REPUBLIC OF THE PHILIPPINES

REPORT ON FEASIBILITY STUDY ON LEYTE POWER TRANSMISSION PROJECT

(SUMMARY)

FEBRUARY 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of the Philippines, the Government of Japan decided to conduct a survey on Leyte Power Transmission Project and entrusted the survey to the Japan International Cooperation Agency (JICA). The JICA sent to the Philippines a survey team headed by Mr. Hitoshi Kitazawa from March 2 to March 31, from July 5 to July 25 and from October 7 to October 21, 1981.

The team exchanged views with the officials concerned of the Government of the Philippines and conducted a field survey in Luzon, Leyte and Samar areas. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the team.

February, 1982

Keisuke Arita

Keisuke Arita, President
Japan International Cooperation
Agency

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SUMMARY

This report summarizes the essential points of the results of studies and investigations given in "Republic of the Philippines Report on Feasibility Study on the Leyte Power Transmission Project" carried out by the Japan International Cooperation Agency (JICA) on behalf of the Japanese Government in response to a request from the Government of the Republic of the Philippines. It is suggested that reference to the Main Report will provide a better comprehension of the Project.

The reports concerning the Project consists of the following three volumes.

Volume I : Summary

Volume II : Main Report

Volume III : Appendix

February, 1982

H. Kitazawa

Hitoshi Kitazawa, Team Leader
Survey Team for Feasibility Study
on the Leyte Power Transmission
Project

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1. OBJECTIVE AND SCOPE OF STUDY

Development of geothermal energy has been continued on Leyte Island since the beginning of 1970's. A test plant of 3,000 kW started its operation in the middle of 1977 in Tongonan, and a plant of 37.5 MW x 3 is under construction in Tongonan to supply electric power to Leyte and Samar area including Isabel Industrial Complex on Leyte Island in 1983. Furthermore, development of geothermal energy of 440 MW in Tongonan area has been confirmed and construction of the plants is scheduled to be completed by 1985. In addition, development of the additional 550 MW by 1990 is planned by NAPOCOR.

The electric power to be generated at these plants is planned to be transmitted to Metro Manila for making major contribution to reduction of consumption of oil.

Long distance power transmission lines of as long as about 800 km are required including crossing of San Bernardino strait by means of submarine cables for transmitting electric power from Tongonan in Leyte to Metro Manila.

The purpose of this study is to examine the technical and economic viability of the Leyte Power Transmission Project based on the agreement concluded by the Prefeasibility study team with "Report for Pre-feasibility Study on the Leyte Power Transmission" and

"Preliminary Feasibility Report on the Leyte Power Transmission Project" by Nippon Koei Co., Ltd. used as references.

The field surveys were implemented on the following items.

(1) Survey of submarine cable route

(2) Survey of sites of converter stations

(3) Survey of electrodes and electrode lines

(4) Survey of route of overhead lines

(5) Survey of sites of radio repeating stations

(6) Data collection

Fig. 1-1 attached hereto indicates the locations of power transmission equipment and facilities which were the object of the study made by the survey team, and Fig. 1-2 is the figure that indicates the scope of equipment and facilities.

Fig. 1-1 LENGTH OF TRANSMISSION LINE AND ELECTRODE LINE (PRELIMINARY)

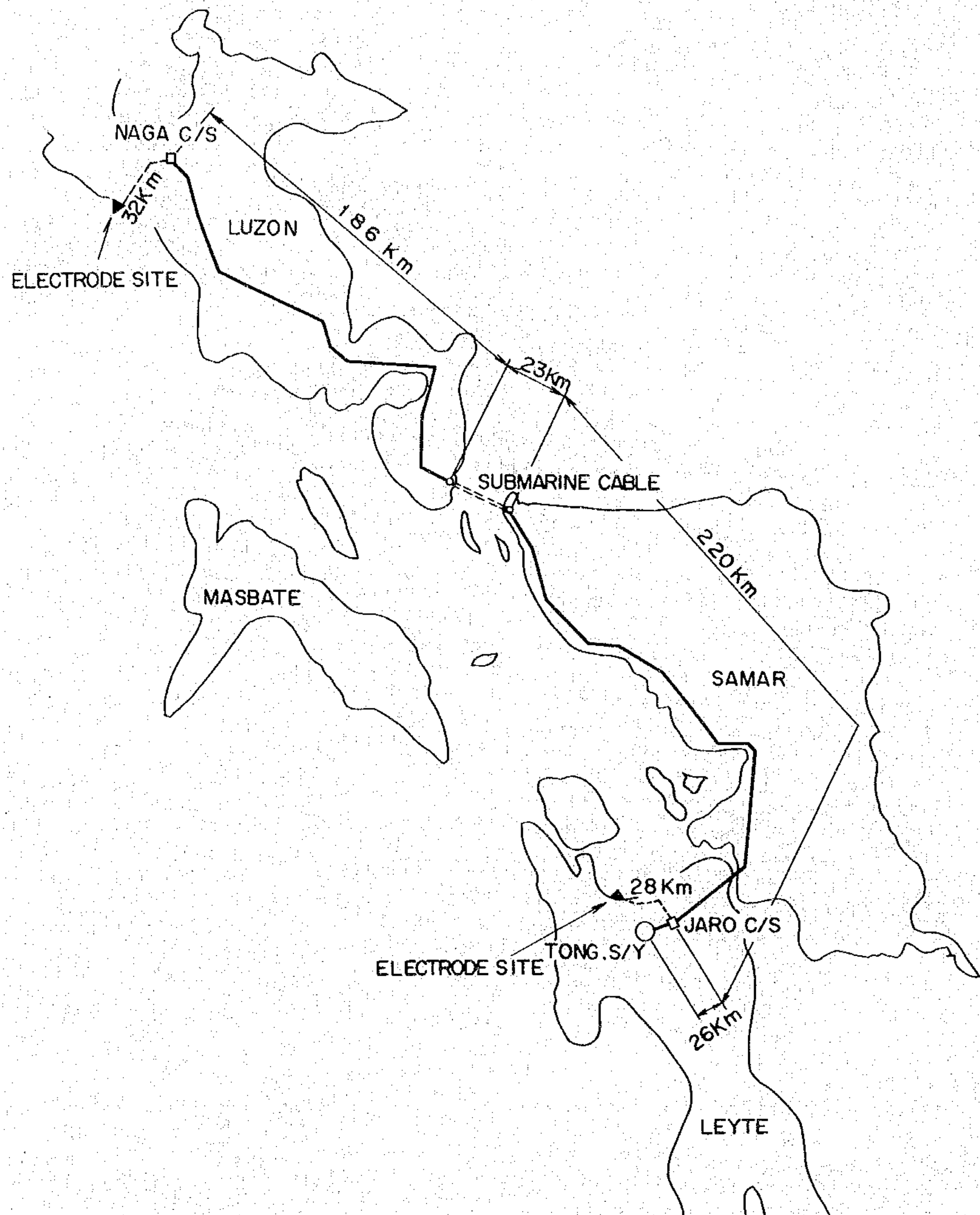
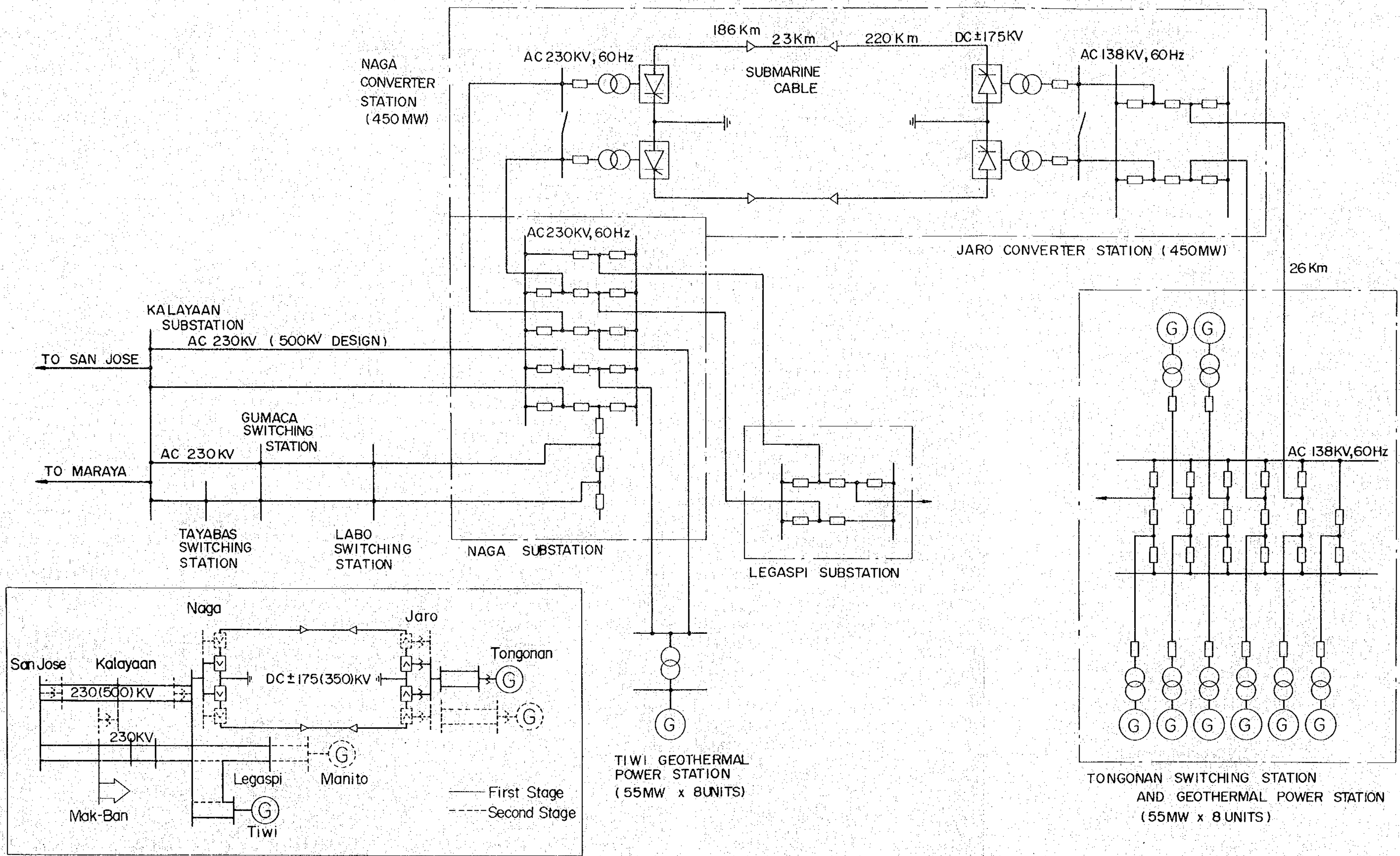


Fig.1-2 SINGLE LINE DIAGRAM OF THE NEIGHBOURING A.C SYSTEM (FIRST STAGE) (PRELIMINARY)



2. OUTLINE OF THE PROJECT

2.1 Leyte Geothermal Power Generation Project and Transmission Power by the Leyte Power Transmission Project

According to the power development plan of NAPOCOR, it is scheduled that 8 units (440 MW) of a geothermal power plant will be developed in 1986, and then 4 units (220 MW) will be added in 1991 and 6 units (330 MW) will be further added in 1992 to 1993. It is scheduled that the electric power generated by these units will be transmitted to the Luzon grid, the largest consumption area of electric power.

Year	No. of Units	Installed Capacity (MW)
1986	8	440
1991	12	660
1992	16	880
1993	18	990 (final)

When #1 - #3 units and pilot plant in Tongonan are added to the above, the total capacity of the entire power generating equipment in the Leyte-Samar grids will be as follows.

Year	Installed Capacity (MW)
1986	587.6
1991	807.5
1992	1,027.5
1993	1,137.5

When the demand for electric power in the Leyte-Samar grid is subtracted from the installed capacity indicated above, the surplus power of this grid is assumed as follows.

Year	Surplus Power of Leyte-Samar Grids (MW)
1986 - 1990	414 - 427
1991	611
1992	807
1993 - 2000	876 - 904

Accordingly, the transmission capacity of the Leyte power transmission project should be matched with this surplus electric power.

2.2 Year of Construction of the Project

The Leyte power transmission lines should be constructed in two stages with the initial equipment capacity of the Tongonan geothermal power plant, final equipment capacity, period of time required for development of power sources and so forth are taken into account. That is, the equipment for 50% of the final equipment capacity are constructed in the first stage, and the equipment for the final equipment capacity are constructed in the second stage.

The year of commencement of operation of the power transmission lines will be 1986 if it is matched with Tongonan geothermal power plant development program. Accordingly, the program for construction of the Leyte power transmission lines is as follows.

	Year	Installed Capacity (MW)
First stage	1986	450
Second Stage (final)	1991	900

2.3 Power Transmission Project

2.3.1 AC Power Transmission and DC Power Transmission

The Leyte power transmission lines for transmitting the electric power generated at Tongonan geothermal power plant should be constructed up to a terminal substation for 500 kV transmission lines to be constructed in the southern Luzon area. The route of these power transmission lines includes the section of submarine cables between Luzon and Samar.

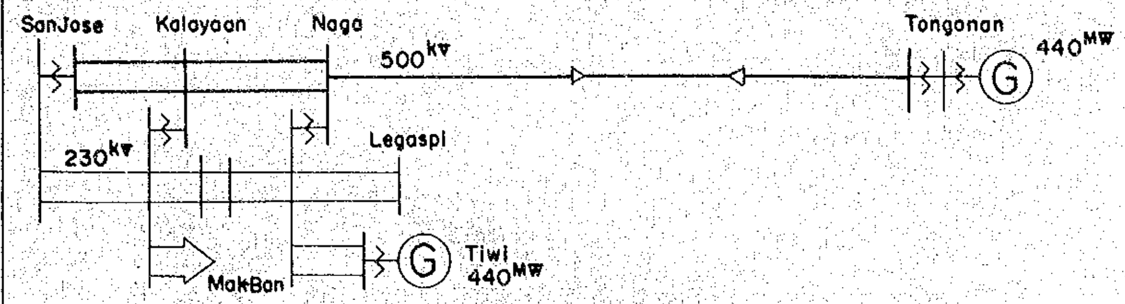
The electric power from Tongonan geothermal power plants will be further transmitted to the San Jose substation located in the heart of demand together with the power generated at the other power plants in southern Luzon such as Tiwi and Manito.

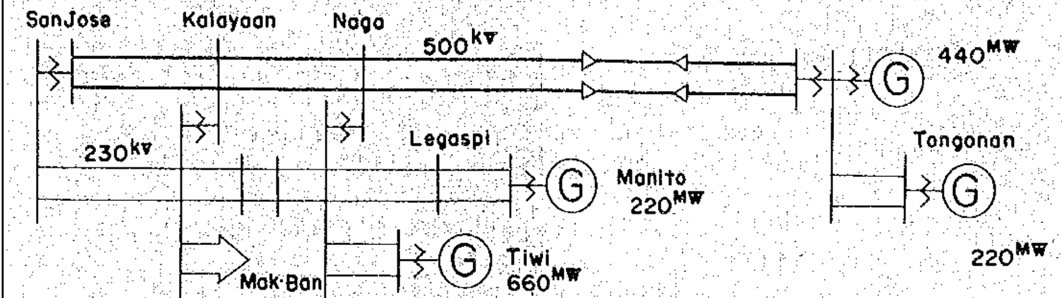
This power transmission project, therefore, is a long distance power transmission lines of about 800 km from Leyte to San Jose.

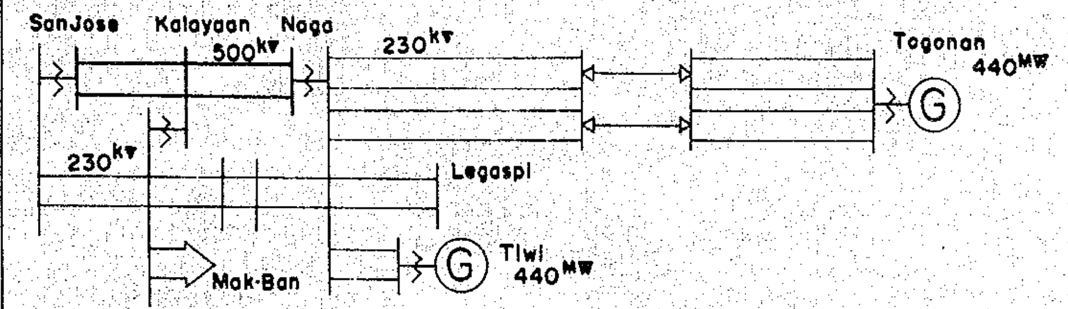
A comparative study of AC power transmission and DC power transmission is made for the Leyte power transmission project. 500 kV and 230 kV were selected for AC power transmission, as they are the voltage levels used or will be used in the Philippines, and ±350 kV was selected based on technical and economic consideration for DC power transmission.

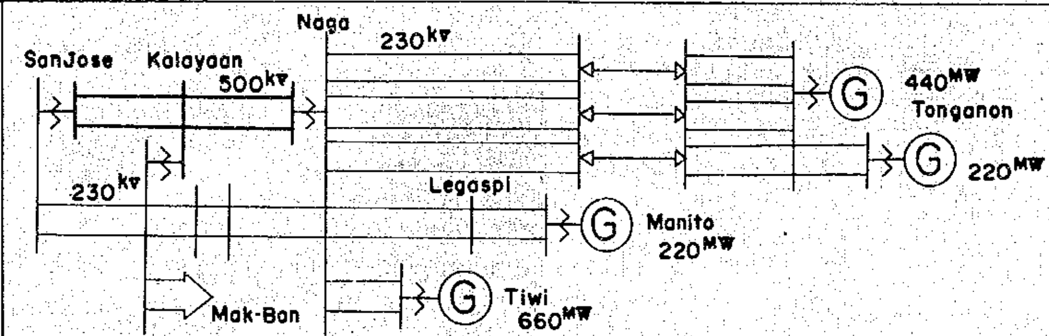
In the comparison of construction cost including the expenses for voltage stepping-up of the Luzon grids, the plan of HVDC power transmission is most advantageous as shown in Table 2.1. With this plan, the size of steel towers for overhead lines and the right-of-way required for each steel tower can be considerably reduced compared with the pattern of AC power transmission, and therefore, it is considered to be more acceptable from the standpoint of social environment. A rough comparison of steel towers and right-of-way is shown in Fig. 2-1.

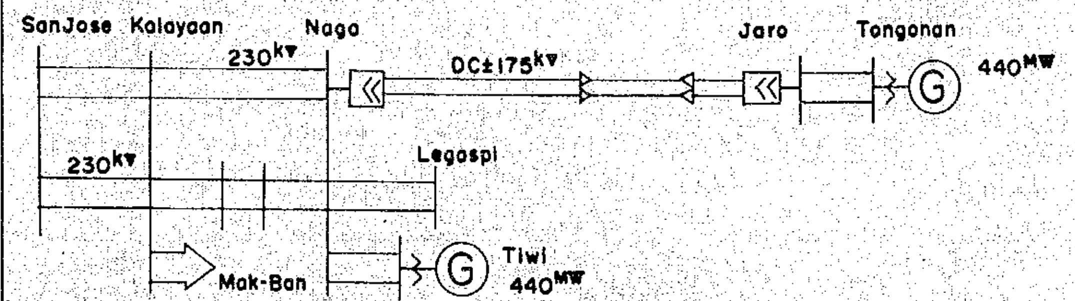
TABLE 2-1 AC · DC ECONOMICAL COMPARISON (DIRECT COST)

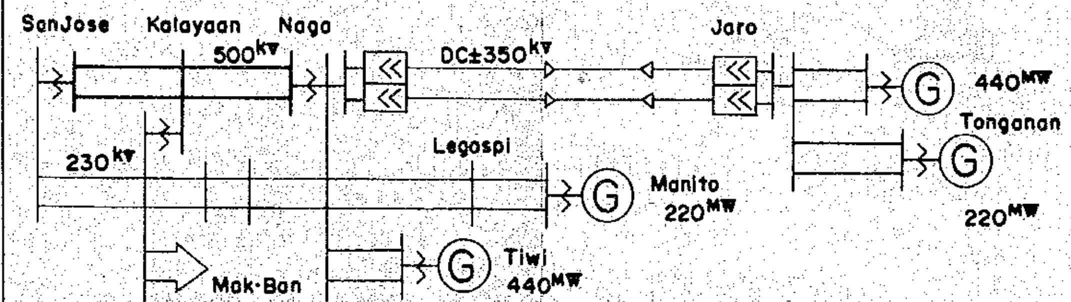
<table>
<tr><th>PLAN</th><th>1ST STAGE (1986)</th><th>2ND STAGE (1991)</th><th>Total Const -ruction Cost △</th></tr>
<tr><td>AC 500kV</td><td>

Construction Cost US $ 419×10^6
• Tongonan~Naga 500kV T/L 1/2cct (including submarine cable)
• SanJose, Kalayaan, Naga, 230kV→ 500kV step up cost</td><td>

Construction Cost US $ 133×10^6 △
• Tongonan~Naga 500kV T/L 1/2cct (including submarine cable)
• Tongonan 138kV T/L 2cct 80km</td><td>US $ 552 ×10^6</td></tr>
<tr><td>AC 230kV</td><td>

Construction Cost US$ 307×10^6
• Tongonan~Naga 230kV T/L 2cct×2route (including submarine cable)
• SanJose, Kalayaan, Naga 230kV→ 500kV step up cost</td><td>

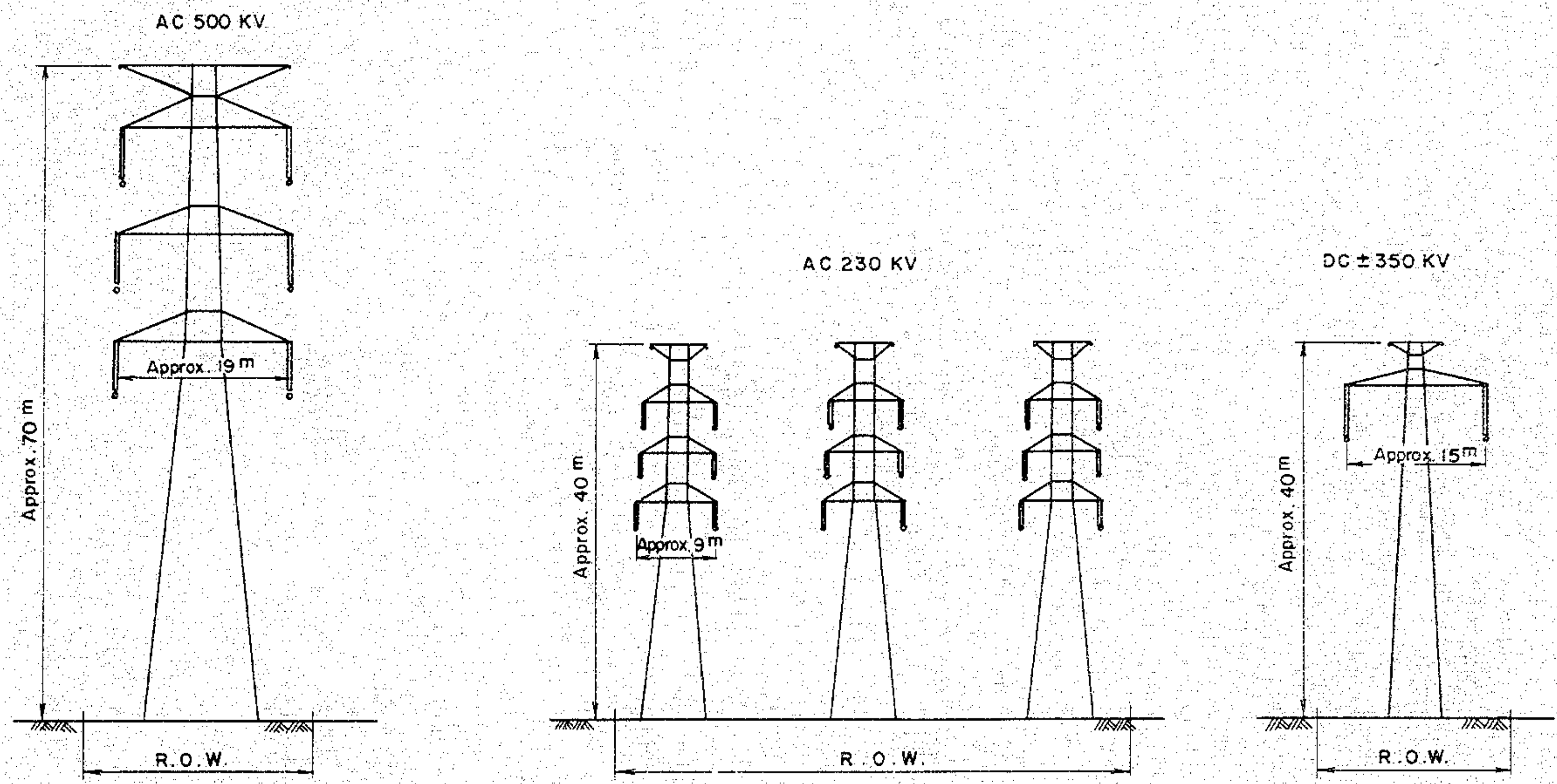
Construction Cost US $ 103×10^6 △
• Tongonan~Naga 230kV T/L 2cct (including submarine cable)
• Tongonan 230kV T/L 2cct 80km</td><td>US $ 410 ×10^6</td></tr>
<tr><td>HVDC ±350kV</td><td>

Construction Cost US$ 213×10^6
• Jaro~Naga HVDC±175kV bipolar system (including submarine cable)
• Tongonan Jaro 138kV T/L 2cct 26km</td><td>

Construction Cost US $ 107×10^6 △
• Jaro~Naga HVDC System DC Voltage ±175kV→ ±350kV
• Tongonan 138kV T/L 2cct 80km
• SanJose, Kalayyaan, Naga 230kV→500kV step up cost</td><td>US $ 320 ×10^6</td></tr>
</table>

Note △ Price in year 1986, Discount rate 10%/year, NO Price escalation.

Fig.2-1 COMPARISON OF R.O.W. OF OVERHEAD TRANSMISSION LINES



As for submarine cables, it is to be noted that 6 cables for 2 circuits are required for 500 kV transmission and 9 cables for 3 circuits are required for 230 kV transmission, while, only 2 cables will be needed for HVDC transmission.

As a result of comparison of the above three alternative plans, it was decided to adopt the HVDC power transmission system, as this is evaluated to be the most advantageous in terms of economy, technology and social environment.

2.3.2 Pattern of HVDC Power Transmission

The following three patterns were compared considering the stages of development of transmission of electric power from geothermal energy in Leyte to the Luzon grids:

Pattern 1 : To construct bipolar 450 MW equipment for transmission of power of 400 MW in 1986, and to expand the equipment to bipolar 900 MW by making series addition of converters in 1991.

Pattern 2 : To construct bipolar equipment for 450 MW in 1986, and to make parallel addition of 450 MW converters in 1991.

Pattern 3 : To construct bipolar equipment for final power transmission capacity of 900 MW from the beginning.

The result of comparative study of three patterns stated above is shown in Table 2-2. It is indicated in this table that all of these patterns have no technical problems and that pattern 1 is the most economical. Therefore, pattern 1 is recommended for the HVDC power transmission.

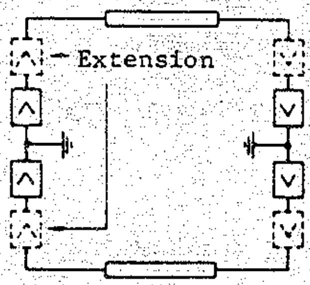
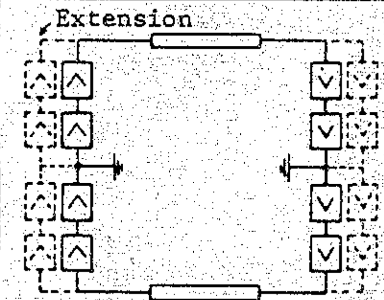
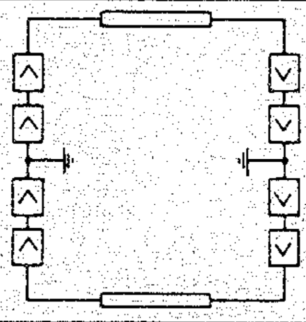
2.3.3 Selection of Voltage and Conductor Size

Selection of voltage and cable size is one of the important factors for designing of the power transmission lines because voltage and conductor size exert a major influence over the economy of the power transmission projected.

There are many comparative parameters for selection of voltage and conductor size, and it was decided to adopt the minimum cost method for the Leyte power transmission project. The voltage and conductor size were selected with total expenses (annual expenses of construction + annual expenses of power loss) compared.

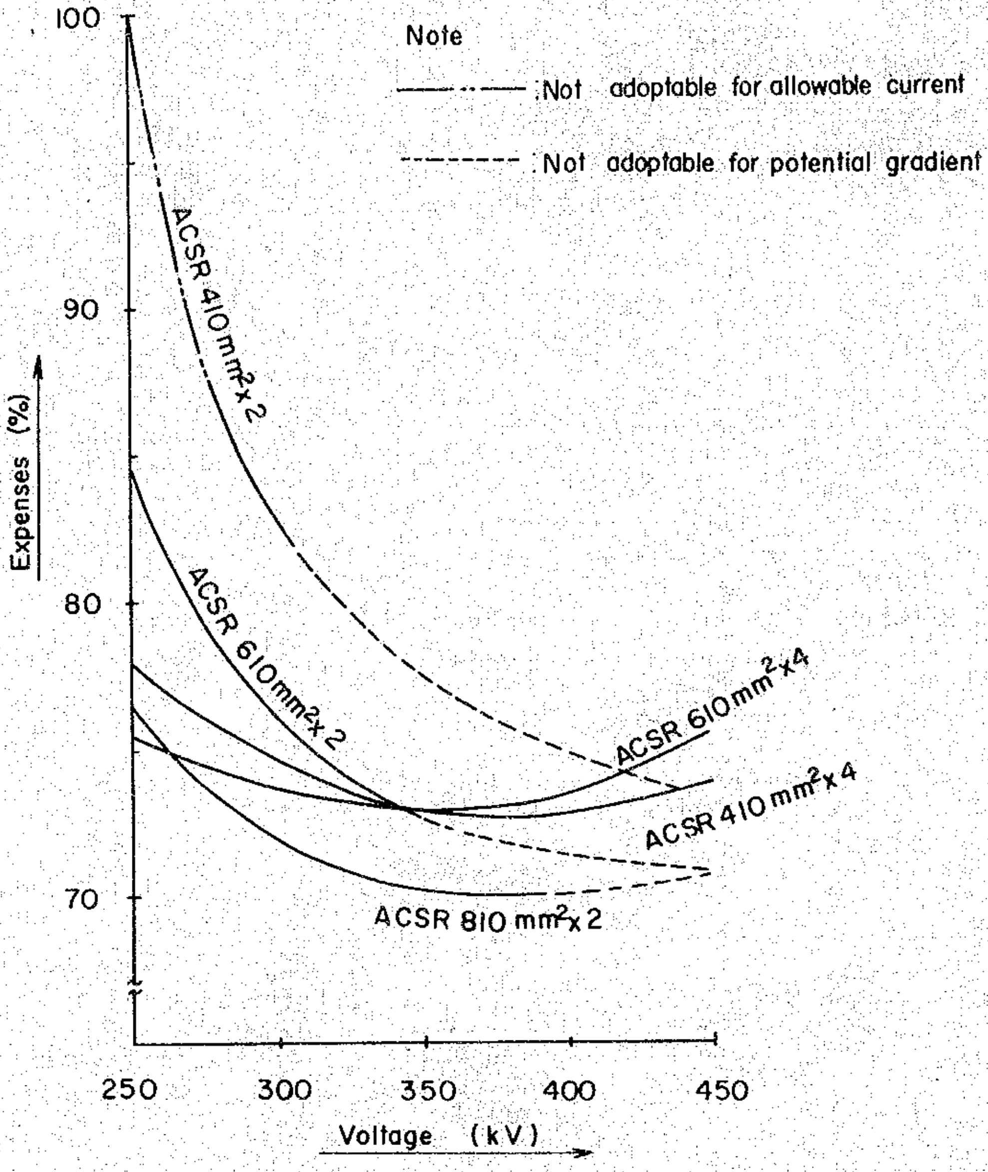
The result of comparison of economy is shown in Fig. 2-2. It is found that conductor size of ACSR 810 mm^2 x 2 and voltage of 350 kV will provide the minimum cost in the total expenses, and because of the fact that the expenses are considered to be within

Table 2 - 2 Comparison of HVDC Patterns

Pattern	HVDC Schemes	Technical Items	Total Construction Cost /1 (%)
1		∘ This extension is common method in the world. ∘ Operates in 6-pulse during the other pole's failure.	100
2		∘ Parallel extension means new technology of multi-terminal HVDC System, and can be adopted for this project.	115
3		∘ No additional work	110

Note: /1 Price in year 1986. Discount rate 10%. No price escalation.

Fig. 2-2 Comparison of Expenses on Voltages and Conductors



the most economical range of this project, the voltage of 350 kV and conductor size of ACSR 810 mm^2, 2-conductor were determined.

2.4 HVDC System

(1) Transmission Section (Refer to Fig. 1-1)

Transmission Line

Transmission Section	Voltage Rating	Length (km)
Tongonan S/Y - Jaro C/S	AC 138 kV Overhead Line	26
Jaro C/S - Cable Head in Samar	DC ±350 kV Overhead Line	220
San Bernardino Strait	DC ±350 kV Submarine Cable	23
Cable Head in Luzon - Naga C/S	DC ±350 kV Overhead Line	186
Naga C/S - Naga S/S	AC 230 kV Bus	Short Distance (Same place)
Total Line Length (km)		455

Electrode Line

Section	Length (km)
Jaro C/S - Managasnas Electrode	28
Naga C/S - Pasacao Electrode	32
Total Line Length (km)	60

(2) Transmitting Capacity

Transmission Section	Voltage	Transmitting Capacity
Tongonan S/Y - Jaro C/S	AC, 138 kV	440 MW
Jaro C/S - Naga C/S	First Stage DC±175 kV	450 MW
	Final Stage DC±350 kV	900 MW

(3) Transmission Method

a) Tongonan S/Y - Jaro C/S   AC, 2 cct, transmission

b) Jaro C/S - Naga C/S   Bipolar, 1 cct, transmission

(4) Main Circuit Diagram (Refer to Fig. 2-3)

(5) Method of Grounding Main Circuit

a) AC system   Neutral point directly earthed

b) DC system   Both neutral points earthed through electrode lines

(6) Transmission Line

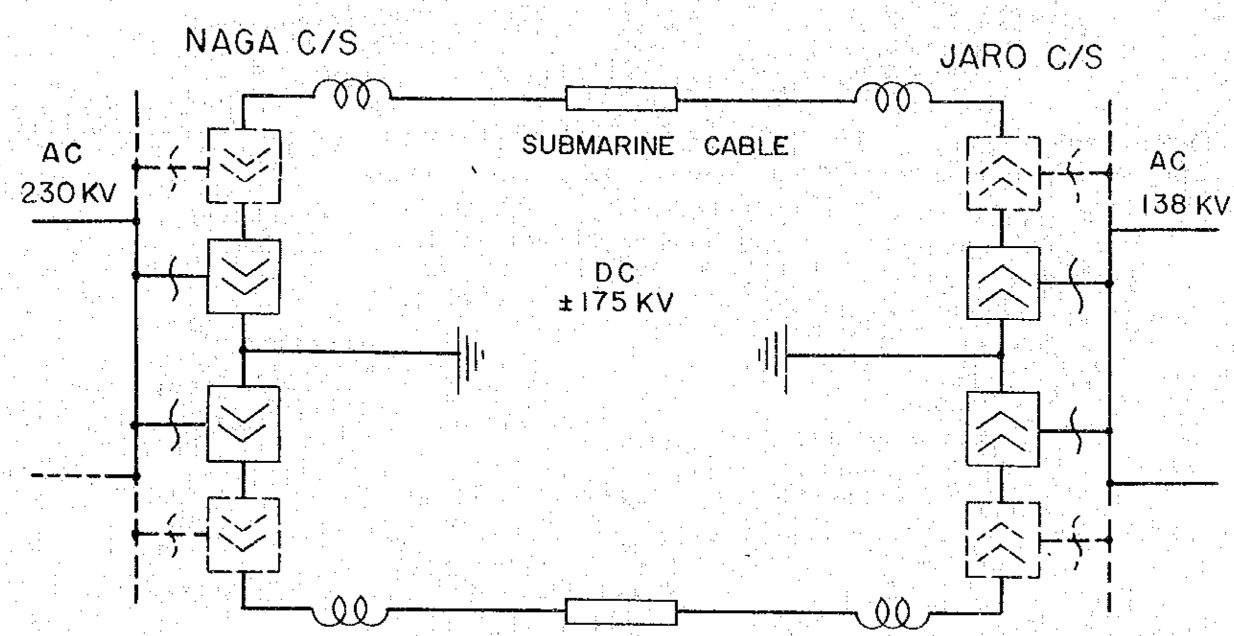
a) AC Transmission line
(Tongonan S/Y - Jaro C/S)

Voltage, frequency : AC 138 kV, 60 Hz

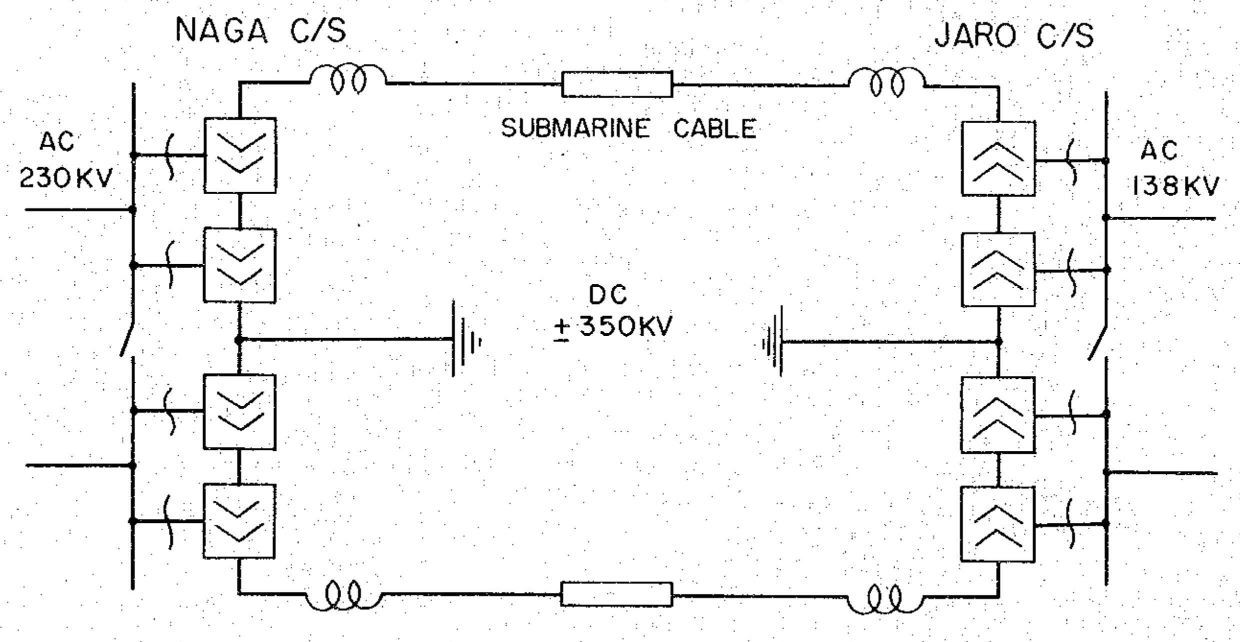
Overhead line : ACSR 610 mm^2 x 2, 2 cct.

Fig. 2-3 MAIN CIRCUIT DIAGRAM (PRELIMINARY)

(a) FIRST STAGE (450MW)



(b) FINAL STAGE (900MW)



b) DC Transmission line
(Jaro C/S – Naga C/S)

Voltage : First Stage DC±175 kV

Final Stage DC±350 kV

Overhead line : Main Conductor, ACSR 810 mm^2 x 2, and AACSR 520 mm^2 x 2 for the Sun Juanico strait crossing

Electrode line ACSR 410 mm^2 x 2

Submarine cable: OF 1000 mm^2, 2 Cables

(7) Converter Station

a) Thyristor valve

First Stage : DC±175 kV, 450 MW, (225 MW x 2)

Final Stage : DC±350 kV, 900 MW, (225 MW x 4)

b) Reactive power supply method

Jaro converter station : Supply of reactive power by means of Tongonan generators and AC filters.

Naga converter station : Supply of reactive power by means of AC filters and var compensators.

2.5 Preliminary Design

(1) Criteria of preliminary design

- Bipolar configuration was adopted at the beginning of the first stage, with maintenance of supply reliability and influence over linked AC system equipment taken into account. Furthermore, it was decided to adopt the series expansion in the second stage considering ease of maintenance and expansion, construction cost and so forth. (Fig. 2-3)
- With Jaro converter station as the main control station, bi-directional transmission can be made possible by constant power control. However, sufficient short-circuit capacity is required for the bus bar of converter stations.
- Operation with sufficient harmony with the Tongonan power plant is required.

(2) DC power transmission lines

(a) Overhead lines

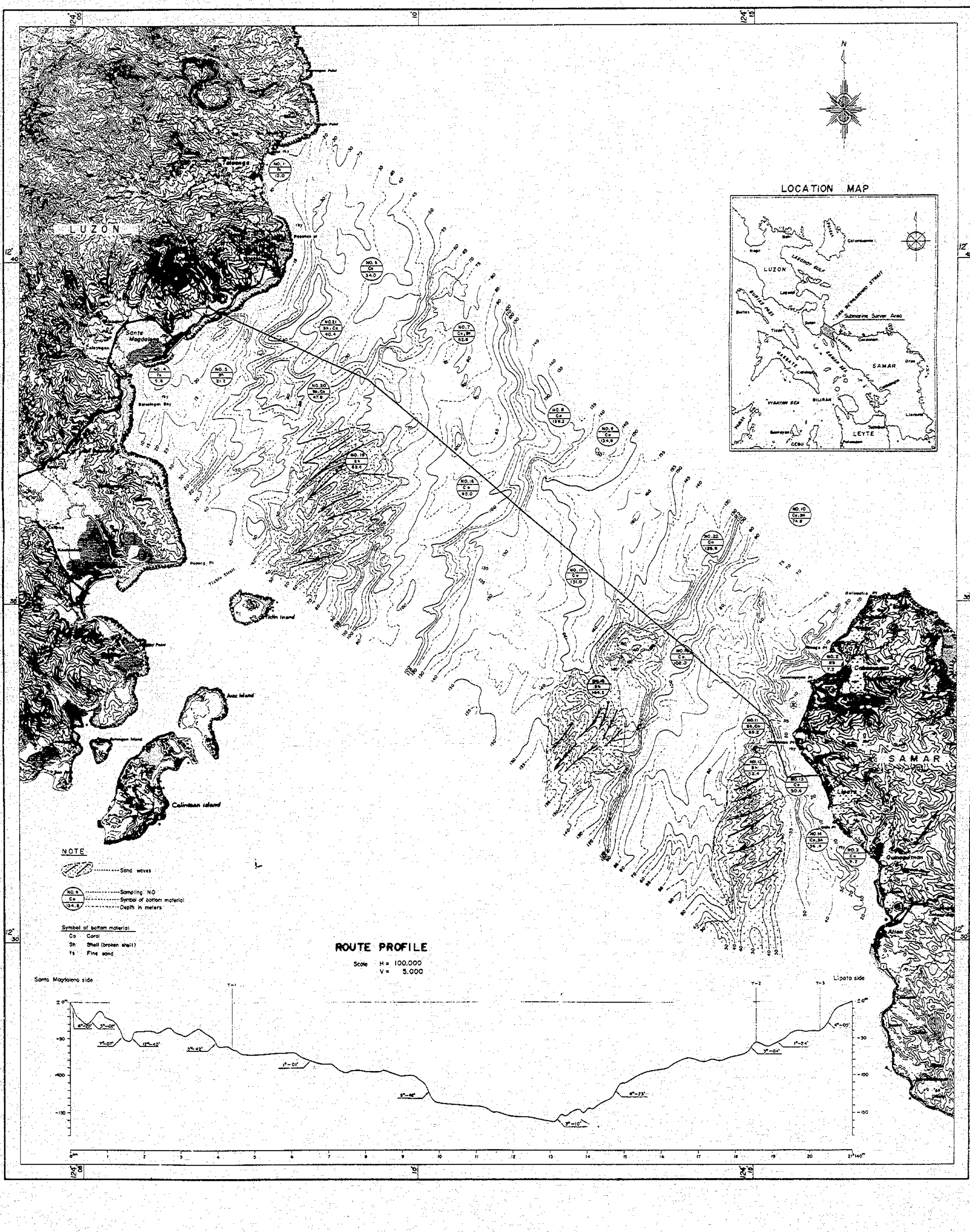
- The places where the transmission lines pass through are close to coastlines and are subjected to the effect of typhoons salt contamination. Therefore, thorough consideration was made against salt contamination, and it was decided to use fog type insulators with anti-corrosion sleeve.

- It was determined to use steel towers as supporting structure with reliability, mechanical strength and so forth taken into account.
- In the section of the San Juanico straigh crossing, cost reduction is intended with lower steel tower by increasing conductor strength. The conductor size (AACSR 520 mm^2 x 2) was determined with due allowable current and noise interference.

(b) Submarine cables

- The cable route was determined from the result of field surrey. (Fig. 2-4)
- OF cables were selected for the submarine cables considering with reliability and other relevant factor. The conductor size of 1,000 mm^2 is selected to match the transmission capacity.
- The stationary type oil feeding equipment was adopted with cost of maintenance taken into account. It was planned to monitor abnormal oil pressure at a converter station through telecommunication lines.

Fig. 2-4 PLAN AND PROFILE OF SUBMARINE CABLE ROUTE IN THE SAN BERNARDINO STRAIT
(LUZON - SAMAR)



(c) Electrodes and electrode lines

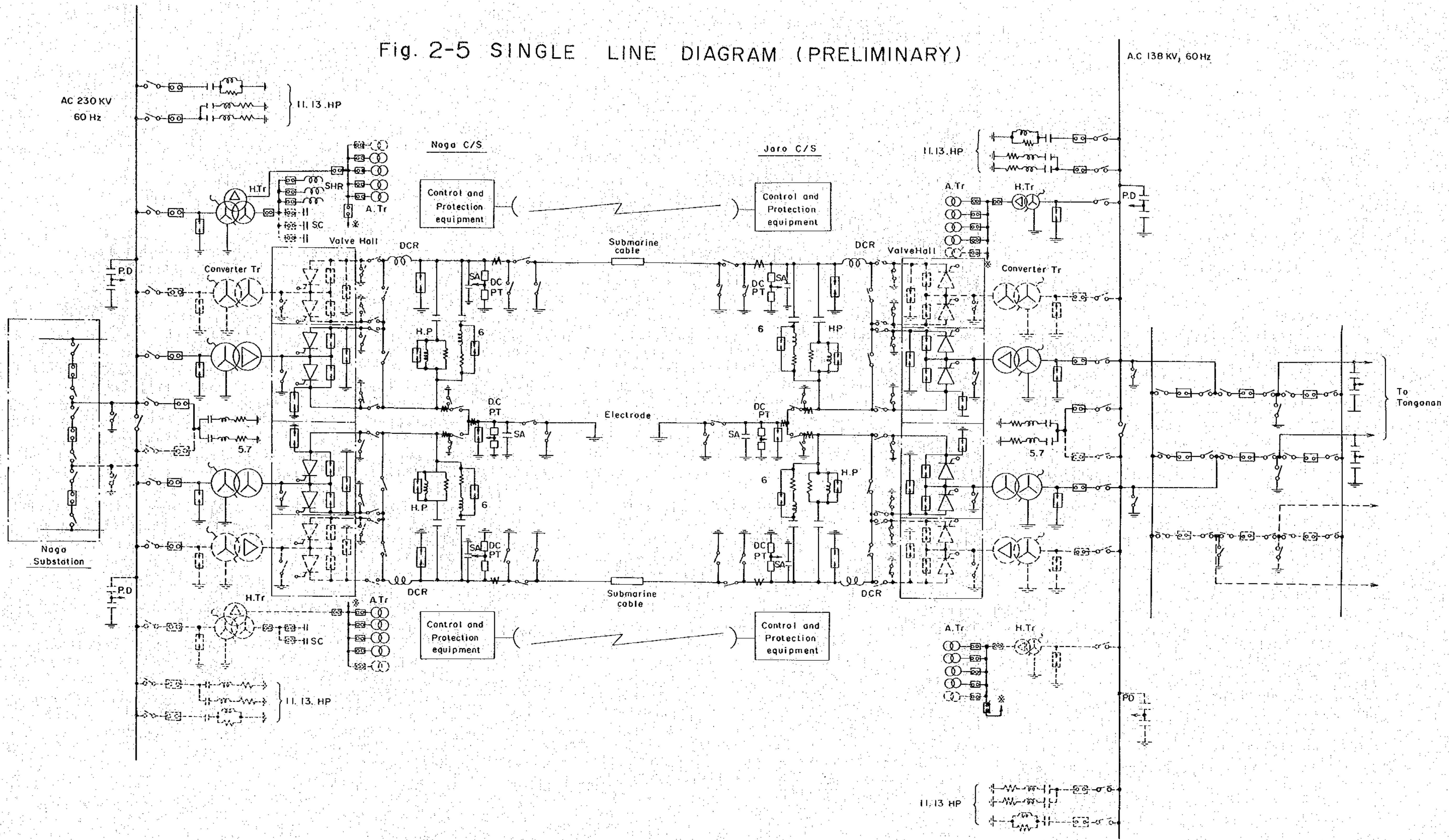
- Electrode sites were studied with its effect on the environment taken into account, and it was decided to install electrodes at the seashore. Graphite is used as electrodes, which will have the capacity that permits continuous flow of DC 1,290 A.
- The size (ACSR 410 mm^2 x 2) of electrode line conductor was determined from the operating current and transmission loss. Wooden poles are used as supporting structure near the electrodes from the standpoint of electrolytic corrosion, and steel poles are used at other places from the standpoint of reliability.

(3) Converter stations

(a) Single line diagram of DC system (Fig. 2-5)

- 12-pulse operation was selected as the basic pattern of operation of converters. However, because bipolar configuration is planned at the beginning of the first stage, the equipment should permit 6-pulse operation during the other one pole failure. Therefore, it was decided to install AC filters of 5th and 7th in addition to 11th, 13th and High-pass branches and to install DC filters of 6th in addition to High-pass branch.

Fig. 2-5 SINGLE LINE DIAGRAM (PRELIMINARY)



- It is planned that a number of AC transmission lines will be come in and out of the Jaro converter station in the future and a configuration of combining a switching station and a converter station was adopted for the Jaro converter station.
- It was decided to apply thyrister valves for the main equipment of converters, and air-insulated, air-cooled type was adopted with ease of maintenance taken into account.
- AC filters (first stage: about 135 MVA, second stage: about 225 MVA) and Tongonan generators for VAR compensation are used for Jaro side. AC filters (same as those of Jaro side) and VAR compensators are used on Naga side, as the reactive power supply equipment required for converters.
- Harmonics generated from converters will be absorbed by AC filters and DC filters, and harmonics that may flow out to the transmission lines will be minimized.
- Block and restart of DC power will be made for maintaining supply reliability on occurrence of ground fault of DC overhead lines.

(b) Layout (Fig. 2-6 and 2-7)

- The site of the converting station is about 62,000 m^2 and about 65,000 m^2 for Jaro C/S and Naga C/S to cover both first and second stage, respectively.
- The layout is separated by the unit of a pole in the equipment layout, from the standpoint of operation and maintenance.
- A shielded valve hall will be provided for accommodation of valves.

(4) Telecommunication system

For operation of the DC power transmission system, high speed transmission of large quantity of data of various kinds are required for control and protection between Jaro converter station and Naga converter station and also between Jaro converter station and Tongonan switching station. Furthermore, emergency telephone for stations and telephone for maintenance of transmission lines are required. As the distance between Naga C/S and Tongonan S/Y through Jaro C/S is as long as about 500 km, microwave radio system which is of high reliability and which permits transfer of data of large quantity is most suitable as the means of telecommunication which permits sure and stable transfer of important data over such a long distance. It is also advantageous from the economical viewpoint.

Fig.2-6 LAYOUT OF JARO CONVERTER STATION (FIRST STAGE)

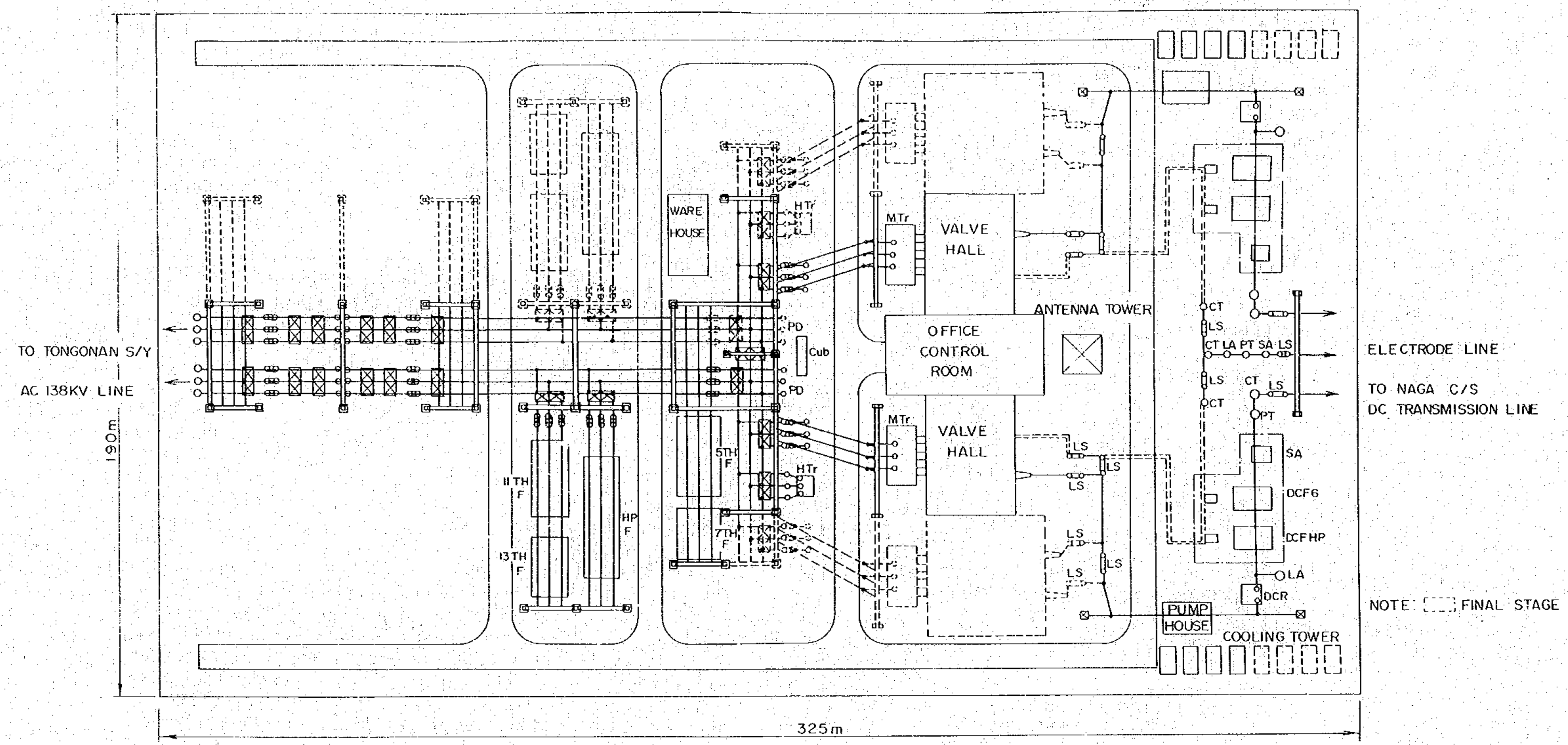
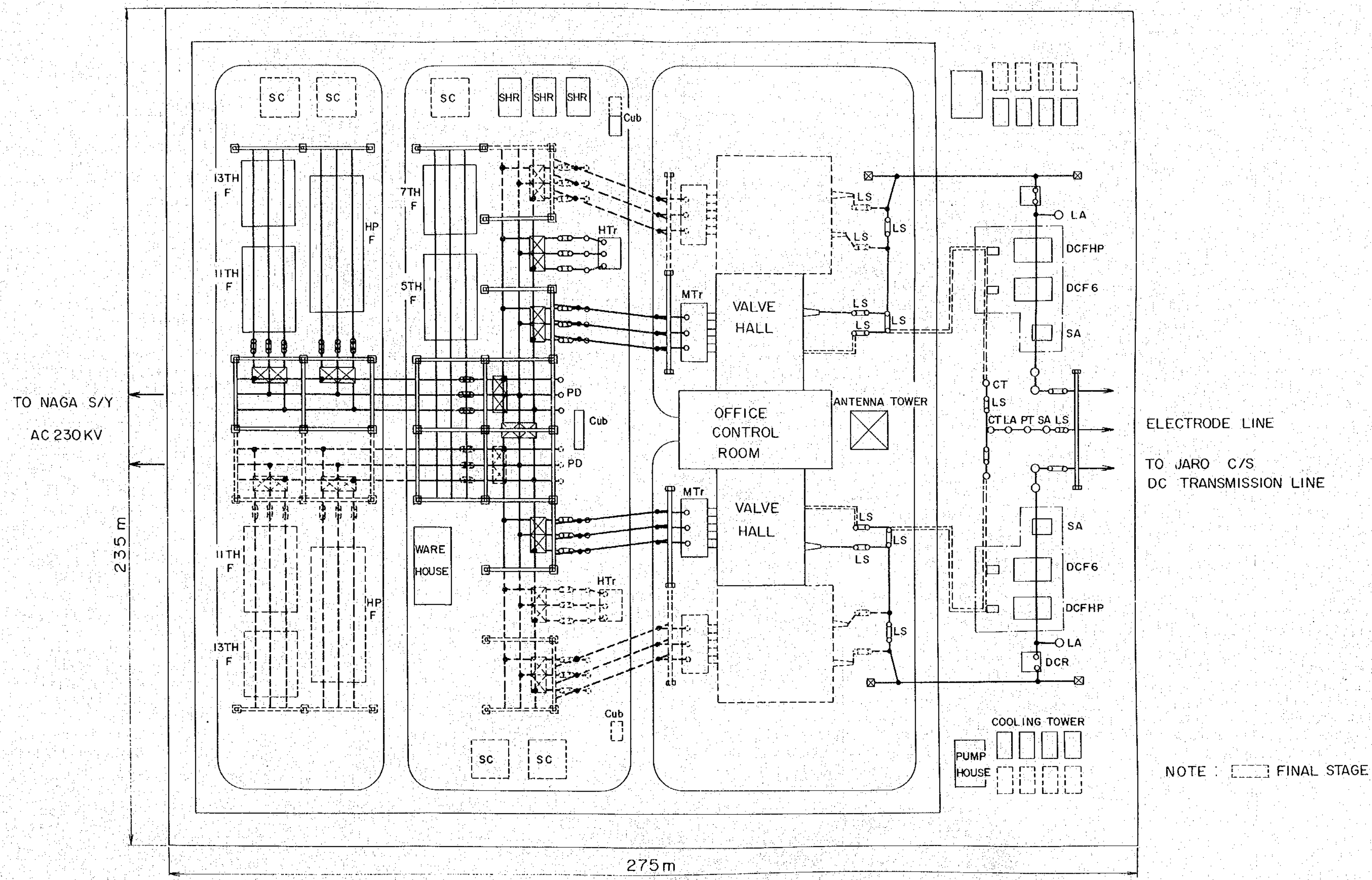


Fig.2-7 LAYOUT OF NAGA CONVERTER STATION (FIRST STAGE)



Accordingly, the telecommunication system of this project will be constituted by this system. (Fig. 2-8)
The load dispatching data transfer system between the central load dispatching center and Jaro C/S and Tongonan Power Station as well as the control, protection and supervisory data transfer system between Tongonan P/S and Tongonan S/Y are required for the Leyte power transmission project are are not included in this project, as they are included in the load dispatching project and Tongonan geothermal power plant development project planned by NAPOCOR.

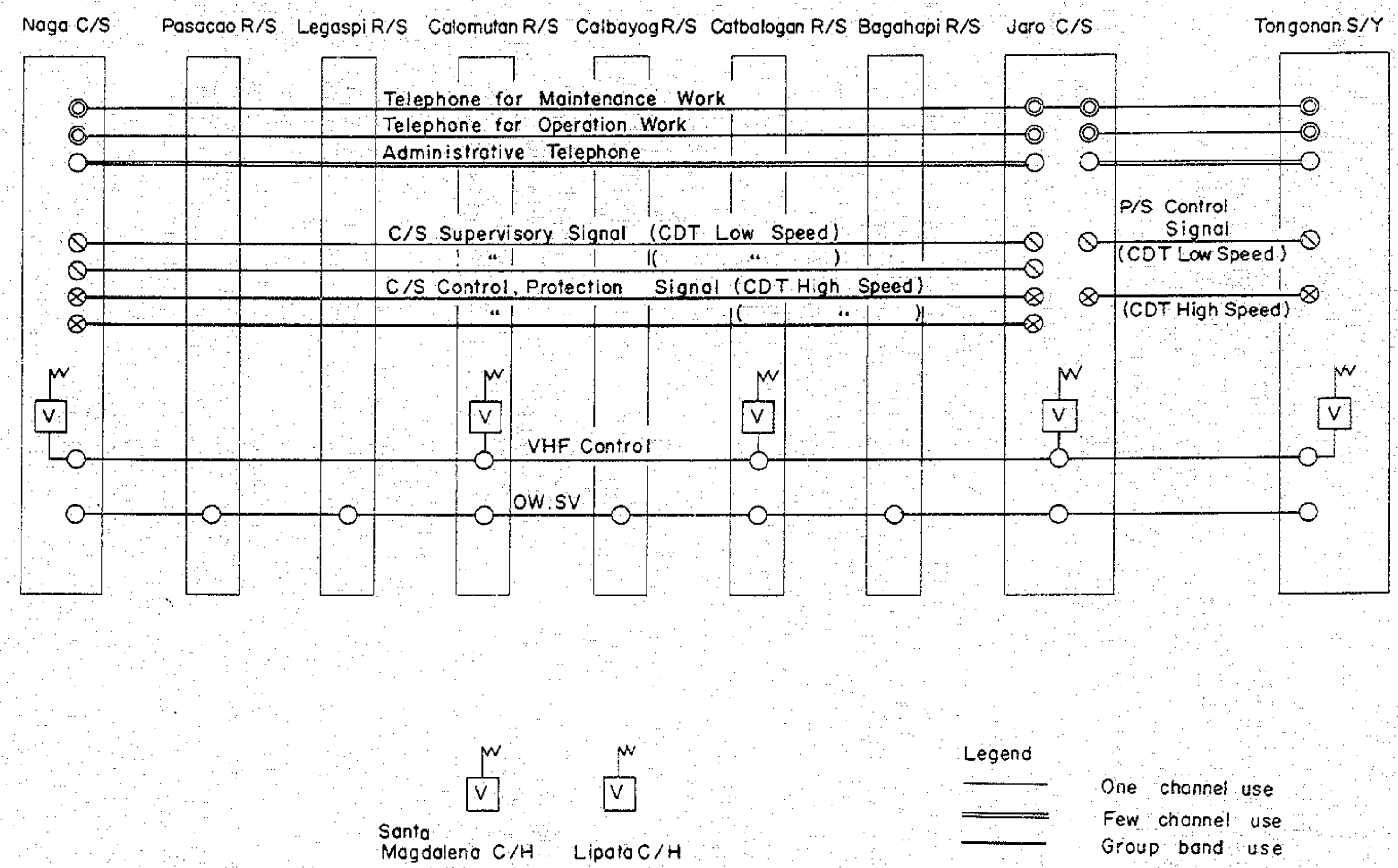
2.6 System Analysis

In order to transmit stably the electric power generated in Leyte geothermal power plants to the Luzon grids, power flow and voltage fluctuation in steady state of the systems linked by HVDC and stability on occurrence of a ground fault on transmission lines were examined.

For transmission of the Leyte geothermal power through the HVDC system, there is no essential problem in the stability of synchronized operation between the Leyte thermal power and the Luzon grid because of non-syncronized linkage by HVDC.

The Naga station, which is the receiving end of this HVDC system, is located on the sending end of the EHV 500 kV power transmission

Fig. 2 - 8 TELECOMMUNICATION CIRCUIT (Preliminary)



system for transmitting Tiwi and Manito geothermal power from the southern part of the Luzon.

The Leyte geothermal power, therefore, is transmitted through EHV 500 kV (230 kV) system for a distance of about 300 km up to San Jose through Kalayaan, together with the power from Tiwi and Manito.

Accordingly, the electric power transmitted by the HVDC system is determined by the stability of the suthern Luzon system such as Tiwi and Manito.

As a result of system analysis, it was found out that it will be possible to transmit stably the power of 400 MW in 1986 and 900 MW in 1993 by means of the HVDC system, if countermeasures for improvement of stability are taken for Tiwi, Manito, etc.

(1) Transmission of 400 MW of 1986 in the first stage by the HVDC system can be made without any problem with the system configuration being planned by NAPOCOR.
Operation at 230 kV is sufficient for EHV 500 kV designed transmission lines between San Jose, Kalayaan and Naga.

(2) At the time of transmission of 600 MW in 1991 of the second stage, about 1,400 MW from power sources including 600 MW from Tiwi and 200 MW from Manito in addition to 600 MW from

Leyte will be transmitted from southern part of Luzon to Kalayaan and San Jose. From the standpoint of stability, therefore, it is necessary to step up the operating voltage of 500 kV designed transmission lines to 500 kV by 1991.

(3) In order to improve the stability on occurrence of faults in Tiwi and Manito Power Plants, it is desirable to install PSS (power system stabilizers) in all generators of Tiwi, Manito, Mak-Ban and Calaca Coal power plants. At least, Tiwi and Manito power plants which are to be commenced in the future, should be equipped with ultra rapid response AVR with PSS.

(4) New power plants which are to be constructed in the future, other than Tiwi, Manito and Mak-Ban should be equipped with PSS as far as possible.
It is because, when PSS is installed from the beginning, its costs is almost negligible compared with the cost of the generator itself and also because its effect in improvement of stability is large in general. Tongonan can be regarded as an individual power source for some time, and there is no problem of stability. Therefore, no PSS is required for it.

(5) The control of the HVDC system is in steady state and also when any fault occurs it should be thoroughly harmonized with the Leyte geothermal power plants in steady and transient state, so that the frequency fluctuation and voltage fluctuation of the Leyte-Samar system are within the levels which are allowable to the Leyte geothermal power source.

In the stage of detailed design of the project, therefore, examination should be made so that sufficient harmony with the characteristics of AVR, governors and protective devices of the Leyte geothermal power source is obtained.

(6) Provisions should be made so that it is possible to link the Leyte-Samar system and the HVDC system at the Tongonan switching station. As a result, it will become possible to commonly use the reserve power by the Luzon system and the Leyte-Samar system, and it will become possible to make effective use of the surplus geothermal power of the Leyte-Samar system.

(7) Continuation of operation or abolitiion of oil thermal power plants in and around Manila should be closely examined with examination as reserve power during scheduled outage for maintenance or on occurrence of forced outage of large unit capacity power plants such as nuclear (620 MW) and coal

thermal (300 MW) power plants and the Leyte HVDC system. Also thorough examination made regarding power flow and voltage fluctuation of the systems during steady state and transient state due to faults.

It is probably necessary to suitably operate these oil thermal power plants as measures against overloading of power transmission lines and voltage drop of 115 kV system in particular, until such measures are suitably taken.

(8) The short-circuit capacity of the Luzon, Leyte, Samar, EHV system is around 5,000 MVA at maximum in 1993.

The short-circuit capacity of Naga C/S 230 kV bus bar and Jaro C/S 138 kV bus bar are 3,600 MVA and 1,900 MVA respectively.

3. Construction Cost and Schedule

The construction cost of this project has been estimated based on labor charges and machines and material prices as of March 1981 and in consideration of natural conditions of the overhead transmission lines on the land, submarine cable route and positions of the high steel towers for crossing the straits, and local conditions of the scheduled substations, electrodes, electrode lines and microwave repeating stations.

The construction cost is divided into two categories, the Philippine Pesos and foreign currency. The Peso was used in calculating labor charges and material prices that are available in the Philippines and the foreign currency calculation is applied to others not available in the country.

The estimated total construction cost based on the March 1981 is as follows:

Construction Cost for Each Stage Based on the Price in March 1981

Unit: US$

	F.C.	D.C.	Total
First Stage	185,365,000	67,502,000	252,867,000
Second Stage	86,923,000	21,795,000	108,718,000
Total	272,288,000	89,297,000	361,585,000

If the construction cost is recalculated based on price escalation until the scheduled project completion years depending on the table below, the estimated total construction cost is as follows:

Construction Cost for Each Stage
Including Price Escalation

Unit: US$

First Stage	Second Stage	Total
352,425,000	233,584	586,009,000

Annual Escalation Rate

	F.C.	D.C.
1981	10%	15%
1982	9	15
1983	8	15
1984	7	15
1985	7	15
⋮	⋮	⋮

Table 3-1 shows the details of the construction cost. The indirect cost in Table 3-1 consists of interests during the construction period, contingency, NAPOCOR's administrative expenses, training expenses and consultants' technical fees.

Coping with the scheduled completion years of this project (by 1985 end for the first stage and by 1990 for the second stage), 45 months and 36 months are scheduled for the first and second stage respectively covering all stages from preparation of procurement and specifications inclusive of detailed designs up to completion of the construction. Extremely careful construction stage management is required in constructing converter stations during the first stage since it involves concurrent heavy work of civil engineering, building construction and electrical work and these must progress without interrupting each work mutually. The land for each particular converter station should be procured by NAPOCOR under its responsibility before starting the construction.

(Fig. 3-1, Fig. 3-2)

It is also to be noted that detailed surveys must be conducted on submarine cable installation routes, cable terminal points and electrode sites, and locations of these points, cable type and electrode type must be determined before the construction contracts are concluded.

Table 3-1 Construction Cost

Unit : 1,000 U.S. dollars

Item	Construction cost						Total construction cost (1st & 2nd)		
	First stage			Second stage					
	F.C.	D.C.	Total	F.C.	D.C.	Total	F.C.	D.C.	Total
– Converter stations									
Jaro C/S	37,528	8,113	45,641	29,471	4,123	33,594	66,999	12,236	79,235
Naga C/S	39,935	7,533	47,468	32,790	4,180	36,970	72,725	11,713	84,438
Sub Total	77,463	15,646	93,109	62,261	8,303	70,564	139,724	23,949	163,673
– Transmission lines									
DC ± 350 kV overhead T/L	43,673	27,538	71,211	–	–	–	43,673	27,538	71,211
DC ± 350 kV submarine cable	29,563	524	30,087	–	–	–	29,563	524	30,087
AC 138 kV overhead T/L	4,086	2,005	6,091	14,439	7,088	21,527	18,525	9,093	27,618
Electrode & electrode lines	1,844	1,537	3,381	–	–	–	1,844	1,537	3,381
Sub Total	79,166	31,604	110,770	14,439	7,088	21,527	93,605	38,692	132,297
– Telecommunication facility	5,462	729	6,191	–	–	–	5,462	729	6,191
– Temporary facility & others	–	809	809	–	209	209	–	1,018	1,018
Total of direct cost	162,091	48,788	210,879	76,700	15,600	92,300	238,791	64,388	303,179
– Indirect cost	23,274	18,714	41,988	10,223	6,195	16,418	33,497	24,909	58,406
Total construction cost	185,365	67,502	252,867	86,923	26,795	108,718	272,288	89,297	361,585
Escalation	57,893	41,665	99,558	73,703	51,163	124,866	131,596	92,828	224,424
Grand total	243,258	109,167	352,425	160,626	72,958	233,584	403,884	182,125	586,009