Fig. 3-1 Schedule Leyte Power Transmission Project (First Stage)

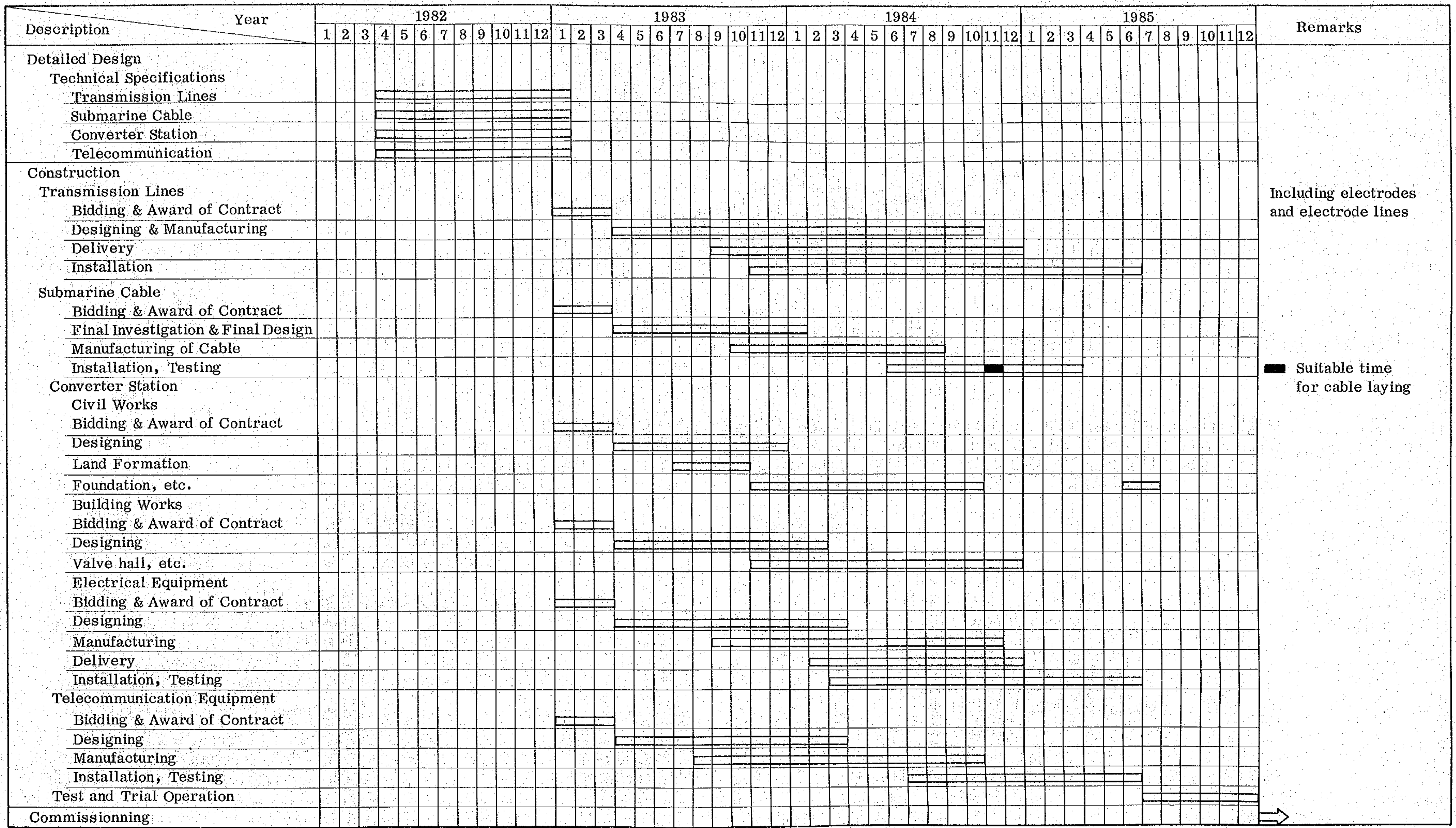
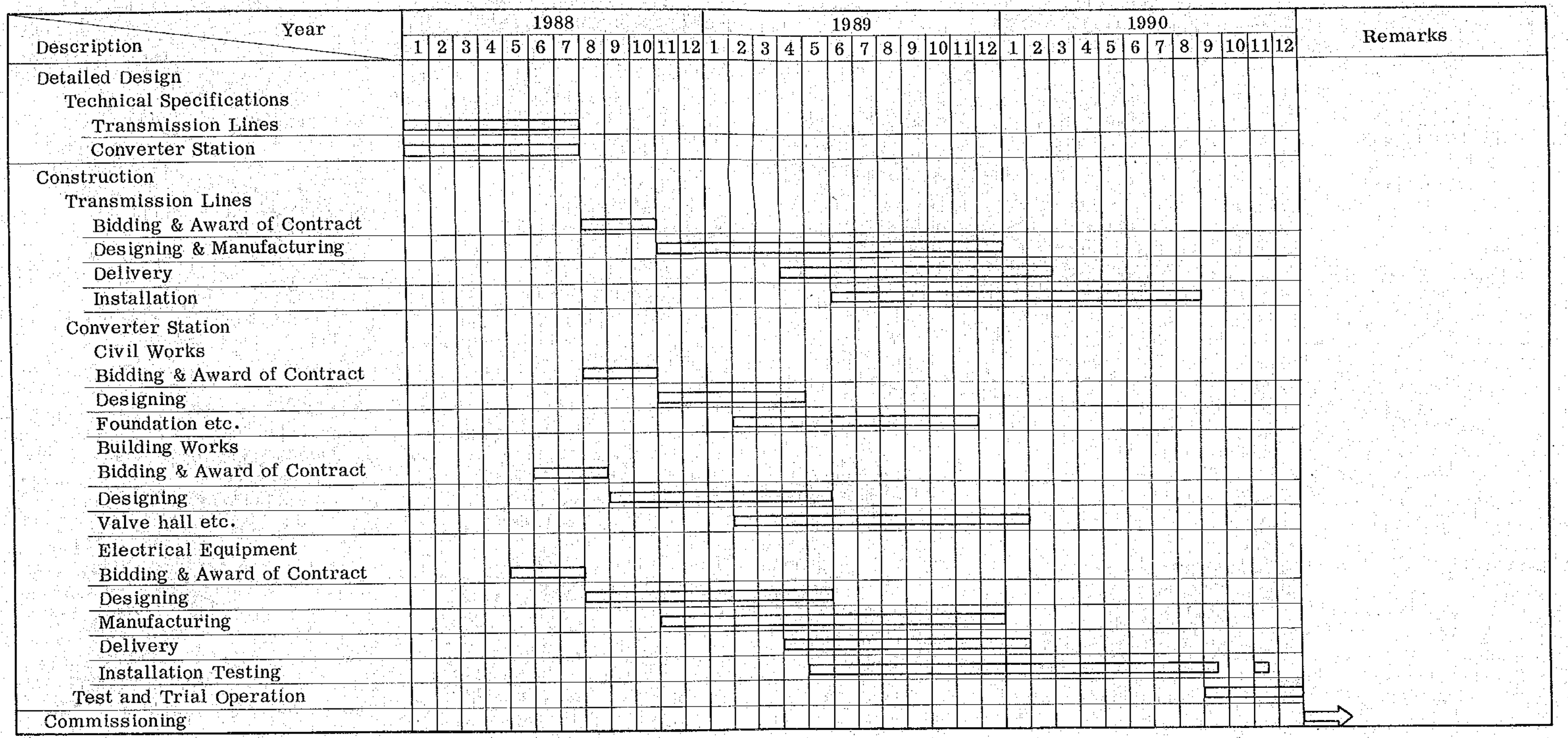


Fig. 3-2 Schedule Leyte Power Transmission Project (Second Stage)



4. ECONOMIC EVALUATION

As stated in the foregoing item 2.3.1 dealing with the power transmission plan, there are three alternative systems of AC 500 kV, AC 230 kV and HVDC for transmission of geothermal energy at Tongonan to San Jose Substation situated in consuming center of Luzon.

The Survey Team has put aside the AC 500 kV plan out of detailed economic comparison in terms of construction costs, because the said plan ranks obviously at the worst, higher by about 35 percent than the AC 230 kV and by about 70 percent than the HVDC plan.

4.1 Foundamental Conditions for Economic Comparison

Economic comparison covers the transmission system over total length of about 800 km from Tongonan Switch Yard of 138 kV system to San Jose Substation, since the Project plans transmission of power from Tongonan Geothermal Power Plant to San Jose Substation situated in the suburbs of Manila. However, the scope of evaluation will exclude the 340 km section from San Jose Substation to Naga Converter Station, since the said portion is planned definitely for construction of the AC 500 kV transmission line. It should be noted, however, that the AC 230 kV transmission plan will require operation of AC 500 kV for the San Jose - Naga section from the beginning of 1986 scheduled for start-up of power transmission from Tongonan Geothermal Power Plant while the HVDC plan is scheduled to step up its voltage rating to 500 kV with time lag until 1991. The cost difference due to time lag in stepping up the voltage between the AC 230 kV transmission and HVDC plans has also been incorporated into the economic evaluation. The evaluation reflects, besides the above time lag, possible difference in power transmission energy loss in the Tongonan S/Y - San Jose S/S section between the two alternatives.

4.1.1 Construction Costs

Construction costs for the section between Tongonan Switchyard and San Jose Substation may be estimated as shown below. Note, however, that such costs are based upon the price level as of March 1981, not taking into account any interest accruals during construction and price escalation.

Unit = 10^6 US$

Items	HVDC		AC 230 kV	
	1st Stage	2nd Stage	1st Stage	2nd State
Direct const. cost	213.0	* 172.3	* 307.0	167.0
Physical contingency	16.0	7.0	23.0	12.5
Engineering & adm.	10.2	4.5	7.0	4.0
NPC's Eng. enducation	0.2	0.1	0	0
Total	239.4	183.9	337.0	183.5

Note : including voltage step up costs from AC 230 kV to AC 500 kV

4.1.2 Energy Loss

Generally, the applicable method of power loss evaluation may be divided into kW-based and kWh-based assessments. In the case of this Project, however, it is considered reasonable to evaluate power loss only in terms of kWh because power transmission proposed under the Project is intended to take place of the existing oil-fueled power plants. Then, oil fuel price for evaluation has been considered as the price as of March 1981, the basic time point of this economic evaluation. On the above basis, energy loss has been assumed as follows:

Transmission energy loss = 50 U.S. mills per kWh

Where, 32.0 U.S. dollars per barrel

4.1.3 Opportunity Cost of Capital and Discount Rate

The discount rate has been determined at 10 percent per year. This discount rate is regarded as the opportunity cost of capital when viewed on the capital investment side and is normally the expected minimum rate of return for a project in the case of there being financed by the I.B.R.D. Cost comparison is, therefore, made between the two alternatives after the projected cash flow (cost flow) for both HVDC and AC 230 kV plans has been discounted by the opportunity cost of capital.

4.1.4 Period for Evaluation

Tongonan Geothermal Power Plant is planned for future expansion to complete Unit No. 4 thru Unit No. 11 by 1986 and subsequently to Unit No. 21 by 1993. The durable service life of the geothermal power plant is stipulated at 20 years. Under both HVDC and AC 230 kV plans the transmission line (including submarine cable) has a service life of 50 years and the substation (including converters) has a life of 25 years.

Although the Project constitutes various components diversified in each durable service life, the cash flow is projected on the basis of 30-year durable service life uniformly counting from initial start-up of operation.

4.2 Result of Economic Evaluation

The benefit-cost ratio has been compared as follows between the HVDC and AC 230 kV plans after discounting by 10 percent as the capital opportunity cost the total cash flow inclusive of construction, operation, maintenance and energy loss costs.

B Benefit (Cost for AC 230 kV) 786.9×10^6 US$

C Cost (Cost for HVDC) 711.2×10^6 US$

$$B/C = 786.9 \times 10^6 \text{ US\$} / 711.2 \times 10^6 \text{ US\$}$$

$$= 1.106$$

5. FINANCIAL ANALYSIS AND FINANCING ARRANGEMENTS

Some hypothetical conditions are required for financial analysis and financing plan for the Project.

a) Power Rate

Financial analysis is shown in the income statement and in the cash flow statement of the project, and various power rates are applied for calculation of reasonable return rates.

b) Cost

The cost for this analysis includes the allocated portion of construction cost for the AC 500 kV transmission line from San Jose substation to Naga converter station, the total HVDC cost and the power generating cost at Tongonan.

c) Evaluation Period

Both income statement and cash flow statement are calculated for the period of 25 years after commencement of the project.

5.1 Financial Analysis

Sensitivity of the return rate on the average power rates and increase in cash on the interest rates are shown in Table 5-1 and 5-2.

According to the above, the return rate is expected to be about 8% a few years after the start of operation in the case of average power rate of 75 US mills/kWh.

In the case of 6% of interest rate for the foreign fund, negative cash flow just after the commencement will be recovered gradually and considerable amount of internal reserve is possible after about ten years.

5.2 Financing Arrangements Plan

Vast sum of investment will be required for implementation of this Project.

10^6US$

Items	First Stage			Second Stage			1st plus 2nd
	F.C	D.C	Total	F.C	D.C	Total	Total
Direct const. cost	162.1	48.8	210.9	76.7	15.6	92.3	303.2
Indirect cost	23.3	18.7	42.0	10.2	6.2	16.4	58.4
Price escalation	57.9	41.6	99.5	73.7	51.1	124.8	224.4
Total cost required	243.3	109.1	352.4	160.6	73.0	233.6	586.0

The foreign currency portion of such costs should be financed by the fund of low interest, longer term of repayment.

The local currency portion should preferably be financed by the Philippines Government. If it is difficult, the important thing to do is to seek any available financing source which can afford any loan fund of low interest rate, longer term of repayment, same as in the case of arrangements for the foreign currency portion.

Table 5-1 Sensitivity of Return Rate on Average Power Rate

Unit: %

Year \ Power Rate (US Mill/kWh)	65	70	75	80
1986	3.28	5.21	7.09	9.09
1987	3.10	5.10	7.10	9.10
1988	2.94	5.01	7.08	9.15
1989	2.75	4.90	7.04	9.19
1990	2.50	4.73	6.95	9.18
1991	3.40	5.57	7.75	9.92
1992	3.91	6.18	8.46	10.73
1993	3.98	6.33	8.67	11.02
1994	4.14	6.59	9.05	11.50
1995	4.28	6.85	9.41	11.97
1996	4.51	7.21	9.91	12.61
1997	4.76	7.61	10.46	13.31
1998	5.05	8.07	11.09	14.11
1999	5.37	8.58	11.79	15.00
2000	5.73	9.15	12.58	16.01
2001	6.14	9.81	13.49	17.16
2002	6.62	10.58	14.54	18.50
2003	7.18	11.47	15.79	20.06
2004	7.84	12.53	17.22	21.91
2005	8.64	13.80	18.97	24.13

Table 5-2 Sensitivity of "Increase in Cash" on the Interest Rate

Unit: 10^6 US$

Year \ Interest Rate (%)	4	6	8	10
1982	0	0	0	0
1983	-1.2	-1.8	-2.4	-3.1
1984	-7.8	-11.8	-15.7	-19.6
1985	-9.7	-14.6	-19.5	-24.3
1986	73.1	68.2	63.3	58.5
1987	71.2	66.2	61.4	56.6
1988	68.4	63.2	58.1	52.9
1989	61.5	54.0	46.5	39.0
1990	57.6	49.6	41.5	33.4
1991	107.9	99.9	91.8	83.7
1992	148.4	140.4	132.3	124.2
1993	157.6	149.5	141.5	133.5
1994	155.1	147.3	139.4	131.6
1995	154.3	146.7	139.1	131.5
1996	154.8	147.4	140.1	132.7
1997	154.7	147.5	140.4	133.3
1998	149.3	142.4	135.6	128.7
1999	148.5	142.0	135.5	129.1
2000	149.2	143.1	137.1	131.0
2001	150.0	144.4	138.7	133.0
2002	150.9	145.6	140.3	135.0
2003	151.7	146.8	141.9	137.1
2004	152.5	148.0	143.6	139.1
2005	153.3	149.3	145.2	141.1

6. RECOMMENDATIONS

(1) Implementation of detailed design (D/S)

In order to complete the first stage construction by the end of 1985, the detailed design should be completed and the tender documents including technical specifications should be prepared during 1982 at the latest. For this reason, the detail design must be started as quickly as possible.

(2) Construction fund procurement

It is essential that negotiation with the related agencies should be made for obtaining the fund necessary for this project at as an earliest opportunity as possible and every effort is made to realize the project.

(3) Survey of submarine cable installation route

The submarine cable installation route must be surveyed in detail based on the preliminary survey result conducted in March, 1981 before tender of the cable installation starts.

(4) Survey of grounding electrode sites

Regarding grounding electrodes of the Jaro and Naga converter stations, surveys for selecting for sites and detail design of the electrodes must be executed.

(5) Salt contamination survey

Salt contamination is an especially crucial check item for HVDC equipment. Salt adhesion to insulators must be measured throughout the whole planned area for detailed design.

(6) Early start of land procurement

Procurement work of the sites for converter stations, transmission lines and microwave repeating stations must be started well in advance so that the land problem will not cause delay of the construction schedule.

(7) Microwave system

As information transmission between converter stations is essential for HVDC transmission and the transmission speed must be fast, microwave circuits are essential. Approval on use of microwave system, including allocation of the frequency, must be obtained from the authority at an early stage, so that no inconvenience is caused in ordering the equipment.
Also, detailed field surveys must be conducted well in advance for selection of repeating stations, so that the detailed design can be established in the early stage.

(8) Adoption of full turn-key system

For the purpose of smooth progress of the construction process and for established responsibility system, ordering on the full turn-key basis, in which all processes are delivered after installation adjustment and trial operation, is most preferable.

(9) Spare submarine cable

In the preliminary design, two (2) submarine cables are to be installed in the first stage and installation of a spare cable is not planned. However, in view of the fact that the Leyte power transmission line is a very important power source line for the Luzon power grid, and if very high reliability is needed, installing a spare cable may have to be planned. The decision must be made after careful study.

(10) Operation, maintenance and training

Operation and maintenance of HVDC transmission equipment involves much of new technology and highly developed techniques are vital.

Therefore, sufficient training must be given to engineers who engage in the operation and maintenance to secure enough number of HVDC engineers before the operation starts in 1986. Since such training contributes improvement of technology level, such training program must be planned and enthusiastically implemented allowing sufficient time.

(11) Cooperative operation with Tongonan Power Plant

Close cooperation between the generators of the Tongonan geothermal power plant and HVDC is very important. The necessity of close cooperation in the design stage must not be neglected when planning additional installation of the power plant.

(12) Power System Stabilizer (PSS)

Necessity of installing PSS in generators for stable operation of the entire power system, including HVDC, has been proven through system analysis. PSS must be installed in all new generators stations except Tongonan ones. It is desirable to install PSS in the existing generators as well.

(13) Schedule for stepping-up the EHV voltage

Based on the system analysis, the EHV transmission line voltage between Naga and San Jose must be stepped up to 500 kV by 1991.

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