THE REPUBLIC OF THE PHILIPPINES

REPORT
ON

CAGAYAN VALLEY ELECTRIFICATION PROJECT

SEPTEMBER 1974

JAPAN
INTERNATIONAL
COOPERATION AGENCY

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Preface

The Government of Japan, in response to the request of the Government of the Republic of the Philippines, decided to make investigation of the Electrification Project in Cagayan Valley, northern part of Luzon Island, and entrusted its implementation to the Overseas Technical Cooperation Agency (which was integrated into the Japan International Cooperation Agency on August 1st, 1974) in January, 1974.

The Agency, being fully cognizant of the importance of this investigation in the light of the economic and social status of the project area, organized a survey team headed by Mr. Tokio Jomoto, Deputy Manager of Operation and Maintenance Department of the Electric Power Development Co., Ltd., comprising ten experts, and sent it to the Philippines on March 5th, 1974 to carry out the investigation in the said area.

After completing the field survey there on March 30th, 1974, the team made an interim report back in Japan toward the end of June in conform with the outcome of the survey performed and the analysis of data collected and immediately Messrs. T. Jomoto and T. Fukuda, members of the team, were sent to Manila for discussion with officials of the Government of the Republic of the Philippines over the interim report.

Hereby presented is a final report on the Cagayan Valley Electrification Project based upon the above-mentioned discussion, containing the findings and recommendation the survey team attained.

It is most grateful if this report could serve to the benefits of the Republic of the Philippines and contribute to further promotion of friendship between the two countries.

Finally, I take this opportunity to express my hearty gratitude to the Government of the Republic of the Philippines and other authorities concerned for their kind cooperation and assistance extended to the survey team.

September, 1974

Shinsaku Hogen
President
Japan International Cooperation Agency
Japan

Letter of Transmittal

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency

Dear Sir;

Submitted herewith is a report on the Cagayan Valley Electrification Project. The Survey Team was organized by the Overseas Technical Cooperation Agency - OTCA, and was composed of ten experts from the OTCA, Overseas Economic Cooperation Fund and Electric Power Development Co., Ltd. The Team was headed by Tokio Jomoto, Deputy Manager of Operation and Maintenance Department of Electric Power Development Co., Ltd. and visited the Philippines for a period of 26 days from the 5th of March, 1974.

An interim report was prepared, based upon the results of field investigations and data and information made available to the Team by the Government of the Philippines during their stay in Manila and according to analysis of these data and findings made after their return to Tokyo. The interim report was forwarded to the Government of the Republic of the Philippines in June 1974 through diplomatic channels. Two persons including the Team Leader visited Manila for a period of eleven days from July 17, 1974 in order to explain to key personnel of the Philippine authorities concerned the contents of the said report and discussed with them ways of acceleration of the implementation of the Project. After the return of the two persons to Tokyo, the Team prepared the final report of the Project according to the results of their visit to Manila.

The study presented in this report covers mainly three provinces: Cagayan, Isabela and Nueva Vizcaya, with respect to a scheme for the construction of transmission lines, substations and related telecommunication facilities and a distribution line scheme required for irrigation and rural electrification.

We would like to take this opportunity to express our heartfelt gratitude for the valuable cooperation that responsible officials of the National Economic and Development Authority, National Power Corporation, National Electrification Administration and National Irrigation Administration as well as the staff of the Embassy of the Philippines in Tokyo and that of the Embassy of Japan in Manila extended to the Team in expediting preparation of this report.

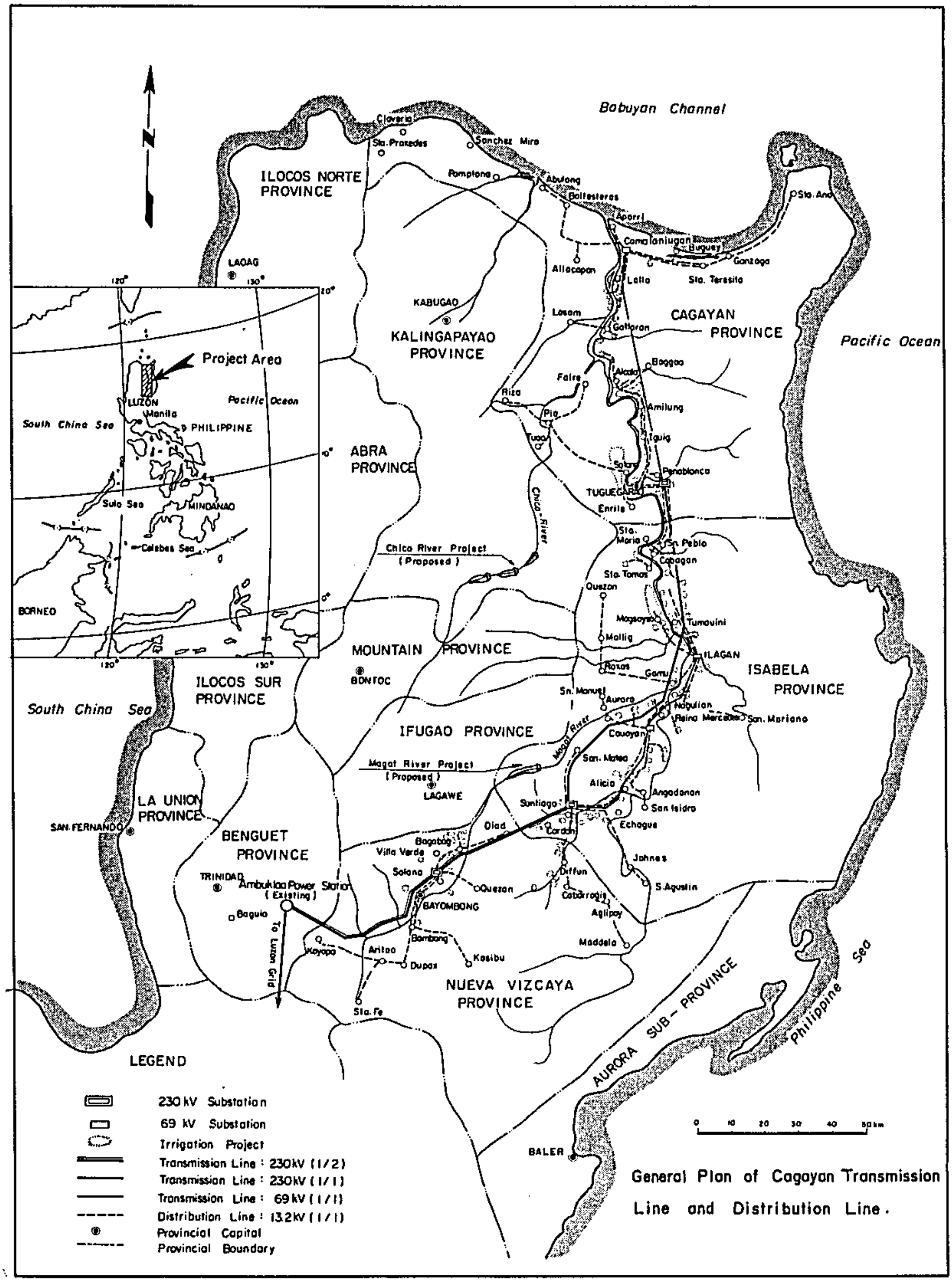
It is our sincere hope that the report will be of great help to the acceleration of the implementation of the Cagayan Valley Electrification Project which is an urgent and high priority project of the Government of the Philippines.

Respectfully yours,

September 1974

Tokio Jomoto

Tokio Jomoto, Leader
Japanese Survey Team
for
Cagayan Valley Electrification Project



General Plan of Cagayan Transmission Line and Distribution Line.

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CHAPTER I

INTRODUCTION

Chapter I Introduction

1-1 Background

The Cagayan Valley is a district blessed with agricultural resources and famous for the high production of Palay in the Philippines. The Valley still has a vast expanse of land to be developed for agricultural purposes. The diversity of crops and their increased production could be expected if rehabilitation and construction of agricultural facilities are undertaken in the future.

However, in view of the present situation of the Valley, it is marked by low per-capita income notwithstanding abundance of various resources. It is also reported that a high tenancy in the Valley obstructs the progress of the Valley, which has frequently aroused social unrest. Therefore, the Government of the Philippines has pinpointed the Cagayan Valley together with Central Luzon and Bicole as a priority land reform area in line with the Presidential Decree issued in October 1972.

On the other hand, the "Supplement to the Four Year Development Plan" (Fy 1974 to 1977) stresses the necessity of "modernization of agricultural systems" and "increase in agricultural productivity" which are regarded as important targets. For these purposes, the Government of the Philippines desires to rehabilitate and construct irrigation systems, bridges, roads and other miscellaneous infrastructures including schools to support the above-mentioned goals which are a matter of the greatest importance and urgency for the Cagayan Valley.

Under the circumstances described above, negotiations have been continued between both governments in connection with technical and/or financial assistance by the Government of Japan toward implementation of a series of development projects including the Cagayan Valley Electrification Project since 1971. Thus, in September 1973 after having undergone considerable vicissitudes, application was made by the Government of the Philippines to our Government for provision of a Japanese loan for this Project. In November 1973, a mission from the Overseas Economic Cooperation Fund (OECF) visited Manila in order to conduct appraisal of the application. In succession to the said mission, our survey team was dispatched by the Japanese Government in order to perform field studies of the Project in March 1974.

The major items of studies undertaken by the Team are;

(1) Power demand forecast which will provide a basis for construction of transmission lines, substations, related tele-communication facilities and distribution lines.

(2) Review and study the transmission lines, substations and related facilities which were proposed by NPC.

(3) Study on distribution systems which are considered most appropriate to supply power for irrigation and electrification projects and for rural electrification.

(4) Collect and compile data, information and findings which are necessary for the performance of the studies from (1) through (3) stated above.

After their return to Tokyo, the Team has prepared this interim report on the basis of the results of the field studies and by reference to the data and information made available by the Government of the Philippines to the Team.

After their return to Japan, the Team prepared an interim report on the basis of the field studies and by reference to the data and information made available to the Team. This interim report was duly forwarded to the Government of the Republic of the Philippines through diplomatic channels in June 1974. In the following month, Tokio Jomoto and Tetsuya Fukuda visited Manila again for a period of eleven days from July 17, 1974 in order to explain to key personnel of the Philippine authorities concerned and they also discussed with these people ways of acceleration of the Project.

After the said persons returned to Tokyo, this final report has been prepared by the Team according to the results of the visit of those persons to the Philippines.

1-2 Formation of Survey Team

The Team was composed of the following personnel. The specialities and assignments of the members and their respective organizations are as listed below.

Leader:	Tokio Jomoto (Electrical Engineer) Deputy Manager of Operation and Maintenance Department of Electric Power Development Co.,Ltd.	Overall Responsibility for Project Formulation
Member:	Kazuo Sasano (Liaison Expert) Internal Operation Department of Overseas Technical Cooperation Agency	Coordination
Member:	Kazuhide Kumagai (Financial Expert) Manager, 1st Division Loan Department II, Overseas Economic Cooperation Fund	Financial Studies
Member:	Tetsuya Fukuda (Project Economist) Assistant to the Manager of Foreign Activities Department of Electric Power Development Co., Ltd.	Power Economy
Member:	Teizo Toyama (Electrical Engineer) Assistant Manager of Transmission and Sub-station Section, Operation and Maintenance Department of Electric Power Development Co., Ltd.	Transmission Engineering

Member:	Hiroshi Kagami (Project Economist) Staff, Foreign Activities Department of Electric Power Development Co., Ltd.	Power Economy
Member:	Azuma Tsunoda (Agricultural Engineer) Staff, Foreign Activities Department of Electric Power Development Co., Ltd.	Irrigation Engineering
Member:	Masayuki Furukawa (Electrical Engineer) Staff, Operation and Maintenance Department of Electric Power Development Co., Ltd.	Substation Engineering
Member:	Nobuyoshi Okuhira (Electrical Engineer) Staff, Foreign Activities Department of Electric Power Development Co., Ltd.	Distribution Engineering
Member:	Yukiharu Mitsunaga (Electrical Engineer) Staff, Foreign Activities Department of Electric Power Development Co., Ltd.	Distribution Engineering

CHAPTER II

SUMMARY AND RECOMMENDATIONS

Chapter II Summary and Recommendations

(1) Power Demand Forecast

Power demand in the Cagayan Valley is estimated to the 23.5 MW in 1978 when the transmission lines, substations and associated facilities are scheduled to be commissioned. In 1987 after 10 years from the said year, the value of power demand is estimated to be 61.4 MW with expansion of proposed distribution systems.

Of the values showing growth of power demand given above, required power for irrigation is to account for 70% and 30% of the total power demand in 1978 and 1987, respectively.

(2) Construction Cost

The construction costs of transmission lines, substations and distribution lines can be expressed in the following foreign and domestic currency portions.

Construction Costs

(In Thousand U.S. Dollars)

	Foreign Currency	Domestic Currency	Total
Transmission Lines & Substations	18,989	9,090	28,079
Distribution Lines	3,696	1,943	5,639
Total	22,685	11,033	33,718

(3) Voltage Classification and Other Requirements

The necessary voltage classification, capacity and other important technical requirements of the transmission lines which will lay a firm basis for the Project have been determined with due consideration given to the proposed Magat River Project (final installed capacity: 300 MW) and through economic comparisions between alternatives. Thus, it has proved most economical that 230 kV transmission lines extending to Tuguegarao going out from Ambuklao Hydro Power Plant (75 MW) will be constructed and power will be supplied to other load centers through 69 kV lines.

The salient features of the transmission lines, substations and distribution systems which are to be completed by the end of 1977 are as follows:

<u>230 kV Transmission Lines</u>	
One circuit strung on double circuit tower	110 km
One circuit on one circuit tower	120 km
<u>69 kV Transmission Lines</u>	140 km
Solano Substation	15.0 MVA (230/13.2 kV)
Santiago Substation	40.0 MVA (230/69 kV) 15.0 MVA (69/13.2 kV)
Cauayan Substation	10.0 MVA (69/13.2 kV)
Ilagan Substation	15.0 MVA (69/13.2 kV)
Tuguegarao Substation	40.0 MVA (230/69 kV) 15.0 MVA (69/13.2 kV)
Camalaniugan Substation	15.0 MVA (69/13.2 kV)
<u>13.2 kV Main Distribution Lines</u>	520 km
Low-voltage Distribution Lines	200 km
Transformers for Distribution	24.1 MVA (13.2 kV/120, 240, 480 V)

No consideration is given to transformers for distribution for supply of electric power to industrial consumers in the Cagayan Valley.

(4) As a result of comparisons between annual costs to be incurred in construction of transmission and transformation facilities and those for installation of alternative diesel power plants with an installed capacity of 3,000 kW each, the value of B/C ratio is 1.8. This implies that power supply through construction of the transmission and transformation facilities under this Project is more economical than the alternative of installation of diesel power plants.

The unit cost of energy sold by the existing power utilities in the Cagayan Valley is 58.6 mills per kWh. If NPC wholesales its electric power at a price of 22.0 mills per kWh which can be obtained from

Bataan Thermal Power Plant (75 MW) to enable an internal rate of return of this Project alone to be 7.3% and then a distribution cost of 7.3 mills per kWh is added to the said wholesale price, it will be possible to provide power at a price of 29.3 mills per kWh at the consumer's end. The latter is equivalent to about 50% of the electric charge which consumers in general currently pay to the existing power utilities in the Cagayan Valley. In view of the above fact, it is easily understandable that this Project will be more economical.

(5) The transmission and transformation facilities given in (2) for which a loan application was made by the Government of the Philippines is enumerated on the list submitted at the conference of "Application of the First Project Aid."

Moreover, it is believed that transmission lines, substations and related facilities could be constructed in accordance with the Construction Schedule stated in Chapter V in view of the present situation and capability of NPC which will be responsible primarily for execution of the Project.

Since construction of distribution lines is closely connected with the effective utilization of the transmission lines and substations, it is essential that distribution systems required for the Project which is to be completed by the end of 1977 in parallel with the construction progress of the transmission lines and substations which are scheduled to be commissioned at the beginning of 1978.

For the above purpose, it is essential that arrangements and preparations for procurement of funds from respective sources be commenced by the Government of the Philippines as soon as possible in order to proceed to definite studies on the distribution scheme. Then, bidding documents required for purchase of major equipment, accessories and materials should be prepared by the end of 1975.

(6) It is recommended that the following works be completed prior to the commencement of the detailed designs.

1) Geological investigations should be conducted on typical sites from a geological standpoint over which transmission lines

are to run and with respect to places where high steel towers are to be built.

2) Investigations should be performed on accidents which might be caused by electromagnetic induction and on possible interference to radios caused by corona on transmission lines.

3) The weight of the heaviest goods (3 phase main transformer) is about 60 tons. Surveys should be conducted in connection with loading and unloading facilities in Aparri and manner of unloading in the said place and the conditions of roads from Aparri to the Project sites.

4) It is considered necessary that due consideration be given to selection of land to be used for the proposed substations stated in this report. Also, necessary arrangements for procurement of such land should be made.

CHAPTER III

PURPOSE AND AIM OF THE PROJECT

Chapter III Purpose and Aim of the Project

3-1 General Descriptions of the Cagayan Valley

3-1-1 General

The Cagayan Valley with an area of about 36,200 square kilometers is located in northern Luzon and composed of five provinces; Cagayan, Ifugao, Isabela, Kalinga-Apayao and Nueva Vizcaya (including Quirino Province which has recently become independent). The area of this Valley accounts for around 12% of the total land of the Philippines. It has a population of 1,680,000 which occupies approximately 5% of the total population. Of the five provinces, Cagayan and Isabela Provinces are larger in population and area of land. The area of the former is about 25% and the latter 33% of the total land area of the Valley while the population of both provinces accounts for more than 70% of the total population which the Cagayan Valley has.

The Cagayan River with an annual average discharge of 49 billion cubic meters meanders from the south to the north in the Valley and empties into the Babuyan Channel near Aparri. There are several major tributaries such as Ilagan, Magat, Chico and the like. Most of these rivers are rich in run-off. The Cagayan Valley is blessed with fertile land and abundant water. It is reported that there are many mineral deposits in the Valley which are promising and awaiting further development in the future.

3-1-2 Economic Structure

The regional economy of this Valley greatly relies upon agriculture as the primary industry because 80% of the total number of employment is engaged in agriculture and 14% in mining, commerce and transportation. The manufacturing industry in the Valley is still inmatured and negligible at the present stage. A majority of them are agricultural processing factories, rice mills, and belong to the "cottage industry or small scale industry."

The ratio of employment in the industrial sector in the Cagayan

Valley is only 1.1% of the whole employed labor force throughout the Philippines. In this sense, industrialization in this district is not worthy of remarks.

According to actual records of 1965, the annual income per family is ₱975 to ₱1,322 against ₱1,648 to ₱2,541 of the average annual income per family in the whole Philippines and the former accounts for only approximately 55% of the latter. As seen from the above, the Cagayan Valley is one of the low income areas in the Philippines.

Table 3-1 Number of Employees by Sectors

(%)

Sector	Cagayan	Isabela	Nueva Vizcaya	Ifugao	Kalinga Apayao	Whole Cagayan Valley	Whole Philippines
Primary Industry	75	78	76	78	90	79	55
Secondary Industry	8	7	7	6	2	7	17
Tertiary Industry	17	15	17	16	8	14	28
Total:	100	100	100	100	100	100	100

Source: Data furnished by the National Economic and Development Authority.

3-2 Existing Power Utilities in the Cagayan Valley

As of March 1974, 13 electric utilities are in operation in the Cagayan Valley. All the power facilities totalling up to 78 units owned by the power utilities are diesel power plants whose capacity varies from 15 kW to 425 kW. The details of power generation are as shown in Table 3-2.

The management of the existing power utilities has been worsening because of the oil crisis which has been taking place on a worldwide scale since 1973. A majority of these enterprises have difficulty, especially in raising necessary funds for procurement of fuel. Consequently, some of them manage to supply electric power against advance payment by their consumers of electric charges.

Under these circumstances, Aparri and Santiago Power

Utilities were forced to suspend their power supply due to incompetent management and are waiting for financial assistance from the National Electrification Administration or town offices or to be taken over by these organizations concerned for resumption of power supply.

Three enterprises; Solano, Cauayan and Tuguegarao Power Utilities provide 24 hours supply of electric power and other power companies furnish power for a limited length of time; during the night or at the time of lighting.

Industrial and commercial enterprises have their self-generating facilities because of difficulty in the assured supply by the power utilities of stable and cheap power satisfying the operation of their businesses.

Table 3-2 Existing Electric Plant Utilities in Cagayan Valley

	Installed Capacity (kW)	Peak Load (kW)	Annual Energy Generation (MWh)
Nueva Vizcaya Province:			
1. Aritao	90	30	89.7
2. Bayombong*	430	250	758.6
3. Diffun*	60	30	30.4
4. Solano	300	250	994.4
Isabela Province:			
1. Alicia	112	76	45.9
2. Cauayan*	515	350	1,213.4
3. Echague	60	30	23.6
4. Ilagan*	375	240	702.9
5. Santiago	390	360	600.0
Cagayan Province:			
1. Aparri	300	284	1,324.2
2. Baggao	60	31	46.3
3. Camalaniugan	30	30	53.8
4. Gonzaga	90	60	115.0
5. Pamplona	27	6	13.6
6. Tuguegarao*	945	750	2,448.2
Total:	3,784	2,777	8,460.0

Note: * implies actual records in 1973 while other figures indicate those in 1971.

Source: Magat River Feasibility Report, June 1973.

3-3 Irrigation and Electrification Projects in the Cagayan Valley

The Cagayan Valley is blessed with natural conditions such as abundance of precipitation, suitable temperature and land resources for carrying on agriculture. However, except for certain areas of the Valley, most of land has not yet been utilized to the fullest extent. The Government of the Philippines has recently determined to formulate and implement agricultural development projects in order to fully utilize this fertile land. Of these development projects, the Magat River Multi-Purpose Project is a typical large national irrigation project which aims at acceleration of the development of the Cagayan Valley through increased agricultural production, provision of electric power and flood control as an incidental objective. In addition to the above-mentioned big project, there are many relatively small-scale proposed electrification and irrigation projects which are to pump-up necessary quantities of water from rivers, creeks and lakes by driving electric motor mainly for increased production of Palay.

It is hardly possible to cope with shortage of food in a short period of time through development of only large scale irrigation projects which will require a great deal of time and expenditure in construction of such projects. In this regard, the Government of the Philippines has decided to exert its utmost to materialization of a great number of small scale electrification and irrigation projects so that rural areas can be electrified and shortage of Palay production can be augmented for a short period of time.

3-4 Objectives and Components of the Project

3-4-1 Objectives of the Project

Due to the characteristics of the Valley as stated before, production of Palay, corn and tobacco amounts to 9.4%, 8.4%, and 31.1% of the total amount in the Philippines. However, agricultural systems in the Valley rely upon rain water for the most part. For the purpose of realizing self-reliance in production of Palay, the Government of the

Philippines intends to irrigate about 40,000 ha of land scattered along the Cagayan River as top priority projects.

Accordingly, it is considered necessary to obtain power for driving electric motors. Besides power for irrigation, another goal to achieve for the Philippines is regarded as rural electrification. The Valley is remarked by the lowest per-capita income on the Island of Luzon. In order to get away with the poverty from which the Valley is suffering, it is believed that the Project will be of the greatest help to the assured supply of power not only for irrigation purposes but also for rural electrification, which will lead to remarkable increase in agricultural production and improvement of the living standard of people in the Valley.

3-4-2 Components of the Project

(1) Progress of Previous Studies

The Cagayan Valley Electrification Project described in the report is to be composed of a transmission line scheme including substations for which the National Power Corporation (NPC) will be responsible and a distribution line scheme under the jurisdiction of National Electrification Administration (NEA).

These two schemes, however, differ from each other in respect of the grade of project studies, such as the availability of data and findings and the progress of necessary investigations. For example, the following reports and data can be listed in connection with the transmission line and substation scheme.

1) Long-Range Development Plan for Luzon Grid by IECO (September 1973)
2) Long-Term Generation Expansion Program for Luzon Grid by NPC (September 1973)
3) Magat River Project Feasibility Report by AID and USBR (June 1973)
4) Feasibility Report on the Development of the Cagayan Valley Electrification by NPC (May 1972)

5) Plans and Specifications for Furnishing and Erecting by NPC (November 1973)

As of March 1974, site surveys were being undertaken on the proposed transmission line routes and most of profiles covering mountainous areas had been completed. Therefore, it was possible for the Team to review and study these transmission lines proposed by NPC, based on the results of the field studies conducted by NPC and by reference to the above-mentioned reports and data. Accordingly, the accuracy of our studies is of a level of feasibility studies.

As far as the distribution line scheme is concerned, field studies were progressing with respect to some parts of Nueva Vizcaya and Cagayan Provinces. It was reported by NEA staff that reports on such studies would be submitted to NEA by around the middle of April 1974. Due to the progress of necessary studies to be performed by NEA, it can be said that the distribution line scheme presented herewith is not in detail as a "feasibility study" but more refined than a "preliminary (reconnaissance) study in respect of its contents.

(2) Transmission Line and Substation Scheme

As seen from the Construction Schedule given in Chapter V, it is believed that the construction of these facilities could be started at the beginning of 1976 if contracts are awarded in connection with procurement of necessary equipment, accessories and materials to be imported by June 1975. Construction works will be completed by the end of 1977, 24 months after the commencement of the said works. The Team is of the opinion that additional expansion of the capacity of transformers would be unnecessary for 10 years from 1978 through 1987 in view of estimated demand for power during this period. The total construction cost of the transmission and transformation facilities including related telecommunication facilities is estimated at US$28, 079, 000.

Under this scheme it is proposed that 230 kV main transmission lines 230 km long and 69 kV transmission lines with a length of 140 km and substations with a total bank capacity of 165 kVA at 6 sites be constructed. It is believed that this scheme will constitute a nucleus of later transmission and transformation schemes in the Cagayan Valley.

The concept of this scheme is also to conform with fundamental plans for construction of transmission and transformation systems included in the Luzon Grid.

(3) *Distribution Line Scheme*

According to the progress of the transmission line and substation scheme described in the proceeding Paragraph, it is essential that the distribution line scheme for constructing 13. 2 kV main distribution lines 520 km long and low voltage distribution lines with a length of 200 km be completed by the end of 1977.

The total construction cost of this scheme is estimated to be US$5, 639, 000, and upon completion of this scheme, it will be made possible to supply electric power for proposed national, communal and private pump-irrigation projects covering about 40, 000 ha and for towns and municipalities adjacent to these project sites to be electrified by late 1977. Additional expenditures to be incurred in extension of distribution lines for 10 years from 1978 are estimated to be US$14, 470, 000. In this manner, the electrification ratio in the Vallay is expected to reach 44% in late 1987.

CHAPTER IV

DEMAND FORECAST

Chapter IV Demand Forecast

4-1 Demand Forecast in the Cagayan Valley

4-1-1 Basic Principles of Forecast

In estimating power demand in the Cagayan Valley, first of all, forecast has been made on the respective power demand to arise from the four categories of "lighting demand in towns and municipalities", "lighting demand in rural areas", "industrial demand" and "demand by electrification for irrigation". Then the final value of power demand has been determined by adding the values of power demand tabulated in each category. The forecast is based upon the assumption that power distribution for electrification and irrigation projects which are given the highest priority and for towns and municipalities near the said project sites are to be materialized by the year 1977 in which the transmission and transformation systems are scheduled to be completed.

4-1-2 Forecast on Lighting Demand in Towns and Municipalities and Rural Area

(1) Lighting Demand in Towns and Municipalities

According to the Census of 1970, an average annual population growth rate for the past 10 years from 1960 in the whole Cagayan Valley is recorded as 3.4%; such rate in towns and municipalities is 4.0% and that in rural areas is 3.2% during the same period. The number of consumers which provides a basis for demand forecast has been calculated by multiplying the number of consumers as of 1971 by 3% that is slightly below the population increase rates given above.

There are towns where existing distribution systems are available and non-electrified ones without power service among towns and municipalities in the Cagayan Valley. Accordingly, the following monthly energy consumption in towns and municipalities was projected corresponding to three classes of consumers, based upon the actual records as of 1973 in the

Valley, as given in Table 4-1.

Table 4-1 Energy Consumption per Customer in 1973

(1) Solano Electric Plant (24 hour service)

Number of Customers;	1,342
Energy Sales;	727 MWh
Energy Sales per Customer;	45 kWh per month

(2) Cauayan Electric Plant (24 hour service)

Number of Customers;	910
Energy Sales;	1,037 MWh
Energy Sales per Customer;	95 kWh per month

(3) Bayombong Electric Plant (12 hour service)

Number of Customers;	1,326
Energy Sales;	659 MWh
Energy Sales per Customer;	42 kWh per month

(4) Ilagan Electric Plant (12 hour service)

Number of Customers;	1,128
Energy Sales;	551 MWh
Energy Sales per Customer;	41 kWh per month

(5) Tuguegarao Electric Plant (24 hour service)

Number of Customers;	2,313
Energy Sales	2,081 MWh
Energy Sales per Customer;	75 kWh per month

(Unit: kWh/month)

Town Classification	1973	1978	1987
Class A	71	80	100
Class B	52	60	80
Class C	0	40	60

Note) Consumers belonging to Class A are the principal towns with 24-hour power supply service of the provinces while Class B shows towns and municipalities with 12-hour power supply service. Class C is non-electrified municipalities.

Power demand of towns and municipalities has been obtained by multiplying the number of consumers by the monthly energy requirement per consumer in the respective categories. Demand arising from street lighting which is generally regarded as "lighting demand" is incorporated in the energy requirement per consumer. The results of such projection is as given in Table 4-3.

(2) Lighting Demand in Rural Areas

The power demand in rural areas has been estimated through multiplying monthly requirement (kWh) per consumer by the number of projected consumers according to the data compiled by NEA.

Estimate of the number of consumers is based on the assumption that an electrification ratio of rural areas is to be raised from 0% to 30% which is almost equivalent to that of towns and municipalities in 1987 in 10 years from the completion of the transmission lines and substations.

The population growth rate of rural areas for 10 years from 1960 through 1970 is recorded as 3.2%. Such rate after 1970 is expected to taper down to 2% due to the propagation of social education including family planning especially in rural areas promoted by the Philippine Government.

Then, the number of households was tabulated by dividing the increasing rural population in the future by 6 on the assumption that a family is to be composed of six persons by reference to the Census of 1970. The said number was further multiplied by the above-mentioned electrification ratio in order to obtain the number of consumers.

The monthly energy consumption per consumer in rural areas has been estimated to be 35 kWh in the initial year, 50 kWh in the 10th year as shown in Table 4-2 which gives monthly requirement per residential consumer by paying attention to the results of a power market survey in the Valley conducted by

NEA in 1972.

It seems that the energy requirement of 75 kWh for residential use stated in the table is slightly overestimated in comparison with the actual records of such energy requirement in towns. The results of power demand estimated by the Team are shown in Table 4-3.

In this study, the values of power demand from commercial facilities and public buildings are included in those of lighting demand in towns and municipalities in the Valley.

Table 4-2 Energy Consumption by Sectors from Feasibility Report Prepared by NEA

(Unit: kWh/month)

	Cagayan		Isabela		Nueva Vizcaya	
	1st	10th	1st	10th	1st	10th
1. Residential	30	75	30	75	35	80
2. Commercial	35	105	35	105	35	105
3. Public Buildings	25	70	25	70	25	70

Source: Feasibility Report on Rural Electrification prepared by NEA, April 1972.

Table 4-3 Load Forecast for Towns and Rural Districts in Cagayan Valley

	Existing (1971)	1st year (1978)			10th year (1987)			Remarks
	Number of Customers	*No. of Customers	Energy Consumption (kWh/month)	Annual Energy (MWh)	No. of Customers	Energy Consumption (kWh/month)	Annual Energy (MWh)	
1. Cagayan Province Town classification								
A class	3,592	2,576	80	2,473	5,932	100	7,118	Tuguegarao, Aparri
B class	2,063	712	60	512	2,900	80	2,784	Baggao, Camalaniugan Gonzaya
C class	11,188	3,505	40	1,682	14,711	60	10,591	Others Permplona
Rural districts	0	0	35	0	35,400	50	21,240	
2. Isabela Province Town classification								
A class	2,233	2,746	80	2,636	3,687	100	4,424	Cauayan, Santiago
B class	2,056	2,528	60	1,820	3,395	80	3,259	Alicia, Ilagan
C class	14,514	6,994	40	3,377	24,120	60	17,366	Others
Rural districts	0	0	35	0	40,000	50	24,000	
3. Nueva Vizeaya Province Town classification								
A class	0	0	80	0	0	100	0	
B class	2,590	3,185	60	2,293	4,277	80	4,106	Bayombong, Solano
C class	6,565	3,819	40	1,833	10,831	60	7,798	Others
Rural districts	0	0	35	0	12,150	50	7,290	

Note: * implies the number of consumers who are expected to be supplied with electric power in 1978 after completion of the distribution scheme (1st Stage).

4-1-3 Power Demand from Industrial Sector and Electrification for Irrigation

(1) Power Demand from Industrial Sector

Demand by the industrial sector for power in the Cagayan Valley consists of various industries such as threshing, rice-polishing, sawmills, ice-manufacturing, automobile repair shops, etc. Present demand from the rice-threshing and polishing industries, among others, is estimated to be 2,000 to 2,500 kW in consideration of rice production in the Valley. However, power required for their undertaking is met by their own generating facilities. The number of industrial consumers and their demand are as shown in Table 4-4.

Table 4-4 Industrial Demand in 1971

Province	Number of Consumers	Max. Demand (kW)	Energy Requirement (MWh)
Cagayan	104	2,147	10,424
Isabela	135	1,963	13,863
Nueva Vizcaya	64	945	6,354
Total	303	5,055	30,641

Note) The figures shown above include potential demand according to the "Magat River Project Feasibility Report, Vol. 1" prepared by the National Irrigation Administration (NIA).

Irrigated area at present and land to be irrigated in 1987 cover 77,000 ha and 178,000 ha, respectively. The production of rice is anticipated to become more than twice as large as the amount of the present production. Hence, it is considered that industrial demand for power will increase in proportion to increase in rice production unless there is any remarkable change in the economic structure of the Cagayan Valley. An average annual growth rate of 7.2% has been projected in this study.

(2) Power Demand from Electrification for Irrigation

As a result of reviewing the value of power demand with appropriate consideration given to the technical features of irrigation projects proposed by NIA, the following values of power demand for irrigation and electrification projects have been estimated. (See Table 4-5, Table A-2-2 and Fig. A-2-1 in Appendix A-2)

Table 4-5 Pump Capacity in kW

Year	National Project	Communal Project	Private Project	Total
1978	2,570	11,473	2,557	16,600
1982	2,570	11,473	3,427	17,470
1987	2,570	11,473	4,627	18,670

4-1-4 Load Forecast by Substations

Based upon the figures of power demand with respect to the Cagayan Valley Electrification Project, tabulations were made in the respective substations, as stated in Table 4-6. Annual average growth rates of demand and energy requirement in the whole Cagayan Valley are 11.2% and 10.5%, respectively.

Details of load forecast is shown in Table A-2-1 in Appendix A-2.

Table 4-6 Load Forecast in Cagayan Valley

Substations	1978	1982	1987	Increase (%)
(1) Solano				
Max. demand (MW)	3.4	5.4	8.7	11.0
Energy requirement (GWh)	15.3	23.8	36.7	10.1
(2) Santiago				
Max. demand (MW)	4.5	8.0	13.1	12.6
Energy requirement (GWh)	20.7	34.2	53.9	11.1
(3) Cauayan				
Max. demand (MW)	3.0	4.5	6.8	9.5
Energy requirement (GWh)	13.7	20.1	29.4	8.9
(4) Ilagan				
Max. demand (MW)	4.3	6.5	9.6	9.2
Energy requirement (GWh)	20.1	29.6	41.8	8.5
(5) Tuguegarao				
Max. demand (MW)	5.2	7.9	12.3	10.0
Energy requirement (GWh)	23.6	35.5	52.8	9.3
(6) Camalaniugan				
Max. demand (MW)	3.1	6.4	10.9	15.0
Energy requirement (GWh)	13.6	27.0	43.8	13.8
Total				
Max. demand (MW)	23.5	38.7	61.4	11.2
Energy requirement (GWh)	107.0	170.3	258.4	10.5

In additional to the demand for pumping-up water from rivers and creeks, it has become apparent that another 30 to 40 MW of power demand will arise by 1987 because power will be utilized for new irrigation projects including ground water development projects covering 30,000 ha. However, since the features of these projects are not made clarified at present, power demand for these new projects is not included in the power demand given in this study.

4-2 Luzon Grid and Cagayan Valley Power System

4-2-1 Present Situation of Luzon Grid

Maximum power demand in the Luzon Grid is recorded as 1,210 MW as of 1972 and power to satisfy this demand is supplied through the interconnected power systems (2,040 MW) of NPC and MERALCO. As shown in Table 4-7, most of power plants owned by NPC are hydro power plants while those of MERALCO are thermal.

Table 4-7 Existing Generating Power Plants in Luzon Grid in 1973

Name of Plants	Installed Capacity (MW)	Available Energy (GWh)
National Power Corporation		
1. Ambuklao H.E. Plant	75.0	398.1
2. Angat H.E. Plant	212.0	552.0
3. Bataan Thermal Plant	75.0	492.7
4. Binga H.E. Plant	100.0	437.0
5. Caliraya H.E. Plant	36.0	188.0
6. Small Plants	4.3	18.8
NPC Total	502.3	2,086.6
Manila Electric Company		
1. Botocan H.E. Plant	15.0	49.1
2. Blaisdell Thermal Plant	37.0	243.0
3. Gardner Thermal Plant	385.0	2,529.4
4. Rockwell Thermal Plant	333.0	2,187.8
5. Tengen Thermal Plant	220.0	1,445.4
6. Snyder Thermal Plant, Unit 1	220.0	1,445.4
7. Snyder Thermal Plant, Unit 2	330.0	2,168.1
MERALCO Total	1,540.0	10,068.2
Grand Total for Luzon Grid	2,042.3	12,154.8

NPC is responsible for supply of power to places other than Manila and its adjacent places and for sale of power to MERALCO. Mutual exchange of power is made between both organizations from a standpoint of effective utilization of power systems. In other words, while water level of reservoirs is high and whenever there is a great quantity of run-off from rivers NPC supplies power to MERALCO, and NPC purchases necessary quantities of power from MERALCO when and if reverse situation takes place, especially during the dry season.

The growth rate of demand for 12 years from 1960 in the past was 20.9% within the grids of NPC, as seen from Table 4-8 while that of MERALCO is recorded as 10.7% during the same period. The reason for the remarkable increase in power demand observed at a quick tempo in NPC's grids is attributable to the fact that this organization has positively been undertaking development and expansion of possible power demand through construction of 230 kV, 115 kV and 69 kV transmission lines and related facilities with the aim of supplying power to rural districts which had been relying mostly upon inefficient self-generating facilities. Fig. 4-1 gives the electrified areas in the Luzon district.

Fig. 4-1 Luzon Area Electrification in 1973

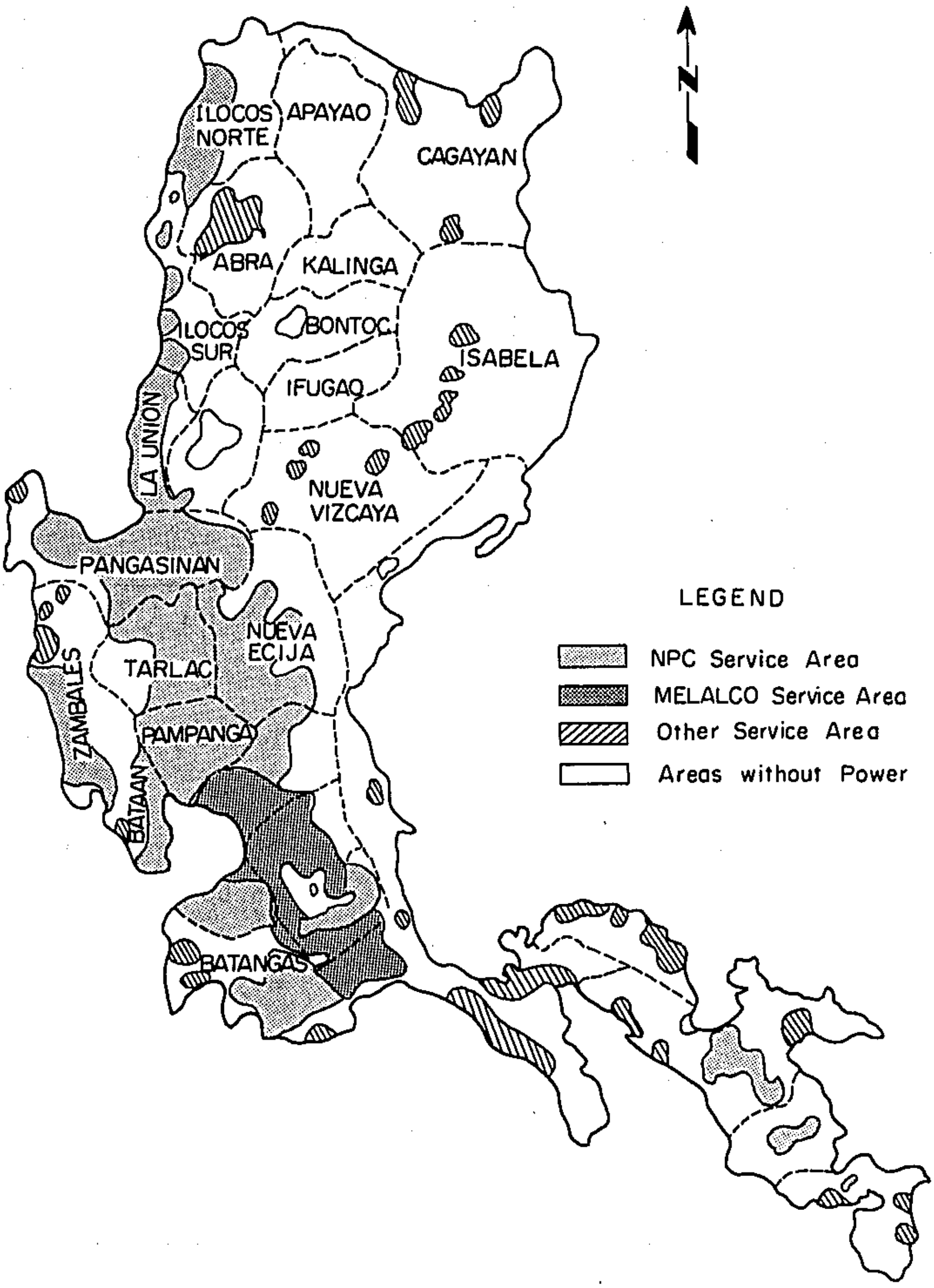


Table 4-8 Actual Load Demand and Energy Consumption in Luzon

Fiscal year	NPC		MERALCO		NPC-MERALCO	
	MW	GWh	MW	GWh	MW	GWh
1960	24.3	150.9	271.7	1,559.4	287.1	1,750.3
1961	34.9	219.9	331.8	1,815.7	355.7	2,035.6
1962	39.9	262.2	377.9	2,074.8	405.3	2,337.0
1963	46.5	302.9	417.8	2,347.4	450.4	2,650.3
1964	62.1	397.0	474.1	2,629.1	520.1	3,026.2
1965	72.7	464.7	513.4	2,916.3	568.5	3,381.0
1966	93.0	510.7	551.5	3,240.9	625.2	3,751.6
1967	121.4	745.8	613.1	3,629.5	712.5	4,375.3
1968	132.2	772.7	670.3	4,052.9	778.4	4,825.6
1969	169.7	1,026.2	731.1	4,529.7	873.8	5,555.9
1970	189.8	1,097.1	851.2	4,897.0	1,009.8	5,994.1
1971	224.3	1,247.9	912.4	5,147.1	1,102.6	6,395.0
1972	249.6	1,467.0	1,001.8	5,427.2	1,213.9	6,894.2
Growth rate (%)	21.4	20.9	11.5	10.7	12.7	12.1

Source: "Long-range Development Plans for Luzon Grid, 1973-2002" prepared by IECO.

The electricity tariff to be effective in and after July 1974 within the areas of NPC's Luzon Grid is as follows.

	Per meter, Per month
Demand charge:	
First 1,000 kW of billing demand	₱5.00 per kW
Next 9,000 kW of billing demand	₱3.00 per kW
All excess kW	₱1.00 per kW
Basic energy charge:	
First 300 kWh per kW of billing demand	₱0.085 per kWh
Next 150 kWh per kW of billing demand	₱0.070 per kWh
All excess kWh	₱0.050 per kWh

4-2-2 Power Development Programs and Demand-Supply Balance within Luzon Grid Area

There are the following reports which deal with long-term forecast on power demand and power development programs to satisfy the said demand.

(1) Long Range Development Plans for Luzon Grid by IECO (September 1973)

(2) Magat River Project Feasibility Report by AID and USBR (June 1973)

These reports predict future demand as follows:

	FY 1972		FY 1977		FY 1982		Increase in GWh (%)
	MW	GWh	MW	GWh	MW	GWh	
IECO Report	1,213	6,894	1,960	11,100	2,993	16,714	9.2
AID & USBR Report	1,359	7,447	2,244	12,382	3,459	19,333	10.0

The growth rate of power demand after 1972 tapers down, in comparison with the growth rate of 12.1% which is observed during the period from 1960 to 1972. This tendency could be regarded as reasonable. Great expectation is held by the Government of the Philippines for development of hydro and geothermal power resources in order to cope with the oil crisis which has been more acute since 1973. In fact, many hydro power development projects, except for Malaya Thermal Power Project under the jurisdiction of MERALCO and NPC-owned Bataan No. 2 Thermal Power Project, are under planning. Among others, a geothermal project located in the Tiwi district of southern Luzon is reported to be very attractive, and five pilot wells have already being drilled. An order for purchasing two units of 10 MW each of the pilot generating plant was scheduled to be placed in April 1974. The geothermal power project is to have an installed capacity of 500 MW as given in Fig. 4-2 and is scheduled to be interconnected with the Luzon Grid by 1982.

The generating facilities to be installed by the said year are as follows:

Table 4-9 Generating Plants to be Installed up to 1982

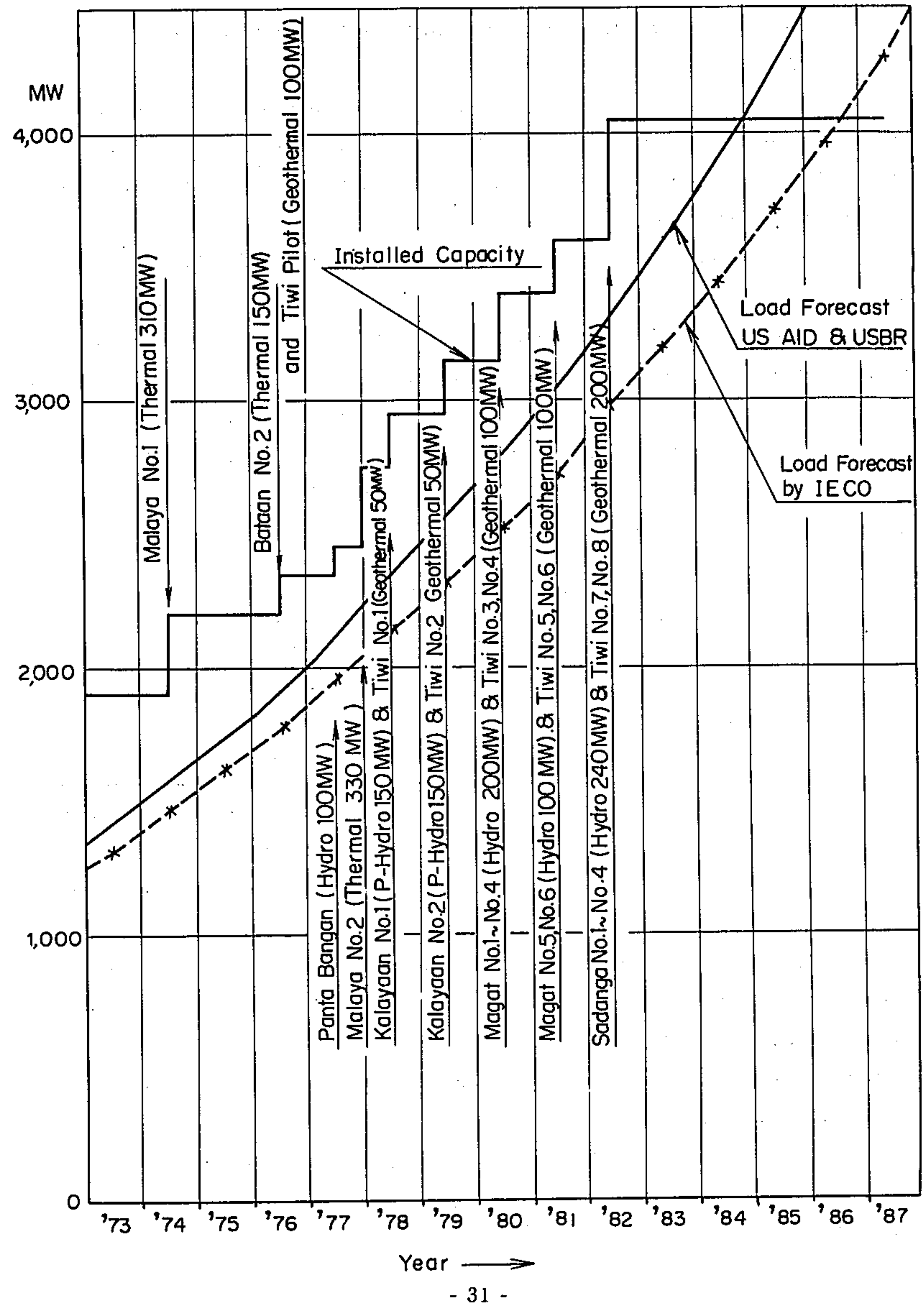
Name of Power Plant	Installed Capacity (MW)	Available Energy (GWh)	Commis-sioning Year
National Power Corporation			
1. Bataan Thermal Unit No. 2	150	985.5	1976
2. Tiwi Pilot Plant (Geothermal)	510	3,350.7	1978
3. Panta-bangan HE. Plant	100	227.0	1977
4. Kalayan Pump Hydro Plant	300	-	1978
5. Magat HE. Plant	300	991.0	1981
6. Sadanga HE. Plant	240 (Final: 360 MW)	784.5	1982
NPC Total	1,600	6,338.7	
Manila Electric Company			
Malaya Thermal Plant	340	2,233.8	
Grand total for Luzon Grid	1,940	8,572.5	

Of the proposed generating plants, the Kalayan Pumped-Storage Project is to be completed in 1978, by the utilization of the existing reservoir of the Caliraya Hydro Plant to the maximum extent, this forming the upper pool, with Laguna de Bay used for the lower pool. The Kalayan site is favored with outstanding natural topography as a pumped storage project site.

The recent technical feasibility study, conducted by Electro Consult indicates that a potential capacity of around 3,000 MW can be developed at the Kalayan site by construction of dam forming the upper pool.

Proposed Magat Power Plant and Sadanga Hydro Power Plant are located in the Cagayan Valley and are most promising projects. As shown in Fig. 4-1, 230 kV transmission lines (one circuit strung on double circuit tower) with a total length of 301 km between the proposed Malaya project site in Laguna de Bay and Naga in Camalines Sur Province are scheduled to be constructed by the end of 1975, in order to supply power to non-electrified areas in southern Luzon.

Fig. 4-2 Luzon Grid Long-Term Generation Expansion Program Prepared by NPC.



4-2-3 Status of Cagayan Power System to be Occupied in the Luzon Grid

It is an intension of the Government of the Philippines that power will be supplied from the Luzon Grid to the Cagayan Valley in order that electrification for irrigation and rural electrification can be materialized as soon as practicable.

In line with this policy, it has been planned by the Team that 69 kV transmission lines 140 km long, three 230 kV substations and the same number of 69 kV substations are to be completed, pivoted on 230 kV trunk transmission lines with a total length of 230 km to satisfy energy requirements for irrigation to 100% by the end of 1977 and to enable the electrification ratio of the Cagayan Valley to reach 44% by 1987.

The power demand in the Cagayan Valley to be occupied in the Luzon Grid is as follows:

Maximum Demand in MW

	1978	1982	1987
Luzon Grid	2,134	2,993	4,289
Cagayan Valley	24	39	61
Relation (%)	(1.1)	(1.3)	(1.4)

The Magat River Project located in Isabela Province is envisioned as a multi-purpose project with irrigation and power generation as primary functions. Municipal water supply, fish and recreation are the secondary functions while flood control is an incidental purpose.

If the total construction costs amounting to 1,539 million Pesos of the Magat River Project are allocated to each purpose of the Project, 682 million Pesos of the above figure would be shared by the power sector including construction of the 230 kV transmission lines extending to Santiago Substation.

The Magat River Project Feasibility Report also enumerates the following unit costs of power and energy at the Santiago Substation (See Table 4-10).

Table 4-10 Unit Cost of Power and Energy

Capital investment (10^3US$)			103,000
Annual cost			
Amortization (7%-50 years)		(10^3US$)	7,486
O.M. and replacement		(10^3US$)	423
Taxes and insurance		(10^3US$)	207
Total annual cost		(10^3US$)	8,116
Installed capacity	(MW)		300
Dependable capacity	(MW)		172
Average annual energy	(GWh)		991
Cost per kW	(US$/kW)		47.2
Cost per kWh	(mills/kWh)		8.2

Hydro power plants with a final installed capacity of 910 MW are proposed to be constructed at three sites on the Chico River. Another hydro power project is proposed by NPC. This is the Sandanga Hydro Power Project which will be completed by 1982 and will have an installed capacity of 360 MW. The power cost of this plant is estimated at 12.1 mills per kWh.

CHAPTER V

CAGAYAN TRANSMISSION LINE
AND
SUBSTATION SCHEME

Chapter V Cagayan Transmission Line and Substation Scheme

5-1 Basic Assumption

The proposed transmission line and substation scheme has been formulated under the following assumptions.

(1) Review is made on a "Feasibility Report on the Development of the Cagayan Valley Electrification" prepared by NPC in May 1972.

(2) Design is made on required equipment and facilities which will be sufficiently enough to assure the supply of dependable power for at least 10 years from the beginning of 1978, based upon the forecast on power demand in the Valley presented in this report.

(3) Special and due considerations should be given to the scale of the proposed transmission lines in order to easily cope with power demand in the future even if it should exceed the value of power demand forecasted in the report.

(4) Conformity should be ensured with the proposed power development programs in the Cagayan Valley and long-range power development plans on the Island of Luzon.

(5) Although transmission lines and substations are under the respective ownership of NPC and NEA, planning of these facilities and equipment has been made in disregard of such jurisdiction. The substation facilities include take-off facilities for 13.2 kV lines.

(6) The telecommunication facilities required for operation and maintenance of the transmission and transformation facilities to the minimum extent has been designed.

Special care has been given to the proposed radio apparatuses in order that they can be commonly used by NPC and NEA to prevent double investment.

5-2 Preliminary Design

5-2-1 Preliminary Design of Transmission Lines

(1) Basic Principle of Preliminary Design

In order to promote the effective electrification of the Cagayan Valley, substations are to be provided at 6 places based on the results of a study of the electric power demand in the region, the transmission lines leading to these substations are to be newly constructed from Ambuklao Hydroelectric Power Station located at the northern end of the Luzon Grid.

The transmission line route of this Project taking into consideration the economy, importance, etc. is to be from Ambuklao Hydroelectric Power Station through Solano in Nueva Vizcaya Province to Santiago in Isabela Province where it will branch into two routes. One of these is from Santiago through Tuguegarao in Cagayan Province to reach Camalaniugan and the other is to link to Ilagan through Cauayan in Isabela Province to supply electric power to the Cagayan Valley.

The transmission line from Ambuklao to Tuguegarao is to have a transmission voltage of 230 kV in consideration of interconnection with the existing Luzon Grid, transmission of power from the projected Magat Hydroelectric Power Station, and interconnection in the future with the Chico Hydroelectric Power Complex, together with the Long Term Generation Expansion Program for Luzon Grid.

As for the transmission line, one circuit will be sufficient to meet the power demand of the Cagayan Valley for the time being.

As for Santiago to Cauayan to Ilagan and Tuguegarao to Camalaniugan, it has been determined that the transmission voltage is to be 69 kV and the number of circuit is to be one circuit in consideration of power demands in the areas to be served by the transmission line.

In Fig. 5-1 is given the routes of the transmission lines of

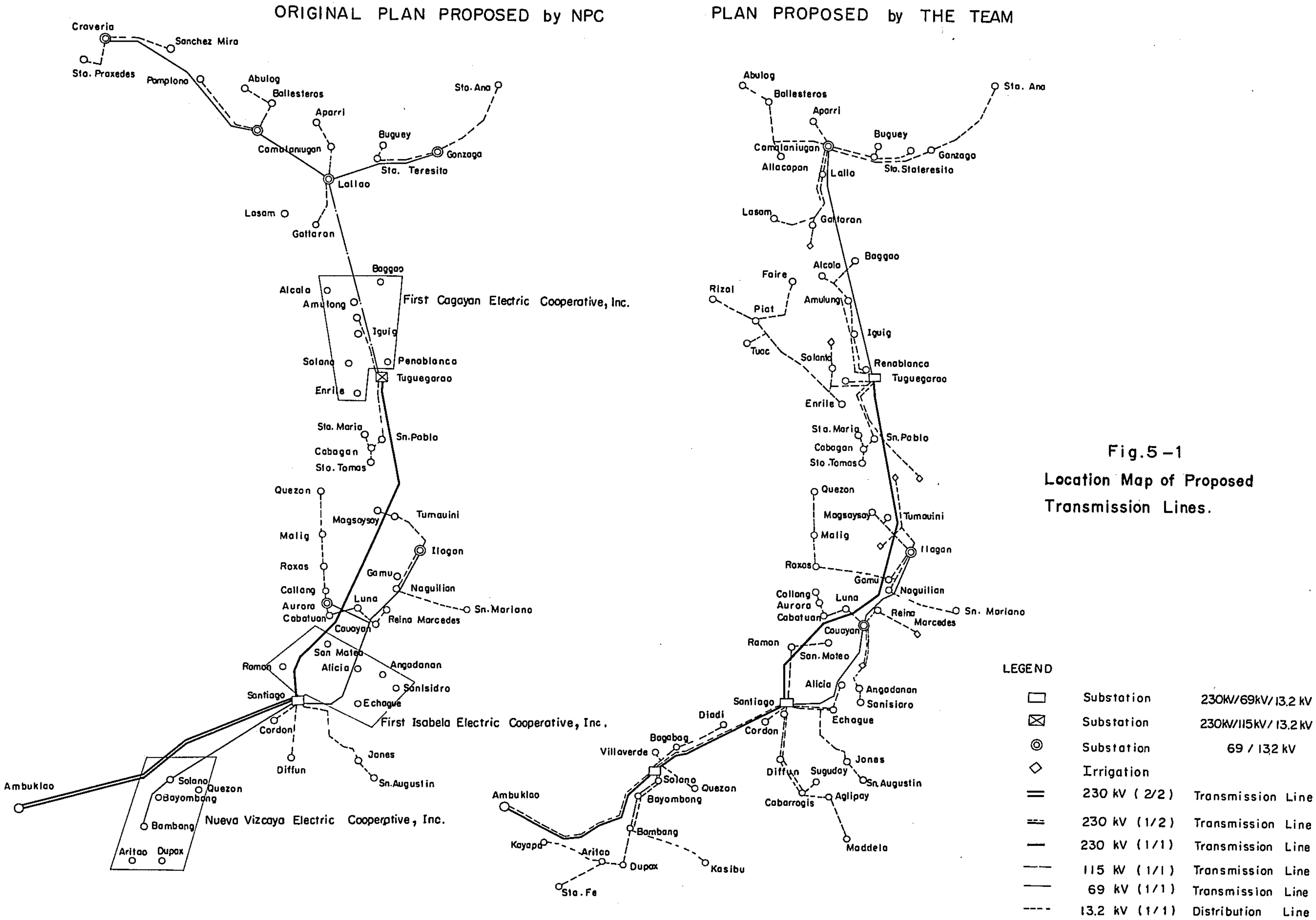
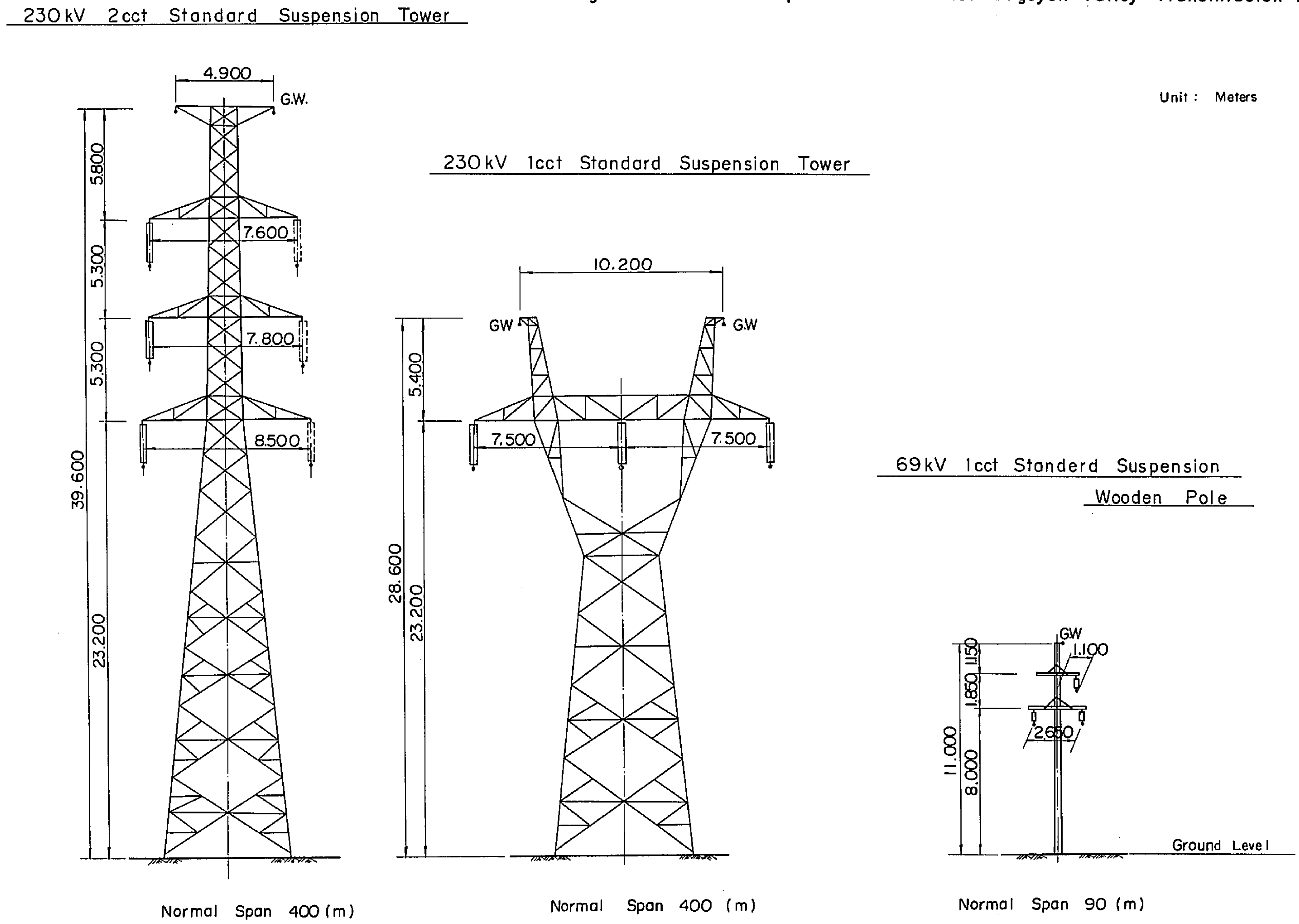


Fig. 5-1
Location Map of Proposed Transmission Lines.

Fig. 5-2 Standard Suspension Tower for Cagayan Valley Transmission Line.



the original plan of NPC and our proposed plan.

A review was made on the design prepared by NPC of the transmission lines, based on the data gathered by the Team during the field investigations and by checking the design criteria and principles adopted by NPC in connection with transmission lines of the same scale as this Project. In conducting the review, special attention has also been given to the minimization of initial investment.

Moreover, in consideration of system reliability in 1981 when Magat Hydroelectric Power Station is to be commissioned, the number of circuits from Magat to Santiago, Santiago to Ambuklao and Ambuklao to Binga is to be two circuits. The section of Ambuklao to Salano to Santiago would have double-circuit steel towers with only one circuit strung initially.

(2) Outline of Preliminary Design

1) Transmission Line Routes

The route between Ambuklao and Solano except for approximately 6 km of rice field in the vicinity of Solano is mainly in mountainous area with rugged undulations at the border between Benguet Province and Nueva Vizcaya Province. Of this route, areas approximately 20 km long on the site of Ambuklao are at elevation higher than 1,000 m, the highest being approximately 1,600 m. In order to facilitate construction and maintenance of this section, NPC has selected a winding route along National Highway No. 9 and this is thought to be unavoidable in view of the surrounding topography:

The 230 kV transmission line route between Solano and Santiago will be over the pass at the border between Nueva vizcaya Province and Isabela Province, but topographically, this is relatively flat and the route has been selected along National Highway No. 5.

In areas north of Santiago, a stretch of hilly areas spread on the east side of the Cagayan River, but areas along the proposed transmission line routes are generally flat. The 230 kV transmission line has been located along National Highway No. 5.

As described above, topographical surveys of the route have already been completed for the 230 kV transmission line and the route is considered to be generally reasonable. Although the 69 kV transmission line routes have not yet been surveyed, it is presumed that there will not be any large restrictions on selection of the routes.

2) Conductors

Conductor size is mainly decided from the current capacity meeting the required transmission capacity and corona disturbance.

In connection with the 230 kV transmission lines, as shown in Appendix A-4, as a result of comparison between conductor size required for the transmission capacity between Santiago and Ambuklao -- where the power will be maximum -- and the size considered proper, based on corona disturbance, it was decided from the standpoint of corona disturbance to use 795 MCM ACSR.

In design of sag and tension, it is necessary to make a study from both conductor stresses during normal times and conductor stresses during typhoons. Here, the study was made with every day stresses of conductor to be not more than 22% of ultimate strength in a condition of air temperature of 15°C and no wind and also the maximum working tension of 4,600 kg at the NPC load condition, viz. at an air temperature of 7.22°C (45°F), wind velocity of 46 m/sec. with an effectiveness factor of 0.6. Also, in order to prevent vibration fatigue of conductors, attachment of vibration damper and armor rods were considered for points of conductor support.

For the 69 kV transmission lines, approximately 336.5 MCM ACSR is suitable in view of power demand. The maximum working tension of conductor is to be 2,300 kg and armor rods are to be attached to conductor support points.

3) Clearances and Insulators

The clearances and insulators of the 230 kV transmission line were considered for maximum system voltage of 242 kV, elevation of less than 1,600 m, and an effectively grounded system. Since it is considered that there will be no salt contamination, the line insulator was decided by switching surge as a principle.

One string of insulators are to be of fourteen 254 mm suspension insulators. Standard insulation clearance is to be 2.05 m and minimum required clearance 0.65 m. There will be 4 insulators per string for 69 kV transmission lines. Standard insulation clearance is 0.65 m and minimum required clearance 0.2 m.

4) Countermeasure for Lightning Flashover

The average number of thunderstorm days per year, according to data from 1961 to 1970, is 45 days at Aparri and 35 days at Tuguegarao. In consideration of the figures it is estimated that there will be approximately 80 lightning strikes annually per 100 km of transmission line length and it is considered essential that overhead ground wires be employed.

Two overhead ground wires are to be strung for 230 kV, double-circuit transmission lines with a shielding angle of less than 10 degrees with upper conductors, and two overhead ground wires are to be strung for the 230 kV, single-circuit transmission lines with conductors arranged horizontally and at a shielding angle of within 20 degrees with the outer conductors in order that about 100% shielding will be possible.

Thus, in estimating the rate of tripouts due to lightning strikes based on the AIEE lightning stroke current probability curve, it is thought it will be between 2 and 3 times annually per 100 km.

For 69 kV transmission lines, one overhead ground wire will be strung to reduce lightning tripouts.

5) Supports

For the 230 kV transmission line, steel towers which are higher in mechanical reliability were selected taking into consideration that the transmission line will pass through mountainous areas and the region is subject to onsets of typhoons. Although angle steel, cross-shaped steel and steel pipe, etc. may be used for steel towers, the study was pursued assuming that only angle steel would be used in view of the sizes of towers for this Project.

As for 69 kV transmission lines, it was decided that wooden poles will be used as supports in order to reduce initial investment.

Shapes and dimensions of standard type supports are shown in Fig. 5-2.

With respect to design wind velocity for supports, since there are no statistical data on the routes of this Project, the study has been made for design wind velocity for supports of the same scale in the Luzon Grid of NPC while the same method was applied to design load conditions.

The design wind velocity and wind pressures are as indicated on the next page.

Wind velocity (gust)	103 mph (= 46 m/sec)
Wind pressure for steel tower	220 (kg/m^2)
Wind pressure for wooden pole	130 (kg/m^2)
Wind pressure for conductor and overhead ground wire	span length under 100 m 130 (kg/m^2)
"	span length 100 to 300 m 91.4 (kg/m^2)
"	span length over 300 m 78.2 (kg/m^2)

(3) Outline of Transmission Line Installation

The outline of transmission line installation for this Project is as indicated below.

1) Ambuklao Hydroelectric Power Station to Solano Substation

Length	:	60 km
Voltage	:	230 kV
Electric supply system	:	3-phase, 3-wire, 60 Hz
Number of circuits	:	1 (2-cct design)
Conductor	:	795 MCM (= 403 mm^2) ACSR
Overhead ground wire	:	3/8" (= 51 mm^2) galvanized steel wire, 2 wires
Insulator	:	254 mm suspension insulator, 14 discs per string
Support	:	double-circuit vertical formation steel tower

2) Solano Substation to Snatiago Substation

Length	:	50 km
Voltage	:	230 kV
Electric supply system	:	3-phase, 3-wire, 60 Hz
Number of circuits	:	1 (2-cct design)
Conductor	:	795 MCM ACSR
Overhead ground wire	:	3/8" galvanized steel wire, 2 wires
Insulator	:	254 mm suspension insulator, 14 discs per string

Support	:	double-circuit vertical formation steel tower

3) Santiago Substation to Tuguegarao Substation

Length	:	120 km
Voltage	:	230 kV
Electric supply system	:	3-phase, 3-wire, 60 Hz
Number of circuits	:	1
Conductor	:	795 MCM ACSR
Overhead ground wire	:	3/8" galvanized steel wire, 2 wires
Insulator	:	254 mm suspension insulator, 14 discs per string
Support	:	single-circuit horizontal formation steel tower

4) Santiago Substation to Cauayan Substation to Ilagan Substation

Length	:	70 km
Voltage	:	69 kV
Electric supply system	:	3-phase, 3-wire, 60 Hz
Number of circuits	:	1
Conductor	:	336.4 MCM (= 170 mm^2) ACSR
Overhead ground wire	:	3/8" galvanized steel wire, 1 wire
Insulator	:	254 mm suspension insulator, 4 discs per string
Support	:	wooden pole

5) Tuguegarao Substation to Camalaniugan Substation

Length	:	70 km
Voltage	:	69 kV
Electric supply system	:	3-phase, 3-wire, 60 Hz
Number of circuits	:	1
Conductor	:	336.4 MCM ACSR
Overhead ground wire	:	3/8" galvanized steel wire, 1 wire

Insulator	:	254 mm suspension insulator, 4 discs per string
Support	:	wooden pole

5-2-2 Substations

(1) Basic Principles of Preliminary Design

As transforming facilities for this Project, substations in 6 locations described below are to be installed, based on the power demand forecast up to 1987 for the Cagayan Valley.

In design of individual transforming facilities, the economy and regional characteristics were taken into account, and necessary studies were conducted on technical aspects such as transition of power demand, system operation, system structure, stability, voltage fluctuation, current analysis, fault calculation, insulation coordination with existing facilities, future expansion space, etc. The outline of the design is as shown in Fig. 5-3.

1) Bus System

a) It is considered essential that in view of the importance of the Santiago Substation, 1 1/2 CB bus system, the same as the original plan of NPC be employed in principle for the said substation. However, a ring bus system should be used for the time being until the time when extension of feeders from Santiago Substation will be made in preparation for the commissioning of the Magat Hydro Power Station in 1981. The system described hereinabove is deemed as most appropriate in respect of the economy, easy maintenance and reliable operation.

b) As for Ambuklao Power Station, the construction of another switchyard is recommended. Extension or modification of the existing bus of this power station was also studied, but due to the narrowness of the land around the existing switchyard and also in view of the importance of this additional switchyard which is to interconnect the existing 230 kV system and Cagayan Valley System as well as future Magat System, it is recommended that a switchyard be built newly and separately in the vicinity of the Power Station. From the view point of system reliability 1 1/2 CB bus system is desirable. From the restriction of available site, however, a single bus system which is the same as the original plan of NPC is considered appropriate.

c) Since the estimated power demand at Solano Substation is considered to be small for several years, a single-circuit-T-branch system is to be adopted in consideration of its economy. Upon realization of double-circuit lines between Ambuklao Power Station and Santiago Substation, a double-circuit-T-branch system is to be employed if transmission line operation is taken into consideration.

2) Specifications of Substation Equipment

Insulation design of main buses in the substations is to be coordinated with the transmission lines. The following basic insulation levels are recommendable for substation equipment.

230 kV	BIL 900 kV
69 kV	BIL 350 kV
13.2 kV	BIL 110 kV

Overvoltages exceeding the above BIL are to be protected by lightning arresters and line entrance gaps. Designing of the equipment and bus against salt contamination is not considered.

a) Transformers

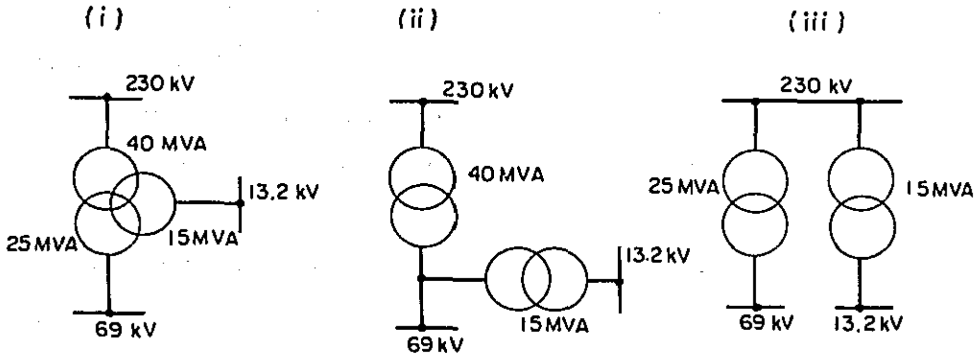
Winding System

To obtain two voltage classes of 69 kV and 13.2 kV from 230 kV primary side, three alternatives are considered.

(i) One transformer with three windings

(ii) Two transformers in cascade-step-down

(iii) Two transformers in parallel, stepping down separately to 69 kV and 13.2 kV.



The study has revealed that two transformers (Alt. (ii)) in cascade-step-down is advantageous, considering various aspects, such as operation adaptability, transformer design, future expansion, arrangement, transport weight, etc.

Further, a two-winding transformer was selected instead of an auto-transformer since the ratio of primary voltage to secondary voltage is large.

Three-Phase Transformer

Recently manufactured transformers have extremely low fault rates so that there will be no necessity to install reserve transformers, and it is recommended to install 3-phase unit which is more economical than 3 single-phase units.

b) Voltage Regulating Equipment

Power flow and voltage regulation study was made for the years 1978, 1982 and 1987, assuming that the load condition in this district is a power factor of 90% during peak hours and that of 95% during off-peak hours and actual load is 30% of that of peak hours during off-peak hours. The recommendation is to install the transformers with on-load tap changers (OLTC) capable of regulating voltage within a range of 10%. Further, it is recommended that 15 MVA shunt reactors be connected with 69 kV buses at both Santiago Substation and Tuguegarao Substation, to suppress voltage rise of 230 kV system. This voltage rise would occur during several years after the initial operation of this system, especially in the off-peak time at night.

c) Circuit Breaker

The system configuration in 1987 has been determined on the basis of the results of the load forecast and by reference to an impedance map made available to the Team by NPC. Then fault calculations were made in respect of the respective locations of 230 kV, 69 kV and 13.2 kV buses to be installed at each substation. According to the results of such studies, the interrupting capacity of the circuit has been determined.

3) Land Required

Necessary land area for the substations is as shown in Fig. A-3-7 through A-3-11. This area is spacious enough to install all equipment given in the single-line diagram in Fig. A-3-1 through Fig. A-3-6. The said diagram was drawn in consideration of system configuration up to 1987 and possible future extension of related facilities. At the same time, easy maintenance and smooth extension work were also considered.

(2) Outline of Preliminary Design

1) Substation Equipment for 230 kV Circuit

a) Since the existing Ambuklao Hydroelectric Power Station (75 MW) will be the take-off point to the transmission system of this Project, take-off equipment for the 230 kV transmission line is to be provided.

b) Regarding Solano Substation, a direct 230 kV transmission line from Ambuklao Power Plant, extending to Santiago Substation is favorable in comparision with the 69 kV transmission lines from Santiago Substation to Solano Substation stated in the original plan of NPC. Therefore, the primary side voltage of Solano Substation is to be 230 kV.

c) It is recommended that 230 kV substation be built at Santiago, as stated in the original plan of NPC, in order that electric power can be supplied for irrigation and for rural electrification in Santiago and its adjacent places. The transmission line to Cauayan Substation and Ilagan Substation is also to be connected with the 69 kV bus of this substation.

This substation will be of the greatest importance because it will be interconnected with the Magat Hydro Power Station which is scheduled to be commissioned in 1981 according to the original plan of NPC.

d) Tuguegarao Substation is to be provided for power transmission to Tuguegarao, the center of Cagayan Province, as well as to the Aparri area in the northern part of Cagayan Province. 230 kV is recommended for the primary side voltage of this substation based on the results of the technical study on transmission capacity and system reliability. Also, there is a proposed plan for the introduction of power from the Chico River (Ultimate Generating Capacity; 910 MW) through EHV transmission line into the Tuguegarao area.

Interconnection to this EHV system will be made possible from this substation.

2) 69 kV Substations

In addition to the above-stated study on 230 kV transmission lines and substations, it is recommended that three 69 kV substations be constructed at Cauayan, Ilagan and Camalaniugan. These substations are to satisfy demands up to 1987 in the three provinces of Cagayan, Isabela and Nueva Vizcaya. In Fig. 5-1 there is a comparison between this recommendation and the original plan by NPC.

3) Protection System

Refer to Appendix A-5.

4) Outline of Preliminary Design for Substations

a) Ambuklao Switchyard (Extension for Transmission Line Take-off)

i) Initial

230 kV Transmission line take-off equipment	2 ccts
Circuit breaker, 245 kV, 5.0 GVA	2 units
Disconnecting switch, 245 kV	4 units
230 kV Main transformer bus equipment	1 set
Circuit breaker 245 kV, 5.0 GVA	1 unit
Disconnecting switch, 245 kV	1 unit

ii) Extension at the Stage of Connection of Magat Project

(Future Plan)

230 kV Transmission line take-off equipment	2 ccts
Circuit breaker, 245 kV, 5.0 GVA	2 units
Disconnecting switch, 245 kV	4 units

b) Solano Substation

i) Initial

230 kV Transmission line take-in equipment	1 cct
Circuit breaker, 245 kV, 5.0 GVA	1 unit
Disconnecting switch, 245 kV	1 unit
230/13.2 kV Main transformer, 15MVA, 3-phase, 2-winding with OLTC±10% and stabilizing winding	1 unit
13.2 kV Distribution line take-off equipment	3 ccts
Circuit breaker, 15.5 kV, 250 MVA	3 units
Disconnecting switch, 15.5 kV	6 units
13.2 kV Station service equipment	1 set
Circuit breaker, 15.5 kV, 250 MVA	1 unit
Disconnecting switch, 15.5 kV	1 unit

ii) Extension at the Stage of Connection of Magat Project

(Future Plan)

230 kV Transmission line take-in equipment	1 cct
Circuit breaker, 245 kV, 5.0 GVA	1 unit
Disconnecting switch, 245 kV	3 units

c) Santiago Substation

i) Initial

230 kV Transmission line take-off equipment	2 ccts
Circuit breaker, 245 kV, 5.0 GVA	3 units
Disconnecting switch, 245 kV	6 units
230/69kV Mine transformer 40MVA, 3-phase, 2-winding with OLTC±10% and stabilizing winding	1 unit
69 kV Transmission line take-off equipment	1 cct
Circuit breaker, 72.5 kV, 1.0 GVA	1 unit
Disconnecting switch, 72.5 kV	2 units

69 kV Shunt reactor equipment	1 unit
Shunt reactor, 69 kV, 15 MVA	1 unit
Circuit breaker, 72.5 kV, 1.0 GVA	1 unit
Disconnecting switch 72.5 kV	1 unit
69 kV Main transformer bus equipment	1 set
69/13.2 kV Main transformer, 15 MVA, 3-phase, 2-winding with stabilizing winding	1 unit
Circuit breaker, 72.5 kV, 1.0 GVA	1 unit
Disconnecting switch, 72.5 kV	1 unit
13.2 kV Distribution line take-in equipment	4 ccts
Circuit breaker, 15.5 kV, 250 MVA	4 units
Disconnecting switch, 15.5 kV	8 units
13.2 kV Station service equipment	1 set
Circuit breaker, 15.5 kV, 250 MVA	1 unit
Disconnecting switch, 15.5 kV	1 unit

ii) Extension at the Stage of Connection of Magat Project

(Future Plan)

230 kV Transmission line take-off equipment	3 ccts
Circuit breaker, 245 kV, 5.0 GVA	6 units
Disconnecting switch, 245 kV	12 units

d) Tuguegarao Substation

230 kV Transmission line take-in equipment	1 cct
Circuit breaker, 245 kV, 5.0 GVA	1 unit
Disconnecting switch, 245 kV	1 unit
230/69 kV Main transformer, 40 MVA, 3-phase, 2-winding with OLTC±10% and stabilizing winding	1 unit
69 kV Transmission line take-off equipment	1 cct
Circuit breaker, 72.5 kV, 1.0 GVA	1 unit
Disconnecting switch, 72.5 kV	2 units

69 kV Shunt reactor equipment	1 unit
Shunt reactor, 69 kV, 15 MVA	1 unit
Circuit breaker, 72.5 kV, 1.0 GVA	1 unit
Disconnecting switch, 72.5 kV	1 unit
69 kV Main transformer bus equipment	1 set
69/13.2 kV main transformer,	1 unit
15 MVA, 3-phase, 2-winding with stabilizing winding	
Circuit breaker, 72.5 kV, 1.0 GVA	1 unit
Disconnecting switch, 72.5 kV	1 unit
13.2 kV Distribution line take-off equipment	4 ccts
Circuit breaker, 15.5 kV, 250 MVA	4 units
Disconnecting switch, 15.5 kV	8 units
13.2 kV Station service equipment	1 set
Circuit breaker, 15.5 kV, 250 MVA	1 unit
Disconnecting switch, 15.5 kV	1 unit

e) Cauayan Substation

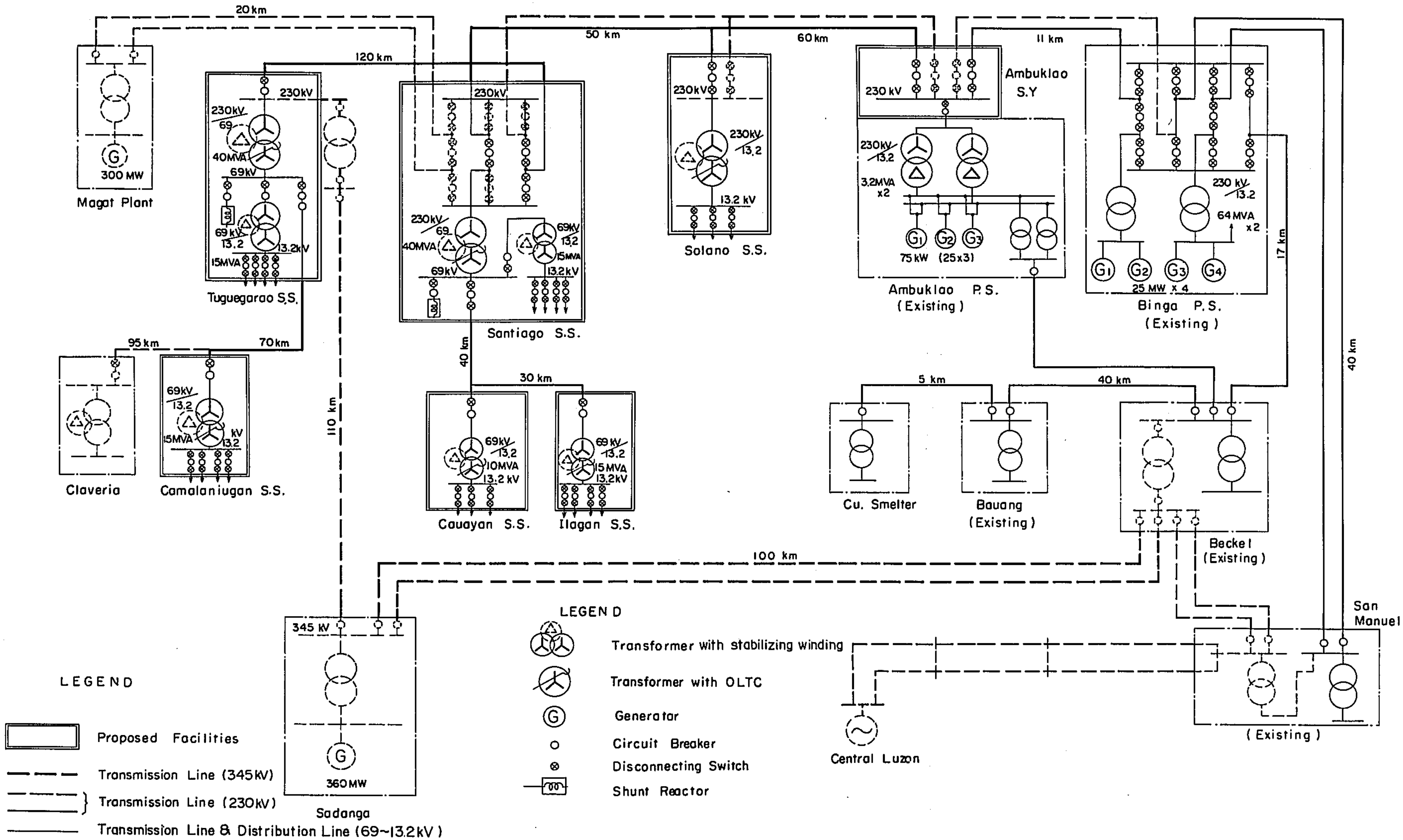
69 kV Transmission line take-in equipment	1 cct
Circuit breaker, 72.5 kV, 1.0 GVA	1 unit
Disconnecting switch, 72.5 kV	1 unit
69/13.2 kV Main transformer, 10 MVA, 3phase, 2-winding with OLTC±10% and stabilizing winding	1 unit
13.2 kV Distribution line take-off equipment	3 ccts
Circuit breaker, 15.5 kV, 250 MVA	3 units
Disconnecting switch, 15.5 kV	6 units
13.2 kV Station service equipment	1 set
Circuit breaker, 15.5 kV, 250 MVA	1 unit
Disconnecting switch, 15.5 kV	1 unit

f) Ilagan and Camalaniugan Substations

69 kV Transmission line take-in equipment	1 cct each

Circuit breaker, 72.5 kV, 1.0 GVA	1 unit each
Disconnecting switch, 72.5 kV	1 unit each
69/13.2 kV Main transformer	1 unit each
15 MVA, 3-phase, 2-winding with OLTC±10% and stabilizing winding	
13.2 kV Distribution line take-off equipment	4 ccts each
Circuit breaker, 15.5 kV, 250 MVA	4 unit each
Disconnecting switch, 15.5 kV	8 units each
13.2 kV Station service equipment	1 set each
Circuit breaker, 15.5 kV, 250 MVA	1 unit each
Disconnecting switch, 15.5 kV	1 unit each

Fig.5-3 Layout of Cagayan Valley Transmission Network



5-2-3 Preliminary Design of Telecommunication Facilities

(1) Basic Principles of Preliminary Design

The tele-communication channels presented in the report have been designed under the principles outlined below for minimum necessary for operation and maintenance, based on the preliminary design of the proposed transmission line and substation scheme and distribution line scheme.

1) Telephone Channels for Load Dispatching

Dialing telephone channels for load dispatching between power stations are to be provided by power line carrier. Further, relay groups possessing exchange functions are to be provided at these stations with 5 extension lines at each station, but load dispatching telephones are to be given highest priority.

2) VHF Channels for Line Maintenance

Communication will be made between places along the routes of the transmission and distribution lines and offices of line maintenance. The proposed VHF stations are to be installed at the respective substations without providing relay stations.

3) Power Line Carrier Relay, Fault Locator, Telemeter

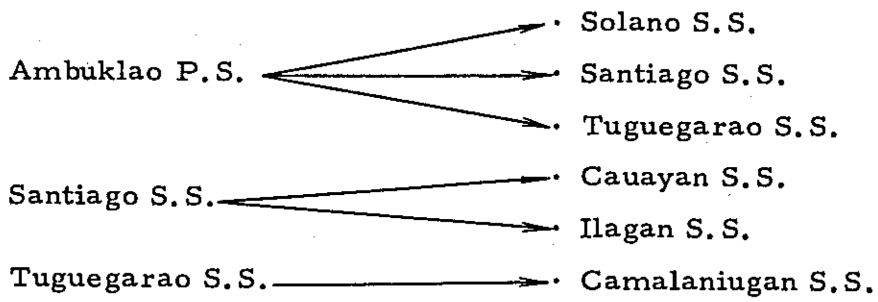
In consideration of the importance of an electric power facility, these facilities will be provided only between 230 kV system power stations.

(2) Outline of Preliminary Design

Telecommunication channels required for load dispatching, and security and maintenance of transmission lines are to be composed as described below.

1) Load Dispatching Telephone Channels

Considering that load dispatching is to be performed as follows at Ambuklao Power Station, Santiago Substation and Tuguegarao Substation, respectively, load dispatching telephone channels are to be provided for each section using power line carrier equipment.



The outline of the power line carrier telephone channels is as given below.

Ambuklao P.S. to Santiago S.S.	3 ch, 1 system
Santiago S.S. to Tuguegarao S.S.	3 ch, 1 system
Ambuklao P.S. to Solano S.S.	2 ch, 1 system
Solano S.S. to Santiago S.S.	1 ch, 1 system
Tuguegarao S.S. to Camalaniugan S.S.	1 ch, 1 system
Santiago S.S. to Cauayan S.S. to Ilagan S.S.	1 ch, (3 terminals), 1 system

Further, relay groups possessing exchange functions are to be provided at these stations, and it will be possible to connect 5 extension lines at each station.

2) Power Line Carrier Relay

Power line carrier relays of triple-terminal type are to be provided for Ambuklao Power Station to Solano Substation to Santiago Substation.

3) Fault Locator

In order to facilitate speedy clearance of transmission line faults, fault surge receiving-type fault locator equipment is to be provided at Ambuklao Power Station and Santiago Substation for Ambuklao Power Station to Solano Substation to Santiago Substation,and a pulse radar type fault locator equipment is to be installed at Santiago Substation for Santiago Substation to Tuguegarao Substation.

4) Telemeter

It is to be made possible for telemetering of transmission speed of 200 bauds and 4 elements to be performed at Ambuklao Power Station to Santiago Substation and Santiago Substation to Tuguegarao Substation.

5) VHF Channels for Power Transmission Line Maintenance

In order to make it possible to communicate between the various stations and line maintenance personnel along the transmission lines, VHF base stations are to be provided at 7 places and line maintenance VHF channels are to be structured between these base stations and mobile VHF equipment (6 units) and portable VHF equipment (12 units).

6) VHF Channel for Power Distribution Line Maintenance

Mobile VHF equipment (24 units) and portable VHF equipment (6 units) for distribution line maintenance, and portable VHF equipment (12 units) for customer fault repair are to be assigned. Base stations will be in common with those for the proposed transmission lines and these will constitute line maintenance channels along with the above-mentioned equipment.

(3) Outline of Facilities

The outline of the telecommunication facilities for this scheme is as shown in Table 5-1 and Fig. A-3-12 to Fig. A-3-14 in Appendix A-3.

Table 5-1 Tele-communication Facilities for Transmission and Distribution Lines

Items		Power station & substations							Total
		Ambuklao P.S.	Solano S.S.	Santiago S.S.	Tuguegarao S.S.	Camalaniugan S.S.	Cauayan S.S.	Ilagan S.S.	
1. Telecommunication Facilities for Transmission Lines									
Power line carrier equipment	(3ch, 35 dBm, with TM)	1		2	1				4
Power line carrier equipment	(2ch, 35 dBm)	1	1						2
Power line carrier equipment	(1ch, 35 dBm)		1	2	1	1	1	1	7
Power line carrier coupling equipment	(230 kV)	1	1	2	1				5
Power line carrier coupling equipment	(69 kV)			1	1	1	1	1	5
Carrier relay equipment	(power line carrier type)	1	1	1					3
Fault locator equipment	(fault surge receiving type) (pulse radar type)	1		2					3
VHF base radio equipment	(Height of antenna tower 50 m)	1	1	1	1	1	1	1	7
VHF mobile radio equipment	(output 10 W)	1	1	2	1	1			6
VHF portable radio equipment	(output IW)	2	2	2	2	2	1	1	12
Power unit for tele-communication	(DC 24 V)	1	1	1	1	1	1	1	7
2. Tele-communication Facilities for Distribution Lines									
VHF mobile radio equipment	(output 10 W)		4	4	4	4	4	4	24
VHF portable radio equipment	(output 1W)		3	3	3	3	3	3	18

5-2-4 Comparison between Plan prepared by NPC and that proposed by the Team

Comparison between the Plan incorporated in the "Feasibility Report on the Development of the Cagayan Valley Electrification" prepared by NPC and that proposed by the Team based on the field studies conducted in March 1974 has been made (See Fig. 5-1). The particulars of the comparative studies are shown hereunder.

(1) Transmission Lines

Plan by NPC	Plan by the Team
Ambuklao to Santiago 230 kV, (2/2), 795 MCM ACSR Steel Tower, 115 km	Ambuklao to Solano 230 kV, (1/2), 795 MCM ACSR Steel Tower, 60 km
——	Solano to Santiago 230 kV, (1/2), 795 MCM ACSR Steel Tower, 50 km
Santiago to Tuguegarao 230 kV, (1/1), 795 MCM ACSR Steel Tower, 120 km	Santiago to Tuguegarao 230 kV, (1/1), 795 MCM ACSR Steel Tower, 120 km
Tuguegarao to Lallo 115 kV, (1/1), 336.4 MCM ACSR Wooden Pole, 67 km	Tuguegarao to Camalaniugan 69 kV, (1/1), 336.4 MCM ACSR Wooden Pole, 70 km
Santiago to Bambang 69 kV, (1/1), 336.4 MCM ACSR Wooden Pole, 63 km	——
Santiago to Ilagan 69 kV, (1/1), 336.4 MCM ACSR Wooden Pole, 70 km	Santiago to Cauayan to Ilagan 69 kV, (1/1), 336.4 MCM ACSR Wooden Pole, 70 km
R. Mercedes to Aurora 69 kV, (1/1), 336.4 MCM ACSR Wooden Pole, 17 km	——

Tuguegarao to Amulong 69 kV, (1/1), 336.4 MCM ACSR Wooden Pole, 25 km	—
Lallo to Claveria 69 kV, (1/1), 336.4 MCM ACSR Wooden Pole, 87 km	—
Lallo to Gonzaga 69 kV, (1/1), 336.4 MCM ACSR Wooden Pole, 34 km	—

Total Length of Transmission Line

230 kV (2/2)	115 km	230 kV (1/2)	110 km
230 kV (1/1)	120 km	230 kV (1/1)	120 km
115 kV (1/1)	67 km		
69 kV (1/1)	269 km	69 kV (1/1)	140 km

(2) Substations

Plan by NPC	Plan by the Team
Ambuklao 230 kV, 2 cct. take-off	Ambuklao 230 kV, 1 cct. take-off Solano 230/13.2 kV, 15 MVA
Santiago 230/69 kV, 50 MVA 67/13.8 kV, 5 MVA	Santiago 230/69 kV, 40 MVA 69/13.2 kV, 15 MVA
Tuguegarao 230/115 kV, 55 MVA 110/69 kV, 15 MVA 110/13.8 kV, 10 MVA	Tuguegarao 230/69 kV, 40 MVA 69/13.2 kV, 15 MVA
Lallo 110/69 kV, 30 MVA 67/13.8 kV, 10 MVA	Camalaniugan 69/13.2 kV, 15 MVA

Ilagan	Ilagan
67/13.8 kV, 10 MVA	69/13.2 kV, 15 MVA
Aurora	Cauagan
67/13.8 kV, 5 MVA	69/13.2 kV, 10 MVA
Claveria	—
67/13.8 kV, 10 MVA	
Ballesteros	—
67/13.8 kV, 5 MVA	
Gonzaga	—
67/13.8 kV, 5 MVA	

(3) Installed Capacity of Transformers

Plan by NPC		Plan by the Team
230/115 kV	55 MVA	0 MVA
230/69 kV	50 MVA	80 MVA
230/13.8 kV	0 MVA	15 MVA
115/69 kV	45 MVA	0 MVA
115/13.8 kV	10 MVA	0 MVA
69/13.8 kV	50 MVA	70 MVA
Total	210 MVA	165 MVA

5-3 Construction Cost

The construction cost of the Project was based on the preliminary design presented in 5-2 and is expressed in portions of foreign and domestic currencies, respectively. The cost cited in the foreign currency portion has been obtained, allowing escallation of prices of equipment, accessories and materials to be imported from Japan for the Project at 5% for a period of one year from April of this year through March 1975, based on the prices of the said goods available as of April 1974. Necessary calculations are made at the conversion rate of US$1 = ¥300.

As for estimate of costs belonging to the domestic currency portion, considerations are given to the present situation of commodity prices observed during the stay of the Team in the Philippines and by reference to the construction cost of 230 kV transmission lines employed in the "Plans and Specifications for Furnishing and Erecting (Turn-key

Basis, Except for the Supply of Some Specified Materials for Schedule II) Complete the 230 kV, 3-Phase, Transmission Lines under Four (4) Schedules of the Luzon Electrification Project, Luzon, Philippines" on which a contract was concluded between NPC and the contractor in March 1974 and other necessary information.

5-3-1 Scope of Construction Work

(1) Transmission Lines

1) Ambuklao to Solano
   60 km, 230 kV, one circuit strung on double circuit tower
2) Solano to Santiago
   50 km, 230 kV, one circuit strung on double circuit tower
3) Santiago to Tuguegarao
   120 km, 230 kV, one circuit tower
4) Santiago to Cauayan to Ilagan
   70 km, 69 kV, one circuit wooden pole
5) Tuguegarao to Camalaniugan
   70 km, 69 kV, one circuit wooden pole

(2) Substations

1) Ambuklao Hydro Power Plant
   Take-off facilities for 230 kV line and other facilities
2) Solano Substation
   Transformer (15 MVA, 230/13.2 kV), take-off facilities for 230 kV and 13.2 kV lines and other facilities
3) Santiago Substation
   Transformers (40 MVA, 230/69 kV and 15 MVA, 69/13.2 kV), take-off facilities for 230 kV, 69 kV and 13.2 kV lines and other facilities
4) Cauayan Substation
   Transformer (10 MVA, 69/13.2 kV), take-off facilities for 69 kV and 13.2 kV lines and other facilities

5) Ilagan Substation

Transformer (15 MVA, 69/13.2 kV), take-off facilities for 69 kV and 13.2 kV lines and other facilities

6) Tuguegarao Substation

Transformers (40 MVA, 230/69 kV and 15 MVA, 69/13.2 kV), take-off facilities for 230 kV, 69 kV and 13.2 kV lines and other facilities

7) Camalaniugan Substation

Transformer (15 MVA, 69/13.2 kV), take-off facilities for 69 kV and 13.2 kV lines and other facilities

Note)

a) The cost of substation equipment at Santiago Substation to receive power from Magat Hydro Power Plant is not included.

b) The cost of dormitories and houses for operation and maintenance personnel is not included.

(3) Tele-Communication Facilities

Power Line Carrier Equipment	1 set
VHF Tele-Communication Equipment	1 set

(4) Automobiles as well as Equipment and Tools for Operation and Maintenance

Automobiles	27 cars
Equipment and Tools	1 set

5-3-2 Costs by Currency Portions

(1) Foreign Currency Portion

1) The following major equipment, accessories, and materials listed in this portion are to be imported from Japan.

Towers, conductors and cables, insulators, main transformers, breakers, tele-communication equipment, transformers for distribution, breakers for distribution, switches, self-voltage regulators, etc.

2) The marine transportation cost of these equipment, accessories and materials between Japan and the Philippines is taken into consideration. However, such cost does not include import duties and other charges to be normaly levied upon the abovementioned goods which are to be imported from Japan.

(2) Domestic Currency Portion

1) Domestic products such as cement, reinforcing steel, etc. to be used for construction works.

2) The installation cost of substation equipment and erection and stringing of transmission lines, including control and miscellaneous buildings.

3) Cost for procurement of land and right-of-way construction cost.

4) Inland transportation cost of equipment, accessories and materials.

5-3-3 Division of Construction Cost

The construction cost is divided into three categories; that for transmission lines, substations and related tele-communication facilities.

In computing the construction cost, the first step was to calculate direct cost and then 10% of the direct cost as contingencies, 7% and 5% of the direct cost have been calculated as administration cost and engineering fee, respectively. Interest during construction equals to 13% for the foreign currency portion and 10% for domestic currency portion of the total field cost. Thus the total estimated construction cost is US$28, 079, 000 (See Table 5-2). The breakdown of the direct cost of the transmission lines, substations and related tele-communication facilities is as shown in Table 5-3 to Table 5-6.

Table 5-2 Total Construction Cost of Cagayan Valley Electrification Program at 13.2 kV Take-off Facility End

(In Thousand U.S. Dollars)

	Items	F.C.	D.C.	Total
A	Substation	5,868	802	6,670
B	Transmission line	7,681	5,368	13,049
C	Telecommunication	638	33	671
D	Total direct cost (A + B + C)	14,187	6,203	20,390
E	Plus 10% contingencies	1,419	620	2,039
F	Sub-total (D + E)	15,606	6,823	22,429
G	Administration cost (D x 0.07)	0	1,427	1,427
H	Engineering fee (D x 0.05)	1,020	0	1,020
I	Sub-total (F + G + H)	16,626	8,250	24,876
J	Service facilities	178	14	192
K	Total field cost (I + J)	16,804	8,264	25,068
L	Interest during construction	2,185	826	3,011
	Total construction cost (K + L)	18,989	9,090	28,079

Table 5-3 Direct Construction Cost of Transmission Line

(In Thousand U.S. Dollars)

Voltage (kV)		Length (km)	Unit Cost F.C.	Unit Cost D.C.	Total Direct Cost F.C.	Total Direct Cost D.C.
230	Ambuklao to Solano	60	33.1	27.7	1,986	1,662
230	Solano to Santiago	50	32.3	19.8	1,615	990
230	Santiago to Tuguegarao	120	25.6	15.4	3,072	1,848
69	Santiago to Ilagan	70	7.2	6.2	504	434
69	Tuguegarao to Camalaniugan	70	7.2	6.2	504	434
	Total				7,681	5,368

Table 5-4 Direct Construction Cost of Substations

(In Thousand U.S. Dollars)

Substations	F.C.	D.C.	Total
Ambuklao	651	89	740
Solano	665	91	756
	(90)	(12)	(102)
Santiago	1,922	262	2,184
	(298)	(41)	(339)
Cauayan	376	51	427
	(376)	(51)	(427)
Ilagan	421	58	479
	(421)	(58)	(479)
Tuguegarao	1,412	193	1,605
	(298)	(41)	(339)
Camalaniugan	421	58	479
	(421)	(58)	(479)
Total	5,868	802	6,670
	(1,904)	(261)	(2,165)

Note: Figures in parenthesis are the construction cost to be borne by NEA, which are included in the total cost.

Table 5-5 Direct Construction Cost of Telecommunication Facilities

(In Thousand U.S. Dollars)

Items	F.C.	D.C.	Total
A. NPC			
a. Telephone Channels for Load Dispatching	128	7	135
b. VHF Channels for Line Maintenance	97	5	102
c. Other Facilities	113	6	119
d. Common Facilities	197	10	207
Sub-total	535	28	563
B. NEA			
a. Telephone Channels for Load Dispaching	37	2	39
b. VHF Channels for Line Maintenance	0	0	0
	(66)	(3)	(69)
c. Other Facilities	0	0	0
d. Common Facilities	66	3	69
Sub-total	103	5	108
	(66)	(3)	(69)
Total	638	33	671
	(66)	(3)	(69)

Note: Figures in parenthesis are included in the cost of distribution equipment and materials.

Table 5-6 Service Facilities for Transmission Lines and Substations.

(In U.S. Dollar)

Items	F.C.	D.C.
1. Construction Works		
a. Transmission Lines		
Jeep: 10 ea.		
@ F.C. 4,000 D.C. 200	40,000	2,000
b. Right of Way		
Jeep: 8 ea.		
@ F.C. 4,000 D.C. 200	32,000	1,600
c. Substations		
Jeep: 3 ea.		
@ F.C. 4,000 D.C. 200	12,000	600
2. Maintenance Works		
Utility Truck: 3 ea.		
@ F.C. 15,000 D.C. 500	45,000	1,500
Jeep: 3 ea.		
@ F.C. 4,000 D.C. 200	12,000	600
Maintenance Equipment	37,000	7,700
Total	178,000	14,000

5-3-4 Unit Construction Cost

In estimating the construction cost of the transmission lines, the first step is to calculate construction costs for the respective transmission voltages and number of circuits as shown in Table 5-7 and the value tabulated in this manner is to be multiplied by the total length of the transmission lines which has been made available as a result of preliminary design in order to obtain the total cost.

The cost of major equipment, accessories and materials including steel towers, conductors and insulators is listed in the foreign currency portion because they are to be imported from Japan. Locally available products such as cement and reinforcing steel bars, including installation costs are included in the domestic portion.

Table 5-7 Unit Construction Cost of Transmission Lines per km

(In U.S. Dollar)

Section	230 kV (1/2) Ambuklao to Solano		230 kV (1/2) Solano to Santiago		230 kV (1/1) Santiago to Tuguegarao	
	F.C.	D.C.	F.C.	D.C.	F.C.	D.C.
Steel Tower	21,400		21,400		14,950	
Insulators, Hardwares, Accessories and Tower Dressings	3,550		2,750		2,500	
Conductor and OHGW	7,350		7,350		7,350	
Tools and Equipment (Vibration Dampers)	800		800		800	
Tower Foundations		14,450		10,200		6,800
Erection of Towers		3,500		2,500		1,650
Stringing of Conductors and OHGW		2,950		2,200		2,050
Survey and Right-of-Way		6,800		4,900		4,900
Total	33,100	27,700	32,300	19,800	25,600	15,400

Items	69 kV (1/1)	
	F.C.	D.C.
Wooden Poles, Cross Arms, Bolts and Hardware, Guy Wires and Accessories	1,750	2,050
Conductors and OHGW	3,400	
Insulators, Hardwares and Accessories	2,050	
Erection of Poles and Cross Arms		1,200
Installing of Guy Wires		150
Stringing of Conductors and OHGW		1,300
Survey and Right-of-Way		1,500
Total	7,200	6,200

5-4 Construction Schedule

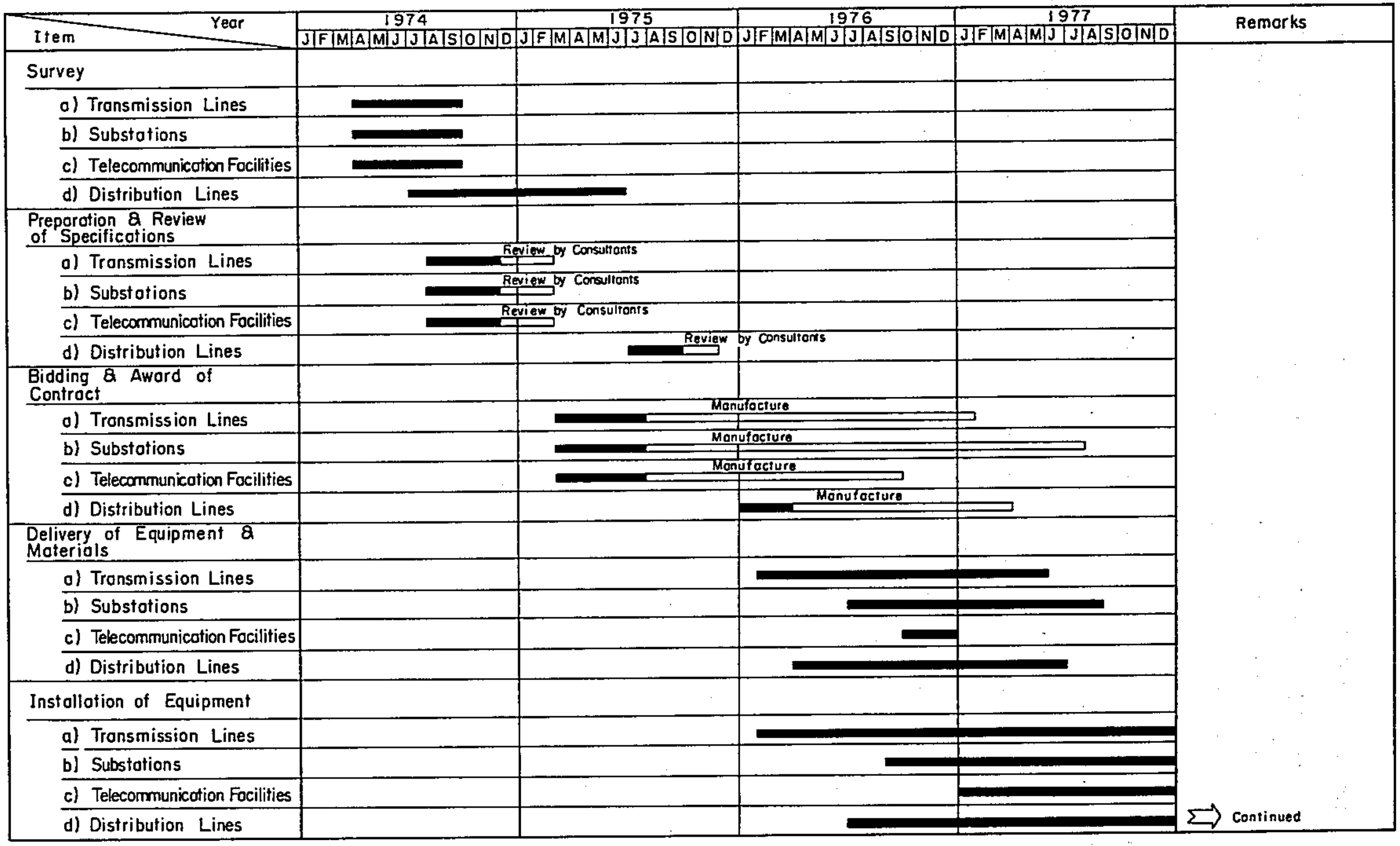
In view of the urgent necessity of the Project, the construction schedule has been prepared on the assumption that the transmission lines, substations and related telecommunication systems are to be completed by the end of 1977 in order to enable them to be commissioned at the beginning of 1978. For this purpose, it is essential that distribution lines about 520 km long for power supply to irrigation projects and major towns and municipalities stated in Chapter VI be also constructed by late 1977 corresponding to the progress of construction of the above transmission lines and transformation facilities.

The required construction period of transmission lines is considered to be about two years on the assumption that fully-qualified and experienced personnel are to be engaged in construction of transmission lines, especially 230 kV lines. In scheduling construction of substations and related telecommunication facilities, due consideration has also been paid to various requirements (See Fig. 5-4).

It is essential that detail designs and specifications for bidding be prepared and award of construction contracts be made as soon as possible.

As for the survey which constitutes a basis for various works, ground surveying concerning 69 kV lines is assumed to be finished within the designated time given in the Construction Schedule.

Fig. 5-4 Construction Schedule



5-5 Annual Expenditure Requirements

As given in 5-3, the total field cost of the transmission line and substation scheme will amount to US$25,068,000 compring US$16,804,000 and US$8,264,000 in the foreign and domestic portions, respectively. Annual expenses to be incurred in each fiscal year of the Philippines in accordance with the Construction Schedule stated in 5-4 of this Chapter are as shown in Table 5-8.

Table 5-8 Annual Expenditure Requirements for Transmission Line and Substation Scheme

(In Thousand U.S. Dallars)

	Description	Total			1974			1975			1976			1977		
		F.C.	D.C.	Total	F.C.	D.C.	Total	F.C.	D.C.	Total	F.C.	D.C.	Total	F.C.	D.C.	Total
A	Substations	5,868.0	802.0	6,670.0	-	-	-	1,173.6	216.1	1,389.7	4,107.6	433.9	4,541.5	586.8	152.0	738.8
B	Transmission Line	7,681.0	5,368.0	13,049.0	-	1,160.0	1,160.0	1,743.0	586.0	2,329.0	4,558.0	2,648.0	7,206.0	1,380.0	974.0	2,354.0
C	Telecommunication Facilities	638.0	33.0	671.0	-	-	-	128.0	0	128.0	318.0	15.0	333.0	192.0	18.0	210.0
D	Total Direct Cost	14,187.0	6,203.0	20,390.0	-	1,160.0	1,160.0	3,044.6	802.1	3,846.7	8,983.6	3,096.9	12,080.5	2,158.8	1,144.0	3,302.8
E	Contingencies	1,419.0	620.0	2,039.0	-	116.0	116.0	304.5	80.2	384.7	898.4	309.7	1,208.1	215.8	114.4	330.2
F	Sub-total	15,606.0	6,823.0	22,429.0	-	1,276.0	1,276.0	3,349.1	882.3	4,231.4	9,882.0	3,406.6	13,288.6	2,374.6	1,258.4	3,633.0
G	Administration Cost	0	1,427.0	1,427.0	-	81.1	81.1	-	269.2	269.2	-	845.5	845.5	-	231.2	231.2
H	Engineering Fee	1,020.0	0	1,020.0	58.0	-	58.0	192.5	-	192.5	604.2	-	604.2	165.3	-	165.3
I	Sub-total	16,626.0	8,250.0	24,876.0	58.0	1,357.1	1,415.1	3,541.6	1,151.5	4,693.1	10,486.2	4,252.1	14,738.3	2,539.9	1,489.6	4,029.5
J	Service Facilities	178.0	14.0	192.0	84.0	4.2	88.2	-	-	-	-	-	-	94.0	9.8	103.8
	Total Field Cost	16,804.0	8,264.0	25,068.0	142.0	1,361.3	1,503.3	3,541.6	1,151.5	4,693.1	10,486.2	4,252.1	14,738.3	2,633.9	1,499.4	4,133.3

Note: The total field cost shown above does not include interest during construction.

5-6 Economic Justification

5-6-1 Appraisal in Comparison with Alternative Diesel Plants

As the first step to conduct economic analysis of the Project, comparisons were made between annual monetary costs required to pursue the objectives and aims of the Project, and estimated annual costs (regarded as "benefits") to be accrued from installation of alterne-tive diesel power plants which would be made necessary if there were not these transmission lines and substations for a serviceable life of the Project. Then, conversionof the above-mentioned annual costs and benefits into their present value was carried out in order to obtain a benefit/cost ratio.

The serviceable life of the transmission lines and substation facilities, their annual interest rates and annual cost ratios by facilities against total construction cost are as shown in Table 5-9.

(1) Cost

1) The annual energy requirement covering the 10 years from 1978 through 1987 is given in Chapter IV. Power supply is assumed to be made from NPC-owned Bataan Thermal Power Plant during the period from 1978 to 1980 and thereafter from Magat Hydro Power Plant up to 1987. As shown in Table 5-10, the unit energy cost of Bataan Thermal Power Plant is 22.0 mills per kWh and the unit cost of Magat Hydro Plant is 8.2 mills per kWh.

2) The annual cost of the transmission lines and substations has been obtained by multiplying the annual cost ratio with the total construction cost of the said facilities including take-off facilities for 13.2 kV line.

3) The annual cost of the transmission lines and take-off facilities between Ambuklao and Santiago has been tabulated on the assumption that 75.3% of the construction cost to be incurred in this section would be allocated to the Project upon completion of the Magat Hydro Power Plant (See Appendix A-7).

US$36, 683, 000 covering the entire period of the serviceable life of the Project has been tabulated as present value of the "cost" in the year 1978 (See Table 5-11).

Table 5-9 Presuppositions Employed in Estimation of Annual Costs

(1) Serviceable Life of Facilities

Diesel Plants	18 years (alternative facilities)
Thermal Plant 1/	30 years (alternative facility)
Transmission Lines (wooden poles)	25 years
(steel towers)	50 years
Substation Equipment	25 years
Distribution Lines	20 years

(2) Rates of Interest on Transmission Lines, Substations and Distribution Lines

Foreign Currency	3.5%
Domestic Currency	10.0%

(3) Annual Cost Ratio by Facilities (covering the serviceable life)

Items	Interest Depreciation	Operation and Maintenance	Administration	Total
Transmission Lines (%)	6.60	2.50	0.50	9.60
Substations (%)	6.60	2.50	0.50	9.60
Distribution Lines (%)	8.50	3.50	0.50	12.50

Note: 1/ A standard thermal power plant which provides a basis for cost allocation of the transmission line between Magat Hydro Plant and Santiago Substation.

Table 5-10 Alternative Diesel Power Plants

Plant capacity (kW)	3,000
Plant factor (%)	40
Annual energy production (million kWh)	10.5
Station service use (%)	3
Annual available energy (million kWh)	10.2
Thermal efficiency at sending end (%)	30
Construction cost (thousand US$)	960
Foreign currency (thousand US$)	796
Domestic currency (thousand US$)	164
Serviceable life (years)	18
Annual cost (thousand US$)	
Fixed cost	
Amortization	79.5
Repair and maintenance	15.4
Salaries and wages	10.5
Miscellaneios cost	1.9
Administration cost	2.5
Sub-total	109.8
Variable cost	
Fuel cost (including lubricating oil)	309.5
Repair and maintenance	3.8
Sub-total	313.3
Total	423.1
Fixed cost (US$/kW)	36.6
Variable cost (mills/kWh)	30.7
Total cost (mills/kWh)	42.3

Note: 11,800 BTU/kWh

(2) Benefit

1) It has been assumed that diesel power plants to satisfy the power demand given in Appendix A-2 are erected. In this case, the installed capacity of these plants is to be 3,000 kW which could be expanded corresponding to the increasing demand. Thus, it will be necessary that 12 units of 3,000 kW each be installed in 1978, and their number will be increased up to 24 units in total in 1987.

2) The fixed cost and the variable cost will be US$36.6 per kW and 30.7 mills per kWh, respectively (See Table 5-10). In this manner, the annual costs in the respective years have been obtained by multiplying these two kinds of unit costs with the kW and kWh which will be required each year.

3) As a result, the present value of US$66,392,000 covering the whole serviceable life of these alternative diesel power plants has been obtained (See Table 5-12). Therefore, the following formula indicates the B/C Ratio of the Project.

$$\frac{66,392,000}{36,683,000} = 1.80$$

4) The price of Bunker C oil at Santiago that was used for tabulation of the benefit is 1.45 times as expensive as that for Bataan Thermal Power Plant due to the increased transportation cost of the fuel.

Price of Bunker C Oil as of February 1974

Place of Delivery	Increase rate (%)
At Bataan ₱0.44 per litre	100%
At San Fernand ₱0.52 per litre	117%
At Santiago ₱0.64 per litre	145%

Note: Marine transportation between Bataan and San Fernand
Overland transportation between San Fernand and Santiago

Table 5-11 Annual Cost of Cagayan Electrification Program at 13.2 kV Take-off Facility End

Items	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Energy requirement (GWh)	107	126	139	154	170	189	205	222	240	258
Magat P.S. energy cost (mills/kWh)	-	-	-	8.2	8.2	8.2	8.2	8.2	8.2	8.2
Bataan P.S. energy cost 1/ (mills/kWh)	22.0	22.0	22.0	-	-	-	-	-	-	-
(1) Generating cost (10^3US$)	2,354	2,772	3,058	1,263	1,394	1,550	1,681	1,820	1,968	2,115
(2) Annual cost (10^3US$) (Transmission & transforming facilities in Cagayan Valley)	2,695	2,695	2,695	2,184	2,184	2,184	2,184	2,184	2,184	2,184
(3) Total (10^3US$)	5,049	5,467	5,780	3,447	3,578	3,734	3,865	4,004	4,152	4,299
(4) Present value (10^3US$) (discount rate at 12%)	4,503 (0.892)	4,357 (0.797)	4,109 (0.711)	2,188 (0.635)	2,028 (0.567)	1,889 (0.506)	1,746 (0.452)	1,613 (0.403)	1,494 (0.360)	1,380 (0.321)
(5) Total present value 2/ during serviceable life (10^3US$)	36,683									

Note: 1/ implies an estimated rate

2/ equals 25,307,000 + (4,299,000 x 8.244 x 0.321) = 25,307,000 + 11,376,000 = US$36,683,000 (50 years)

Table 5-12 Annual Cost of Alternative Diesel Power Plants

Items	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Energy requirement (GWh)	107	126	139	154	170	189	205	222	240	258
(1) Fixed cost (10^3US$)	1,317	1,317	1,537	1,537	1,756	1,866	2,086	2,196	2,305	2,635
No. of diesel units	(12)	(12)	(14)	(14)	(16)	(17)	(19)	(20)	(21)	(24)
Unit cost (US$/kW)	36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6	36.6
(2) Variable cost (10^3US$)	3,284	3,868	4,267	4,727	5,219	5,802	6,293	6,815	7,368	7,920
Unit cost (mills/kWh)	(30.7)	(30.7)	(30.7)	(30.7)	(30.7)	(30.7)	(30.7)	(30.7)	(30.7)	(30.7)
(3) Total (10^3US$)	4,601	5,185	5,804	6,264	6,975	7,668	8,379	9,011	9,673	10,555
(4) Present value (10^3US$)	4,104	4,132	4,126	3,977	3,954	3,880	3,787	3,631	3,482	3,388
(discount rate at 12%)	(0.892)	(0.797)	(0.711)	(0.635)	(0.567)	(0.506)	(0.452)	(0.403)	(0.360)	(0.321)
(5) Total present value 1/ during serviceable life (10^3US$)	66,392									

Note: 1/ 38,461,000 + (10,555,000 x 8.244 x 0.321) = 38,461,000 + 27,931,000
= US$66,392,000 (50 years)

5-6-2 Internal Rate of Return

(1) NPC employs a uniform tariff schedule within the Luzon Grid area where no disparity is observed in its electric tariff. In the case of contract demand of 5,000 kW with monthly energy consumption of 1,800 MWh, the average unit cost is 13.9 mills per kWh. If the wholesale cost of power to be furnished by NPC is 13.9 mills per kWh, the internal rate of return will become zero to make the value of costs equal to that of revenues.

(2) NPC is contemplating to raise electric charges in the years to come, extending over a long period of time. Accordingly, if it is assumed that NPC's electric charge should be 22.0 mills per kWh, which is equivalent to the figure obtained from the Bataan Thermal Power Plant in 1978 when the transmission lines are to be commissioned, it could be expected that the internal rate of return of the Project will be 7.3% (See Table 5-13).

Major revision by NPC of its electricity tariff is as follows.

	5,000 kW, 1,800 MWh/month	Increase rate (%)
1972	10.8 mills per kWh	100
1973	11.5 mills per kWh	106
1974	13.9 mills per kWh	129

Table 5-13 Internal Rate of Return at 13.2 kV Take-off Facility End

		Construction cost (10^3US$)	Energy Cost			Maintenance cost (10^3US$)	Total cost (10^3US$)	N P C		I. R. R. (i = 7.3%)		
			Requirement (GWh)	Unit cost (mills/kWh)	Cost (10^3US$)			Unit rate (mills/kWh)	Revenue (10^3US$)	Present worth factor	Cost (10^3US$)	Revenue (10^3US$)
-3	1975	5,014					5,014			1.235	6,192	-
-2	1976	15,040					15,040			1.151	17,311	-
-1	1977	5,014					5,014			1.073	5,380	-
1	1978		107	22.0	2,354	842	3,196	22.0	2,354	0.932	2,979	2,194
2	1979		126	22.0	2,772	842	3,614	22.0	2,772	0.869	3,141	2,409
3	1980	-4,754	139	22.0	3,058	842	-854	22.0	3,058	0.809	-691	2,474
4	1981		154	8.2	1,263	682	1,945	22.0	3,388	0.754	1,467	2,560
5	1982		170	8.2	1,394	682	2,076	22.0	3,740	0.703	1,459	2,629
6	1983		189	8.2	1,550	682	2,232	22.0	4,158	0.655	1,462	2,723
7	1984		205	8.2	1,681	682	2,363	22.0	4,510	0.611	1,446	2,756
8	1875		222	8.2	1,820	682	2,502	22.0	4,884	0.569	1,424	2,779
9	1986		240	8.2	1,968	682	2,650	22.0	5,280	0.530	1,405	2,798
10	1987		258	8.2	2,116	682	2,798	22.0	5,676	0.494	1,382	2,804
.	.				const.		const.		const.			
.	.				(2,116x34=71,944)		(2,798x34=95,132)		(5,676x34=192,984)		2,798	5,676
.	.										x 0.494	x 0.494
.	.		const.	const.		const		const.				
.	.										x 12.881	x 12.881
.	.				71,944		95,132		192,984		= 17,804	= 36,118
.	.											
.	.											
45	2022		258	8.2	2,116	682	2,798	22.0	5,676		const.	const.
46	2023		258	8.2	2,116	682	2,798	22.0	5,676			
47	2024		258	8.2	2,116	682	2,798	22.0	5,676			
48	2025		258	8.2	2,116	682	2,798	22.0	5,676			
49	2026		258	8.2	2,116	682	2,798	22.0	5,676			
50	2027		258	8.2	2,116	682	2,798	22.0	5,676			
Total		20,314			104,616		159,510		266,860		62,159	62,244

CHAPTER VI

DISTRIBUTION LINE SCHEME

Chapter VI Distribution Line Scheme

6-1 Basic Assumption

6-1-1 Maximum Load for Design of Distribution Lines

The maximum load for design of the distribution lines has been calculated subject to the following equation.

Lighting Max. Demand + 1/2 x Industrial Max. Demand + Max. Demand by Irrigation

The lighting maximum demand has been estinated, based upon energy requirement on the assumption of a load factor of 35%. The industrial maximum demand was obtained from the "Magat River Project Feasibility Report". The maximum demand by irrigation is as shown in Table A-2-1.

6-1-2 Method of Design

Site surveys were made on possible routes of main distribution lines, and studies were performed on the present formation of major towns and municipalities. Random studies of location and distribution of villages and barioses were also conducted. Data and information furnished by the authorities concerned were also used for our study. Based upon the results of the above investigation and data, the distribution line scheme was formulated from desk studies.

6-1-3 Calculation Manner of Construction Cost

(1) Standard design has been conducted with respect to kinds of construction works thereby tabulating required quantities of equipment, accessories, materials and man-power.

(2) Standard construction costs were computed by multiplying appropriate costs with the figure obtained in (1). As for the prices of major equipment, accessories and materials, Japanese prices were used while as for local products such as equipment, accessories and materials, other than major ones, prices prevalent in the Philippines were employed.

(3) Then, the standard construction costs were multiplied with total quantities of works, and the total construction cost of the scheme was estimated.

6-2 Preliminary Design

6-2-1 Principle of Planning

Since the Cagayan Valley is an isolated district in the Philippines, emphasis has been placed upon formation of high-voltage and long distance distribution networks to cope with power demand by limiting the number of substations as much as possible judging from the overall and harmonious economy of the transmission lines, substations and distribution systems in the commissioning year of these facilities.

Primarily, self-voltage regulators are to be utilized to the fullest extent for the purpose of coping with anticipated voltage drop of distribution lines. Substations are to be newly built or expanded corresponding to increase in demand from time to time in the future.

The construction of the distribution systems is to be undertaken in three consecutive stages, taking into account the urgency and importance of power supply, investment efficiency and capability of Philippino laborers, and these stages are referred to as the "First Stage", "Second Stage" and "Third Stage".

First Stage

In the first stage, the first priority is placed upon power supply to demands from irrigation as well as major towns and municipalities to which power can be supplied without extending distribution lines. Power supply to the said demands is regarded as absolutely necessary from the standpoint of the economy of the transmission and transformation facilities planned under the Project, and it is essential that these distribution systems be constructed so that power may be distributed on the commissioning date of the transmission and transformation facilities.

Second Stage

Power should be distributed mainly to towns and municipalities which were left unserved in the first stage and to rural areas adjacent to these localities which can be supplied with power at this stage, and villages scattered along the distribution line routes without extending distribution lines. It is anticipated that main distribution networks will be realized in five years after the commissioning of the transmission and transformation facilities.

Third Stage

Villages to which economical power supply is to be made possible through branch from main distribution lines or distribution lines running through towns and municipalities will be electrified during the third stage.

A considerable length of time will be required for electrification of most of villages and barioses scattered in the Valley. Under this scheme, it is essential that an electrification ratio of 30% (electrification in the whole Valley: 44%) in rural areas will be attained in 10 years from the end of the first stage.

The scope of construction of the distribution lines is given in the following table.

Table 6-1 Construction of Distribution Lines

Items	1st Stage (1978)	2nd Stage (1982)	3rd Stage (1987)	Total
High-Voltage Line				
Line Distance (km)	520	750	580	1,850
(Circuit Length (km))	(630)	(870)	(580)	(2,080)
Pole Transformer				
Number of Units	540	1,050	810	2,400
Total Capacity (kVA)	24,100	21,100	16,300	61,500
Low-Voltage Line				
Length (km)	200	530	420	1,150
Electrification Ratio				
For Irrigation	90% 1/	95%	100%	
For Towns and Municipalities	72%	100%	100%	
For Rural Areas	-	15%	30%	
Total	13%	34%	44%	

Note: 1/ Power demand by national and communal irrigation projects proposed as of 1974 to be completely satisfied in 1987.

The outline of the distribution line scheme is as shown in Fig. 6-1. The distribution lines by the respective substations are given in Fig. 6-2 to Fig. 6-7.

6-2-2 Design of Distribution Facilities

1) Power Distribution System

a) Voltage and Power Distribution System

(i) High-Voltage Line

7.62/13.2 kV, 3-phase, 4-wire, Y. connection

Neutral line multiple-grounded system

(ii) Low-Voltage Line

Lighting: 120 V, single-phase, 2-wire system

120 V/240 V, single-phase, 3-wire system

240 V, single-phase, 2-wire system (standard)

Motive power: 240 V, 3-phase, 3-wire system

480 V, 3-phase, 3-wire system (standard)

Combined lighting and motive power:

120 V/240 V, 3-phase, 4-wire system

(iii) Service Lines

Lighting: 120 V, single-phase, 2-wire system

120 V/240 V, single-phase, 3-wire system

240 V, single-phase, 2-wire system

Motive power: 240 V, 3-phase, 3-wire system

480 V, 3-phase, 3-wire system

Note: See Appendix Fig. A-6-1.

b) Form of Distribution Line

Both high-voltage lines and low-voltage lines are to be of "T" branch type.

Note: See Appendix Fig. A-6-2.

2) Circuit Capacity of High-Voltage Line

Standards were not especially provided for rural distribution lines since they are difficult to fix indiscriminately from the aspect of voltage drop, but taking into account power exchange during faults, the normal capacity was taken to be a minimum of 3,000 kW.

Note: $\sqrt{3}$ x 13.2 kV x (58 mm^2; 114 MCM ACSR, permissible current 225 A) x power factor 0.9 x 2/3 = 3,086 kW

3) Voltage Drop and Voltage Regulation

a) The standard values for the limits to voltage drops in distribution systems were taken to be the following.

High-voltage lines:	700 V for phase voltage of 7.62 kV
Low-voltage lines :	Lighting, 7 V for 120 V
	Motive power, 24 V for 240 V
	Motive power, 48 V for 480 V

b) Voltage regulation is to be achieved by combined use of a transformer with on-load tap changer (OLTC) of sending voltage at substation and self-voltage regulators (SVR) attached to distribution lines in order to compensate for distribution line voltage drops, while pole transformers are to be transformers with 2.5% taps.

By the above system, it will be possible for the voltage fluctuation range at lighting customer service entrances to be 244 ± 16 V.

4) Power Factor of Distribution Line Load

It is necessary to install condensors at points of use for improvement of power factor of motive power loads. The condensors to be installed on distribution lines are to correspond to excitation capacities of pole transformers.

5) Supply Reliability

a) One to three reclosers are to be provided per circuit for reclosing of instantaneous faults and automatic elimination of permanent faults. As for branch distribution lines, line fuses are to be attached as suited to automatically take out faulted sections so that propagation of faults to main lines can be prevented.

b) Air break switches are to be arranged about every 3 km of the lines as section switches in order to reduce time for recovery of faults and to shorten the sections during faults and during repair works.

6) Countermeasures for Short Circuit Faults

Conductors and cables sufficiently capable of resisting short circuit currents are to be adopted.

7) Countermeasures for Lightning Faults

Arrestors are to be installed at reclosers, air break switches, self-voltage regulators, condensors and pole transformers, as well as connecting points of cables and overhead lines.

8) Countermeasures for Salt Contamination

For areas within 5 km from the shoreline in the coastal area around Aparri, insulators, high-voltage cutouts and pole transformers designed against salt contamination are to be used.

9) Countermeasures for Typhoons

As measures against typhoons, spacing between wooden poles is to be not more than 50 m with high-voltage conductors strung not more than two circuits. Horizontal guys are to be provided every 5 spans and longitudinal guys every 10 spans.

10) Supports

a) Wooden poles are to be mainly used as supports with steel towers adopted only for long spans crossing rivers. As for crossarms, they are all to be steel arms.

b) Solid-core line post insulators are to be used while dead end insulators for distribution lines are to be in 2-unit strings.

c) High-voltage lines are to be in horizontal arrangement while low-voltage lines are to be in vertical arrangement.

Note: See Figs. A-6-3 to A-6-6.

11) Conductors

Conductors for high-voltage distribution lines are to be of ACSR of 120 mm^2 (237 MCM), 58 mm^2 (114 MCM), and 25 mm^2 (49.3 MCM), respectively. Insulated conductors corresponding to the said sizes are to be mainly used for low-voltage distribution lines.

Cables are to be employed for wooden poles for distribution lines leading out from substation cubicles. In portions where it is possible for cables to be fixed with bridges, cables are also to be used from the standpoint of "river-crossing".

12) Pole Transformers

a) Pole transformers are to be mainly single-phase transformers and the standard capacities are to be 10 kVA, 20 kVA, 30 kVA, 50 kVA and 100 kVA.

b) High-voltage cutouts are to be provided at the primary sides of pole transformers and no circuit breakers provided at secondary sides.

c) The pole transformers are to be mounted on poles with "transformer mounting bracket" in consideration of space for pole-climbing and of economy.

Note: See Figs. A-6-7 and A-6-8.

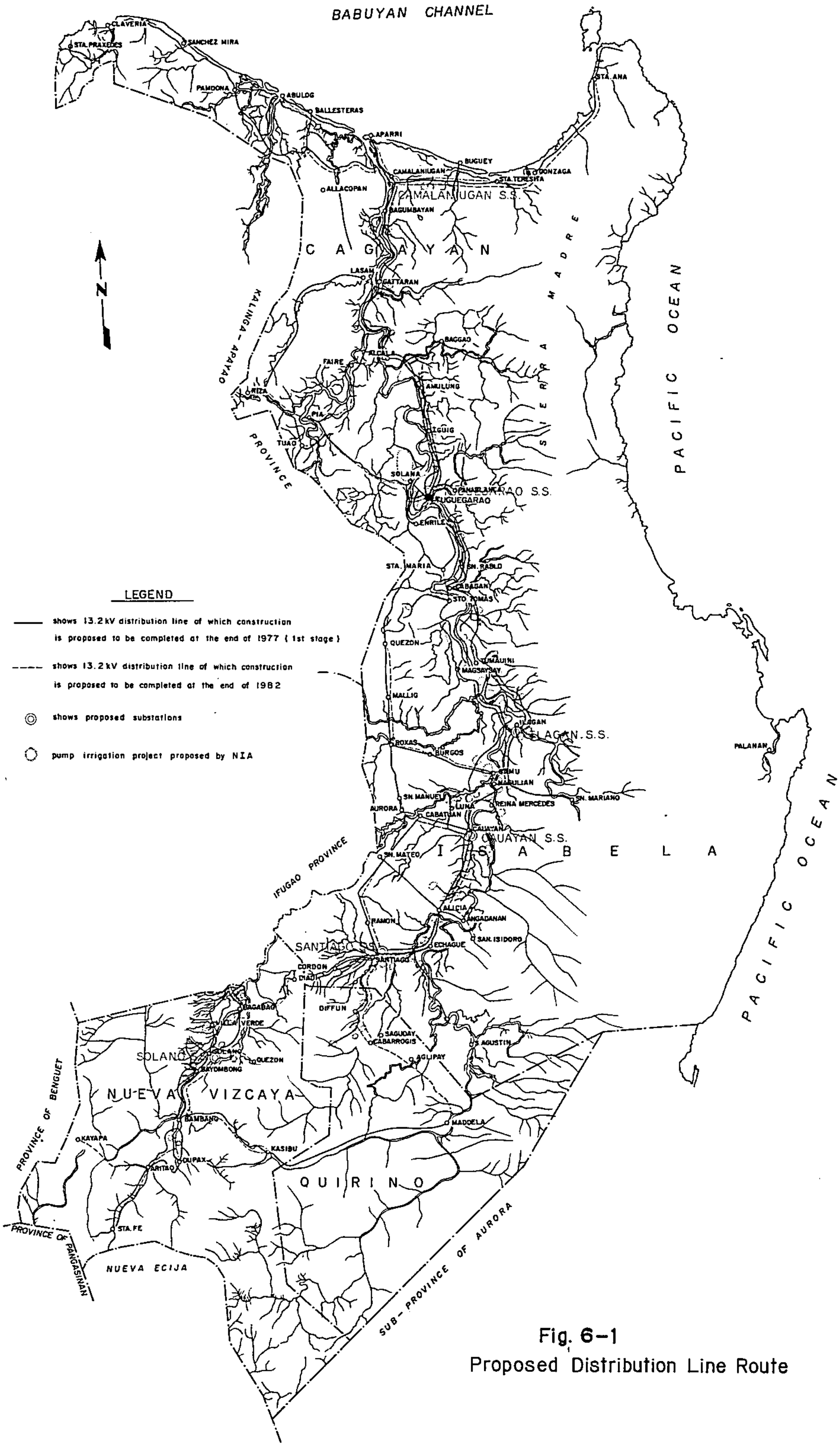


Fig. 6-1
Proposed Distribution Line Route

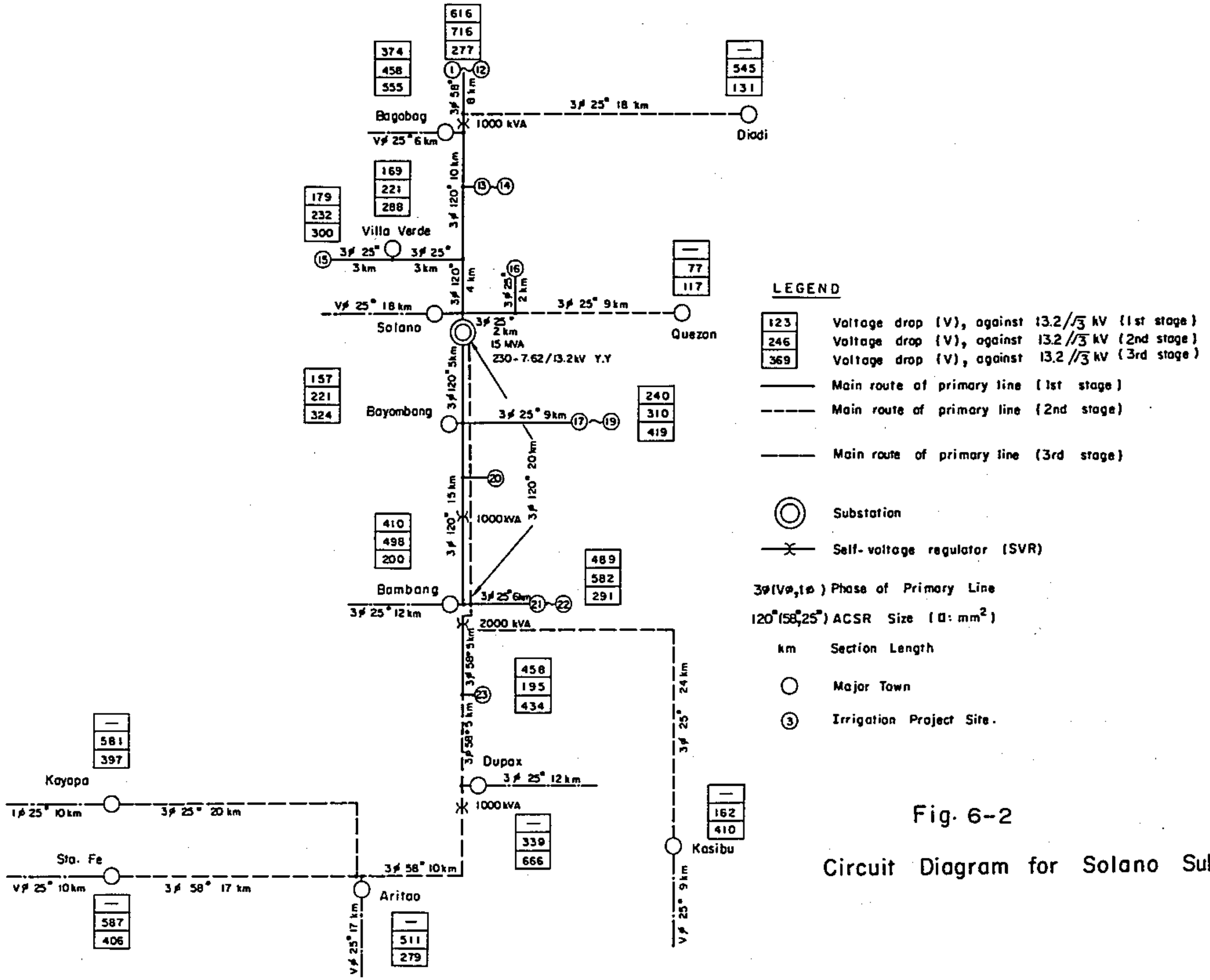


Fig. 6-2

Circuit Diagram for Solano Substation

Fig.6-3 Circuit Diagram for Santiago Substation

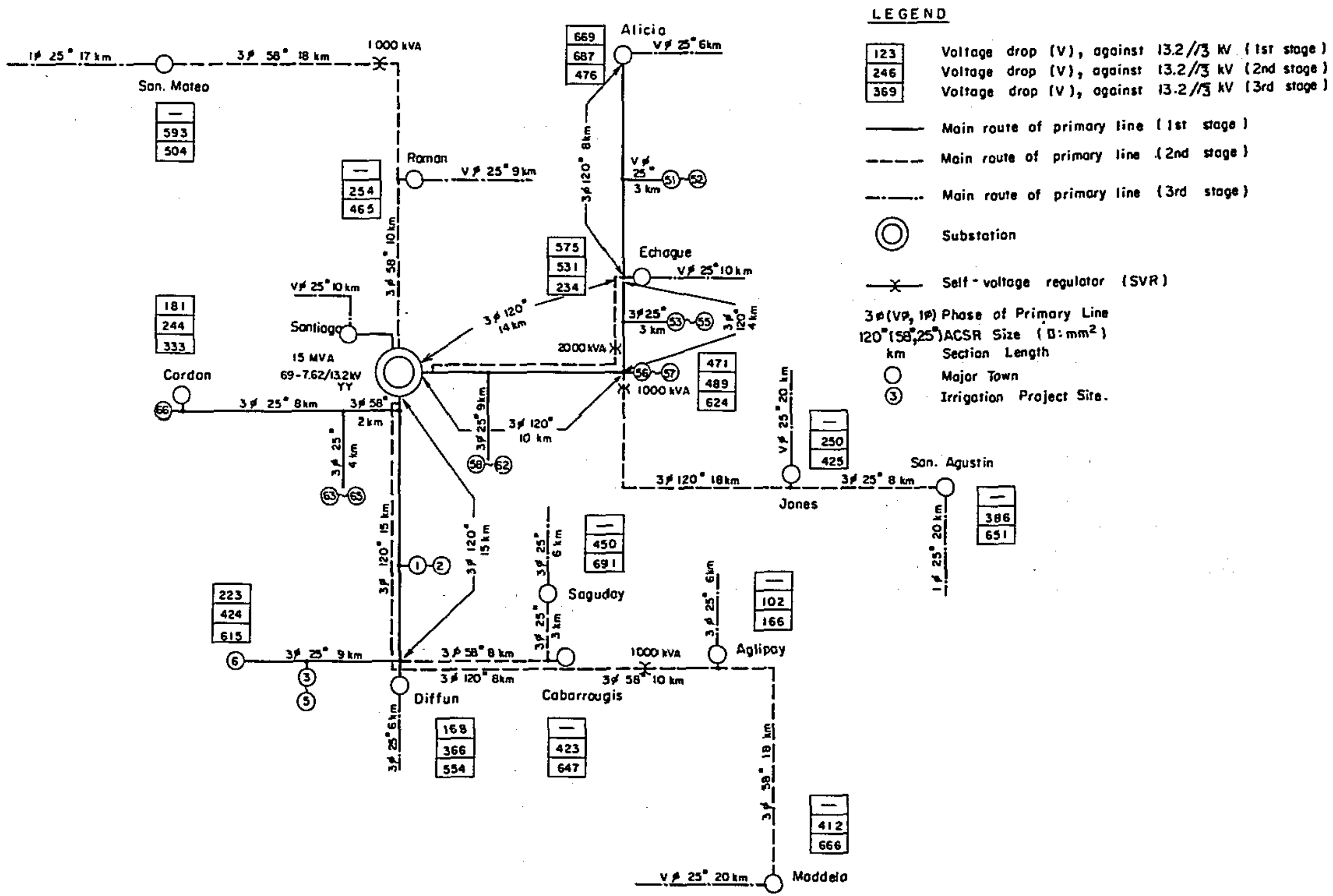
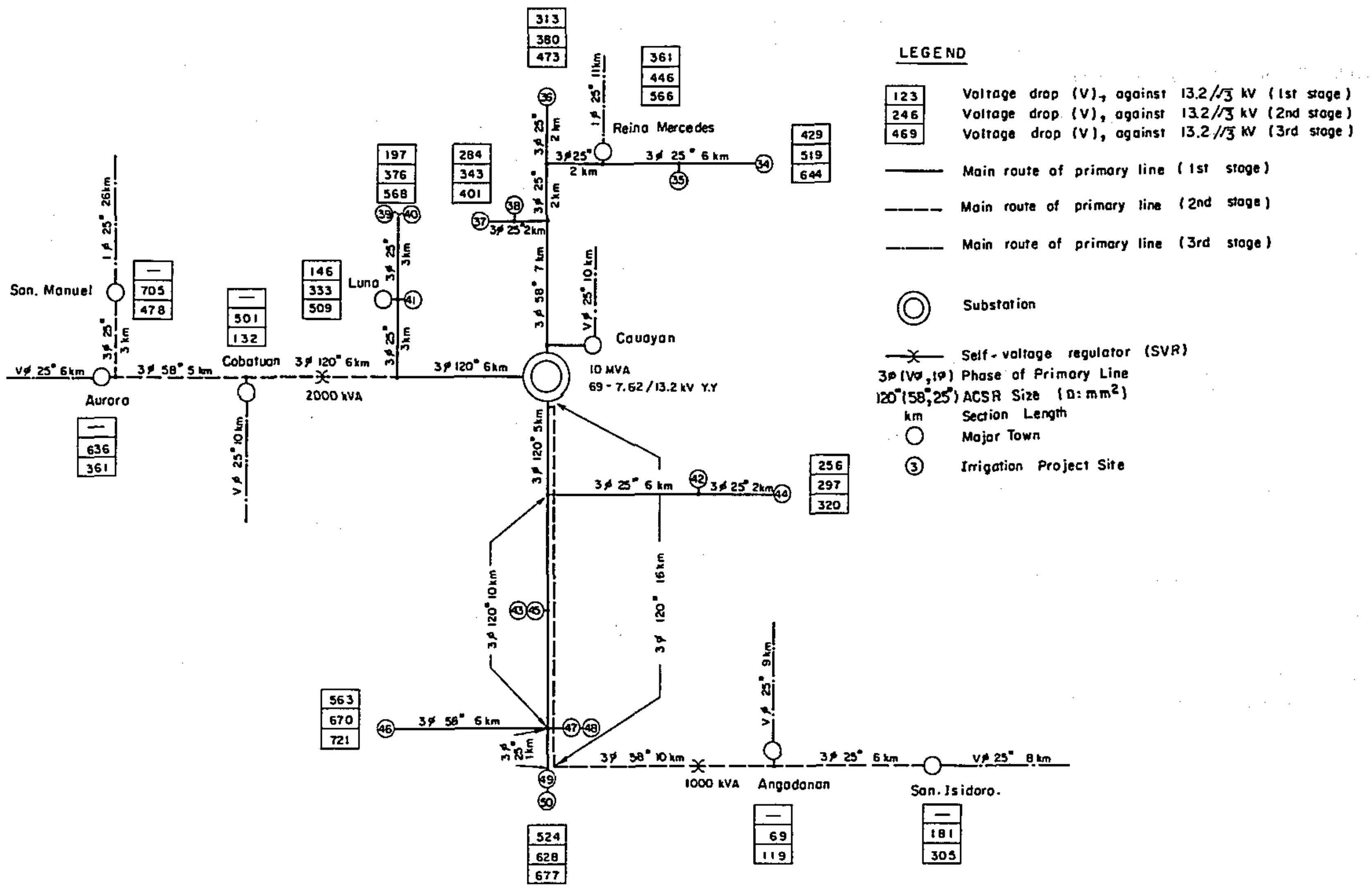


Fig. 6-4 Circuit Diagram for Cauayan Substation



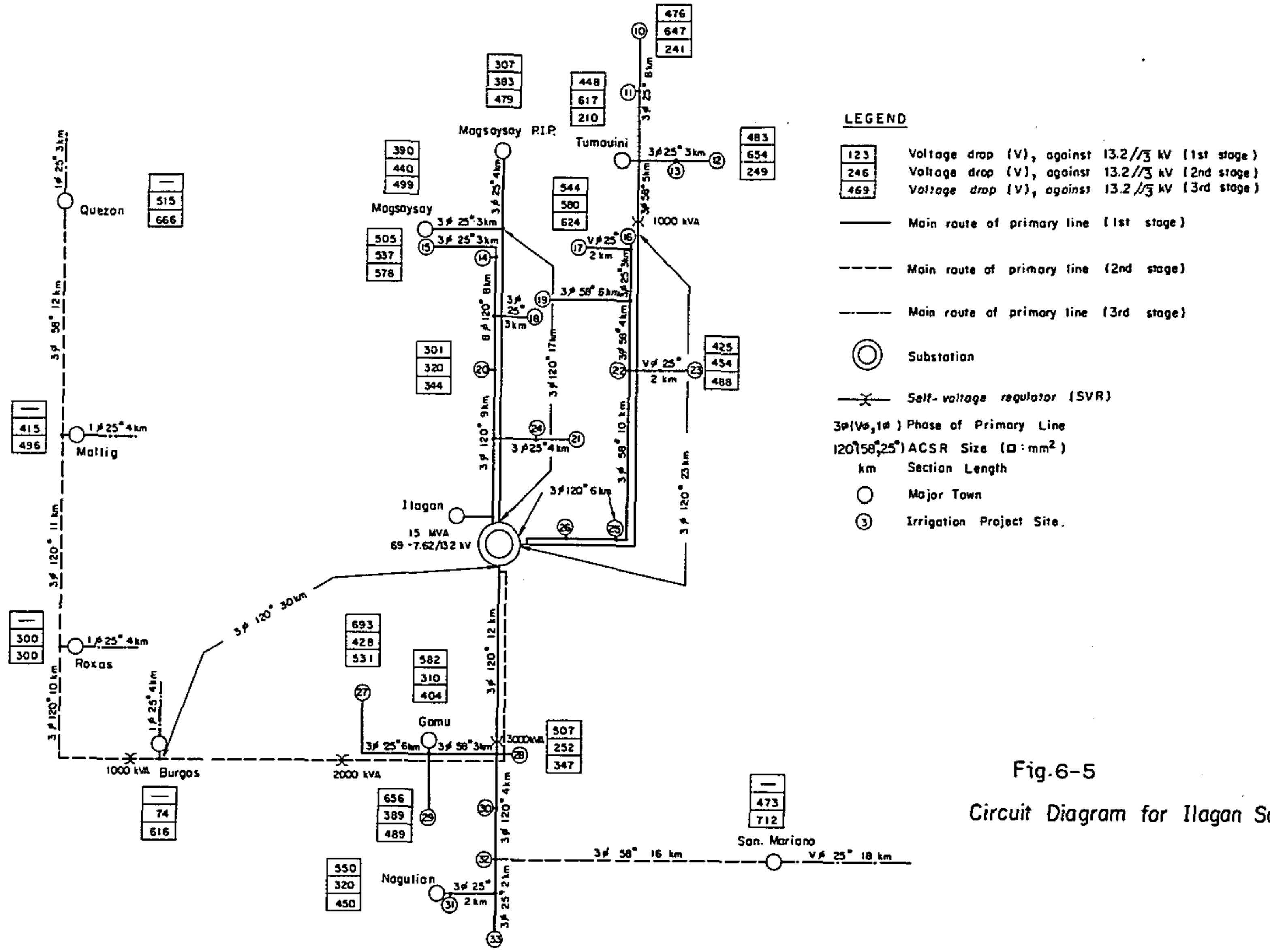


Fig.6-5

Circuit Diagram for Ilagan Substation

Fig. 6-6 Circuit Diagram for Tuguegarao Substation.

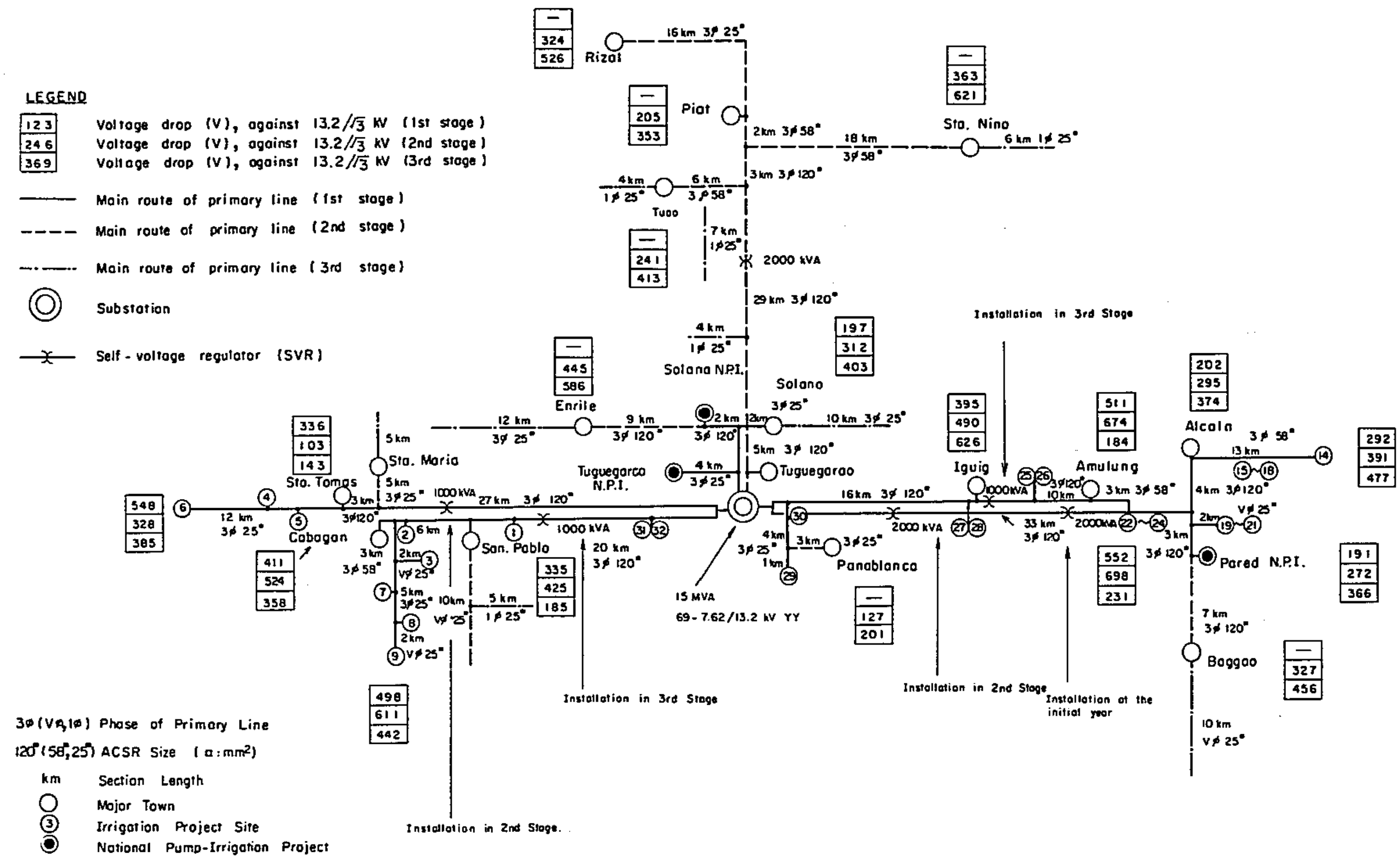
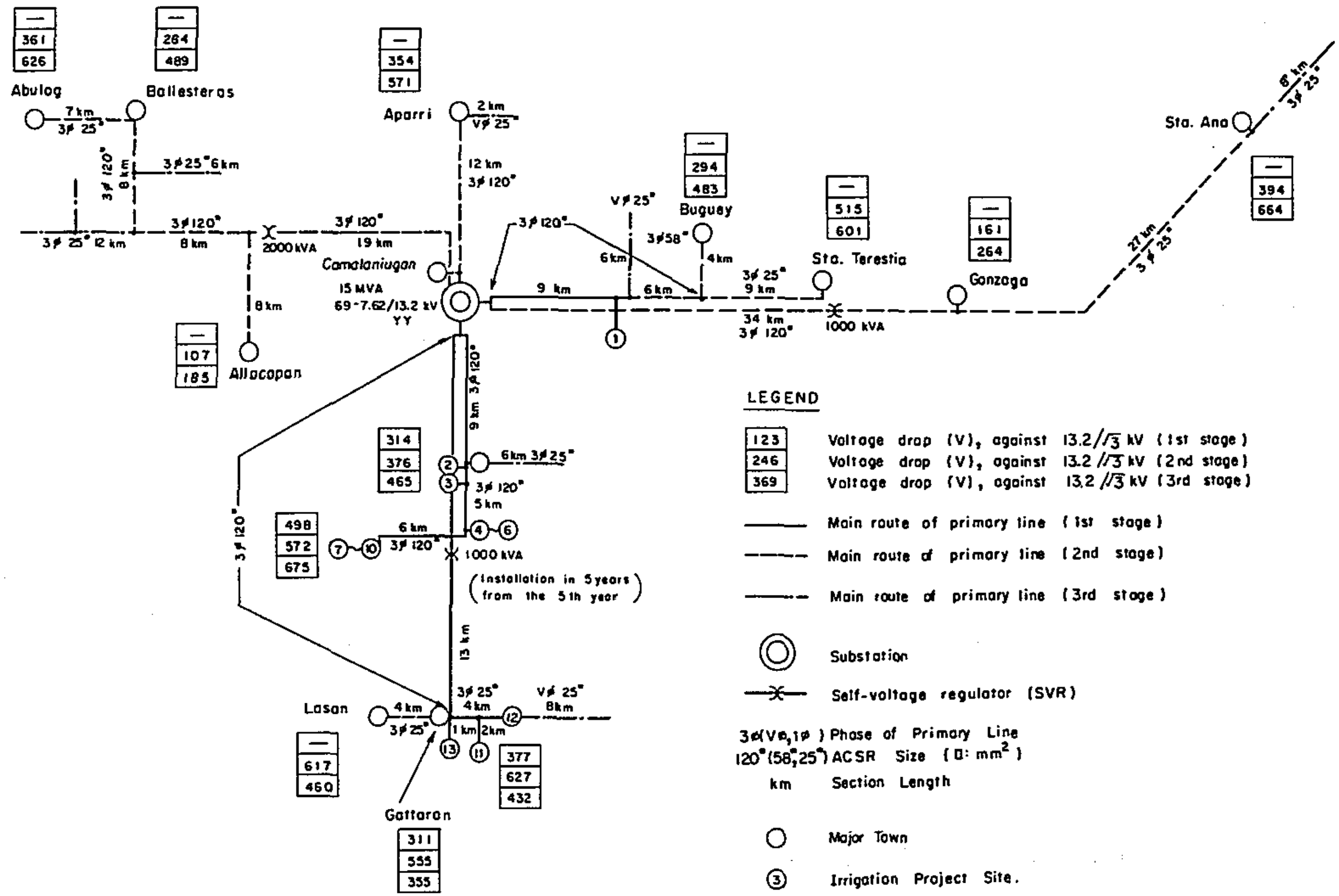


Fig. 6-7 Circuit Diagram for Camalaniugan Substation



6-3 Construction Cost

6-3-1 Scope of Calculation of Construction Cost

The construction cost of the distribution lines includes take-off facilities to be constructed at six substations in the Cagayan Valley, 13.2 kV high-voltage distribution lines leading to final consumers, transformers for distribution and low-voltage distribution lines.

Since power supply to industrial consumers is made through 13.2 kV high-voltage distribution lines, the costs of receiving transformers are to be borne by consumers to be supplied with power.

As stated in 6-2, construction of the distribution lines is proposed to be undertaken in the three consecutive stages. This report primarily deals with expenditures for construction of distribution lines which are scheduled to be carried out during the first stage. Construction costs for the second and third stages are also shown, for reference, in this study.

6-3-2 Construction Cost

As given in Tables 6-2 & 6-3, direct costs of the respective items at the six substations are tabulated, and 10%, 7% and 5% of these costs are enumerated as contingencies, administration costs of NEA or its cooperatives and engineering fee. As for the interest during construction of distribution lines, 10% and 7% of the field cost as given in Table 6-2 are computed for foreign currency portion and domestic currency portion, respectively.

In consideration of the scale of construction works and mobility and mechanization of operation and maintenance work in the future, costs for procurement of equipment for construction and operation and maintenance have been included in the construction cost.

Equipment & Devices Required for Operation & Maintenance

(In U.S. Dollar)

Items	Quantity	Unit Cost	Amount
VHF Mobile Radio Equipment	24	1,700	40,800
VHF Portable Radio Equipment	18	600	10,800
Automobile for Maintenance	12	3,200	38,400
Automobile for Construction	12	4,000	48,000
Automobile for Hot-line Job	6	16,600	99,600
Automobile for Service to Consumers	12	1,700	20,400
Test Apparatus	6	10,000	60,000
Measuring Instruments	6	3,000	18,000
Others			2,000
Total			338,000

The construction cost of distribution lines during the first stage totals US$5,639,000. Costs to be incurred for the second and third stages are estimated to be US$9,170,000 and US$5,300,000, respectively. Therefore, necessary construction costs covering the three stages will amount to US$20,109,000.

Table 6-2 Construction Cost of Distribution Lines (1st Stage)

(In Thousand U.S. Dollars)

		F.C.	D.C.	Total
A	Distribution line	2,552	1,353	3,905
B	Plus 10% contingencies (A x 0.1)	255	135	390
C	Sub-total (A + B)	2,807	1,488	4,295
D	Administration cost (A x 0.07)	0	301	301
E	Engineering fee (A x 0.05)	215	0	215
F	Sub-total (C + D + E)	3,022	1,789	4,811
G	Service facilities	338	27	365
H	Total field cost (F + G)	3,360	1,816	5,176
I	Interest during construction	336	127	463
	Total construction cost (H + I)	3,696	1,943	5,639

Table 6-3 Direct Construction Cost of Distribution Lines (1st Stage)

(In Thousand U.S. Dollars)

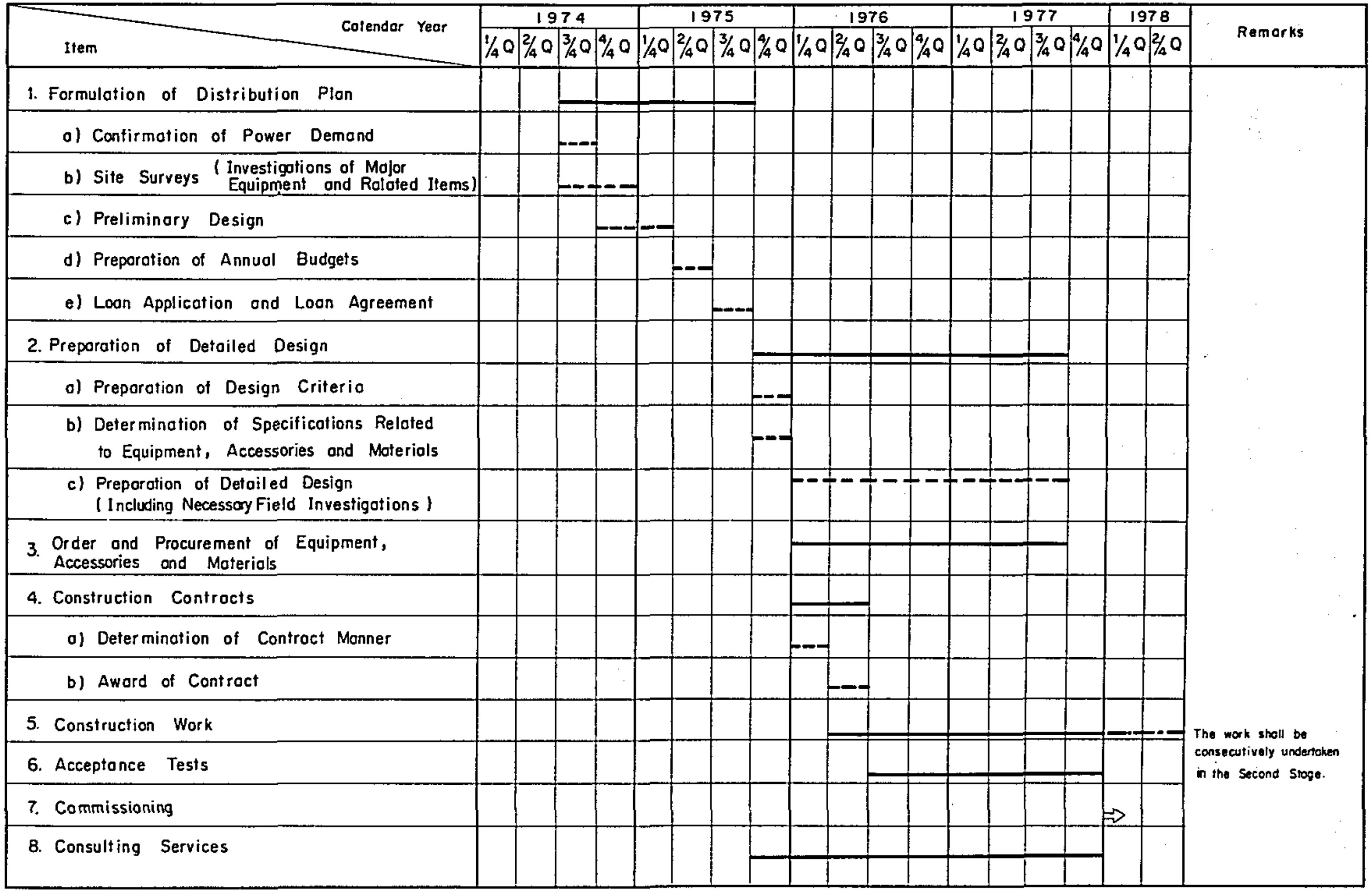
Name of Substation	Currency	Primary Line	Equipment for High-Voltage Line	Trans-former	Secondary Line	Service Wire	Total
Camalaniugan	F.C.	226.8	16.4	26.6	16.1	15.5	301.4
Substation	D.C.	123.2	0.8	0.8	20.2	1.0	146.0
Sub-total		350.0	17.2	27.4	36.3	16.5	447.4
Tuguegarao	F.C.	536.8	71.4	70.2	34.0	40.9	753.3
Substation	D.C.	271.5	2.4	2.1	44.7	2.8	323.5
Sub-total		808.3	73.8	72.3	78.7	43.7	1,076.8
Ilagan	F.C.	437.6	37.0	66.6	29.8	29.9	600.9
Substation	D.C.	254.7	1.6	1.9	34.9	2.0	295.1
Sub-total		692.3	38.6	68.5	64.7	31.9	896.0
Cauayan	F.C.	157.5	17.0	40.8	17.4	12.7	245.4
Substation	D.C.	133.1	0.8	1.1	19.2	0.8	155.0
Sub-total		290.6	17.8	41.9	36.6	13.5	400.4
Santiago	F.C.	198.0	14.4	53.1	34.9	28.9	329.3
Substation	D.C.	166.5	0.8	1.6	46.7	1.9	217.5
Sub-total		364.5	15.2	54.7	81.6	30.8	546.8
Solano	F.C.	203.8	16.4	43.9	32.6	25.0	321.7
Substation	D.C.	167.9	0.7	1.4	44.2	1.7	215.9
Sub-total		371.7	17.1	45.3	76.8	26.7	537.6
Total	F.C.	1,760.5	172.6	301.2	164.8	152.9	2,552.0
	D.C	1,116.9	7.1	8.9	209.9	10.2	1,353.0
Grand Total		2,877.4	179.7	310.1	374.7	163.1	3,905.0

6-4 Construction Schedule

It is believed that about one and a half years should be required for construction of distribution lines which are to be completed not later than the end of 1977 in which year the transmission lines, substations and related telecommunication facilities are to be completed to enable assured supply of power to irrigation projects and major towns and municipalities through these distribution lines. In this case, it must be borne in mind that any cooperatives to take overall responsibility for the construction works for electrification should furnish about 150 persons including technicians per day. More than one third of such personnel should be absolutely skilled workers. The time schedule for preparation of detailed designs and specifications and that for bidding and award of construction contracts are as given in the Construction Schedule.

The most important thing under this Schedule is that detailed studies in respect of technical and financial matters are assumed to be finalized one year commencing from the middle of this year. Without this presumption, later time schedules can not be followed. The proposed Construction Schedule is as shown in Fig. 6-8.

Fig. 6-8 Construction Schedule of Distribution Lines —— First Stage.



Note: In order to make a loan application in July 1975, the salient features of the scheme and its implementation manner as well as annual budgets (including a schedule for procurement and repayment of required funds from and to respective sources) should be prepared by the end of June 1975.

6-5 Annual Expenditure Requirements

As given in 6-3, the total field cost of the distribution line scheme (1st stage) will amount to US$5, 176, 000 compring US$3, 360, 000 and US$1, 816, 000 in the foreign and domestic portions, respectively. Annual expenses to be incurred in each fiscal year of the Philippines in accordance with the Construction Schedule stated in 6-4 of this Chapter are as shown in Table 6-4.

Table 6-4 Annual Expenditure Requirements for Distribution Line Scheme

(In Thousand U.S. Dallars)

Description	1975			1976			1977			Total		
	F.C.	D.C.	Total	F.C.	D.C.	Total	F.C.	D.C.	Total	F.C.	D.C.	Total
A Distribution line	182	75	257	1,514	757	2,271	856	521	1,377	2,552	1,353	3,905
B Contingencies	18	7	25	151	76	227	86	52	138	255	135	390
C Sub-total (A+B)	200	82	282	1,665	833	2,498	942	573	1,515	2,807	1,488	4,295
D Administration cost (A x 0.07)	0	20	20	0	175	175	0	106	106	0	301	301
E Engineering fee (A x 0.05)	72	0	72	95	0	95	48	0	48	215	0	215
F Sub-total (C+D+E)	272	102	374	1,760	1,008	2,768	990	679	1,669	3,022	1,789	4,811
G Service facilities	0	0	0	148	12	160	190	15	205	338	27	365
Total field cost (F+G)	272	102	374	1,908	1,020	2,928	1,180	694	1,874	3,360	1,816	5,176

Note: The total field cost shown above does not include interest during construction.

6-6 Anticipated Power Rate

6-6-1 Method of Perusal into Electric Rate

In conducting necessary perusal into the economic features of electric charges, it has been assumed that NPC is to wholesale its electric power to NEA or its cooperatives at a rate of 22 mills per kWh as stated in Chapter V at the take-off facilities of the six substations. Appraisal of the economy of the distribution line scheme is to compare the average power rate charged by the existing power utilities in the Valley with the said charge of 22 mills per kWh plus distribution costs.

This Chapter presents power rates at the consumer's end in the case of expansion of distribution lines in 1978 and in the final years of the second and third stages, using an annual cost ratio of 12.5% applicable to these distribution lines (See Table 5-9).

6-6-2 Studies on Distribution Costs

(1) Current Unit Energy Cost in the Cagayan Valley

The following table is the average unit cost of energy sold by the Tuguegarao, Ilagan, Cauayan, Solano and Bayombong Power Utilities for one year in 1973.

Table 6-5 Unit Energy Cost at the Customer's End in 1973

	Energy sold in MWh	Revenue in Pesos	Pesos/kWh	Mills/kWh
Tuguegarao	2,081	699,000	0.335	(50.8)
Ilagan	551	225,000	0.408	(61.8)
Cauayan	1,037	455,000	0.438	(66.4)
Solano	727	354,000	0.486	(73.6)
Bayombong	659	226,000	0.343	(52.0)
Total	5,055	1,959,000	0.387	(58.6)

(2) Distribution Costs

Based upon distribution costs which can be obtained by salable energy at the consumer's end and the construction cost of distribution lines and taking a wholesale rate by NPC of 22 mills per kWh into account, an anticipated power rate at the consumer's end will be as follows:

(Unit: Mills per kWh)

	Charge at 13.2 kV	Distribution Cost	Charge at Consumer's End
1978	22.0	7.3	29.3
1982	22.0	12.1	34.1
1987	22.0	10.8	32.8

The average rate currently charged by the existing power utilities in the Valley is about 58.6 mills per kWh. Even if transmission lines and substations to be connected with Luzon Grid and to supply to final consumers are to be constructed, it will be possible to reduce electric charge at the consumer's end by 50%, 42% and 44%, respectively in 1978, 1982 and 1987.

CHAPTER VII

ORGANIZATIONS RELATED TO THE IMPLEMENTATION OF THE PROJECT

Chapter VII Organizations Related to the Implementation of the Project

7-1 National Economic and Development Authority (NEDA)

Since issuance of Presidential Decree No. 1 dated September 23, 1972, the Government of the Republic of the Philippines has been exerting its utmost to materialization of integrated policies of political, social and economic affairs with the aim of creating a "New Society". For this purpose, the said Government established NEDA by amalgamating the National Economic Council (NEC) and Presidential Economic Staff (PES) in order to coordinate the functions and assignments of associated governmental organizations and agencies and to effectively strengthen relations with provincial governments of the Philippines.

NEDA consists of the Office of the Director-General composed of the Immediate Office of the Director-General, the Administrative Service, the Management Service, and the Legal Service; the Planning and Policy Office; the Programs and Projects Office; and the National Computer Center.

7-2 National Power Corporation (NPC)

NPC was created in 1936 under Commonwealth Act No. 120 in order to perform generation and supply of electric power throughout the Philippine as its major functions and for the purpose of accelerating studies on hydraulic potentials and expediting development of necessary hydro power projects. In addition to development of hydro power projects which was approved by the Government at the initial stage of incorporation, it was approved that NPC would undertake development of other power sources including thermal and nuclear power projects.

The present functions and assignments of NPC cover development of hydro, thermal and nuclear power projects, construction, operation and maintenance of transmission lines and substations. Moreover, NPC is currently engaged in management of power-oriented industries such as fertilizer factories, electro-chemical enterprises and electro-metallurgical establishments as its secondary functions.

According to Presidential Decree No. 380, NPC is under the direct supervision of the Office of the President. NPC's authorized capital is two billion Pesos divided into twenty million shares having a par value of one hundred Pesos each. By virtue of the said Decree, NPC is authorized to make loans and credits, acquire any convertible foreign currency and issue debentures which in aggregate does not exceed one billion United States dollars from foreign governments, international financial institutions and private financial sources. Such loans, credits and other borrowings to be supplied by foreign sources are to be guaranteed by the President by himself or through his duly authorized representative as primary obligor and not as surety merely in the name and on behalf of the Philippines.

As stated above, NPC not only incurs a heavy responsibility for rehabilitation and construction of the whole land within the territory of the Philippines but also is protected by the Government in respect of the capital and finance.

The organization of NPC comprises the Board of Directors composed of 7 directors from among whom a General Manager is elected. The General Manager directs and controls the respective departments and regional offices.

As of March 1974, NPC had approximately 660 MW of name plate capacity in five hydroelectric plants, one thermal power plant and other small hydro and diesel plants in the three major islands.

In addition to the above generating facilities, NPC owns transmission lines about 3,400 km long in total as well as substations and switching stations whose capacity totals about 1,700 MVA.

7-3 National Electrification Administration (NEA)

NEA was established by reorganization of the Electrification Administration (EA) in 1969 for the purpose of pursuing the total electrification of the Philippines which means electrification for agricultural and industrial development. The definite functions of this new organization are to take over the existing power utilities and to establish cooperatives in respective provinces. For this aim NEA provides necessary loans to cooperatives and extends technical assistance to them.

Whenever cooperatives of non-profit nature construct or erect power facilities, NEA dispatches supervisors and specialists to such establishments and furnishes required technical assistance.

The highest organization of NEA is the Board of Administrators composed of a Chairman and four members, one of whom is the Administrator as ex-officio member and the three other members are appointed by the President. There are five directorates under the supervision and control of the Administrator at NEA head office.

7-4 National Irrigation Administration (NIA)

NIA is a corporate body created under RA. 3601 in October 1964 after absorbing all the functions, personnel, assets and liabilities, etc. of the former Irrigation Division of the Bureau of Public Works. Besides, the former Irrigation Unit of the Department of Public Works, Transportation and Communications was also merged with NIA in line with the reorganization of the Philippine Government.

The major functions assigned to NIA are:

(1) Investigate, improve, construct and maintain irrigation systems throughout the Philippines.

(2) Conduct investigations on available water resources for irrigation systems.

(3) Bill and collect charges from users of irrigation systems

(4) Do all such other things and transact all such business as are directly or indirectly necessary and incidental to attainment of the works from (1) through (3) given above.

The number of employees of NIA as of June 1973 totaled about 4,500 of whom 400 persons work at the head office. The rest of the employees belong to regional offices and project offices.

The highest organization of NIA is the Board of Directors composed of a Chairman and five other members. One of the Board members takes office of the Administrator under whom there are, at present, five departments at the head office. The office of the Administrator is assisted by two Staff Units. Ten regional offices are located in the field.