REPUBLIC OF THE PHILIPPINES

REPORT ON INTERCONNECTED TRANSMISSION LINE AND SUBMARINE CABLE PROJECT IN THE VISAYAS

(SUMMARY)

VOLUME I

SEPTEMBER 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

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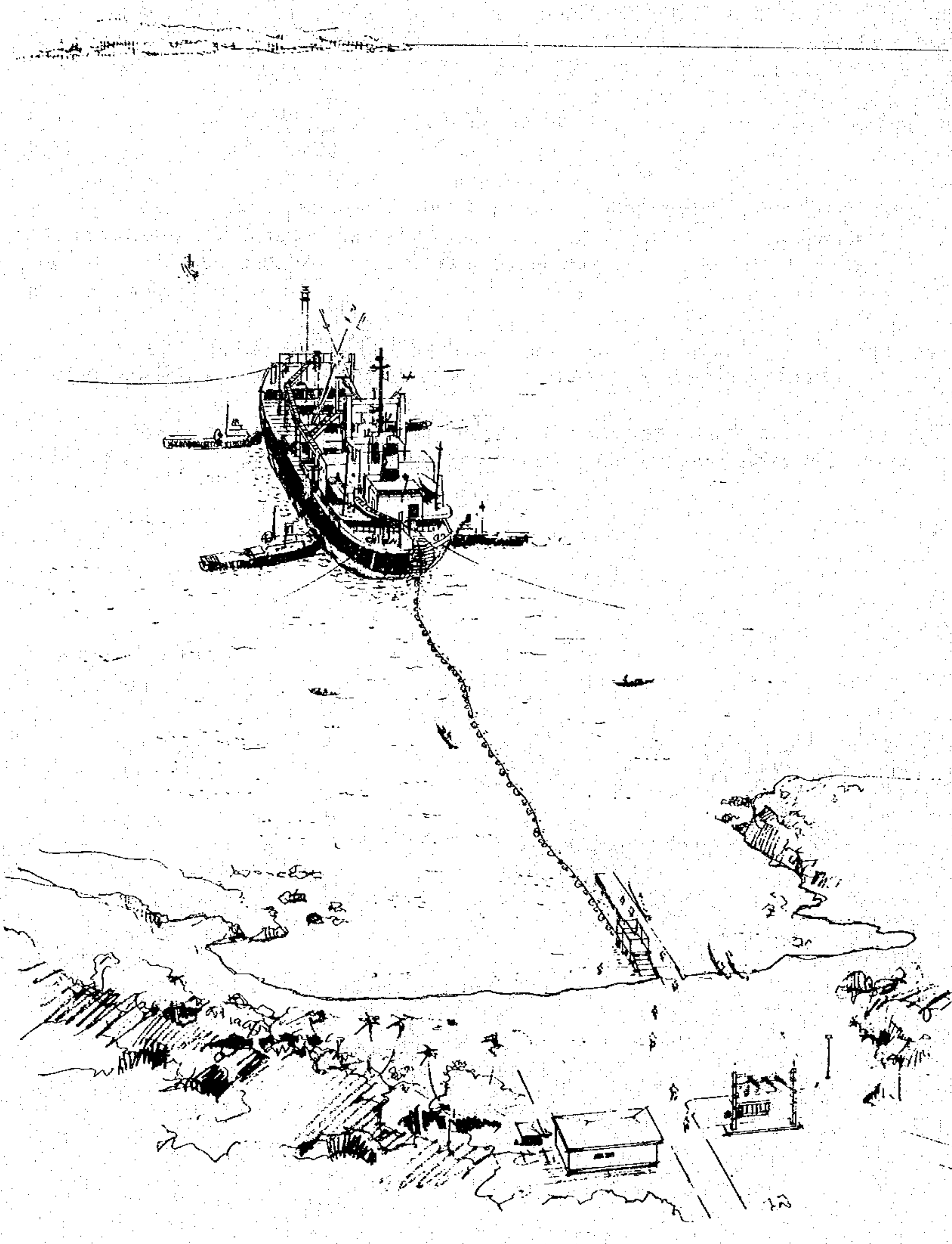
Artist's Imaginary View of Landing Point for 138 kV Submarine Cable



PREFACE

In response to the request of the Government of the Republic of the Philippines, the Japanese Government decided to conduct a feasibility study on the Interconnected Transmission Line and Submarine Cable Project in VISAYAS and entrusted the Japan International Cooperation Agency (J.I.C.A.) with the study. The J.I.C.A. sent to the Republic of the Philippines a survey team headed by Mr. Toshiro Wakamori from January 10 to March 9, 1980.

The team had discussions with the officials concerned of the Government of the Republic of the Philippines and conducted a field survey in the Visayas area. 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.

September, 1980

Japan International Cooperation Agency

SUMMARY

This Report summarizes the essential points of the results of investigation and study given in "Feasibility Report on Interconnected transmission Line and Submarine cable project for Visayas Region in the Philippines" 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 report concerning the Project consist of the three volumes below.

Volume I : Summary
Volume II : Main Report
Volume III : Appendix

September, 1980

T. Wakamori

Toshiro Wakamori, Chief
Survey Team for
Feasibility Report on Interconnected
Transmission Line and Submarine
Cable Project for Visayas Region
in the Philippines

CONTENTS

1. OBJECTIVE AND SCOPE OF STUDY

The Visayas Region of the Republic of the Philippines consists mainly of six principal islands at the central part of the country. The population in 1978 was 10,230,000 (22.1% of the total Philippine population) and the region plays an important role in the economic activities of the country. The growth rate in electric power demand in the most recent years has been high at an annual average of 14%.

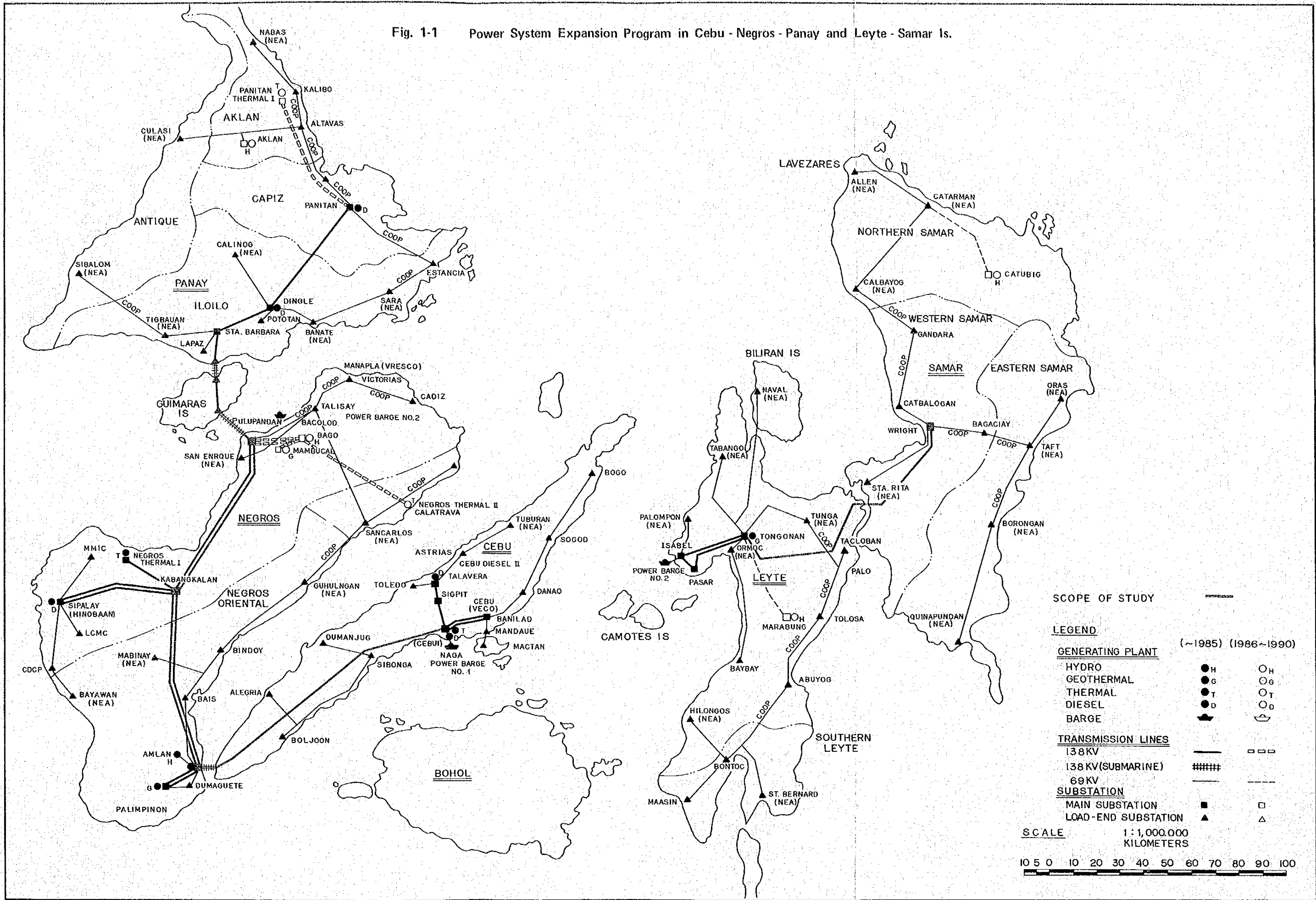
National Power Corporation (NAPOCOR) possessed only two hydroelectric power plants with a total installed capacity of 2.0 MW in this region up to 1976, but completed a total of 90.7 MW of new power generating facilities in the 3 year period from 1977 through 1979. The breakdown in this capacity addition consists of 14.6 MW of diesel power generating facilities on Panay Island, 11.0 MW of diesel power generating facilities on Negros Island, 51.1 MW of diesel power generating facilities on Cebu Island, 11.0 MW of diesel power generating facilities on Bohol Island, and 3.0 MW of geothermal power generating facilities on Leyte Island. Meanwhile, the total installed capacity of power plants presently under construction is 285.5 MW, the breakdown being a 55.0 MW coal-fired thermal on Cebu Island, 54.0 MW of diesel facilities also on Cebu, a 112.5 MW geothermal power plant on Leyte Island, and two power generating barges totalling 64.0 MW.

In step with construction of the above power generating facilities, construction of related power transmitting and transforming facilities is being carried out, and as of the end of 1979 the total length of 69 kV and 138 kV transmission lines was 428 km, and there were 5 substations of total transformer capacity of 127.7 MVA.

According to the power facilities expansion program prepared by NAPOCOR in October 1979, the total installed power generating capacity in the Visayas at the end of 1993 is expected to reach 1,240 MW, and the total length of transmission lines of voltage 69 kV and higher is 2,550 km. With the above situation as the background, the Survey Team made investigations and studies of the technical and economic feasibilities of a Panay-Negros-Cebu power transmitting and transforming project with inter-island interconnection by submarine cable, while for the two islands of Leyte and Samar, crossing of the strait between the two by overhead transmission line employing tall steel towers and long-span. This report is a summary of the essential points of the investigations and studies.

Regarding the Leyte-Samar interconnecting transmitting and transforming facilities, financing from Japan has already been assured. The 138 kV transmission line for which financing has been assured is based on wooden poles as supporting structures and conductor of 336.4 MCM ACSR, 1 cct. The construction of this transmission line was considered as a given condition, but for the portion crossing San Juanico Strait, a preliminary design of long-span, high steel towers was made, while for the overland portion, when it will become necessary for a 138 kV transmission line to be newly constructed (1990 or later), the preliminary design and construction cost estimate prepared by the Survey Team for a 138 kV transmission line (steel tower, 336.4 MCM ACSR, 1 cct) are for reference only. Fig. 1-1 gives the locations of the power transmitting and transforming facilities studied by the Survey Team, and Fig. 1-2 and Fig. 1-3 gives the scopes of facilities installation.

Fig. 1-1 Power System Expansion Program in Cebu - Negros - Panay and Leyte - Samar Is.



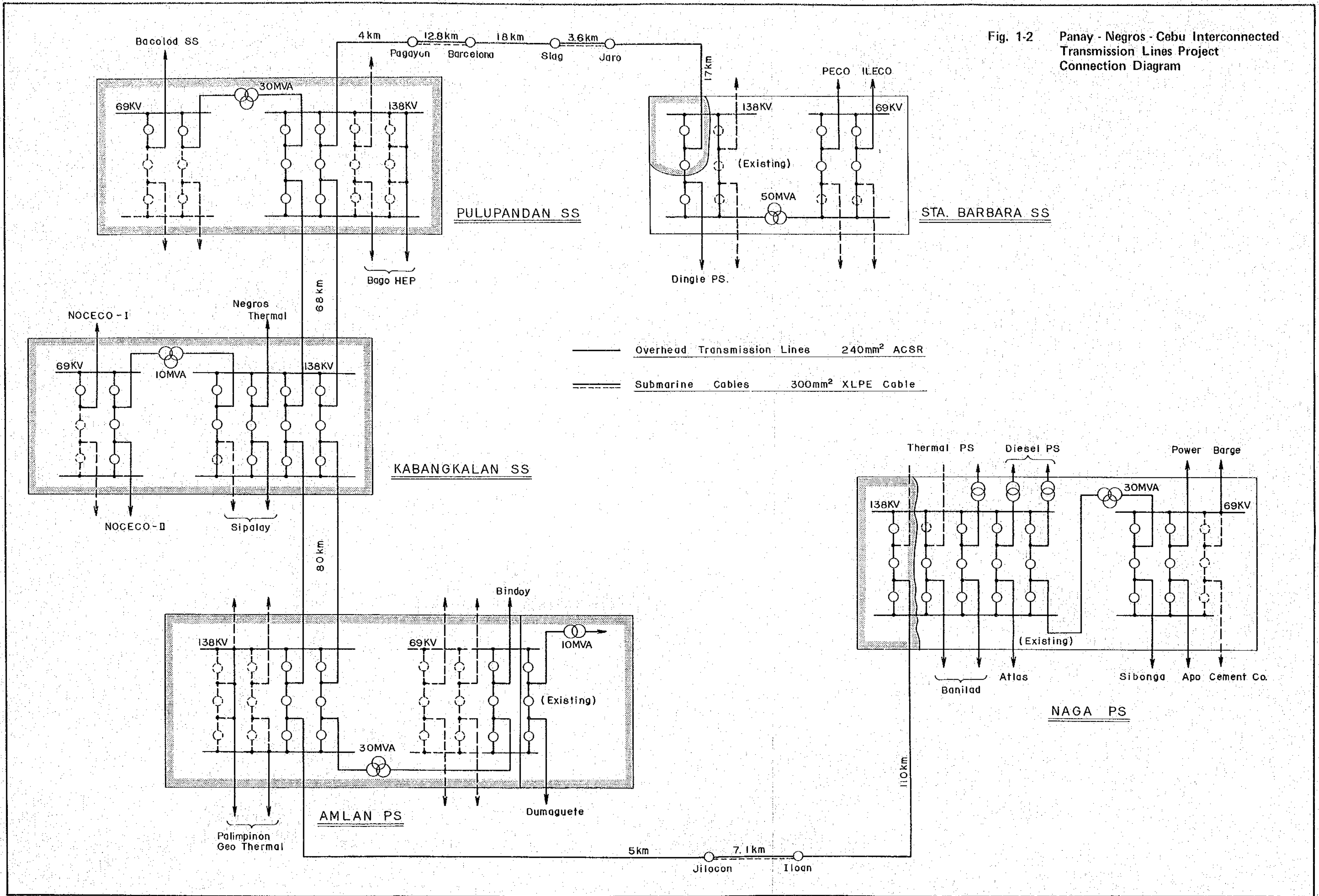
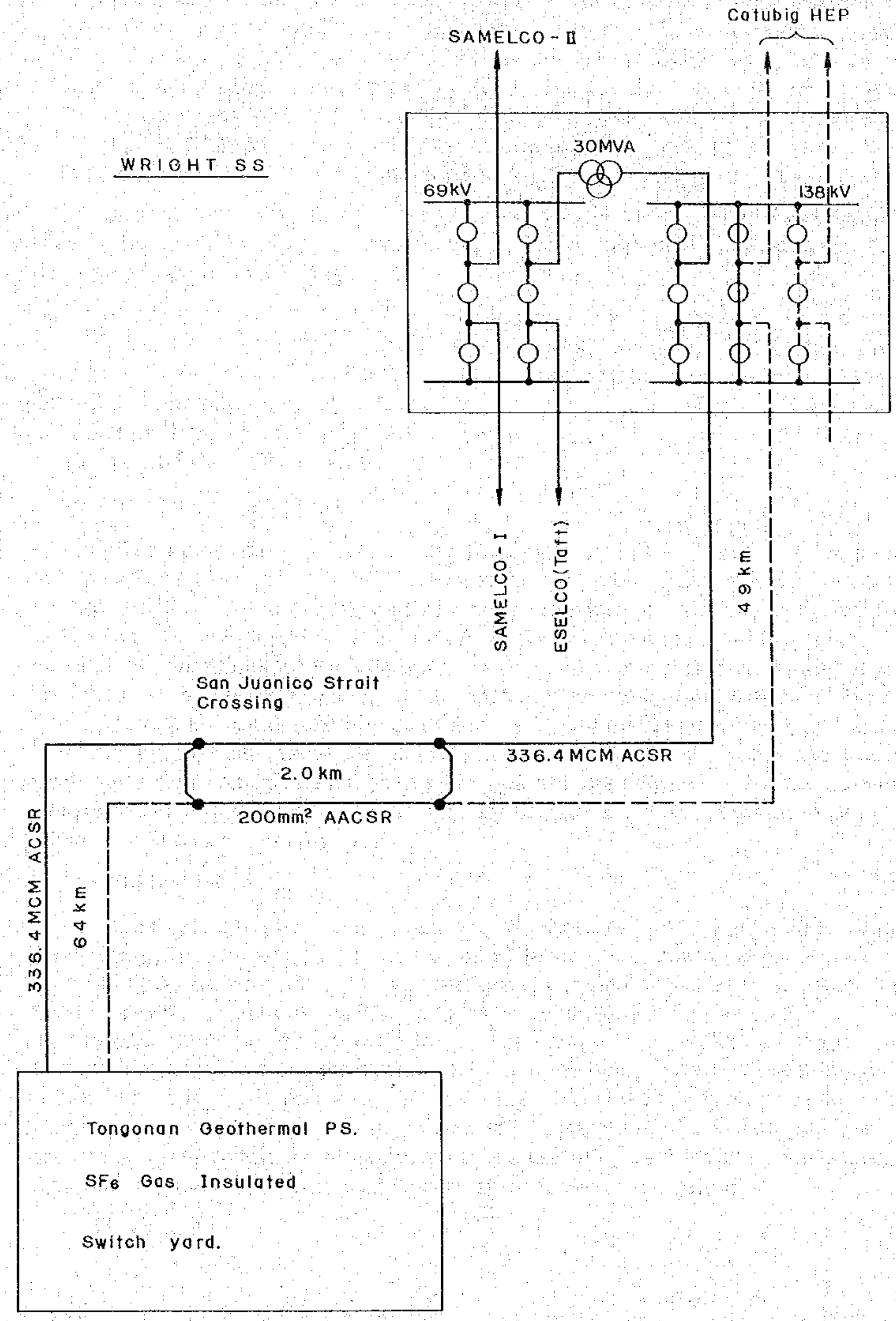


Fig. 1-2 Panay - Negros - Cebu Interconnected Transmission Lines Project Connection Diagram
Bacolod SS
4km
12.8km
18km
3.6km
Pagayon
Barcelona
Slag
Jaro
17km
PECO
ILECO
30MVA
69KV
138KV
PULUPANDAN SS
(Existing)
50MVA
STA. BARBARA SS
Bago HEP
Dingle PS.
68km
NOCECO - I
Negros Thermal
10MVA
KABANGKALAN SS
NOCECO - II
Sipalay
Overhead Transmission Lines 240mm² ACSR
Submarine Cables 300mm² XLPE Cable
Thermal PS
Diesel PS
Power Barge
NAGA PS
Banilad
Atlas
Sibonga
Apo Cement Co.
80km
Bindoy
AMLAN PS
Dumaguete
Palimpinon Geo Thermal
110km
5km
7.1km
Jilocon
Iloan

Fig. 1-3 Leyte - Samar Interconnected Transmission Line Project Connection Diagram



2. OUTLINE OF PROJECT

(1) Panay-Negros-Cebu Interconnected Transmission Project

According to the results of load forecast the power demand of the entire three islands will be 440 MW in 1985 when the three-islands interconnection is to be completed, and 586 MW five years later in 1990. The power generating facilities for coping with this demand will be 602 MW in 1985 and 844 MW in 1990. Of these, non-petroleum energy source (geothermal, coal-fired thermal, hydro) will be approximately 290 MW in 1985 and approximately 550 MW in 1990, and in the latter half of the 1980s, it will be possible to reduce operation of diesel power plants, and diesel units can be diverted to reserve capacity.

The Survey Team made a study of the power flow between the three islands based on the above-mentioned power demands and power development programs. The results are shown in Fig. 2-1.

It will be noted on Fig. 2-1 that the power flow between Panay and Negros will be a maximum of 32 MW and that between Negros and Cebu 83 MW. The power flow of the 138 kV trunk transmission line longitudinally crossing Negros Island will be a maximum of 90 MW. Based on such power flows, the particulars which would be the fundamentals of the power transmitting and transforming scheme will be described below.

a) Transmission Voltage

The maximum voltage presently being used in the Visayas is 138 kV AC. In view of the sizes of power demands on the various islands and the sizes and unit capacities of generating facilities presently under construction or projected, 138 kV will be appropriate as the transmission line voltage of this region. This voltage will be adequate for securing the power transmission capability matching the purpose of interconnection. The length of the submarine cable will be 16.5 km at maximum (total cable length between Panay and Negros) so that the required charging current due to the electrostatic capacitance of a cable which can be problematic in case of an AC power transmission system will not be a problem in this case, and consequently, it will not be necessary to adopt an expensive DC power transmission system.

b) Number of Circuits

The transmission lines from Sta. Barbara to Pulupandan and Amlan to Naga are to be single-circuit, and from Pulupandan to Amlan through Kabangkalan longitudinally crossing Negros Island is to be double circuit. Since this interconnected transmission line will be the backbone from both electrical and symbolical stand-points for the Visayas steel towers which are of high reliability are to be adopted for the entire length of the Project. Also, since this three-island interconnected power system will be a typical long distance series grid (431 km from Panitan Substation to Banilad Substation), the middle section of the series grid between Pulupandan and Amlan is to be double circuit aiming for improvement in stability of the entire three-island system.

c) Submarine Cable

The types of submarine cable which can be considered are oil-filled cable (OF cable) and cross-linked polyethylene cable (XLPE cable).

OF cable has been used for a long time as a power cable for high voltage transmission, but requires accessory facilities for feeding oil, and after laying of OF cable, the oil-feeding apparatus consistently require careful maintenance and inspection. On the other hand, XLPE cable began to be used from the 1950s, and trouble frequently occurred with the early products, but after going through a period in which improvements were made, it has come to a point where it has almost completely replaced OF cable for use in voltage range of 66 to 77 kV, while actual use of 154 kV cable is gradually growing and recently, it is beginning to be adopted for 275 kV to 330 kV systems. XLPE cable is still presently the object of research and development for more improvement, and is a cable which is at the stage of making great strides.

In price comparison of OF and XLPE cables, the XLPE cable cost more, but does not require oil-feeding apparatus, while laying operations are relatively simple, and in addition, maintenance is easy. Consequently, it may be considered that, overall, there is no cost difference between the two types.

The current capacity of a submarine cable is governed by the thermal conductivity of the surrounding soil with the cable in a laid condition. The sea bottom of Iloilo Strait at Panay Island is mainly mud, while that of Tañon Strait between Negros and Cebu is sand. The transmitting capacity will differ depending on the soil at the sea bottom, and in case a 300 mm^2 cable is used, the capacity for the former section will be approximately 100 MW and that for the latter section approximately 130 MW. In case of adopting a 300 mm^2 submarine cable, if it is a 3 core cable, the outside diameter of the cable will be approximately 180 mm ø exceeding the limit of manufacturing, while the tension applied to such cable during laying, even if it could be manufactured, would exceed 10 tons, so a single-core cable is to be adopted.

d) Interconnection Route

Since this is a transmission line to be the backbone of a long-distance series grid, it is basically important from the standpoint of stability for the route to be as short as practicable. It was considered that overhead transmission lines would be constructed parallel to roads as much as possible for easy access, while for submarine cable routes, since the construction cost required would be approximately 10 times greater compared with overhead lines, efforts were made to select short routes as much as possible.

e) Kinds and Sizes of Conductors

Regarding the conductor size for the overhead transmission lines, it was decided to use 240 mm^2 ACSR in consideration of transmission losses, while for submarine cables, it was decided to adopt XLPE, single-core, 300 mm^2, for all three sections in consideration of mechanically required strength and conditions of soil at the sea bottom.

f) Substations

There will be three substations involved in the Project and the transformer capacity will be a total of 70 MVA. These substations will all be constructed on Negros Island and be connected with existing power systems.

Other than the above three substations, 138 kV outgoing facilities are to be provided at Sta. Barbara Substation on Panay Island and at the outdoor switchyard of Naga Coal-Fired Thermal Power Plant on Cebu Island.

g) Telecommunication Facilities

Telecommunication facilities necessary for effective and proper operation, maintenance and administration of the interconnected transmission line and substation facilities of the Project are to be provided. The telecommunication consists of power line carrier equipment, UHF multi-channel radio equipment and VHF radio equipment.

(2) Leyte-Samar Interconnected Transmission Project

Since financing from Japan has already been committed for the transmitting and transforming facilities required for the Leyte-Samar Interconnected Project, the construction was considered as a given condition, and the preliminary design, construction cost estimate and economic analysis given in this Report concern the investigations and studies of the 138 kV transmission line which will become necessary at the next stage. However, the preliminary design for the portion across San Juanico Strait constitutes a part of the above-mentioned project to be completed by 1983.

According to the results of load forecast the power demand of the two islands of Leyte and Samar will be 90 MW in 1985, and 158 MW five years later in 1990. The power demand on Samar to be interconnected will be 12 MW in 1985 and 18 MW in 1990, about 12% of the power demand of the two islands combined. Power flows are indicated in Fig. 2-2.

The length of the transmission line from Tongonan Geothermal Power Plant on Leyte, the starting point of the two-island interconnection, and Wright Substation, the receiving station on Samar is 115 km, and considering the bulk of power to be transmitted, transmition voltage of 138 kV and conductor size of ACSR 336.4 MCM are appropriate. The transmission line will pass through mountainland on Leyte at elevation exceeding 1,000 m at places, but ACSR 336.4 MCM can be adopted even when considering corona noise.

Crossing of San Juanico Strait is to be by overhead transmission line, and the optimum route selected is one where the cross channel transmission line will have a length of 1,700 m, 4 steel towers, maximum span of 1,200 m, and maximum tower height of 115 m.

It was decided that the conductor for this portion should be high strength steel core aluminum alloy stranded conductor (AACSR). The conductor size is to be for current capacity of at least equivalent to that of ACSR 336.4 MCM at the overland portions, and AACSR 200 mm^2 is to be adopted.

The outline of facilities for the transmission line at the portion crossing the strait is given below.

Length	1,700 m
Voltage	138 kV
Electric System	3 phase, 3 wire, 60 Hz
Number of Circuits	2 cct
Maximum Span	1,200 m
Conductor Clearance above Sea Water Surface	30 m (at maximum high tide)
Conductor	200 mm^2 AACSR (rust-preventive grease-coated)
Insulator	250 mm disc × 10 pcs, double string
Overhead Ground Wire	70 mm^2 GSC, 1 line
Steel Towers	2 suspension, 2 tension, total 4 towers total weight approx. 120 tons

The profile of the strait crossing portion is indicated in Fig. 2-3.

The particulars of the Panay-Negros-Cebu and the Leyte-Samar Interconnected Power Transmission and Transformation Project described above are indicated in Table 2-1 through Table 2-4.

Table 2-1 Panay - Negros - Cebu Interconnected Transmission Lines Project

Overhead Transmission Lines

General figures	
Rated voltage, frequency	AC 138 kV 3ø 60 Hz
Conductor	240 mm^2 ACSR
Ground wire	70 mm^2 GSC
Insulator (250 mm Disc type)	8 or 10 pieces single string
Structure	Steel tower
Foundation	Concrete base with base plate

Length of sections

Island	Section	No. of circuits	Length (km)
Panay	Sta. Barbara (SS) - Jaro (CT)	1	17
Guimaras	Salag (CT) - Barcelona (CT)	1	18
Negros	Pagayon (CT) - Pulupandan (SS)	1	4
do	Pulupandan (SS) - Kabangkalan (SS)	2	68
do	Kabangkalan (SS) - Amlan (PP)	2	80
do	Amlan (PP) - Jilocon (CT)	1	5
Cebu	Liloan (CT) - Naga (PP)	1	110
	Sub Total	1	154
		2	148
	Total		302

Note: SS : Substation
PP : Power plant
CT : Cable terminal

Table 2-2 Panay - Negros - Cebu Interconnected Transmission Lines Project

Submarine Cables (XLPE 1ø Submarine Cable)

General figures	
Rated voltage, frequency	138 kV, 60 Hz
Conductor size	300 mm^2 (Copper)
Current capacity	610 A (for sand bottom)
	500 A (for mud bottom)
Insulating material	XLPE
Armouring	8 mm ø galvanized steel wire
Out side diameter	Approx. 110 mm

Length of sections (One phase cable length)

Strait	Section	Length	Max. water depth
Iloilo	Jaro CT - Salag CT	3.7 km	42 m
Guimaras	Barcelona CT - Pagayon CT	12.8 "	18 "
Tañon	Jilocon CT - Liloan CT	7.1 "	220 "

Table 2-3 Panay - Negros - Cebu Interconnected Transmission Lines Project

Transformation Facilities

General figures	
Rated voltage, frequency	AC 138 kV, 3ø/AC 69 kV 3ø, 60 Hz
Bus circuit	1.5 CB/1.5 CB System
Switch yard construction	Conventional steel structure
Main transformer type	Out door, 3ø Auto-transformer
" voltage	138 kV/69 kV/13.8 kV
" connection	Y - Y - Δ

Number of feeders and transformer capacity for the project

Substation	138 kV feeder	69 kV feeder	Tr. capacity	Remarks
Sta. Barbara	1	—	—	Additional
Pulupandan	5	1	30 MVA	
Kabangkalan	6	2	10 "	
Amlan	5	2	30 "	
Naga	1	—	—	Additional

Telecommunication Facilities

Equipment	System and main items
Power line carrier	3 ch. 27 dBm/35 dbm type metaric return system, for line protection, load dispatching telephone, etc.
UHF telecommunication equ.	6 ch. 10 W (400 MHz) for line protection, load dispatching telephone, etc.
VHF mobile radio	25 W (150 MHz) Line maintenance
Fault locator	Pulse radar system, Type - C

Table 2-4 Leyte - Samar Interconnected transmission Lines

Overhead Transmission Lines

General figures	
Rated voltage, frequency	AC 138 kV 3ϕ 60 Hz
Conductor	336.4 MCM ACSR
	200 mm^2 AACSR *
Ground wire	70 mm^2 GSC
	70 mm^2 GSC *
Insulator (250 mm Disc type)	8 or 10 pieces single string
	10 pieces double string *
Structure	Steel tower
Foundation	Concrete base with base plate

Length of section

Island	Section	No. of circuits	Length (km)
Leyte	Tongonan (PP) - Uban (Leyte)	1	64
Leyte - Samar	Strait crossing	2	2
Samar	Uban (Samar) - Wright (SS)	1	49
	Sub-total	1	113
		2	2
	Total	—	115

Note SS : Substation

PP : Power plant

* : Conductor and grounding wire which will be used for crossing of the strait.

Fig. 2-1 Power Flow (Panay - Negros - Cebu Grid)

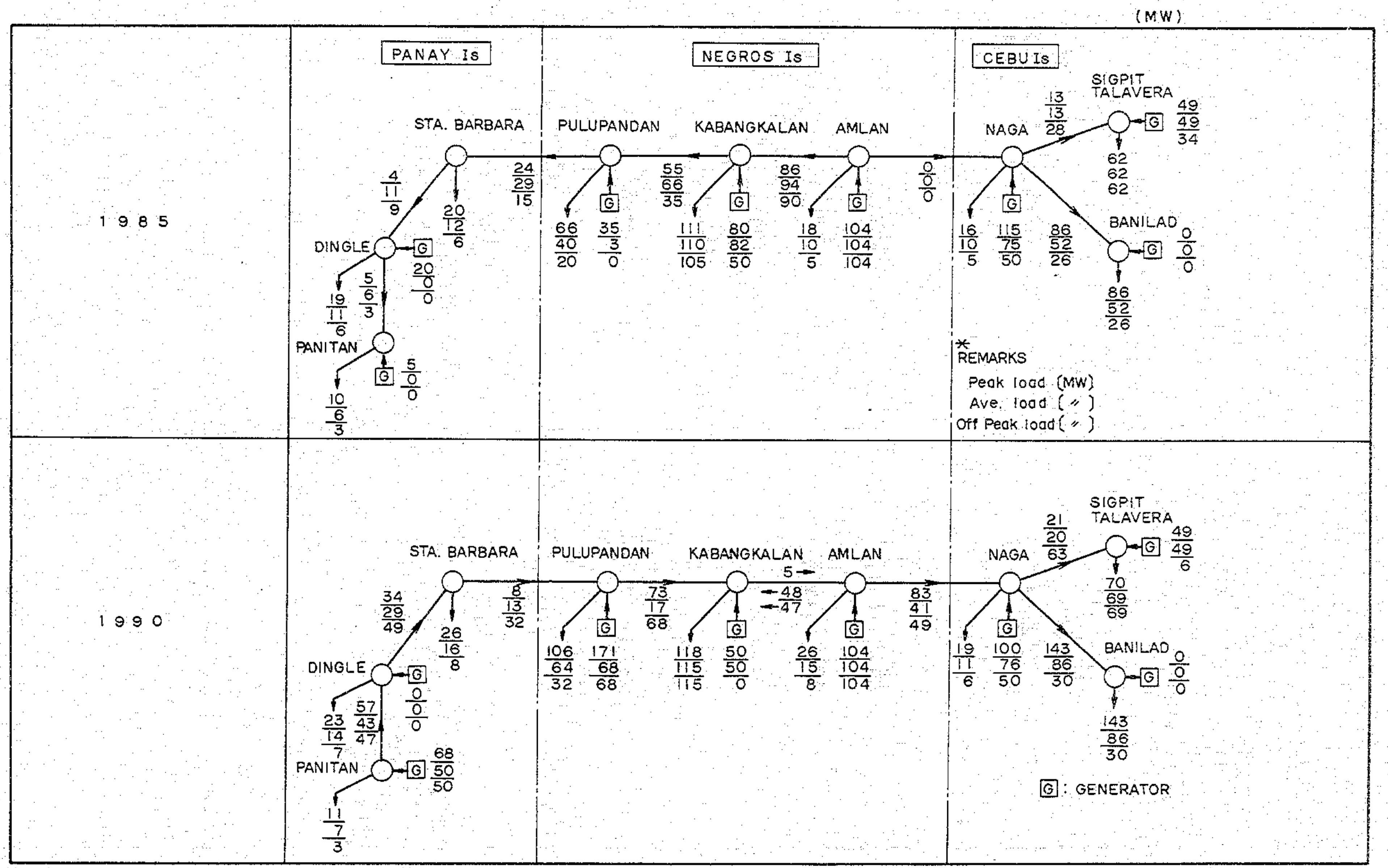


Fig. 2-2 Power Flow (Leyte - Samar Grid)

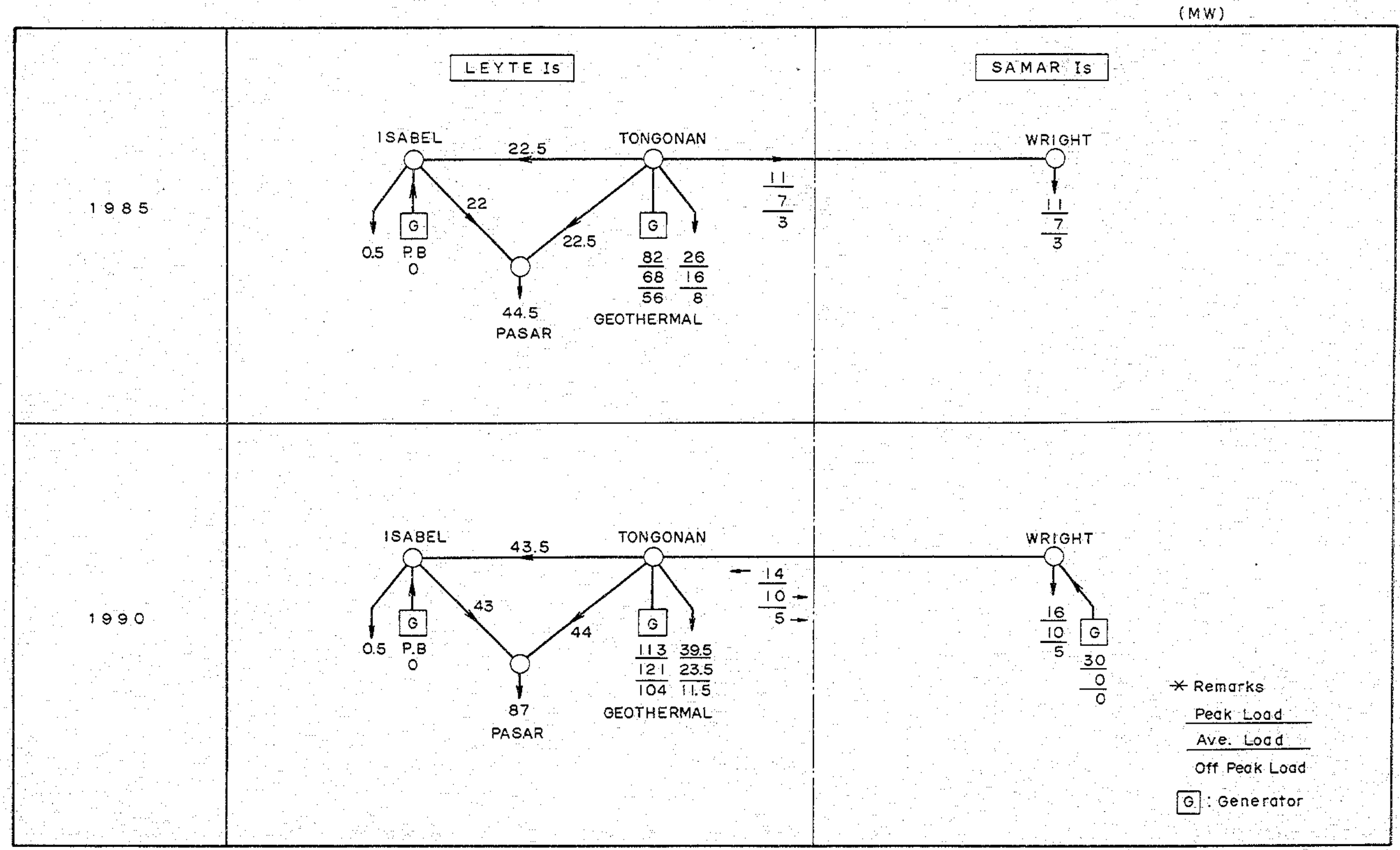
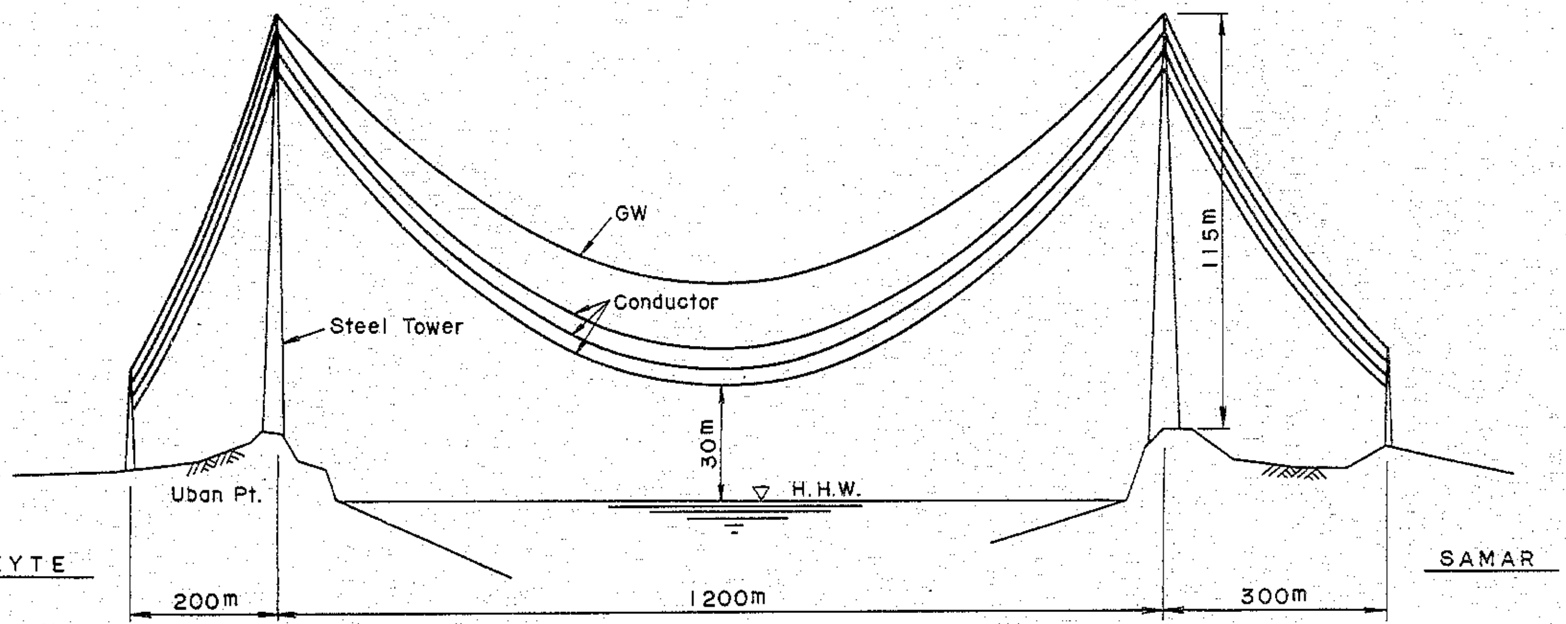


Fig. 2-3 138 kV Overhead Transmission Line of the San Juanico Strait Crossing

(Uban Route)

Scale Horizontal ; 1/10.000
Virtical ; 1/ 2.000



3. CONSTRUCTION COST AND CONSTRUCTION SCHEDULE

In estimation of the construction cost of the interconnected power transmission and transformation projects, the natural conditions of the route of the overland transmission lines, submarine cable routes, and high steel towers for strait crossing, and the regional conditions of the proposed sites of related substations were considered, and computations were made based on labor, equipment and materials costs as of the beginning of 1980.

The construction cost is divided into to foreign and domestic currency requirements. Labor and materials procurable in the Philippines are included in domestic currency portion and the other portion of the construction cost are calculated as the foreign currency.

As a result, the total construction cost of power transmission and transfor mation facilities including the submarine cables connecting the three islands of Panay, Negros and Cebu is US$53,788,000 at March 1980 prices, of which the foreign currency portion is US$41,797,000 and the domestic currency portion US$ 11,991,000. Assuming cost escalations during the period up to the time scheduled for completion of the Project (end of 1984) as being 7.0% per year for the foreign currency portion and 12% per year for the domestic currency portion, the estimated construction cost at the time of completion will have become US$68,256,000, of which US$51,247,000 will be foreign currency and US$17,009,000 domestic currency. The breakdown of the construction cost is given in Table 3-1. The indirect cost in Table 3-1 consists of interest during construction, contingencies, administrative expenses of NAPOCOR, and the engineering fee of the consultant.

On the other hand, the total construction cost of the transmission and transformation project for interconnecting the two islands of Leyte and Samar is US$8,666,000 at prices as of March 1980, of which US$5,378,000 is foreign currency requirement and US$3,283,000 the domestic currency requirement.

The construction period for the overland transmission lines and transforming facilities on the three islands of Panay, Negros and Cebu, and the submarine cables connecting the three islands will require approximately 4 years from preparation of specifications for purchase of equipment and installation work up to completion of construction based on economical methods of work execution. In particular, the submarine cable laying works will be the critical path, and it will be necessary for preliminary investigations of marine phenomena, sea bottom topographies, etc. of the cable routes to be made by NAPOCOR to be completed by around March 1981.

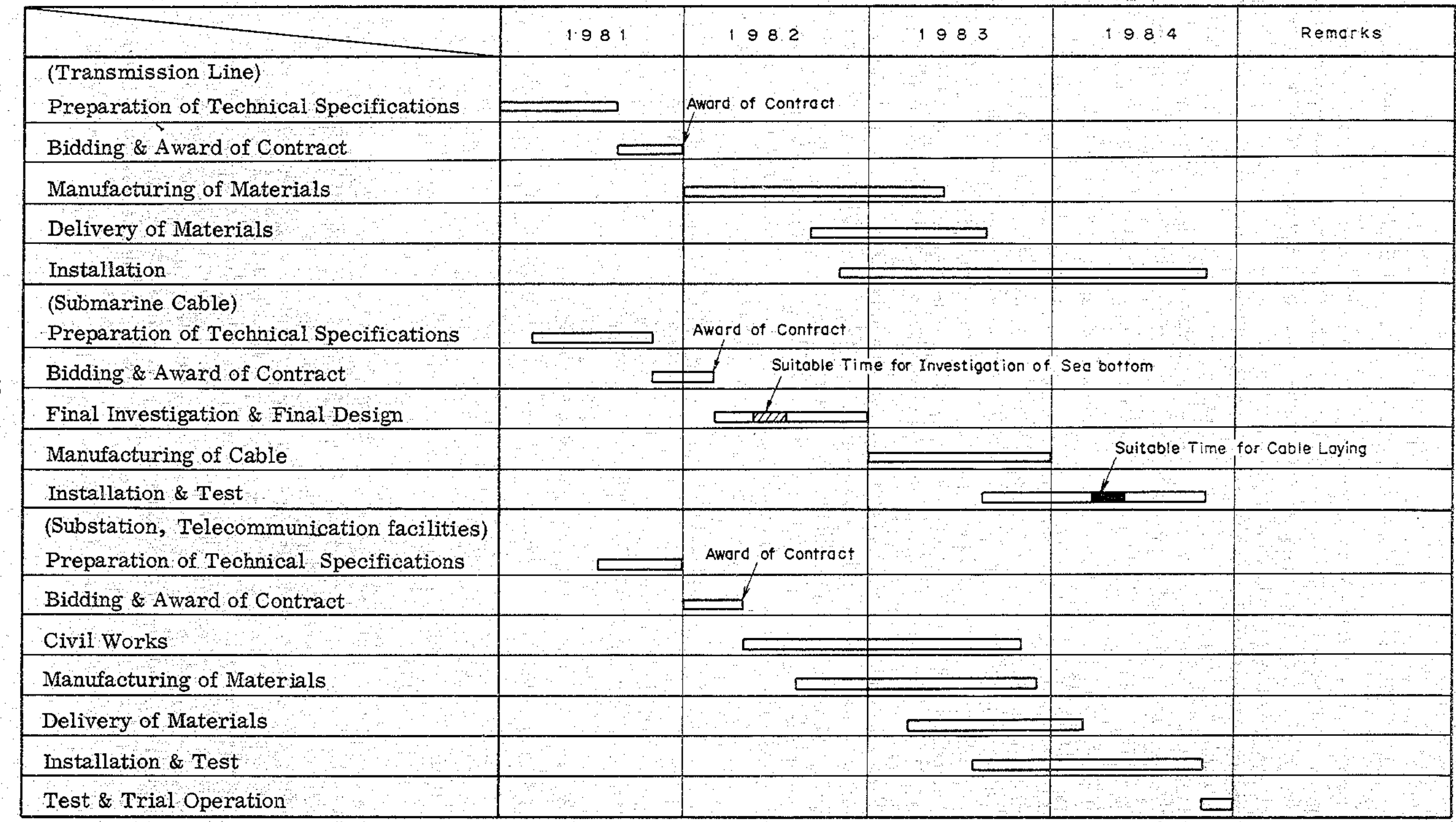
The construction schedule is indicated in Fig. 3-1.

Table 3-1 Panay - Negros - Cebu Interconnected Transmission Lines Project

Construction Cost

	Construction cost (10^3 US$)			Remarks
	F.C.	D.C.	Total	
- Overhead Transmission Lines				
Sta. Barbara SS - Jaro CT	588	297	885	1 cct
Salag CT - Barcelona CT	619	315	934	"
Pagayon CT - Pulupandan SS	138	70	208	"
Pulupandan SS - Kabangkalan SS	3,635	1,747	5,382	2 cct
Kabangkalan SS - Amlan PP	4,277	2,054	6,331	"
Amlan PP - Jilocon CT	173	87	260	1 cct
Liloan CT - Naga PP	3,977	2,361	6,338	"
Sub Total	13,407	6,931	20,338	
- Submarine Cables				
Jaro CT - Salag CT	2,542	77	2,619	
Barcelona CT - Pagayon CT	8,015	77	8,092	
Jilocon CT - Liloan CT	4,654	77	4,731	
Sub Total	15,211	231	15,442	
- Transformation facilities				
Sta. Barbara Substation	317	57	374	Switch yard extension
Pulupandan Substation	1,583	466	2,049	
Kabangkalan Substation	2,738	885	3,623	
Amlan Power Plant	1,707	506	2,213	
Naga Power Plant	448	80	528	Switch yard extension
Sub Total	6,793	1,994	8,787	
- Telecommunication Facilities	886	201	1,087	
Total of direct cost	36,297	9,357	45,654	
- Indirect Cost	5,500	2,634	8,134	
Total construction cost	41,797	11,991	53,788	(in 1980 prices)
Escalation	9,450	5,018	14,468	
Grand total	51,247	17,009	68,256	

Fig. 3-1 Panay - Negros - Cebu Interconnected Transmission Lines Project Construction Schedule



4. ECONOMIC ANALYSIS

The economic analysis of the Panay-Negros-Cebu Interconnected Transmission Project was made on the basis of the difference between the construction program of the three-island interconnection (original scheme) presently being expedited by NAPOCOR, and a construction program of developing the three islands independently without interconnection (alternative scheme), while for the economic analysis of the Leyte-Samar interconnection, since the timing of construction of an additional interconnecting transmission line will be in 1990 or later as first mentioned, the economic benefit was evaluated by comparison of the fuel costs of Tongonan Geothermal Power Plant and diesel power generation.

(1) Panay-Negros-Cebu Interconnection

The advantages of the three-island interconnection are savings in reserve supply capacity, transmission of non-petroleum-based energy (coal-fired thermal, geothermal, hydroelectric) to other islands through regional wide-area power development, reductions in frequency and voltage fluctuations under normal operating conditions of a power system, and mutual interchange of power at times of abnormal conditions such as during natural disasters.

The Survey Team used an electronic computer and calculated the savings in reserve supply capacities for the cases of independent development of individual islands and three-island interconnected development for identical levels of supply reliability. As a result, compared with independent development of the three islands, the interconnected development can be expected to have the effect of producing savings in reserve capacity amounting to 69.3 MW as of 1990.

Through interconnection of the three islands, regional wide-area power development will be possible, and interchange between the islands of electric energy produced from non-petroleum energy can be carried out. The benefit of regional wide-area power development was calculated with respect to the electric energy from 1986 to 1990 based on the difference in the fuel costs for diesel power generation and for non-petroleum energy power generation.

The above two benefits were evaluated in monetary terms as indicated below.

Benefits savings in reserve supply capacity	:	US$35,204,000
Benefits of regional wide-area power development	:	US$16,808,000
Total	:	US$52,012,000

On the other hand, the total construction cost (not including escalation) of the three-island interconnection, which is cost corresponding to benefit, will be US$54,679,000, and when limited to power transmitting facilities necessary only for three-island interconnection, the cost will be US$34,229,000 (Case 1). The 138 kV transmission line, 2 cct, on Negros Island is necessary mainly because of the size of the power flow for power demand and supply balance on Negros, and if 50 % of the construction cost for this 2 cct transmission line (Amlan - Kabangkalan - Pulupandan) were to be deducted from the total construction cost, and the result considered to be the cost for interconnection of the three islands, this would be US$46,439,000 (Case 2).

The benefit-cost ratios (B/C) calculated for the two cases above are the following:

Case 1

$B/C = US\$52,012 \times 10^3 / US\$34,229 \times 10^3 = 1.52$

Case 2

$B/C = US\$52,012 \times 10^3 / US\$46,439 \times 10^3 = 1.12$

According to the above analysis, the Project is economically advantageous, and when the benefits such as reduction in the range frequency and voltage fluctuation and the power interchange between islands during abnormal conditions such as that caused by typhoons are considered, the advantage of the Project will be even greater.

(2) Leyte-Samar Interconnection

The interconnection of Leyte-Samar will not have the effect of producing savings in reserve supply capacity such as in the case of the three-island interconnection since the system source is only the Tongonan Geothermal Power Plant. However, the fuel cost per kWh of a geothermal power plant compared with that of a diesel generating plant using bunker C oil will be lower, and this difference is to be the focal point in the economic analysis. As previously stated, the interconnected power transmission and transformation system designed by the Survey Team should be implemented at the stage (1990 or later) when a line becomes necessary in addition to the 138 kV transmission line already decided on, but it is difficult to determine just when this would be. The evaluation was made with the annual expenses of the transmission line and the receiving Wright Substation calculated from the 1980 total construction cost based on the preliminary design as the ccst, and the product of the electric energy passing through this transmission line multiplied by the difference between the steam cost per kWh of Tongonan Geothermal Power Plant and the bunker C oil fuel cost per kWh of a diesel power generating plant as the benefit, and the quantity of electric energy at Wright Substation which would produce a benefit-cost ratio of 1.0 was obtained. As a result, the quantity of energy which would produce a benefit-cost ratio of 1.0 was found to be 28.3 million kWh, and converted into maximum demand, if more than about 6.0 MW of power were to be transmitted from Tongonan Geothermal Power Plant to Wright Substation, the B/C of the Project will be higher than 1.0.

5. FINANCIAL ANALYSIS AND FUND REQUIREMENT

NAPOCOR revised its electricity rates on February 27, 1980 because of the rise in imported oil prices brought about by the Second Oil Crisis. The electric tariff increase was 32.6% for Luzon and 11.8% for Visayas and Mindanao Island. The electricity rates for the Visayas after these raises are higher than those for Luzon and Mindanao, but even with such electricity rates, the revenue in the Visayas is only enough to cover fuel costs and operation and maintenance costs of facilities, and depreciation of equipment and servicing of debts cannot be coverd. This is because investment for power facilities in the Visayas has only just begun, and diesel power plants which can cope most quickly with power demand were constructed, the time of completion of these plants coinciding with the Second Oil Crisis. As a result, whereas the sharp rise in fuel costs has greatly increased generating cost, the rise in generating cost has not been reflected directly in the elecricity rates.

The Project is for power transmission and transformation, and because of its nature, it will be difficult to make a financial analysis for the Project alone. Therefore, a financial analysis was made based on tariff revenues corresponding to the power facilities of NAPOCOR in the entire Visayas Region and the investment for them including the Project.

The power facilities in the Visayas, with the exception of Amlan Hydroelectric Power Plant (800 kW) on Negros Island, and Loboc Hydroelectric Power Plant (1,200 kW) on Bohol Island which have been in service for many years, were all completed only within the last two to three years. Consequently, a financial analysis was made considering all of the power generating, transmitting and transforming facilities composing the power facilities expansion program from 1976 to 1993. In this case, the construction cost (direct construction cost) of the three-island project was the cost estimated in this Feasibility Report, while for the Leyte-Samar Interconnected System, since financing from Japan is already definite, the construction cost which is the basis for the financing was used.

As for other construction costs, the values in the power facilities expansion program for the Visayas prepared by NAPOCOR were adopted, these values were thought to be reasonable. These construction costs in the financial analysis were all based on 1980 prices and escalation in construction costs due to inflation expected in the future was not taken into consideration. Since electricity revenues and investment are based on 1980 prices, it is thought that to make evaluations omitting escalations in construction costs due to future inflation is acceptable.

Of the total investment from 1976 to 1993, the foreign currency portion would be US$824.7 million, of which 50% would consist of government-to-government development aid loans, with the remaining 50% loans from international financing institutions such as the World Bank. It was considered that the domestic currency portion of US$364.5 million would all be procured by NAPOCOR within the Philippines. The conditions for calculations employed in the financial analysis are as indicated below.

a) Loan Conditions

Foreign Currency Portion	
Av. interest rate:	6.0%/yr
Av. repayment period:	25 yr (including 3 yr grace period)
Domestic Currency Portion	
Av. interest rate:	10.0%/yr
Repayment period:	13 yr (including 3 yr grace period)
Repayment method:	Principal in equal installments

b) Operation and Maintenance Costs

Power Generating Facilities	
Coal-fired thermal:	Direct construction cost × 0.040
Diesel:	Ditto × 0.030
Geothermal:	Ditto × 0.030
Hydro:	Ditto × 0.015
Power Transmission Facilities	
Overhead line:	Direct construction cost × 0.025
Submarine cable:	Ditto × 0.005
Substation Facilities (incl. Telecommunications):	Direct construction cost × 0.025

c) Depreciation of Facilities

Power Generating Facilities	Service Life
Coal-fired thermal	30 yr
Diesel	18 yr
Geothermal	20 yr
Hydro	50 yr
Power Transmission Facilities	
Overhead line (steel tower)	50 yr
Ditto (wooden pole)	30 yr
Submarine cable	50 yr
Substation Facilities	
Transformer, CB, etc.	25 yr

If it were to be attempted to recover the capital invested for the Visayas on the basis of cost with the current electricity rates, it will be necessary to increase the rate by 10% in 1982 and again in 1984.

As a result of financial analyses made on the above rate increases, there will be a surplus of income over cost in 1985 when the three-island interconnection is to be completed, and in 1992 a surplus of US$77.6 million can be anticipated. As for the cash flow, although these will be net income in 1984, the cumulative cash flow will show a surplus only in 1991. (See Table 5-1 to Table 5-4.)

As seen above, the power facilities expansion program for the Visayas will be a fairly difficult undertaking for NAPOCOR. Therefore, the healthy expansion of the electric utility industry for this region will be greatly governed by the success of securing low interest cost and long repayment period funds.

The construction cost required for the Project will be a total of US$68,256 million by 1984 including escalation, of which the foreign currency portion will be US$51,247,000 and the domestic currency portion US$17,009,000. The Project is indispensable for effective utilization of power generating facilities, and has the nature of becoming the main artery for electric power transportation. In considera-tion of the fact that the serviceable lives of the facilities will be long and the current electricity rate level is already fairly high, it is desirable to secure soft loans which may be possible in case government-to-government development aid funds are made available.

Table 5-1 Investment Schedule for Visayas Region

Unit : 10^6 US$

No.	Year	Generation projects			Transmission line projects			Transformation projects			Total		
		F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
1	1976	17.3	3.2	20.5	1.0	1.0	2.0	0.3	0.1	0.4	18.6	4.3	22.9
2	1977	9.5	3.3	12.8	1.8	2.3	4.1	1.2	0.6	1.8	12.5	6.2	18.7
3	1978	34.9	13.8	48.7	1.9	2.4	4.3	2.6	1.6	4.2	39.4	17.8	57.2
4	1979	42.3	15.6	57.9	3.3	3.7	7.0	3.3	1.6	4.9	48.9	20.9	69.8
5	1980	67.8	18.6	86.4	4.9	5.0	10.8	2.9	0.7	3.6	75.6	25.2	100.8
6	1981	60.9	21.8	82.7	5.6	6.1	11.7	1.8	0.7	2.5	68.3	28.6	96.9
7	1982	85.6	31.2	116.8	10.4	7.1	17.5	4.1	1.2	5.3	100.1	39.5	139.6
8	1983	66.3	32.9	99.2	13.9	4.9	18.8	2.0	0.7	2.7	82.2	38.5	120.7
9	1984	48.5	29.3	77.8	8.5	3.1	11.6	5.7	1.8	7.5	62.7	34.2	96.9
10	1985	40.6	27.1	67.7	1.0	1.4	2.4	0.5	0.1	0.6	42.1	28.6	70.7
11	1986	40.9	25.9	66.8	1.2	1.6	2.8	1.6	0.3	1.9	43.7	27.8	71.5
12	1987	18.9	10.7	29.6	0.7	1.0	1.7	0.3	0.1	0.4	19.9	11.8	31.7
13	1988	19.8	8.4	28.2	0.1	0.1	0.2	0.5	0.3	0.8	20.4	8.8	29.2
14	1989	43.0	16.3	59.3	0	0	0	1.4	0.7	2.1	44.4	17.0	61.4
15	1990	59.4	22.0	81.4	0	0	0	0	0	0	59.4	22.0	81.4
16	1991	60.6	23.2	83.8	0	0	0	0	0	0	60.6	23.2	83.8
17	1992	25.9	10.1	36.0	0	0	0	0	0	0	25.9	10.1	36.0
18	1993	0	0	0	0	0	0	0	0	0	0	0	0
	Total	742.2	313.4	1,055.6	54.3	40.6	94.9	28.2	10.5	38.7	824.7	364.5	1,189.2

Table 5-2 Statement of Income

		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
(A) Energy sales																		
Cebu and Panay	GWh	0	114	135	221	770	972	1,106	1,194	1,293	1,398	1,506	1,622	1,742	1,868	1,972	2,084	2,202
Bohole and Negros	GWh	48	97	148	168	222	438	776	992	1,207	1,277	1,347	1,415	1,487	1,559	1,622	1,689	1,758
Leyte and Samar	GWh	3	3	5	7	10	15	120	240	575	596	690	786	881	1,048	1,145	1,247	1,281
Tariff rate per kWh																		
Cebu and Panay	US$/MWh	50.1	50.1	50.1	59.1	59.1	65.0	65.0	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5	71.5
Bohole and Negros	US$/MWh	39.3	39.3	39.3	46.4	46.4	51.0	51.0	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1	56.1
Leyte and Samar	US$/MWh	40.0	40.0	40.0	40.0	40.0	44.0	44.0	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4
Gross revenue																		
Cebu and Panay	10^6US$	0	5.7	6.8	13.1	45.5	63.2	71.9	85.4	92.4	100.0	107.7	116.0	124.6	133.6	141.0	149.0	157.4
Bohole and Negros	10^6US$	1.9	3.8	5.8	7.8	10.3	22.3	39.6	55.7	67.7	71.6	75.6	79.4	83.4	87.5	91.0	94.8	98.6
Leyte and Samar	10^6US$	0.1	0.1	0.2	0.3	0.4	0.7	5.3	11.6	27.8	28.8	33.4	38.0	42.6	50.7	55.4	60.4	62.0
Total	10^6US$	2.0	9.6	12.8	21.2	56.2	86.2	116.8	152.7	187.9	200.4	216.7	233.4	250.6	271.8	287.4	304.2	318.0
(B) Operating cost																		
Generation	10^6US$	0.7	0.7	2.0	2.0	6.9	6.9	10.1	14.6	16.9	19.2	20.5	23.5	23 5	23.8	26.4	28.3	33.2
Transmission	10^6US$	0	0.1	0.2	0.3	0.6	0.9	1.3	1.3	1.9	1.9	2.0	2.1	2.1	2.1	2.1	2.1	2.1
Transformation	10^6US$	0	0	0.1	0.2	0.4	0.4	0.6	0.6	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0
Fuel																		
Diesel	10^6US$	1.7	8.9	12.2	19.2	41.8	65.4	74.8	42.1	52.1	48.8	53.5	43.2	41.4	33.3	32 8	28.3	29.2
Coal	10^6US$	0	0	0	1.1	6.2	6.2	6.2	12.4	18.6	24.8	24.8	31.0	31.0	31.0	31.0	37.2	43.4
Geothermal	10^6US$	0	0	0.1	0.1	0.5	0.5	4.2	13.5	18.8	19.2	18.8	20.2	24.9	30.8	35.6	37.1	37.6
Depreciation	10^6US$	1.1	1.3	3.9	4.3	11.2	11.4	17.8	23.7	26.8	28.8	30.7	33.7	33.7	34.3	38.6	40.2	46.4
Total	10^6US$	3.5	11.0	18.5	27.2	67.6	91.7	115.0	108.2	135.9	143.5	151.2	154.6	157.5	156.3	167.5	174.2	192.9
(C) Operating income: (A) - (B)	10^6US$	-1.5	-1.4	-5.7	-6.0	-11.4	-5.5	1.8	44.5	52.0	56.9	65.5	78.8	93.1	115.5	119.9	130.0	125.1
(D) Financial expenses																		
Interest for F.C.	10^6US$	1.5	3.1	5.8	9.5	13.7	18.6	23.9	27.8	30.4	32.3	33.1	32.9	33.3	34.8	36.6	37.4	36.3
Interest for L.C.	10^6US$	0.7	1.9	3.8	6.2	8.5	11.4	14.5	17.2	19.0	19.8	19.7	18.2	17.0	16.2	16.0	15.0	13.0
(E) Net income: (C) - (D)	10^6US$	-3.7	-6.4	-15.3	-21.7	-33.6	-35.5	-36.6	-0.5	2.6	4.8	12.7	27.7	42.8	64.5	67.3	77.6	75.8

Table 5-3 Amortization Schedule

No.	Year	Borrowing	Foreing currency redemption			Borrowing	Local currency redemption			Borrowing	Total redemption		
		Investment (10^{6}US$)	Principal (10^{6}US$)	Interest (10^{6}US$)	Total (10^{6}US$)	Investment (10^{6}US$)	Principal (10^{6}US$)	Interest (10^{6}US$)	Total (10^{6}US$)	Investment (10^{6}US$)	Principal (10^{6}US$)	Interest (10^{6}US$)	Total (10^{6}US$)
1	1976	18.6		0.6	0.6	4.3		0.2	0.2	22.9		0.8	0.8
2	1977	12.5		1.5	1.5	6.2		0.7	0.7	18.7		2.2	2.2
3	1978	39.4		3.1	3.1	17.8		1.9	1.9	57.2		5.0	5.0
4	1979	48.9		5.8	5.8	20.9	0.4	3.8	4.2	69.8	0.4	9.6	10.0
5	1980	75.6		9.5	9.5	25.2	1.0	6.2	7.2	100.8	1.0	15.7	16.7
6	1981	68.3	0.9	13.7	14.6	28.6	2.8	8.5	11.3	96.9	3.7	22.2	25.9
7	1982	100.1	1.5	18.6	20.1	39.5	4.9	11.4	16.3	139.6	6.4	30.0	36.4
8	1983	82.2	3.5	23.9	27.4	38.5	7.4	14.5	21.9	120.7	10.9	38.4	49.3
9	1984	62.7	5.9	27.8	33.7	34.2	10.3	17.2	27.5	96.9	16.2	45.0	61.2
10	1985	42.1	9.7	30.4	40.1	28.6	14.3	19.0	33.3	70.7	24.0	49.4	73.4
11	1986	43.7	13.1	32.3	45.4	27.8	18.2	19.8	38.0	71.5	31.3	52.1	83.4
12	1987	19.9	18.1	33.1	51.2	11.8	21.6	19.7	41.3	31.7	39.7	52.8	92.5
13	1988	20.4	22.2	32.9	55.1	8.8	24.5	18.2	42.7	29.2	46.7	51.1	97.8
14	1989	44.4	25.3	33.3	58.6	17.0	27.2	17.0	44.2	61.4	52.5	50.3	102.8
15	1990	59.4	27.4	34.8	62.2	22.0	27.5	16.2	43.7	81.4	54.9	51.0	105.9
16	1991	60.6	29.6	36.6	66.2	23.2	26.5	16.0	42.5	83.8	56.1	52.6	108.7
17	1992	25.9	30.6	37.4	68.0	10.1	26.2	15.0	41.2	36.0	56.8	52.4	109.2
18	1993	0	31.6	36.3	67.9	0	25.7	13.0	38.7	0	57.3	49.3	106.6
	Total	824.7	219.4	411.6	631.0	364.5	238.5	218.3	456.8	1,189.2	457.9	629.9	1,087.8

Table 5-4 Statement of Cash Flow

Unit : 10^6US$

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
(A) Cash receipt	16.1	52.1	58.4	83.4	74.5	115.5	101.9	120.1	100.1	105.1	75.1	90.6	137.9	180.2	189.7	153.8	122.2
1) Net income	-3.7	-6.4	-15.3	-21.7	-33.6	-35.5	-36.6	-0.5	2.6	4.8	12.7	27.7	42.8	64.5	67.3	77.6	75.8
2) Depreciation	1.1	1.3	3.9	4.3	11.2	11.4	17.8	23.7	26.8	28.8	30.7	33.7	33.7	34.3	38.6	40.2	46.4
3) Borrowing																	
Foreign currency	12.5	39.4	48.9	75.6	68.3	100.1	82.2	62.7	42.1	43.7	19.9	20.4	44.4	59.4	60.6	25.9	0
Local currency	6.2	17.8	20.9	25.2	28.6	39.5	38.5	34.2	28.6	27.8	11.8	8.8	17.0	22.0	23.2	10.1	0
(B) Cash disbursement	18.7	57.2	70.2	101.8	100.6	146.0	131.6	113.1	94.7	102.8	71.4	75.9	113.9	136.3	139.9	92.8	57.3
1) Construction expenditure (Investment)	18.7	57.2	69.8	100.8	96.9	139.6	120.7	96.9	70.7	71.5	31.7	29.2	61.4	81.4	83.8	36.0	0
2) Repayment of debit																	
Principal of foreign credit					0.9	1.5	3.5	5.9	9.7	13.1	18.1	22.2	25.3	27.4	29.6	30.6	31.6
Principal of governmental credit			0.4	1.0	2.8	4.9	7.4	10.3	14.3	18.2	21.6	24.5	27.2	27.5	26.5	26.2	25.7
(C) Cash balance : (A) - (B)	-2.6	-5.1	-11.8	-18.4	-26.1	-30.5	-29.7	7.0	5.4	2.3	3.7	14.7	24.0	43.9	49.8	61.0	64.9
(D) Accumulated total	-2.6	-7.7	-19.5	-37.9	-64.0	-94.5	-124.2	-117.2	-111.8	-109.5	-105.8	-91.1	-67.1	-23.2	26.6	87.6	152.5

6. RECOMMENDATIONS

(1) The Project comprises the backbone of the power transmission and transformation program for the Visayas Region, and in consideration of reliability, line support structures should all be steel towers, with the conductor size for the overhead transmission lines on the three islands of Panay, Negros and Cebu to be ACSR 240 mm^2. As for the conductors, in the case of the two islands of Leyte and Samar, ACSR 336.4 MCM was adopted for overhead transmission lines, with high-tension conductor AACSR 200 mm^2 having the same current capacity as the conductor for the overland portions used for crossing of San Juanico Strait.

For the submarine cable, cross-linked polyethylene (XLPE) cable, single phase, was adopted in this Study, but whether to use OF cable or XLPE cable should be decided after considering prices at the time of bidding and maintenance costs after laying.

Substation and switching facilities will be required for connections with existing facilities and for power supply to other systems, while telecommunications facilities should be provided as they will be needed for operation of the facilities constructed under the Project.

(2) Construction for the Panay-Negros-Cebu interconnection should be started in 1982 and completed at the end of 1984. Accordingly, various preparations — investigation works, detail design, preparation of equipment and installation specifications — should be carried out taking this construction period into consideration. Preparations such as negotiations for financing should be made in accordance with the overall schedule indicated in Fig. 3-1.

(3) NAPOCOR should carry out as soon as practicable preliminary investigations of the sea-floor topography and geology of the submarine cable routes, topographic surveying along overhead transmission line routes, topographical and geological investigations of steel tower locations, and topographical and geological investigations of the Leyte-Samar strait-crossing portion.

(4) It is thought some time will be required for acquiring substation land and transmission line right -of-way. Therefore, negotiations should be commenced with those concerned for acquisition of land of prospective substation sites selected by the Survey Team, steel tower locations and easements along the proposed transmission line routes.

(5) Vigorous efforts should be made for realization of the Panay-Negros-Cebu three-island interconnection project by approaching agencies concerned to raise necessary funds.

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