REPUBLIC OF THE PHILIPPINES

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

(MAIN REPORT)

VOLUME II

SEPTEMBER 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

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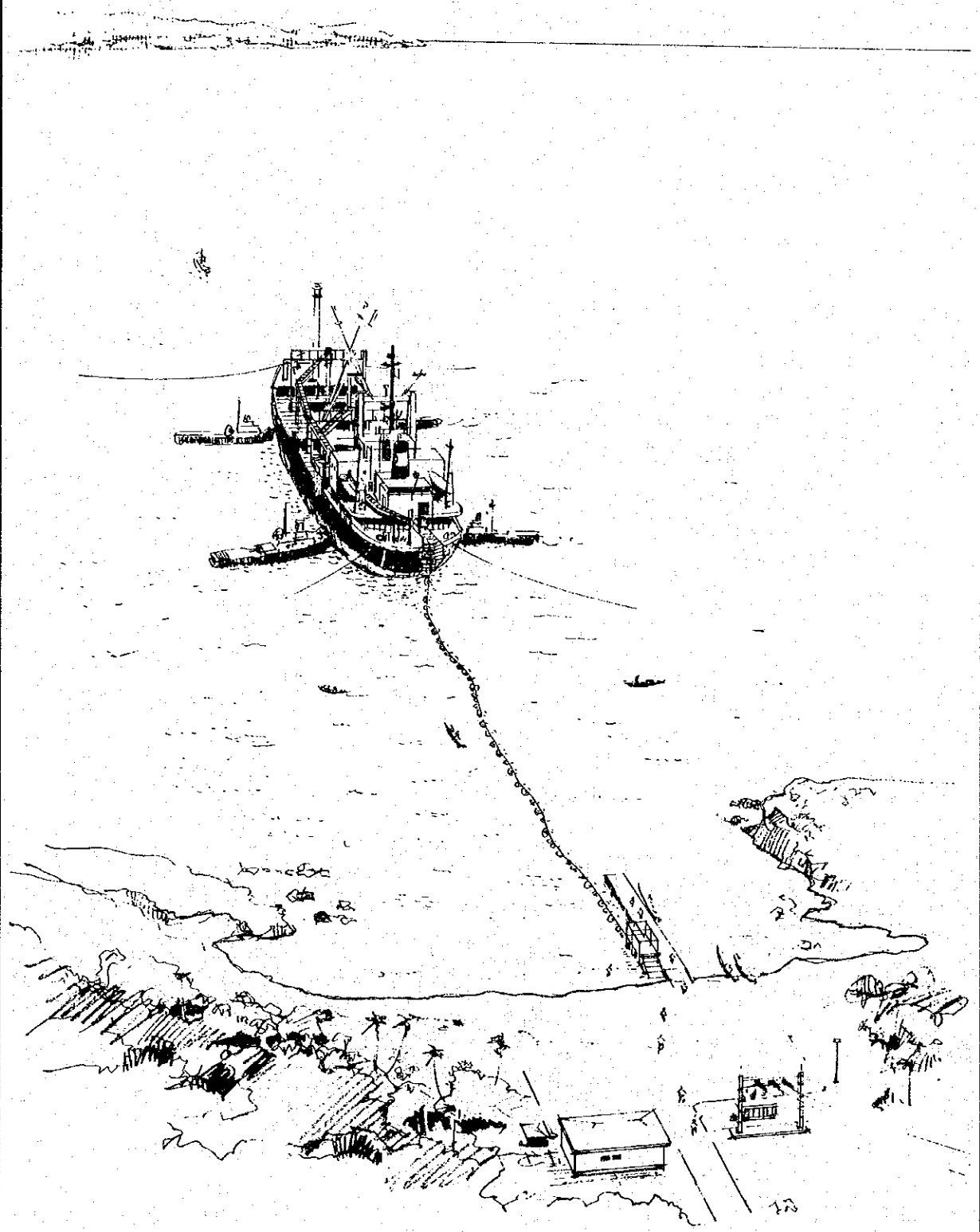
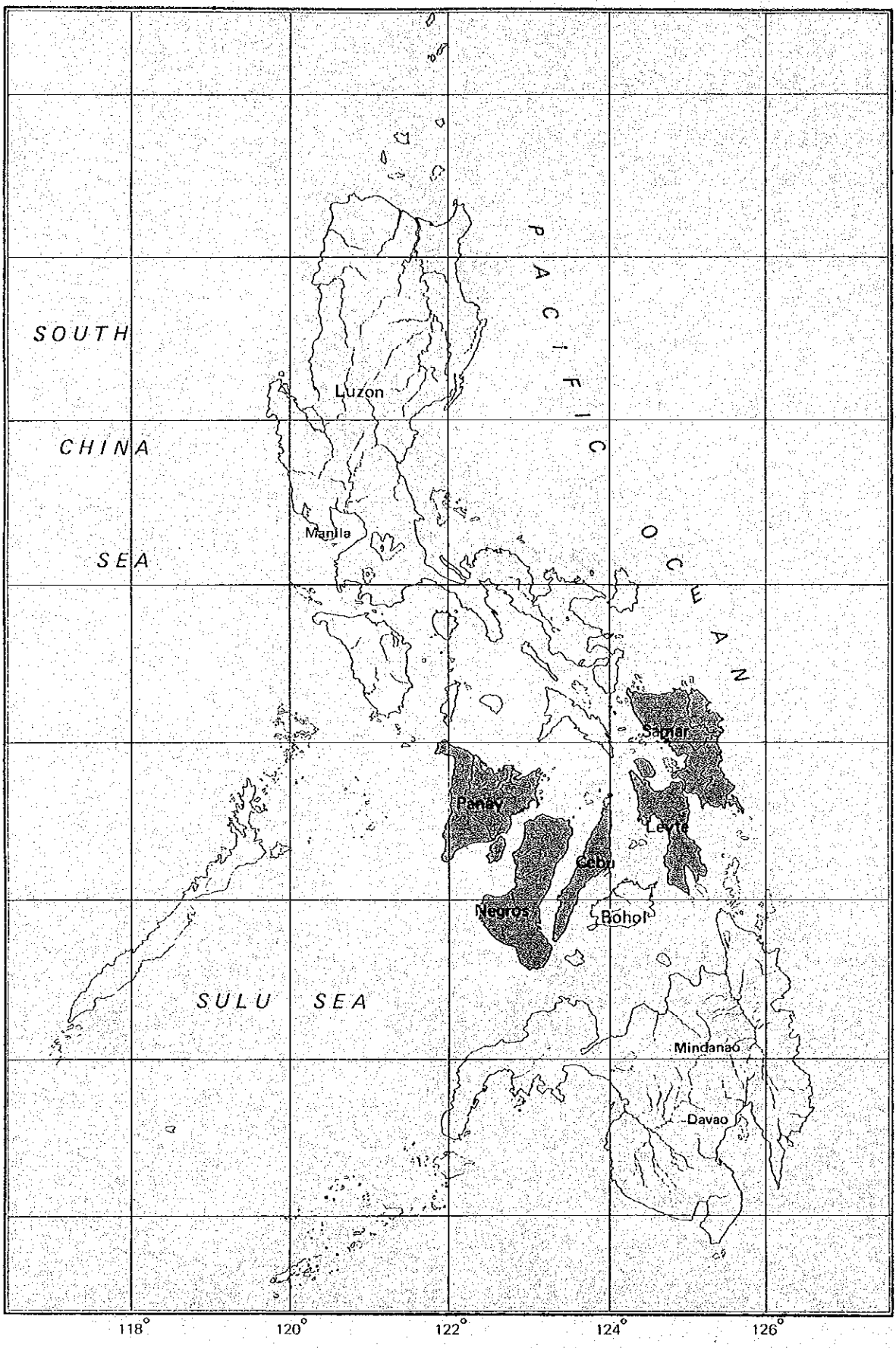
Artist's Imaginary View of Landing Point for 138 kV Submarine Cable

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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

Keisuke Arita

Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Keisuke Arita, President
Japan International Cooperation Agency

Dear Sir:

Herewith submitted is a feasibility study report on the Interconnected Transmission Line and Submarine Cable Project for the Visayas, the Republic of the Philippines.

The objective of the study were to investigate and examine, in accordance with the commission given by Japan International Cooperation Agency, the technical and economical feasibilities for realization of interconnected transmission lines and submarine cables including associated facilities in the Visayas.

In order to achieve the objective, a seven-member survey team headed by Mr. Toshiro Wakamori, of Electric Power Development Co., Ltd. was organized and sent, and field investigation was conducted during a 60 day period from January 10 to March 9, 1980, and basic engineering data on topography, geology, meteorology, etc. as well as data and information as to the situation of electric utilities industry, power expansion program, power market, rate in the Visayas and others necessary for the study were made available to the team. The survey team, upon returning to Japan, studied, examined and analyzed the results of the field investigation and carried out load forecasts, planning and preliminary design of interconnected transmission lines and transformation facilities, power system analyses, cost estimation, construction schedule, economic evaluation, financial plan and analyses, and prepared the feasibility report.

The realization of the Project at an early date is strongly desired by the Philippine Government to cope in the most effective manner with the rapidly increasing power demand accompanying progress in social and economic development of the Visayas. Today, as uncertainty and strain on the global energy situation increase, it is presumed the Project will assume an even more significant nature.

Finally, the team expresses its sincerest and deepest gratitude to all those persons concerned of National Power Corporation and other related agencies of the Government of the Philippines for their kind cooperation in carrying out the study, as well as those persons concerned of the Ministry of Foreign Affairs, the Ministry of International Trade and Industry of Japan, the Embassy of Japan in the Philippines and the Japan International Cooperation Agency for their hearty assistance.

September, 1980

T. Wakamori

Toshiro Wakamori, Chief
Survey Team for Feasibility Study on
Interconnected Transmission Line and
Submarine Cable Project for the
Visayas, the Republic of the Philippines

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CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Antecedents

The Visayas Region of the Republic of the Philippines consists of 6 major islands located at the central part of the country and is of great importance in the economic activities of the nation. The electrification program of this region is now proceeding with development based on "Report on Long-range Power Development Program in the Visayas" submitted to the Philippine Government in March 1973 following field investigations for 3 months by a Japanese Government survey mission dispatched in 1972 by the Overseas Technical Cooperation Agency (OTCA), the predecessor of the Japan International Cooperation Agency (JICA). That is, the National Power Corporation (NAPOCOR) has been increasing power generating and transforming facilities at the various islands based on this report, but at present, the interconnection of the islands proposed in the above report has not yet been realized.

NAPOCOR, in order to cope with the growth in electric power demand in this region in recent years, has decided to introduce power generating barges from Japan in the region based on "Report on Study of Electric Power System of Visayas Region" prepared in August 1978 by the Japan Consulting Institute (JCI), and as recommended in the report, has decided to interconnect the independent power systems of the islands by 138 kV trunk transmission lines and 138 kV submarine cables.

The Philippine Government, in connection with the above-mentioned power generating barge, requested the Japanese Government for a feasibility study on an interconnected power transmission scheme for the Visayas Region by transmission lines, related substations and submarine cables. Based on this request, the Japanese Government decided that the study should be made by JICA and a survey team was dispatched by JICA.

1.2 Objectives and Scope of Investigations

The objectives of this Feasibility Study are to carry out field investigations based on the "Report on Study of Electric Power System of Visayas Region" prepared by JCI, and "Report on Preliminary Study Regarding System Expansion Plan and Interconnected Power Transmission Plan Using Submarine Cables" prepared by NAPOCOR in 1979, and to examine the technological and economic appropriatenesses of the scheme for interconnection of the independent power systems of the islands by 138 kV trunk transmission lines and 138 kV submarine cables.

The field investigations were carried out taking into consideration the following items:

(1) Collection of data for evaluation of present and future electric power systems,

(2) Investigations of the records of power demand and load patterns in power demand in the past and present,

(3) Collection of data on power demand growth in the future,

(4) Studies of expansion of power generation and transformation facilities and future programs,

(5) Selection and reconnaissances of transmission line and submarine cable routes, and projected substation locations,

(6) Collection of data pertinent to related power transmission and distribution networks covering the project area, and

(7) Collection of data for preliminary designs of transmission lines, submarine cables and substations.

Further, in carrying out field investigations, efforts were made to directly obtain data visiting the principal power companies (VECO, PECO, etc.) and electric cooperatives in the region upon being thoroughly briefed regarding the NAPOCOR program.

With respect to the 138 kV trunk transmission lines, since the routes have already been selected by NAPOCOR, field reconnaissances were carried out along these routes by jeep and helicopter. Further, in connection with routes for laying submarine cables, thorough investigations were made in advance through hydrographic charts and periodicals, while provincial port authorities (PPA) having jurisdiction over the object sea area and offices of pilots who would guide vessels navigating these waters were visited to ask about the conditions of the sea bottom, existence of sunken ships and other obstacles, and the optimum season for laying cables. As for the landing sites of cables and connection points with overhead transmission lines, seaborne investigations were made with investigation craft along with field reconnaissances.

The main objective of the Survey Team was to establish the 138 kV interconnected transmission and transformation plan for the Visayas Region, but efforts were made to grasp the present situation regarding the geothermal energy development sites at Palimpinon of the island of Negros and at Tongonan on Leyte which have close relationships with the Project.

With respect to a Leyte-Samar interconnecting transmission line, financing from Japan has already been assured, and the feasibility of this transmission line has been established. However, the Survey Team will make load forecasts and power system analyses of the two islands of Leyte and Samar, while for the crossing of San Juanico Strait by the transmission line, preliminary designs will be made and construction costs calculated respectively for large steel towers for long spans of two routes investigated and tentatively established by the Survey Team, and economic comparisons will be made. The 138 kV transmission line for which financing has been promised is to consist of wooden poles and a single circuit of ACSR 336.4 MCM conductor, but the Report will be written in a manner that the preliminary design and construction cost of the 138 kV transmission line (steel towers, ACSR 336.4 MCM, 1 cct) provided by the Survey Team will be of

reference when a 138 kV transmission line will be newly required for this section.

1.3 Relations with Existing Reports

As a report prepared in the past by the Japanese side in connecting with the Project there is the "Report on Long-range Electric Power Development Program in the Visayas, Republic of the Philippines." This report, on investigating in detail the prevailing conditions in electric power demand and supply on the islands of the Visayas Region at that time had set up a long-range development program for each island, and at present the development program for this region is proceeding based on that report. The interconnection scheme for the various islands which is an object of investigation in the present Study was also mentioned in that report with interconnection by submarine cable proposed for Panay-Negros and Negros-Cebu, and it was suggested that the interconnection be implemented in the first half of the 1980s. An interconnection between Leyte and Samar was also mentioned in the report.

Further, in 1978, there was the "Report on Study of Electric Power System of Visayas Region" prepared by JCI on the occasion of purchase of power generating barges from Japan by the Philippine Government for introduction in the electric power system of the Visayas Region. In this report, it was pointed out that in operating these power generating barges it would be most economical if the barges were to be operated with the electric power systems of Panay, Negros and Cebu interconnected.

As data regarding the Project on the Philippine side there is the "Ten-Year Energy Program from 1979 to 1988" published by the Ministry of Energy. This report explains the energy program for the ten-year period and describes a development program for geothermal power plants as well.

1.4 Composition of Survey Team

The Survey Team was composed of the 7 members below from the Electric Power Development Co., Ltd. (EPDC) and the Japan International Cooperation Agency (JICA), their names and respective responsibilities being as listed below.

Chief	Toshiro Wakamori, Foreign Activities Dept., EPDC (General Supervision)
Member	Isao Asai, JICA (Coordination)
"	Tateshi Murai, Planning Dept., EPDC (Economic Analyses)
"	Hirotaka Minami, Operation & Maintenance Dept., EPDC (Power System Planning)
"	Hiroshi Kagami, Foreign Activities Dept., EPDC (Load Forecasting)
"	Tadao Iso, Operation & Maintenance Dept., EPDC (Power Transmission, Submarine Cable)
"	Koichi Miyajima, Foreign Activities Dept., EPDC (Equipment Planning)

1.5 Field Investigation Schedule

The Survey Team was dispatched divided into a preliminary group and a main group, the former being sent ahead to make various arrangements with NAPOCOR, the host agency on the Philippine side, for accommodating the Survey Team. The preliminary group discussed with NAPOCOR the scope of the investigation works and the facilities and services to be placed at the disposal of the Survey Team by NAPOCOR, compiled an agreement in the form of "The Implementing Arrangement", upon which it joined with the main group.

Field investigations were carried out over a period of approximately one and one-half months from the middle of January 1980. The investigation progressed smoothly with the all-out cooperation of NAPOCOR in the field, and prior to return of the Survey Team to Japan, a report, "The Result of Field Reconnaissance Survey" was submitted to NAPOCOR.

1.6 Fundamental Considerations in Preparation of Report

The fundamental considerations below were confirmed for the examination of the technical and economic soundnesses for construction of the 138-kV trunk transmitting and transforming facilities for the Visayas Region agreed upon between NAPOCOR and the Survey Team based on the data collected in the field investigations.

1.6.1 Load Forecast

A load forecast is the basis for a power generating plant and equipment plan, and at the same time it is also the basis for a power transmitting and transforming plan.

The Survey Team decided to ascertain through cross-checks the appropriateness of the load forecast made by NAPOCOR in September 1979. That is, it was decided to make the Survey Team's own load forecast based on the Visayas Region's past performance in electric power demand, electrification ratio, future population trends, new industrial demand trends, and the distribution network expansion plans of electric cooperatives. It was further decided that thorough considerations would be given to the possibility for switches to purchases of power from NAPOCOR accompanying antiquation of privately-owned power generating facilities.

1.6.2 System Analysis and Determination of Interconnecting Power Transmission Capacity

Power system analyses indispensable for establishing a power transmission and transformation scheme are to be made on the power systems as of 1985 and 1990 respectively, and power flows, voltage distributions, phase angle displacement on buses and generators examined, the necessary reactive power capacity studied, based on the results of which the 138-kV interconnecting transmission lines, transformer capacities of related substations and capacities of submarines cables are to be determined.

Studies of transient stabilities of generators are to be made assuming transmission line faulting conditions. Further, for evaluation of the benefit of the interconnecting transmission line, the diversity in the power demands of the various islands, and forced outage rates of generating facilities by types and by sizes of units are to be investigated, and studies are to be made of probability for shortages in supply capabilities (loss of load probability) with interconnecting capacities of submarine cables as parameters, thereby analyzing the economic effect of this Project.

1.6.3 Preliminary Design and Computation of Construction Cost

Preliminary designing is to be done regarding transmission lines, submarine cables, substations and telecommunications facilities and the construction cost computed. Although designing in detail is to be done at the stage of definite study (D/S) subsequent to the Feasibility Study (F/S), since the estimation of construction cost made at the F/S, stage will be of vital importance affecting the funding plan and the economic analyses, the designs must be of high precision as much as possible. Because of this, even if at the F/S stage, necessary engineering calculations are to be carried out and drawings prepared as much as possible, and the construction cost is to be computed.

1.6.4 Construction Schedule

Increased installation of power generation facilities and construction of interconnecting transmission lines must proceed in step with growth in power demand. As for the construction schedule, it is necessary for it to be one that is most economical and reasonable taking into overall account the capabilities of contractors undertaking construction, production capacities for materials and equipment ordered, and transportation capacities.

The Survey Team will prepare the overall schedule considering marine phenomena conditions with regard to the submarine cable-laying plans which comprise a special aspect of this Project.

1.6.5 Economic Analyses

The merits in construction of an interconnected transmission line lie in interconnection of independently existing power systems to result in reduction of generating reserve capacities required by the individual systems, stabilization of demand and supply through power interchanges, and reduction in power generating costs through construction of large-scale power generating facilities. For this purpose, however, it is necessary for a rigorous economic analyses to be made and the effectiveness of the interconnected transmission line evaluated. Accordingly, in the present Study, the economics will be analyzed from the standpoints of improvement in supply reliability, reduction in generating reserve capacity required, and regional wide-area power development.

1.6.6 Financing Plan and Financial Analyses

With regard to the funding plan the construction cost requirements by year and the loan conditions are to be dealt with in connection with the Project. As for the financial analyses, in view of the nature of the Project, since it will be difficult for an independent analyses to be made, evaluations will be made for the Visayas Region of NAPOCOR as a whole.

CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

As a result of feasibility study conducted by the survey team on the Interconnected Transmission Line and Submarine Cable Project for the Visayas, the following conclusions and recommendations were given below.

2.1 Conclusions

(1) Although the electric power system expansion program for the Visayas has only just been started at the hands of NAPOCOR, efforts are being made throughout the entire Visayas Region to increase the electrification ratio which at present is estimated to be 18%, and the growth rate in power demand in the most recent years has been high at 14.0%. The electrification of this region is being undertaken by NAPOCOR and NEA, which both are government agencies, the former being responsible for construction of large-scale electric power generation facilities and related power transmission and transformation facilities, while the latter is responsible through electric cooperatives for construction, operation and maintenance of transmission, distribution and transformation facilities of 69kV and lower in its franchise area.

(2) In the event the electric power system expansion program for the Visayas should progress smoothly, growth in power demand of an average 12% annually can be looked forward to up to 1995 for the region as a whole. In connection with the Project, the growth in power demand of the three islands of Panay, Negros and Cebu will be an annual average of 11.9% from 1978 to 1995, while the average growth rate for Leyte and Samar will be 43.1% annually. The greater part of the power demand for Leyte-Samar will consist of industrial demand scheduled for Pasar a copper smelting project at nearby Isabel on Leyte Island.

(3) In order to cope with the growth in power demand in the Visayas, NAPOCOR constructed a total of 90.7 MW of new power generating facilities during the three years from 1977 through 1979. The breakdown consists of 14.6 MW of diesel generating facilities on Negros Island, 51.1 MW of diesel generating facilities on Cebu Island, 11.0 MW of diesel generating facilities on Bohol Island, and 3.0 MW of geothermal generating facilities on Leyte Island. The power generation facilities of NAPOCOR up to 1976 in this region consisted only of two hydroelectric power stations with a total installed capacity of 2.0 MW.

NAPOCOR has promoted the electric power system expansion program 1976 to 1993 and the toal installed capacity of power stations presently under construction is 285.5 MW (55.0 MW of coal-fired thermal on Cebu, 54.0 MW of diesel on Cebu, 112.5 MW of geothermal on Leyte, two power generating barges totalling 64.0 MW), and it is scheduled that the total generating capacity will reach 1,240 MW at the end of 1993.

(4) The transmission and transformation facilities for transporting energy produced from the power generating facilities mentioned above consists of, as of

the end of 1979, a total length of 428 km of transmission lines with 138 kV and lower, and 5 substations with a total installed capacity of 127.7 MVA. At end of 1993, the total length of transmission lines of 69 kV and higher will be 2,550 km, and the total installed capacity of transformers is expected to be 570 MVA. Other than the above, there will be 69 kV transmission lines and substations to be constructed by electric cooperatives under the administration of NEA.

(5) The total amount of investment required for construction of these power generating, transmitting and transforming facilities during the period from 1976 to 1993 at 1980 prices is estimated to be US$1,189.2 million, of which US$824.7 million would be a foreign currency portion and US$364.5 million a domestic currency portion.

(6) As a result of investigation and study of technical and economic feasibility for interconnected trunk transmission line, submarine cables and related substations to be constructed in the Visayas in the circumstances mentioned above, it may be concuded that this will be an available and effective project. The outline of the Project is as described below.

(a) Panay-Negros-Cebu Interconnected Transmission Line and Related Substations

- 138 kV Overhead Transmission Line (Steel Towers)

1 cct section	154 km (on-land)
2 cct section	148 km (on-land)
Total	302 km

- Submarine Cable (XLPE, single-phase)

No. of sections	3
Total length	23.6 km

- Substations

Number of substations	3
Additional switching facilities	2 sites

The supports for the on-land overhead transmission lines are to be steel towers for both single circuit and double circuit sections, while conductors are to be 240 mm^2 ACSR. This design, compared with wooden poles and conductors with 336.4 MCM of the original plan of NAPOCOR will have a 27% larger current carrying capacity. The steel tower and conductor size of 240 mm^2 was selected, in view of the facts that this transmission line will be a structural backbone in the three-islan's power systems and therfore will be required high reliability in operation, and as a result of evaluation of transmission losses.

Regarding the submarine cable, economic comparisons were made of OF (oil-filled) cable and XLPE (cross-linked polyethylene) cable, and XLPE cable was selected, but the difference is slight. XLPE cable as a rule requires no maintenance work after laying and the merit of this aspect is great, but the initial investment will be large. Therefore, at the time of taking bids, it will be advisable not to limit the type of cable, and to make a final selection of

either OF cable or CV cable through rigorous comparison and study of the bid prices and the subsequent maintenance costs.

(b) Leyte-Samar Interconnected Transmission Line and Related Substations

- 138 kV Overhead Transmission Line (Steel Towers)

1 cct section	113 km (on-land)
2 cct section	2 km (cross-strait)
Total	115 km

- Substation, 1 station 30 MVA

The entire section is to be constructed with steel towers, while for the strait-crossing section, it is to be 2 cct steel towers and 2 cct line from the beginning stage in anticipation of future increase in transmitting capacity. As for the conductor, the one at the cross-strait portion is to be 200 mm^2 AACSR, which is a high tension conductor having equivalent current-carrying capacity to the 336.4 MCM ACSR for the on-land section.

Regarding the Leyte-Samar Interconnected Transmission Lines and Related Substations Project, financing from Japan has already become definite. The preliminary design, construction cost estimate and economic analysis made in this report is for a 138 kV transmission line which will become necessary for this section on the next occasion. However, the preliminary design for the strait-crossing section comprises a part of the Project to be completed by 1983.

The particulars of the Project are given in Table 2-1 through Table 2-4, and the location of the Project in the Visayas is shown in Fig. 2-1.

(7) The total construction cost of the power transmission lines and related substations project interconnecting the three islands of Panay, Negros and Cebu, including submarine cables, will be US$53,788,000 at March 1980 prices, of which US$41,797,000 will consist of a foreign currency portion and remaining US$11,991,000 a domestic currency portion. If it is assumed that the escalation in costs during the construction period until the time scheduled for completion (end of 1984) will be 7.0% for the foreign currency portion and 12.0% for the domestic currency portion, the estimated construction cost at the time of completion will be US$68,256,000 of which the foreign currency portion will be US$51,247,000 and the domestic currency portion US$17,009,000. The breakdown of the construction cost is given in Table 2-5.

On the other hand, the total construction cost of the transmission lines and related substation project for interconnection of the two islands of Leyte and Samar at prices as of March 1980 is US$8,661,000, of which the foreign currency portion will be US$5,378,000 and the domestic currency portion US$3,283,000.

(8) (a) Panay-Negros-Cebu Interconnection

Generally speaking, when an electric power system is expanded through interconnection, there are various benefit resulting from the interconnection which can be thought of. In case of the three-island interconnection, the two befit of saving reserve capacity and of regional wide-area power development

made possible by the three-island system interconnection are evaluated in monetary terms and considered as the benefit, while the investment amount for the transmission and transformation facilities required for the three-island system interconnection is considered as the cost, and it will be judged that the Project would be economically advantageous if the benefit-cost ratio (B/C) were to be higher than 1.0.

The savings of reserve capacity will be 69.3 MW in 1990, and when this installed capacity is evaluated by converting to a diesel power station that its construction cost per kW is the lowest among the power generating facilities now being constructed by NAPOCOR in the Visayas Region. The benefit of saving reserve capacity was estimated US$35,204,000. As for the benefit of regional wide-area power development, based on the amount of energy which is produced with non-oil fuels and interchanged between the three islands during the 6 years from 1985 when the Project will have been completed through 1990, the difference between fuel costs with bunker C oil and another non-oil fuels (coal, geothermal energy) was considered as the benefit. The benefit of regional wide-area power development converted to present worth as of 1985 when the Project will have just been completed will be US$16,808,000. Consequently, the aggregate of the two benefit will be US$52,012,000.

Meanwhile, the total construction cost (not including escalation) for the three-island interconnection which will correspond to the before-mentioned cost will be US$53,788,000, but when the scope of cost estimate is limited to only transmission facilities required for three-island interconnection, the cost will be US$34,229,000 (Case 1). On the other hand, taking account of that the 138 kV trunk transmission line with 2 cct on Negros is essentially required for the capacity of power flow passing through the line resulted from the projected balance of demand and supply within the island. 50% of the construction cost for this 2 cct transmission line section were deducted and the remainder was considered as the cost required for three-island system interconnection, then that cost would be US$46,439,000 (Case 2). On computing the benefit-cost ratios for the two cases above, the results are as follows.

Case 1: $B/C = US\$52,012 \times 10^3 / US\$34,229 \times 10^3 = 1.52$
Case 2: $B/C = US\$52,012 \times 10^3 / US\$46,439 \times 10^3 = 1.12$

For the above evaluations, the Project is economically advantageous. When benefit such as reductions in frequency and voltage fluctuations, and power exchanges between the islands at times of abnormal conditions which cannot easily be calculated in terms of monetary amounts are considered, the advantageous nature is even more enhanced.

(b) Leyte-Samar Interconnection

Since the Leyte-Samar system interconnection will have a specific system structure that Tongonan Geothermal Power Station is the sole source of power supply in the system, there will be no effect of savings of reserve capacity as in the case of the three-island interconnection. However, since

the fuel cost per kWh of the geothermal power plant is lower than that of a diesel power plant using bunker C oil, an evaluation can be made focusing on the difference between the two fuel costs. Further, as already stated previously, construction of the transmission line designed by the Survey Team will become possible at some time after (1990 or later) the completion of another 138 kV transmission line has already been planned and decided to construct over the same section therefore, it is difficult to determine the time schedule for construction of the project designed by the Team. The evaluation was made with the annual expenses of the both transmission line and receiving Wright Substation calculated from the total construction cost (at 1980 prices) based on the preliminary design as the cost, and with the amount which multiplied the electric energy passing through this transmission line 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 electric energy for which the benefit-cost ratio would become 1.0 at Wright Substation was obtained. As a result, the energy for which the benefit-cost ratio would become 1.0 was found to be 28.3 million kWh. 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 this project will be higher than 1.0.

(9) The construction period for the on-land power transmitting 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 equipment purchasing and installation specifications to completion of construction under the most economical work schedule. In particular, the submarine cable-laying works will constitute the critical path, and it will be necessary to do investigations in connection with marine phenomena, sea-floor topographies, meteorological conditions, etc. of the cable routes to be made and completed by NAPOCOR by around March 1981. The construction schedule is as indicated in Fig. 2-2.

(10) It will be difficult to make a financial analysis of the Project (Panay-Negros-Cebu System Interconnection) alone because of the nature of the Project. Electricity rates for the power generating, transmitting and transforming facilities owned and operated by NAPOCOR in the Visayas are determined based on the cost method. Therefore, it was decided that an evaluation should be made under the existing rates schedule based on a financial analysis of the entire Visayas Region incorporating the investment requirements for the Project in the investments for generating, transmitting and transforming facilities throughout the Visayas Region from 1976 to 1993. The result was that with the current electricity rates schedule it would be difficult to repay principal and interest for this project, so raises of 10% in 1982 and 1984, respectively, would be required. In accordance with the raises of rates the net income for the entire Visayas Region will turn to the balance from 1985, the amount of surplus for the single year of 1988 would be US$27.7 million, and in 1992 the surplus would be US$77.6 million. As for cash flow, it will turn to the balance from 1984, with cumulative cash flow turning to the balance in 1991.

2.2 Recommendations

Based on 2.1, "Conclusions", it is recommended for the items described below to be realized.

(1) The Project will consitute the backbone of the power transmission and transformation expansion program for the Visayas, and in consideration of reliability of the system, all supports should be steel towers, while conductor size for overhead transmission lines on the three islands of Panay, Negros and Cebu should be ACSR 240 mm^2. For the overhead transmission lines of the two islands of Leyte and Samar, the conductor size should be ACSR 336.4 MCM, provided that for the cross-strait section, a high tension conductor, AACSR 200 mm^2, having the same current-carrying capacity as the conductor at the on-land sections should be adopted.
For the submarine cable, XLPE (cross-linked polyethylene) cable, single-phase, was adopted, but the final decision on the type of cable should be made taking into consideration the prices in bidding and maintenance costs after laying of the cable.
Transforming and switching facilities will be required for connections with existing facilities and power supply to other grids, while telecommunications facilities of the Project. The facilities to be provided are indicated in Table 2-3.

(2) Construction Schedule

Construction works for the Project (Panay-Negros-Cebu System Interconnection) should be started in 1982 and completed at the end of 1984. Accordingly, various preparation works such as investigation detail design, and equipment purchasing and installation specifications, should be carried out timed to the above construction works, while other preparations such as negotiations for financing should be made without delay in accordance with the construction schedule indicated in Fig. 2-2

(3) Further Field Investigations

It will be necessary for NAPOCOR to carry out the field investigations below.

i) Topographic Surveying and Geological Investigations along Overhead Transmission Line Routes

Topographic surveying along the routes and of steel tower locations should be performed by March 1981. Ground bearing capacity investigations should be made at sites of soft ground such as rice paddy areas where steel towers are to be erected.

ii) Investigations along Submarine Cable Routes

Detailed investigations of submarine Cable routes are to be made by the cable contractor, but preliminary investigations at least of the sea-floor topographies and floor materials should be completed by NAPOCOR by March 1981.

iii) Investigations of Leyte-Samar Strait-Crossing Section

Topographic surveying of areas along routes selected by the Survey Team, and topographic surveying and geological investigations of projected steel tower construction sites should be carried out as soon as possible.

iv) Insulator Salt Soilage

Pilot insulators should be installed at projected cable terminal sites and representative points at seaside zones of overhead transmission lines, and measurements should be made of insulator soilage by sea salt. It will be desirable for these investigations to be continued even after completion of final designs.

(4) Acquisition of Land

It is thought some length of time will be required for acquiring substation lots and transmission line rights of way. Therefore, negotiations should be commenced with those concerned for acquisition of land in the vicinities of prospective substation sites selected by the Survey Team, and regarding steel tower locations and easements along the projected transmission line routes.

(5) Vigorous efforts should be made for realization of the Project (Panay-Negros-Cebu System Interconnection) carrying out negotiations with agencies concerned in regard to procurement of the necessary funds for the Project.

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 3ø 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.

Table 2-5 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. 2-1 Power System Expansion Program in Cebu - Negros - Panay and Leyte - Samar Is.

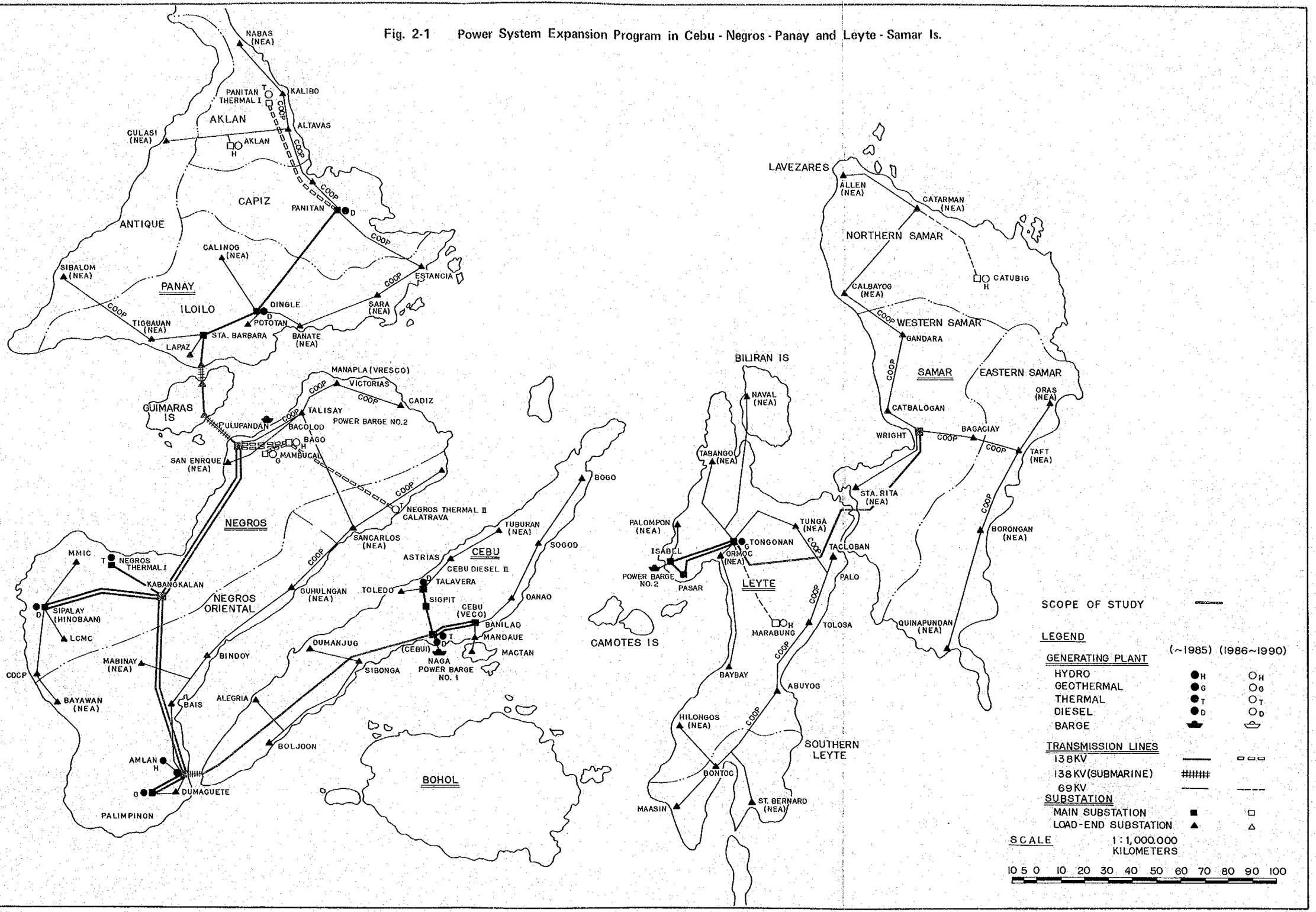

Fig. 2-2 Panay - Negros - Cebu Interconnected Transmission Lines Project Construction Schedule