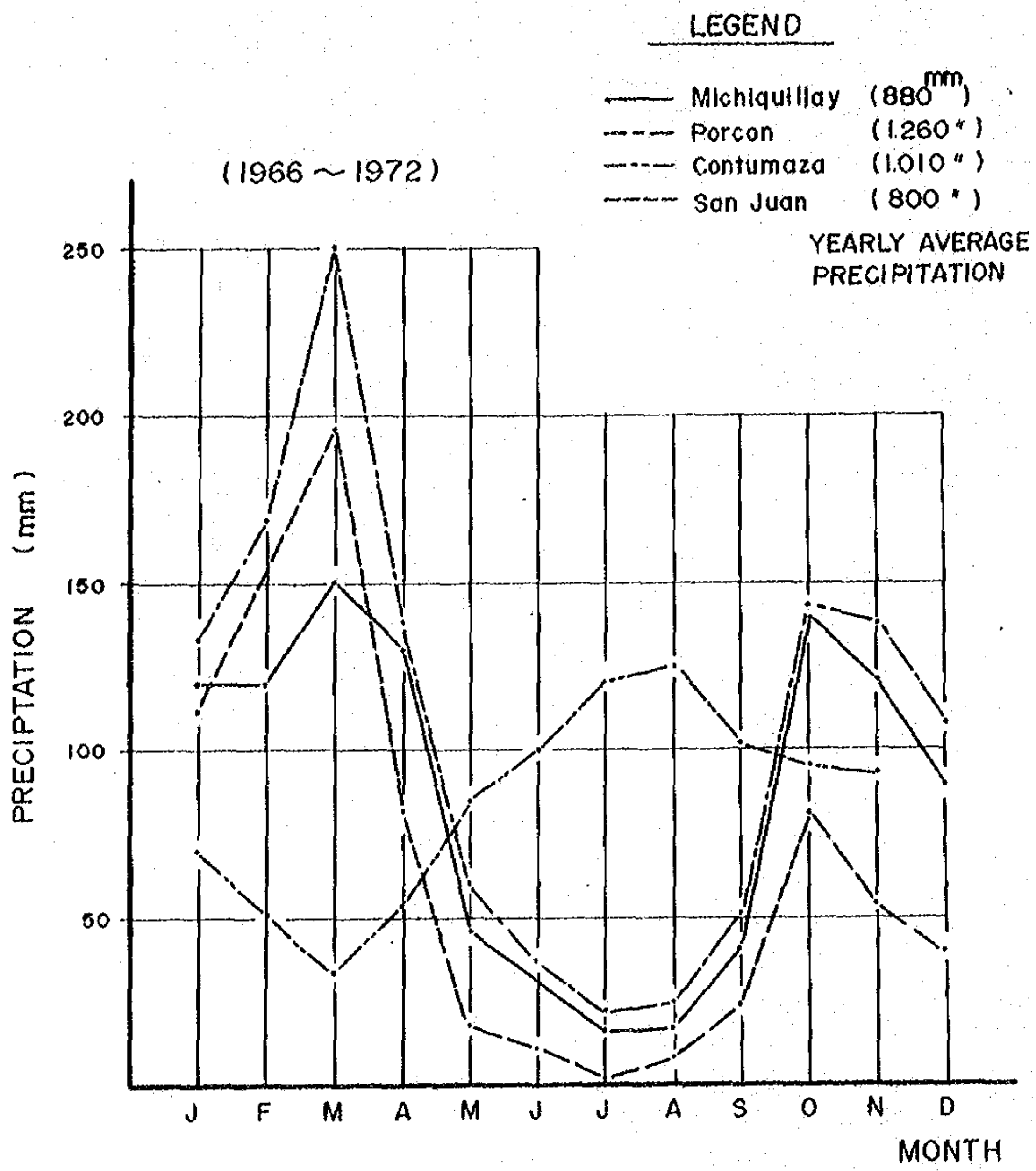


Fig. 6-3 MONTHLY AVERAGE PRECIPITATION CURVE

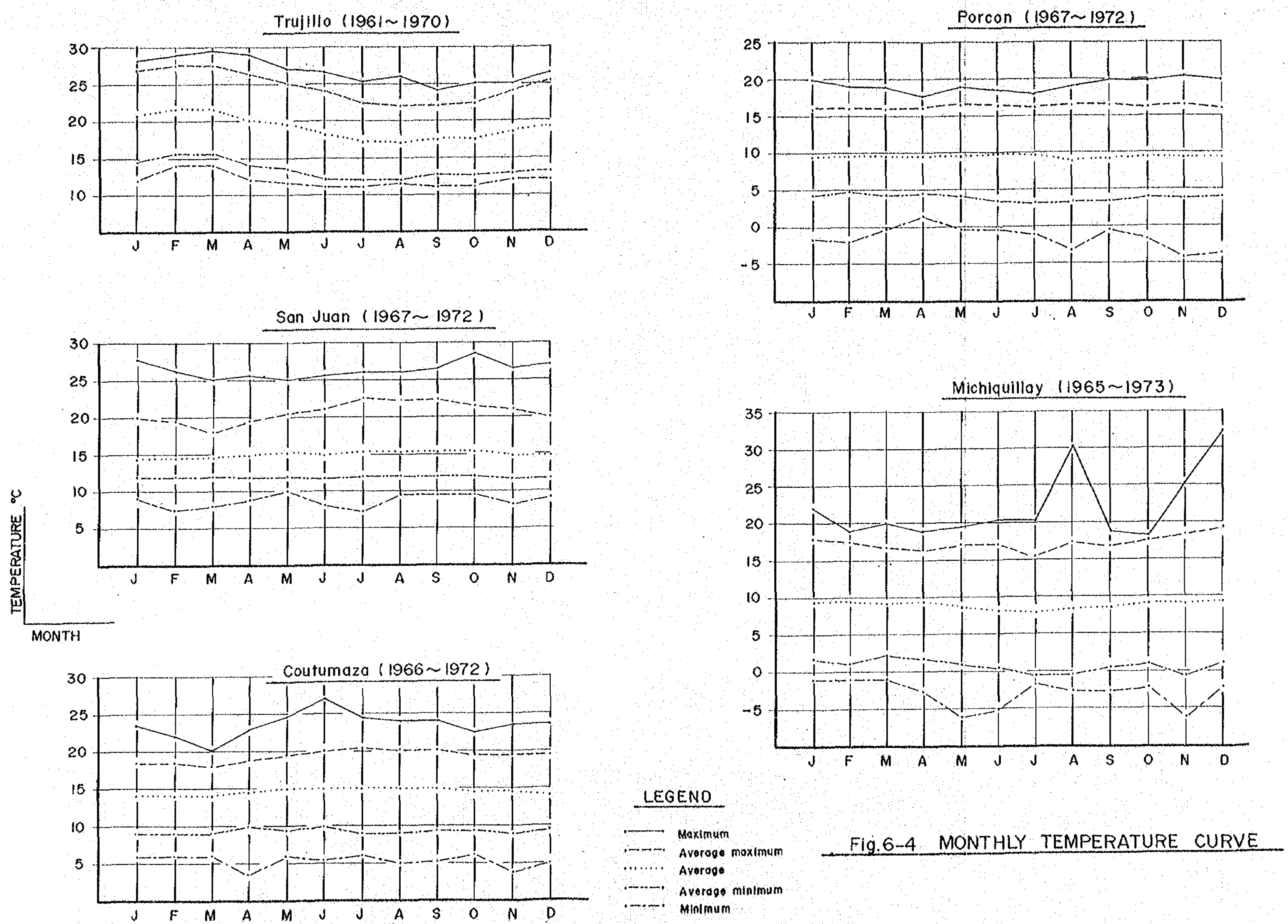


Fig.6-4 MONTHLY TEMPERATURE CURVE

In establishing wind pressure loads due to thinning of air because of high altitude decrease in wind pressure load was taken into consideration.

The statistical data on meteorology were studied as described above and the design work was carried out establishing the design conditions given in Table 6-1.

Table 6-1 Meteorological Conditions for Design of the Transmission Line

Zone	Temperature (^{o}C)			Maximum wind speed (m/s)	Wind pressure load (kg/m^2)	Sleet (mm)
	Average	Maximum	Minimum			
1	20	35	5	25	40	0
2	20	35	5	25	40	0
3	15	35	0	30	45	0
4	10	35	-10	35	50	6

3) Insulation Design

As the basic conditions for insulation design of this transmission line, the 220 kV system was considered to be effectively grounded (direct grounding) and designs were made corresponding with the ambient conditions of the respective zones to withstand switching surges and abnormal internal voltages.

a) As salt would be adhered to insulators in the seacoast area due to the steady wind from the sea, design was carried out with fog type insulators, assuming from the surrounding conditions that the adhesion of salt would be 1.0 mg/cm^2.

b) For Zone 3 and Zone 4, design was done taking into consideration lowering of insulation due to high altitude.

The insulation designs for the respective zones are given in Table 6-2.

4) Lightning Protection Design

There are no available statistical data with respect to lightning in this region, but there have been cases of lightning strokes at Michiquillay and Cajamarca. Therefore, for Zone 3 and Zone 4 of high elevations, it is thought that lightning protection design would be necessary.

As measures against lightning strokes, it was decided that two lines of aerial ground wires should be provided aiming to reduce faulting and arcking horns provided on insulator strings to protect insulators from damage.

Table 6-2 Insulation Design for The Transmission Line

Zone	1	2	3	4
Type of insulator	250 ϕ Fog	250 ϕ	250 ϕ	250 ϕ
No. of insulator	21	13	16	17
Horn-gap (mm)	-	-	1,990	2,110
Standard insulation distance (mm)	1,900	1,900	2,300	2,400
Minimum insulation distance (mm)	1,300	1,300	1,600	1,800

5) Support

Regarding supports, as a result of studies of conditions along the route, reliability, and economy, etc., galvanized angle-steel towers were selected with atmospheric corrosion resisting rolled steel considered especially for the seacoast area.

Sketches of the standard towers for the respective zones are given in Fig. 6-1.

6) Conductor

With respect to conductors, technical aspects such as transmission capacity, corona interference and corrosion at the seacoast area, and economic aspects such as construction cost and transmission loss were studied comprehensively and a conductor optimum for each zone was selected.

The results are the following:

Zone 1 : 400 mm^2 ACAR

Zone 2 : 410 mm^2 ACSR

Zone 3 : 520 mm^2 ACSR

Zone 4 : 610 mm^2 ACSR

Regarding stringing design, it will be necessary to study it on both normal working conditions and maximum load conditions of conductors.

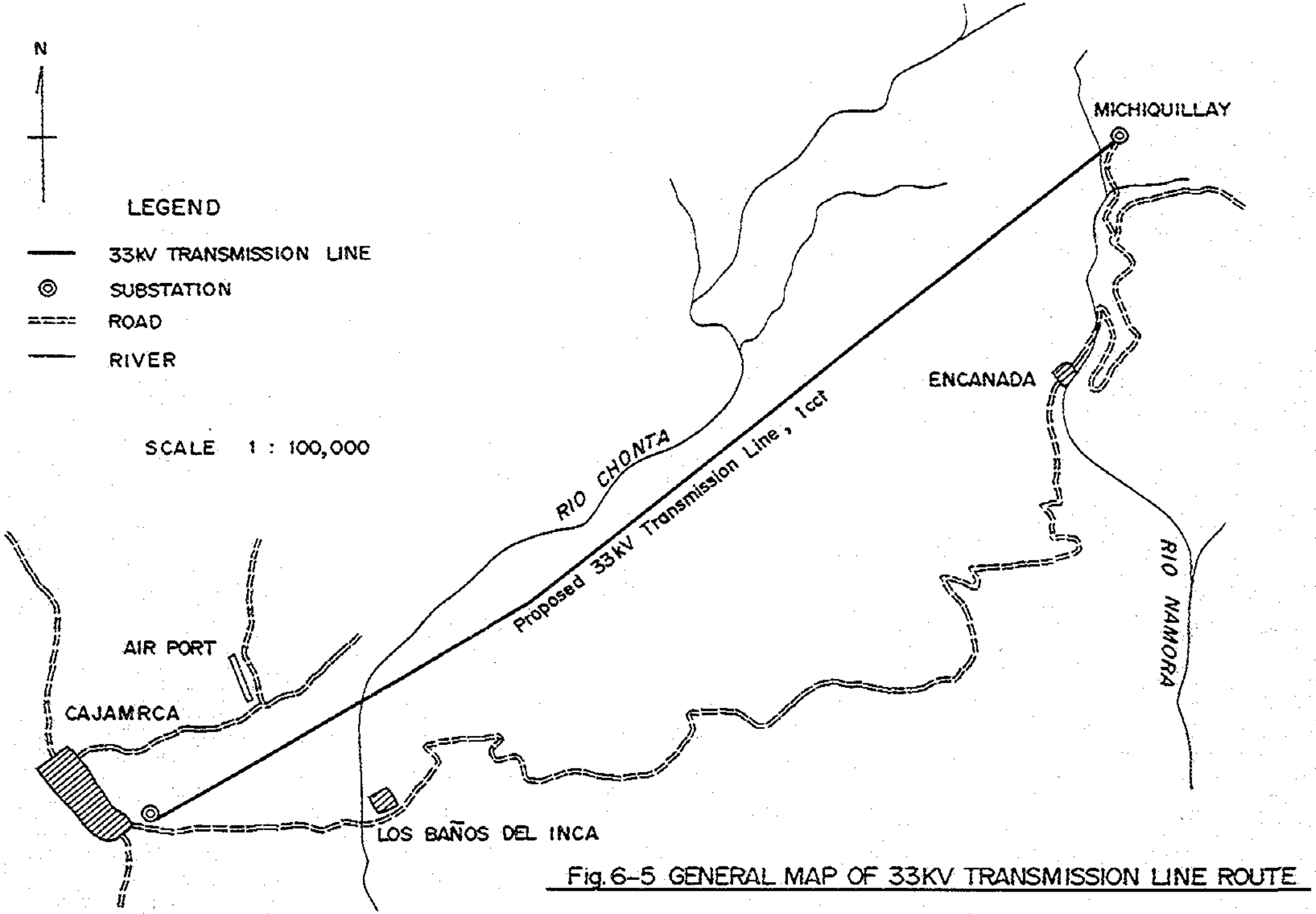


Fig.6-5 GENERAL MAP OF 33KV TRANSMISSION LINE ROUTE

Here, the study was made with conductor stress at normal conditions (annual mean temperature, no wind, no sleet) taken below 18% (ACAR) and 20% (ACSR) of broken load, with maximum working stress having safety factor of more than 3.0 against broken wire load.

Also, in order to prevent fatigue of conductors, dampers and armor rods are to be equiped with conductor at supporting points of conductor.

(3) Outline of Transmission Line Facilities

The outline of the transmission line facilities of this Project is as follows:

Table 6.3 Outline of 220 kv Transmission Line

Distance	240 km			
Voltage	220 kv			
System	A.C., 3 phase, 3 wire			
No. of circuit	1 cct.			
Standard span	400 m			
Zone	1	2	3	4
Conductor	400 mm^2 ACAR	410 mm^2 ACSR	520 mm^2 ACSR	610 mm^2 ACSR
Overhead ground wire	Non	Non	90 mm^2 GSC 2 wire	90 mm^2 GCS, 2 wire
Type of insulator	250 mm Fog, 21 pieces	250 mm, 13 pieces	250 mm, 16 pieces	250 mm 17 pieces
Supporting structure	Steel tower with one (1) circuit			

6-1-2 33 kV Transmission Line

(1) Basic Principle of Preliminary Design

In order to economically supply electric power to the city of Cajamarca, supply is to be made through a transmission line from Michiquillay Substation, and based on the load forecast for Cajamarca, a single-circuit, 33 kV transmission line which is of advantage both technically and economically was selected.

In carrying out the design work, the conditions for Zone 4 of the 220 kV transmission line were followed.

(2) Outline of Preliminary Design

1) Transmission Line Route

The route of the 33 kV transmission line, as shown in Fig. 6-5, is a section of 30 km in length from Michiquillay Substation to the substation at Cajamarca passing through the Cajamarca Plateau area which has a comparatively gentle slope.

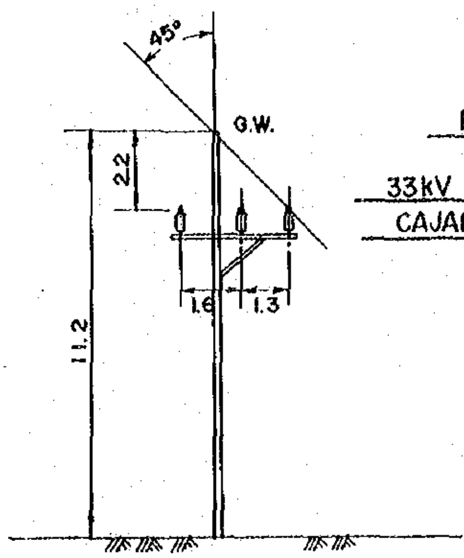


Fig 6-6

33kV STANDARD TYPE POLE FOR CAJAMARCA TRANSMISSION LINE

2) Insulation and Lightning Protection Design

The basic conditions for insulation design were a neutral point resistance grounding system capable of withstanding switching surges and abnormal internal voltage, and the design was made in accordance with the ambient conditions of Zone 4 of the 220 kV transmission line and using line post type insulators.

For lightning protection, one line of aerial ground wire is to be provided with the aim of reducing lightning stroke faulting.

3) Support and Conductor

The design was made with wood poles as supports. As for the conductor, based on the load forecast for Cajamarca, technical aspects such as transmission capacity, voltage drop, etc., and economical aspects such as construction cost and transmission loss were studied, and the optimum 80 mm^2 ACSR conductor was selected. A standard sketch of the wood pole transmission line is shown in Fig. 6-6.

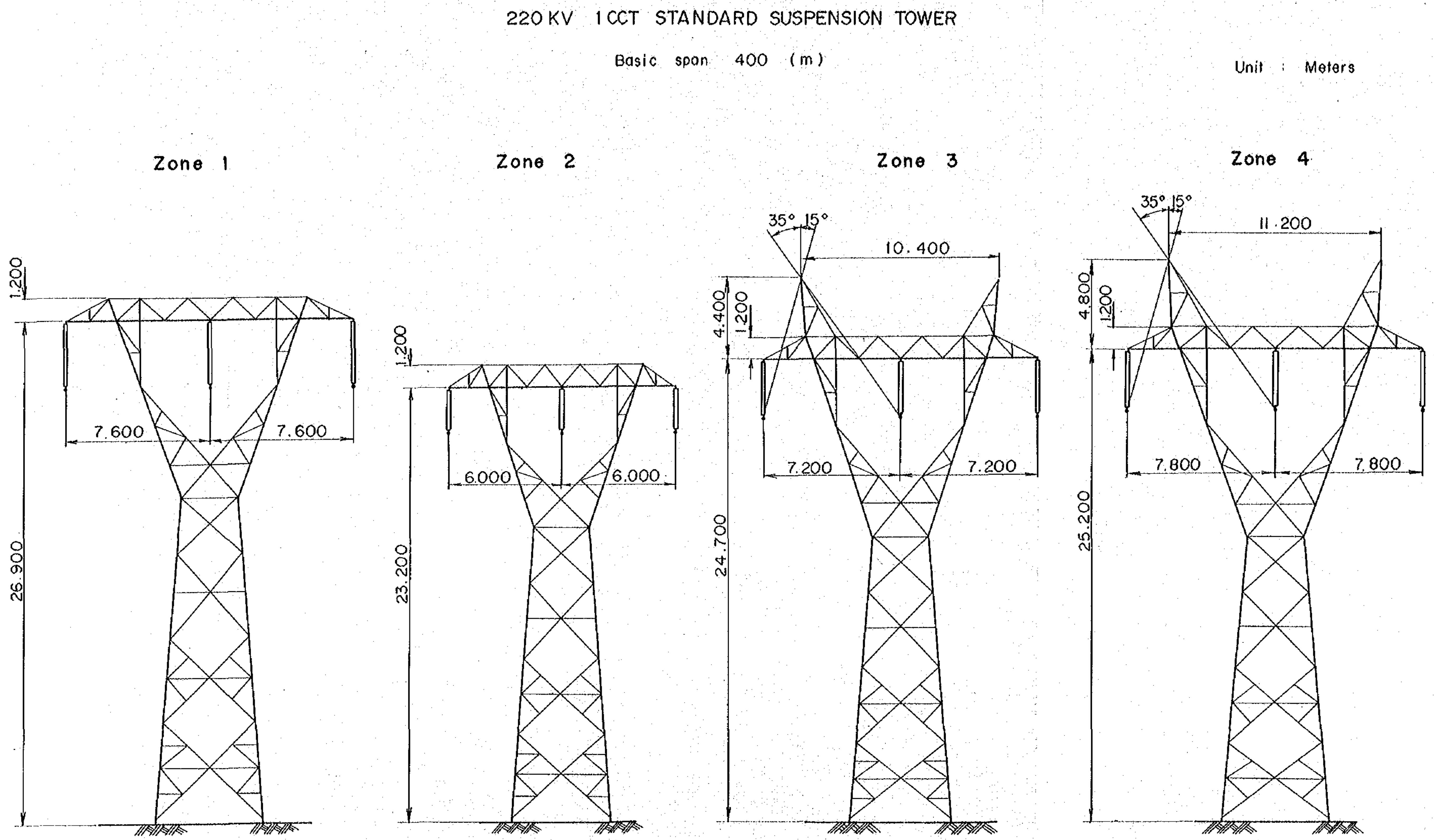


Fig. 6-7 STANDARD SUSPENSION TYPE TOWER FOR MICHIQUILLAY TRANSMISSION LINE

(3) Outline of Transmission Line Facilities

The outline of the projected transmission line facilities is as indicated in Table 6-4.

Table 6-4 Outline of 33 kV Transmission Line

Distance	30 km
Voltage	33 kV
System	A.C., 3 phase, 3 wire
No. of circuit	1 cct.
Standard span	100 m
Conductor	80 mm^2 ACSR
Overhead ground wire	45 mm^2 GSC
Type of insulator	LP insulator
Supporting structure	Wooden pole

6-2 Preliminary Design of Transforming Facilities

6-2-1 Basic Principle of Preliminary Design

The transforming facilities of the Project, based on the load forecast for the Michiquillay Mine and the related area in 1990, are scheduled to consist of the two substations and one transmission line lead-out facility to be described below. In design of the individual transforming facilities, basides examining technical aspects such as the future transition in power demand, system operation, system structure, stability, voltage fluctuation, power flow analysis, fault calculations, insulation design considering salt contamination and altitude difference, equipment capacity ratings and expansion space, the economic and regional characteristics were also taken into account.

6-2-2 Outline of Preliminary Design

(1) Bus System

1) Trujillo Norte Substation

Trujillo Norte Substation which will be the supplying end of this Project will be one of the most important substations along with Chimbote No. 1 in the Region Norte Power System in 1980s.

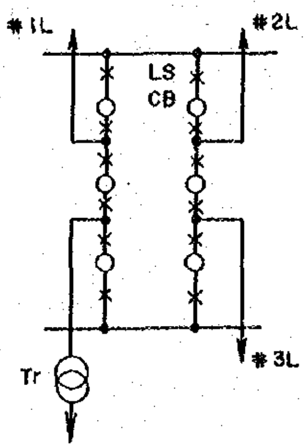
Therefore, the highly reliable One-half circuit breaker system is scheduled to be adopted as the bus system of this substation, and the outgoing facilities of the Michiquillay Transmission Line were planned to match this bus system.

2) Michiquillay Substation

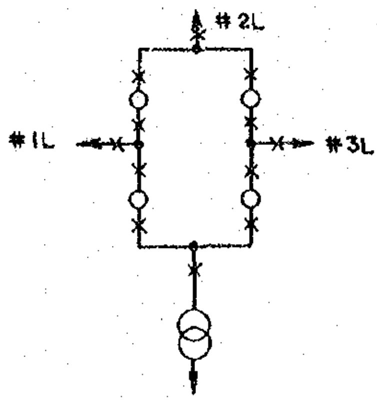
a) 220 kV Bus

Michiquillay Substation will initially have lead-in facilities for a single-circuit transmission line and one transformer bank, but since hydroelectric development of Yangas, San Juan, Crisnejas, etc. is planned for the future, the ultimate scale will be lead-in facilities for 3 circuits of transmission lines and one transformer bank. An examination of the bus system considering the above conditions results in the four alternative plans below.

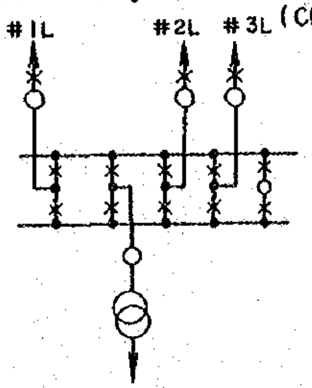
① 1 ½CB System (CB 6Units)



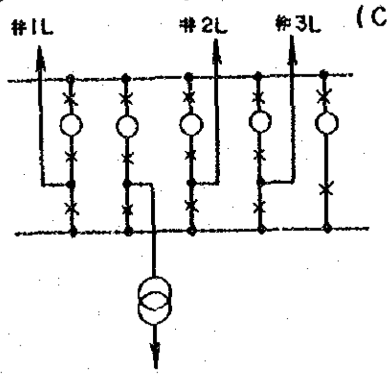
② Ring Bus System (CB 4Units)



③ Double Bus Single Breaker System (CB 5Units)



④ Double Bus System(One Stand-By for Inspection) (CB 5 Units)



As a result of comparative studies of the above four alternatives on system structure, maintenance and operation, number of circuit breakers, and space required, the ring bus system which is technically and economically advantageous was adopted.

At the beginning, however, operation will be made by a single-bus system.

b) 33 kV Bus

Since the main transformer is single-bank structure and there will be many feeders of single-route, single-circuit structure, an inspection bus system was adopted in view of economy.

(2) Insulation Design

In insulation design of substation equipment, insulation coordination with transmission lines was aimed considering salt contamination at Trujillo Norte Substation and high altitudes at the Michiquillay and Cajamarca Substations.

1) Transmission Line Lead-out Facilities at Trujillo Norte Substation

Since this substation is geographically close to the seacoast, design to resist salt contamination was considered.

Unlike the case of a transmission line, there is an economical limit to over-insulation of transforming equipment, and insulation design of equipment was done predicated on periodical cleaning by hot-line washing.

In this case the soiling condition of equipment was taken to be 0.03 mg/cm^2.

2) Michiquillay Substation and Cajamarca Substation

These substations are at high-altitude sites of elevations of 3,500 m and 2,700 m respectively. The lowering rate of dielectric strengths of the atmosphere and insulators due to decreased air density is to 76% at elevation of 3,500 m.

Therefore, the number of insulators for a bus, and insulation spacing would be increased over those for standard atmospheric conditions and would be as given in the following table:

Regarding internal insulation of equipment, corrections will not be made for insulation reduction due to altitude, but for external insulation of bushings and insulator tubes it will be necessary to provide corrections in dielectric strengths by 1.32 times standard insulation.

Table 6-5 Insulation Design for the Substation

System voltage (kV)	No. of insulator 250 mm	Standard insulation distance (mm)			
		Phase-to-ground		Phase-to-phase	
		Minimum	Standard	Minimum	Standard
220	18 (17)	2,500	3,200	3,150	5,000
33	5 (4)	500	720	650	1,250

Note : Figures in parentheses indicate numbers of insulators for transmission line.

(3) Neutral Grounding System

1) 220 kV System

For the neutral grounding system, a direct grounding system was adopted whereby restriction of voltage rise between sound phase and ground, lowering of switching surge voltage, and selective breaking system during fault can be accurately performed at time of one line-to-ground fault.

2) 33 kV, 13.8 kV System

As the 33 kV and 13.8 kV lines of this Project will consist of multi-circuits, it will be necessary for selective breaking system to be done at time of fault. Consequently, a non-grounded system would be undesirable and a direct grounding or high-resistance grounding system will be required.

A direct grounding system would be desirable from the standpoint of the protective relay system, but at voltages of 33 kV and 13.8 kV, the fault current would become large and a problem of induction obstruction to telecommunications lines would be produced so that a high-resistance system whereby fault currents would be small was adopted.

(4) Transformer

1) Extraordinary Three-Phase Transformer

In the event of designing for one unit of a three-phase transformer for Michiquillay Substation, the transport weight would be 95 to 100 tons and a 100 ton trailer would need to be used. As a result of studying the problems of transportation to the site at 3,500 m in elevation, such as road width, curvature ratios of the road at curves, reinforcement of bridges, etc., it is considered that passage of a 100 ton trailer will be impracticable.

In order to solve the above transportation problem, a special three-phase unit of a structure possible to haul each phase separately was adopted.

As a result, the transport weight will be under 40 tons.

2) Winding System

As a result of comparative studies of a three-winding system in which the grounding resistor is put at the secondary neutral point and the station service and phase modifying equipment circuit would be connected with the tertiary winding, and a two-winding system in which the above would be from the 33 kV bus, it was found that the two-winding system would be more economical in comparison with three winding system mentioned above.

(5) Circuit Breaker

Circuit breaker capacities were selected upon carrying out calculations of faults at 220 kV and 33 kV bus of the various substations taking into consideration the power system structure in 1990.

(6) Voltage Regulating Devices

Power system analysis on power flow and voltage fluctuation in 1982, 1985 and 1990 were respectively made based on the conditions at peak load and off-peak hours at the Michiquillay Mine and the surrounding communities of this Project and also on the conditions of the Santa Power System and the Central Power System to be interconnected by the Lima-Chimbote Interconnecting Transmission Line, and as a result, it was decided that substation transformers should be of types equipped with on-load tap changers capable of voltage regulation in a range of $\pm$ 10%, while further, in order to restrict voltage rises and drops of the 220 kV system, two 5 MVA shunt reactors and two groups of 7.5 MVA condensers are to be provided at the 33 kV bus at Michiquillay Substation.

(7) Protective Relay System

In Chapter 8, 8-5, the protective relay system for transmission lines is described.

(8) Rated Capacity of Equipment

When the place where electric power equipment is to be installed is a high-altitude site, due to decrease in air density, there will be lowering of cooling effects on equipment and of discharges of air compressing apparatus with the rates of lowering proportional to elevation, and design of rated capacities of equipment was carried out taking this into consideration.

a) Michiquillay Substation

For an elevation of 3,500 m, oil-immersed insulated equipment (for example, transformers, reactors, condensers and the like) show reduction rates of 12% to 18% in cooling effect, dry-type insulated equipment (for example, disconnecting switches, conductors, terminals and the like, current transformers, circuit breakers, etc.) show a reduction rate of 9% in cooling effect, while the reduction rate of discharge of air compressing equipment is 30%.

b) Cajamarca Substation

For an elevation of 2,700 m, the reduction rates in cooling effect of oil-immersed insulated equipment are 8% to 12%, while the reduction rate for dry-type insulated equipment is 4%.

(9) Plottages Required

The plottages required were determined considering the transmission line system structure up to 1990 shown in the layout of the Michiquillay transmission network in Fig. 6-8, expansion of the system in the future, and facilitation of operation and maintenance, and carrying out layout designs based on the one line diagrams of the various substations indicated in Fig. 6-9 through Fig. 6-11.

The results are shown in Fig. 6-12 through Fig. 6-14.

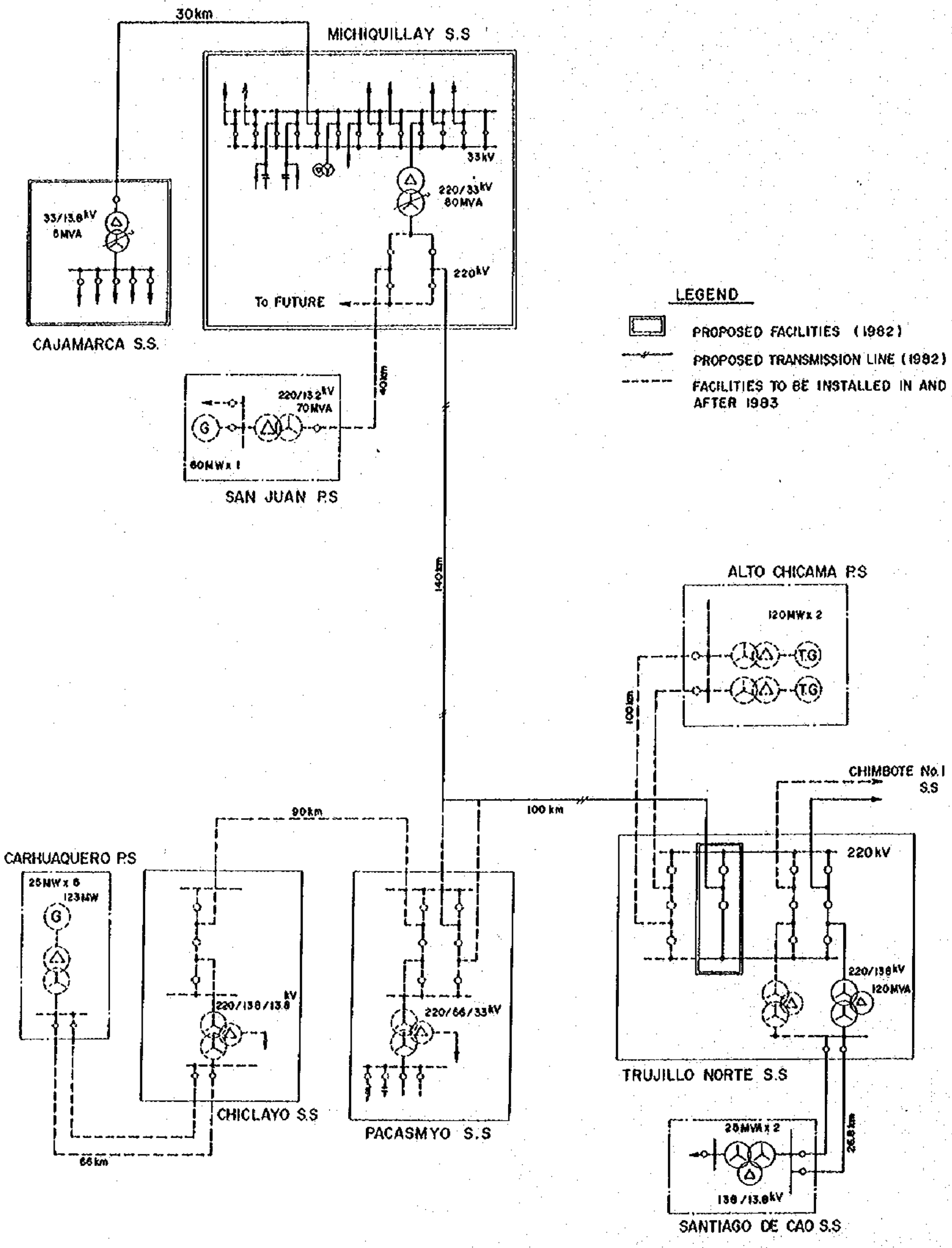


Fig.6-8 SINGLE LINE DIAGRAM RERATED WITH MICHIQULLAY S.S.

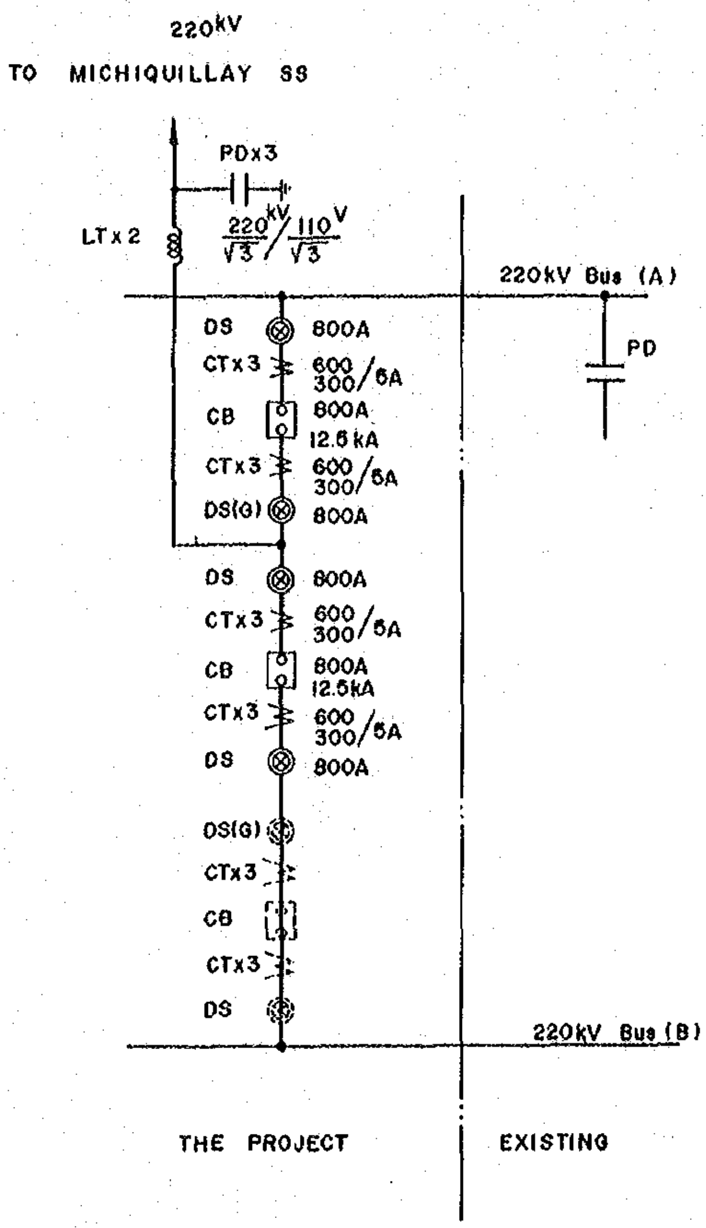


Fig. 6-9 ONE LINE DIAGRAM OF TRUJILLO SUBSTATION

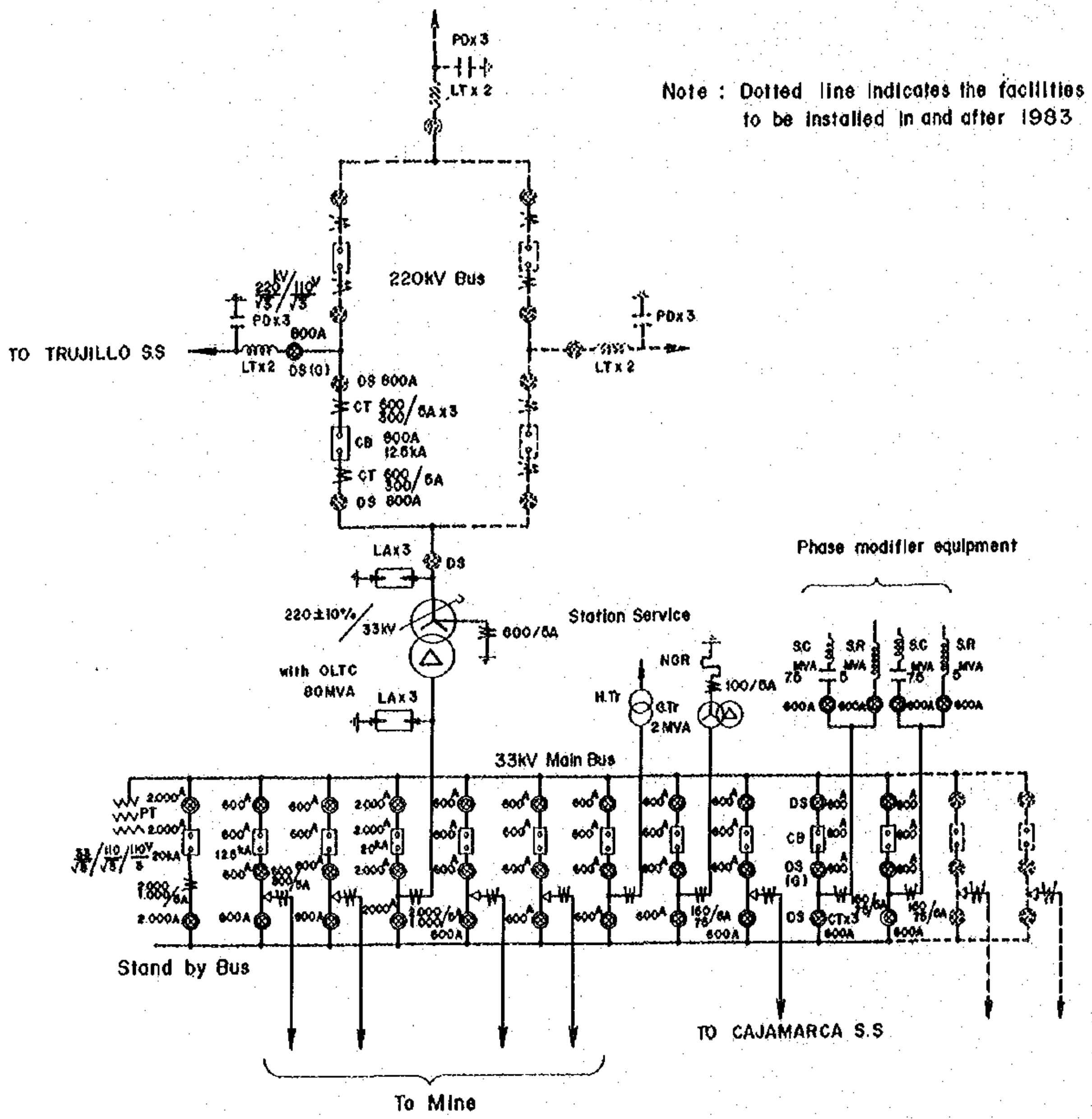


Fig. 6-10 ONE LINE DIAGRAM OF MICHQUILLAY SUBSTATION

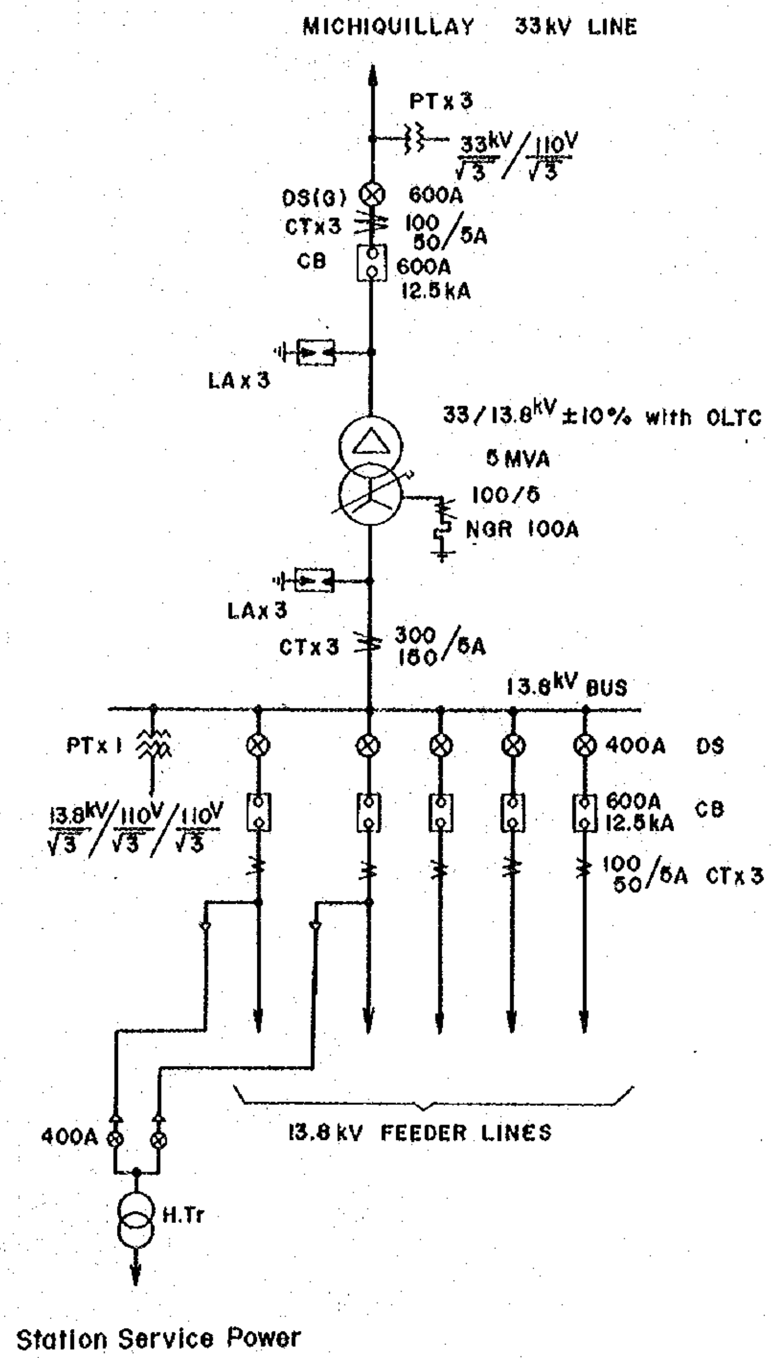


Fig. 6-11 ONE LINE DIAGRAM OF CAJAMARCA SUBSTATION

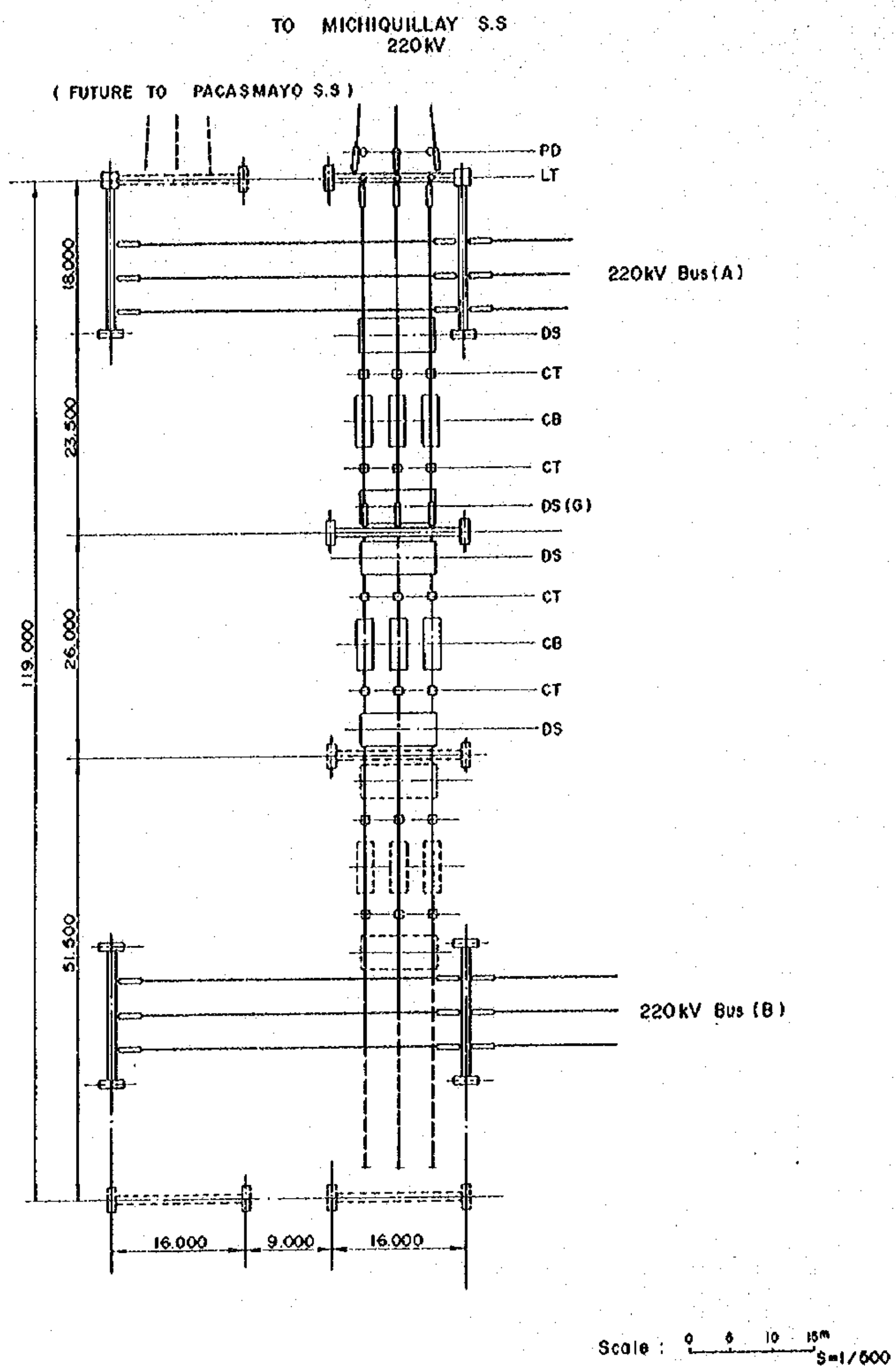


Fig. 6-12 GENERAL ARRANGEMENT OF EQUIPMENT TRUJILLO NORTE SUBSTATION

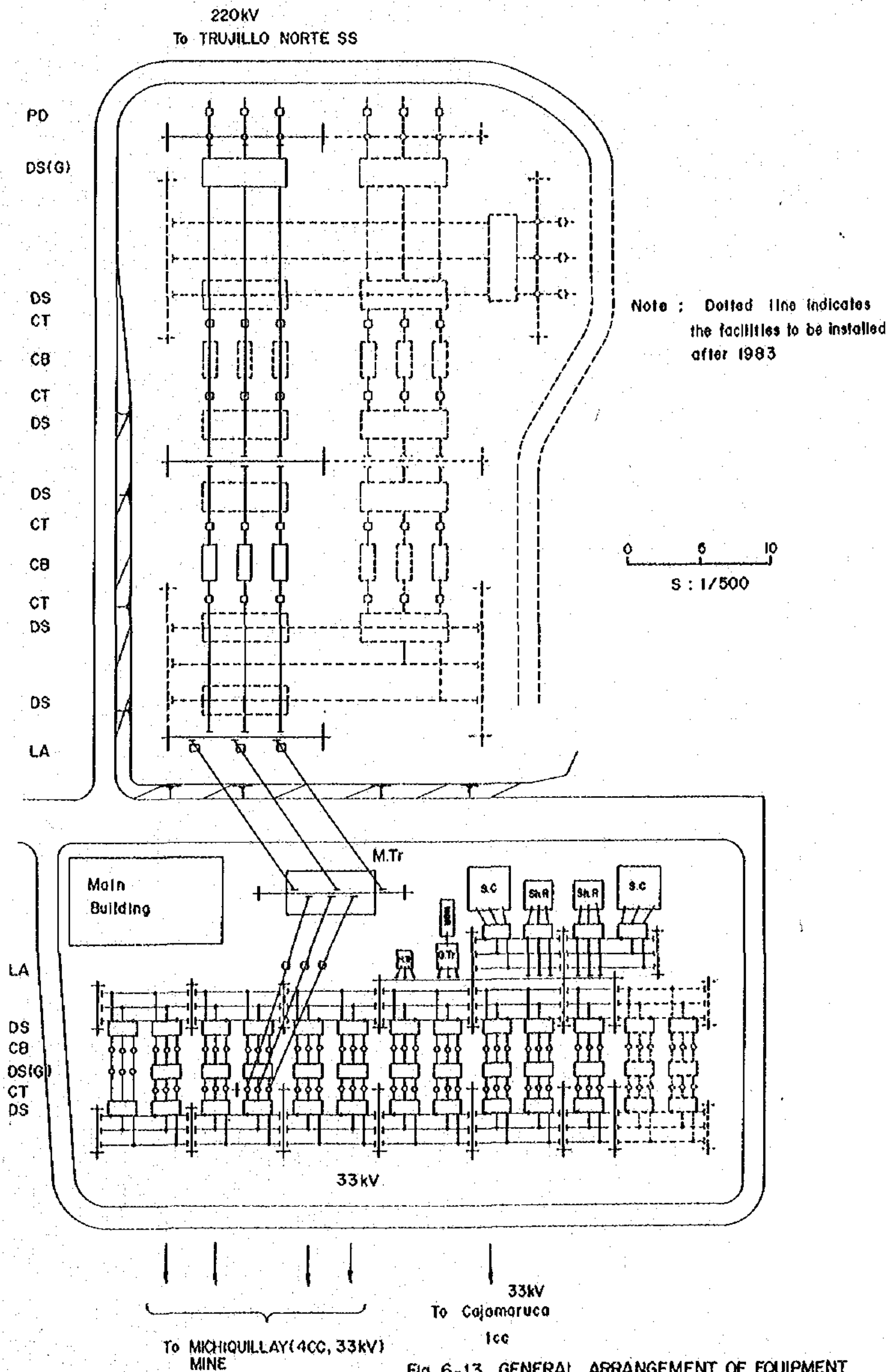
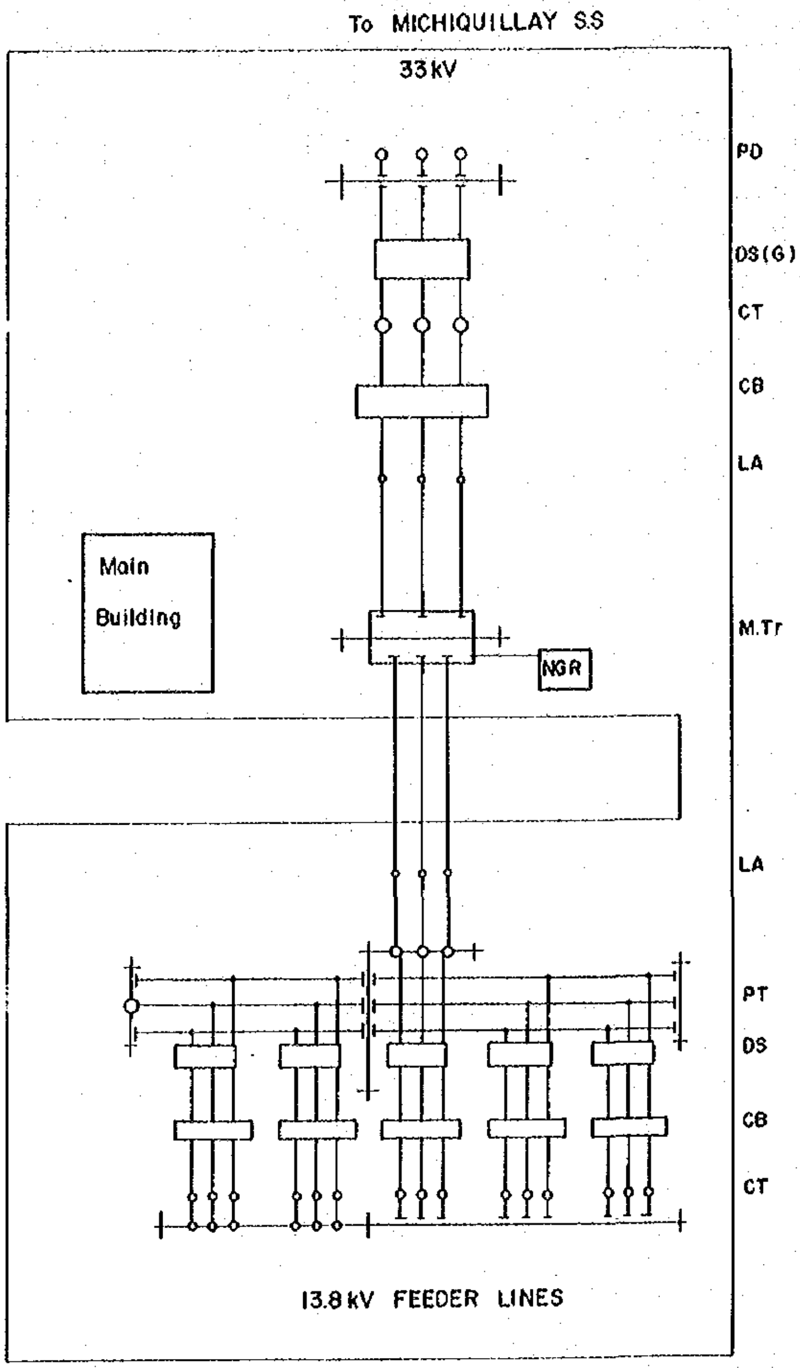


Fig. 6-13 GENERAL ARRANGEMENT OF EQUIPMENT MICHIQUILLAY SUBSTATION



Scale : 0 5 S=1/200

Fig. 6-14 GENERAL ARRANGEMENT OF EQUIPMENT CAJAMARCA SUBSTATION

6-2-3 Outline of Transforming Facilities

(1) Outline of Substations

1) 220 kV Substations

a) Trujillo Norte Substation

Trujillo Norte Substation will be the lead-out point of the transmission lines in this Project and 220 kV transmission line lead-out facilities are to be installed.

b) Michiquillay Substation

In order to supply power to the Michiquillay Mine and the city of Cajamarca, 220 kV transforming facilities are to be installed at a site in the vicinity of the Michiquillay Mine. The transmission lines to the two locations are to be connected to the 33 kV bus at Michiquillay Substation, and one bank of a main transformer of 80 MVA capacity is planned for voltage step-down from 220 kV to 33 kV.

Furthermore, considering that Michiquillay Substation would be interconnected in the future with the hydroelectric power sources of Yangas, San Juan and Crisnejas, the design was made to allow space for extensional lead-in of two circuits of 220 kV transmission lines to structure a ring bus system in the future.

However, the design is to be a single-bus system initially with only one circuit breaker, therefore making the initial investment smaller.

As for the 33 kV circuit, space for the extension of two circuits to supply power to Celendin and its surrounding area was planned in determining the plottage required.

2) 33 kV Substation

A substation is to be provided in the vicinity of the city of Cajamarca where one bank of a 5 MVA main transformer will be installed to receive power through the 33 kV transmission line from Michiquillay and step down voltage to 13.8 kV for power distribution in Cajamarca by 5 circuits of 13.8 kV lines.

(2) Outline of Facilities

1) Trujillo Norte Substation (Transmission Line Lead-out Facilities)

220 kV Transmission Line Lead-out Facilities	1 cct
Circuit breaker, 12.5 kV, 800 A	2 ea
Disconnecting switch, 800 A	4 ea

2) Michiquillay Substation

220 kV Transmission Line Lead-out Facilities	1 cct
Circuit breaker, 12.5 kV, 800 A	1 ea
Disconnecting switch, 800 A	1 ea
220 kV/33 kV Main Transformer	1 ea
Special 3-phase, 2-winding type	
80 MVA, with on-load tap changer, ±10%	
33 kV Phase Modifying Facilities	1 set
Shunt reactor, 33 kV, 5 MVA	2 ea
Condenser, 33 kV, 7.5 MVA	2 groups
Circuit breaker, 12.5 kA, 600 A	2 ea
Disconnecting switch, 600 A	10 ea
33 kV Transmission Line Lead-out Facilities	5 cct
Circuit breaker, 12.5 kA, 600 A	5 ea
Disconnecting switch, 600 A	15 ea
33 kV Bus Facilities	1 set
Circuit breaker, 20 kA, 2000 A	2 ea
Disconnecting switch, 2000 A	5 ea
33 kV System Grounding Facilities	1 ea
Grounding transformer, 2 MVA	1 ea
Circuit breaker, 12.5 kA, 600 A	1 ea
Disconnecting switch, 600 A	3 ea
Grounding resistor, 100 A	1 ea
33 kV Station Service Receiving Facilities	1 set
Station service transformer	1 ea
Circuit breaker, 12.5 kA, 600 A	1 ea
Disconnecting switch, 600 A	3 ea

3) Cajamarca Substation

33 kV Transmission Line Lead-out Facilities	1 cct
Circuit breaker, 12.5 kA, 600 A	1 ea

Disconnecting switch, 600 A	1 ea
33 kV/13.8 kV Main Transformer	1 ea
3-phase, 2-winding type	
5 MVA, with on-load tap changer, ± 10%	
13.8 kV Distribution Line Lead-out Facilities	5 cct
Circuit breaker 12.5 kA, 600 A	5 ea
Disconnecting switch 400 A	5 ea
13.8 kV System Grounding Facilities	1 set
Grounding resistor, 100 A	1 ea
13.8 kV Station Service Receiving Facilities	1 set
Station service transformer	1 ea
Disconnecting switch, 400 A	2 ea

6-3 Preliminary Design of Telecommunication Facilities

6-3-1 Outline of Preliminary Design

Telecommunication circuits will be structured according to the principles described below taking into account the scale of the electric power system of this Project and the relations with existing telecommunication facilities.

(1) Telephone Circuit for Load Dispatching

Chimbote No. 1 Substation is to be the load dispatching office with power line carrier apparatus installed between Chimbote No. 1 Substation and Trujillo Norte Substation, and between Chimbote No. 1 Substation and Michiquillay Substation respectively to structure telephone circuits for load dispatching.

Further, tone ringing party line telephones are to be installed at the Trujillo Norte and Michiquillay substations to make selective calling system.

(2) Administrative Telephone Circuits

A power line carrier administrative telephone circuit is to be structured between Chimbote No. 1 Substation and Michiquillay Substation. This circuit is to connect to the existing automatic exchanger at Chimbote No. 1 Substation and an automatic exchanger to be newly installed at Michiquillay Substation to structure a toll dialing telephone circuit.

(3) VHF Circuit for Transmission Line Maintenance

Two VHF radio base stations are to make possible direct communication from Trujillo Norte Substation and Michiquillay Substation with maintenance personnel along the transmission line, while fixed circuits are to be structured between these base stations and Trujillo Norte Substation and Michiquillay Substation. Of these circuits, between Pozo Seco and Michiquillay Substation it is to be a power line carrier circuit, while between Pacasmayo and Trujillo Norte Substation it is to be a VHF circuit.

(4) Carrier Relay

Carrier relay system will be provided using the telemeter channels of the power line carrier circuit between Trujillo Norte Substation and Michiquillay Substation.

(5) Fault Locator

With the aim of speeding up fault clearance of transmission lines, a C-type fault locator is to be installed at Trujillo Norte Substation.

(6) Telemeter

A telemetering circuit is to be structured utilizing the telemeter channel of the power line carrier circuit between Michiquillay Substation and Chimbote No. 1 Substation.

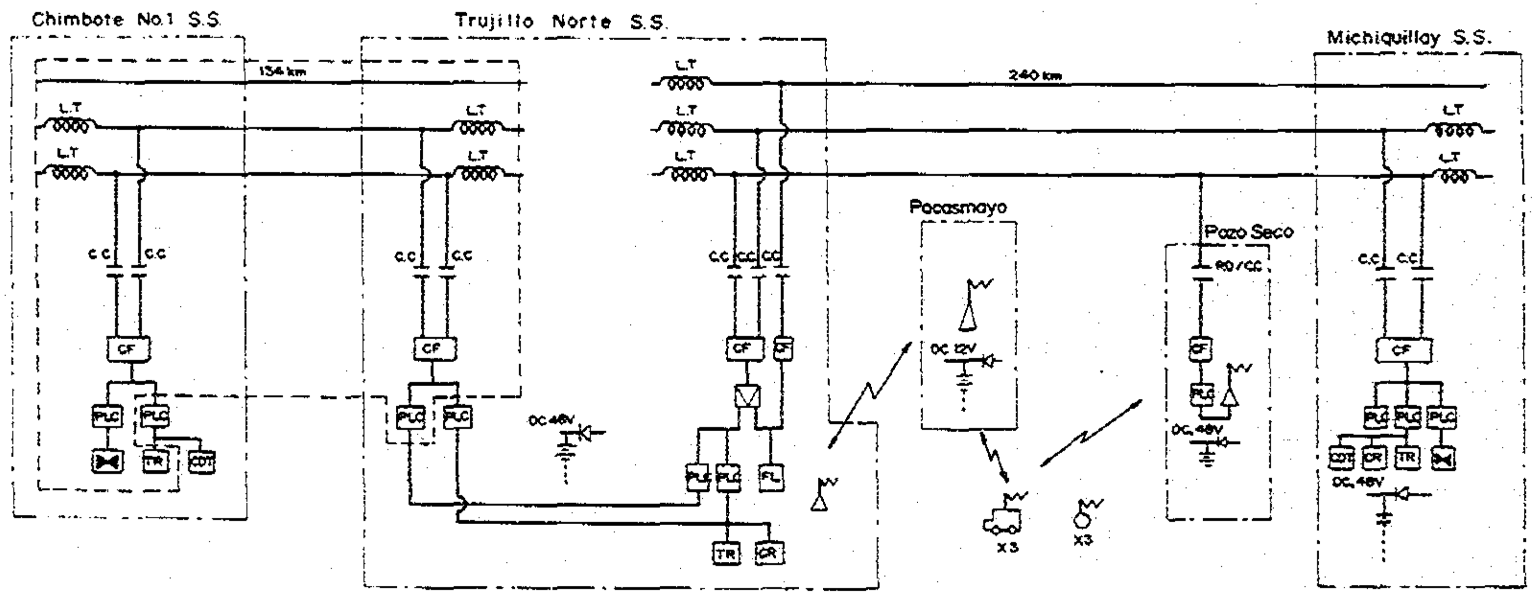
This is for telemetering of active power and voltage on the 220 kV side of Michiquillay Substation and for supervision of the circuit breaker.

Table 6-6 Telecommunication Facilities for Transmission Line

Items	Michiquillay S, S	Trujillo Norte S, S	Chimbote No. 1 S, S
Power line carrier equipment (1 CH, 45 dBr)	2	2	
Power line carrier equipment (1 CH, 35 dBr)	2 1/	1	1
Carrier relay equipment	1	1	
Fault locator equipment (C type)		1	
VHF Base radio equipment (25 W)	1 1/	1 2/	
VHF Stationary radio equipment (10 W)		1	
VHF Mobile radio equipment (10 W)	1	2	
VHF Portable radio equipment (1 W)	1	2	
C. D. T. equipment (6 words 200 bit/sec)	1		1
Automatic telecommunication exchanger (20 ch)	1		
Tone ringger (10 ch.cop)	1	1	
Power unit for telecommunication (48 V)	2 1/	1	
Power unit for telecommunication (12 V)		1 2/	
Distribution line 2 km	1 1/	1 2/	

NOTE, 1/: Including equipment of Pozo Seco VHF Base Radio Station

2/: Including equipment of Pacasmayo VHF Base Radio Station



Legend

L.T : LINE TRAP

C.C : COUPLING CAPACITOR

PD : POTENTIAL DEVICE

CF : COUPLING FILTER

PLC : POWER LINE CARRIER TELEPHONE EQUIPMENT

CDT : CYCLIC DIGITAL TELEMETER

FL : FAULT LOCATOR

CR : PROTECTIVE RELAYING CARRIER SIGNAL EQUIPMENT

[⋈] : AUTOMATIC TELPHONE EXCHANGE

TR : TONE RINGING PARTY LINE EQUIPMENT

Note

(1) [dashed box] Existing Equipment

(2) Trujillo Norte S.S. ~ Pacasmayo : 100km
Michiquilly S.S. ~ Poyo Seco : 40 km

Fig. 6-15 TELE-COMMUNICATION SYSTEM BLOCK DIAGRAM

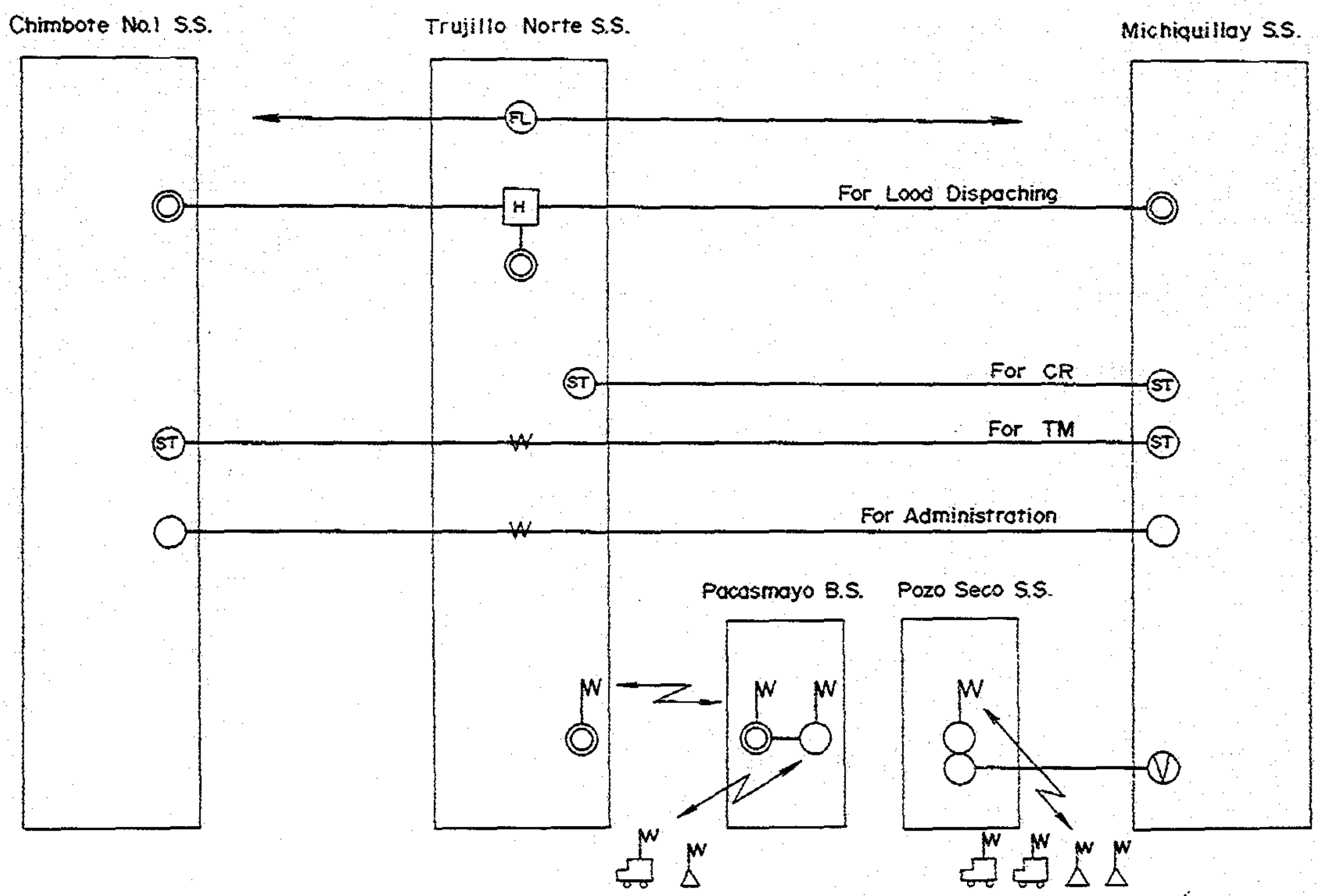


Fig. 6-16 TELECOMMUNICATION CIRCUIT DIAGRAM