the following growth rates are applied to the power demand forecast in the public lighting:

Growth Rate and Energy Demand of
Public Lighting in Limbang

Year	1986	1990	2000	2010
Growth rate	-	10%	8%	6%
Energy Demand (MWh)	70	102	220	394

4.4.5 Results of examinations

This subsection describes the results of examinations on the power demand forecast by using the basic data and criteria mentioned in Subsection 4.4.4. The results express the so-called "normal" growth.

In addition, both high and low cases of power demand are also projected considering the uncertainties involved in the assumed values.

1. Results of demand forecast (Normal)

Power consumption (energy sale) in the Limbang area is estimated by totalling the requirements in the domestic, commercial and industrial sectors and the public lighting. Furthermore, energy generation and maximum demand are predicted based on the estimated power requirement. Following are the summary of demand forecast in the Limbang load centre:

Results of Demand Forecast (Normal)

Year	Energy Consumption (MWh)	Energy Generation (MWh)	Maximum Power Demand (kW)	Annual Load Factor (%)
1984	8,083	9,462	1,912	56.5
1985	9,239	10,609	2,006	60.4
1986	10,212	11,596	2,502	53.0
1987	11,390	13,090	2,720	55.0
1988	12,570	14,450	2,840	58.0
1989	13,730	15,780	3,110	"
1990	14,960	17,200	3,390	"
1995	22,580	25,950	5,110	"
2000	31,110	35,750	7,290	56.0
2005	41,190	47,340	9,650	"
2010	54,020	62,090	12,660	"

System loss and station use are counted in estimating the required energy generation from the power requirement. A value of 13%, obtained from the past records, is applied as the rate of system loss and station use to the energy generation. On the other hand, the annual load factor used for the calculation of maximum demand is determined based on the past trend as given in the above Table by referring to that of the major cities in Sarawak.

2. High and low cases

The high and low cases of power demand are projected by changing the values of the electrification ratio and growth rate of power requirement in the industrial sector, since higher uncertainties may be involved in those factors compared with others.

(a) Electrification ratio

The electrification ratios used for the high and low power demand forecast are given below:

Electrification Ratios in the High and Low Demand Forecast

Unit: percent

Year	Original (Normal)	High	Low
1990	45	50	45
2000	55	60	50
2010	60	70	55

(b) Growth rate of power consumption in industrial sector

The demand forecast in the industrial sector was based on the past trend. Since high uncertainties are expected in the growth rate of power consumption in the industrial sector compared with that of other sectors, following rates are applied in the high and low demand forecasts:

Growth Rate of Power Consumption by Industrial Sector

Unit: percent

Year	Original (Normal)	High	Low
1990	12	14	10
2000	9	12	8
2010	8	10	6

Power demands in the high and low cases are projected applying the procedure used in the normal case to the above conditions. Figs. 4.12 and 4.13 show the summary of projection results, giving 10% and 15% higher power requirement in 2000 and 2005 respectively in the comparison of high and normal cases, whilst 10% and 12% lower power requirement in 2000 and 2005 respectively in the comparison of low and normal cases.

4.4.6 Comparison between previous and present studies

As mentioned in Subsection 4.4.3, there are two previous studies for the power demand forecast of the proposed load centre, Limbang; that is, the projections by SESCO in 1986 and by SAMA Consortium in 1983. The comparison between the previous and present studies was made on the power requirement and maximum demand.

1. SESCO

As seen from Figs. 4.14 and 4.15, there are no remarkable differences on both power requirement and maximum demand, and the average growth rate in the power requirement and maximum demand is compared as follows:

Comparison of Average Growth Rate

Unit: percentage

Year	Power Requirement		Maximum Demand	
	SESCO	JICA	SESCO	JICA
1986 - 1990	8.2	10.0	6.3	7.9
1990 - 2000	7.8	7.6	8.1	8.0
2000 - 2010	5.9	5.7	5.9	5.7

It is judged that the difference in the period from 1986 to 1990 is caused by data employed for the forecast; that is, data of 1986 are used as the base of demand forecast by JICA.

2. SAMA Consortium

The power demand forecast by SAMA Consortium was based on the regression analysis. According to their report, following growth rates were assumed in the energy sale (power consumption):

Growth Rate of Energy Sale

Year	1986	1990	2000	2010
Growth Rate	9.5%	9%	8%	7%

The average growth rate in the period from 1980 to 1986 was recorded at 13.6% per annum, resulting in lower side of demand forecast. However, a higher growth rate of 7% in 2001 onward causes the greater demand than that estimated by JICA after 2009.

4.5 Power Balance Study

According to the power demand forecast discussed in the previous section, peak demand in the Limbang system is expected to increase from 2.5 MW in 1986 to 3.4 MW in 1990, 5.1 MW in 1995, 7.3 MW in 2000 and 12.7 MW in 2010, whilst 11.6 GWh/yr in 1986 to 17.2 GWh/yr in 1990, 26.0 GWh/yr in 1995, 35.8 GWh/yr in 2000 and 62.1 GWh/yr in 2010 in energy demand. In addition, reserve capacity is required for maintaining the system reliability. If a largest diesel unit or 20% of peak demand, whichever is larger, is taken as the reserve capacity, the total capacity will reach 4.4 MW in 1990, 6.1 MW in 1995, 8.8 MW in 2000 and 15.2 MW in 2010.

On the other hand, present power supply capacity in the Limbang system will be strengthened to 5.2 MW by adding two units of diesel plant (1.6 MW in total) and a hydro plant of 0.15 MW by 1990. Since the retirement of diesel plant is expected from 1990 onwards, the supply capacity will gradually decrease. As a consequence, an addition of new plants will be required after 1991. The Medamit-2 hydropower project is a promising scheme to be added to the Limbang system besides diesel plant in line with the energy diversification policy of the Government.

CHAPTER 5 PLAN FORMULATION

5.1 Optimization Study

5.1.1 Approach

An optimal development scale and timing of Medamit-2 will be determined by searching the installation scale and timing of it in the optimal power development programme of a long time span called planting-up. The search for the optimal development scale by this procedure takes into account not only the development merit at the Medamit-2 site itself, but also the system requirement. Namely, a power balance on the load curve or estimate of saleable energy of Medamit-2 is tested for finding out a sequence to minimize the present worth of capital and operating and maintenance costs including fuel costs of power plant needed to the system in a long time span.

The optimal development scale of the Medamit-2 project is, indeed, defined as the scale appeared in the power development sequence to give the net benefit maximum among the sequences including the alternatives of Medamit-2. Counted as benefits are the costs incurred from the least cost development sequence by all diesel plant, which will be most adequate alternative power source as discussed in the subsequent section. On the other hand, costs are counted from the least cost development sequence including the alternative of Medamit-2 project.

The development alternatives of the project for comparison are made by combining plant discharges and dam heights (or full supply levels).

The least cost development sequence for the cases of with-and-without project will be searched by the technique of trials and errors. The estimate of saleable energy will be made using a daily load curve and 365-day runoff data availed in the hydrological analysis.

5.1.2 Conditions and input data for the planting-up study

A number of conditions are set up for this planting-up study considering the reality of construction on power plant. Furthermore, the planting-up study requires input data. Those are summarized as discussed below:

(i) Parameters to be applied to the discounting technique

- Discount rate : 0.10
- Investing horizon : 24 years between 1987 and 2010

- Planning horizon : 50 years between 1987 and 2036.

The discount rate of 10% is selected as the prime test discount rate, and the tests by changing the discount rate are discussed in the sensitivity tests.

(ii) Power and energy demands forecasted by year 2010 including high and low demands.

(iii) Reserve capacity for power demand

A largest diesel unit or 20% of peak demand, whichever is larger, is taken as the reserve capacity.

(iv) Presumed load curve and factor

The load curve, which shows the pattern of energy requirement, is presumed based on the daily load records and the projection of power and energy demands. Figure 5.1 shows the load curve applied to the investing horizon of the Limbang system and stacking of plant to assess whether or not energy requirements are sufficed with the plant conceived is based on this load curve.

The load factor applied to the load curve is changed by year as follows:

1987	:	55%
1988 to 1999	:	58%
2000 to 2010	:	56%

Power of hydro plant in the planting-up sequence is evaluated with guaranteed power, which is defined as the minimum out of power outputs in a year obtained by the simulation of daily load curve and daily runoff data. The power generated from the hydro plant would share the peak portion of load curve in the dry period to increase guaranteed power.

(v) List of existing and under-construction power plant

Table 5.1 shows the list of existing, under-construction and committed power plant in the Limbang system including the information required in the planting-up study.

(vi) Alternative power source

- Type of alternative power plant

Power demand is projected to increase from the level of 2.5 MW in 1986 to 12.7 MW in 2010 in the Limbang system.

An economically feasible range for the addition of gas turbine plant to the power system would be in 10 to 100 MW. The plant size required to be newly added to the system is 1.0 MW or 2.0 MW at most. It is far small from the economically feasible range of gas turbine plant, and then diesel plant is only selected as the alternative candidate to be added to the system.

- Information on diesel candidates

The diesel plant listed in Table 5.2 is assumed to be the candidate which will iteratively come to the system.

The retirement of existing plant is considered, if the retirement of the plant comes during the investing horizon. The replacement of newly added plant is taken into account. The life time of diesel plant is also depicted in Table 5.2. The replacement cost is 90% of initial cost.

The economic cost used in the planting-up study is estimated for the construction cost as follows:

Capital cost	:	0.85
Operation and maintenance costs	:	0.97
Fuel cost	:	0.86.

It is predicted by the World Bank, Department of Energy, U.S.A. and so on that oil price will gradually increase after 1990's onward. This is counted in the optimization study. Table 5.2 also shows the increase rate of fuel price in the investing horizon.

(vii) Transfer and cold reserve of diesel plant

Diesel plant will be transferred to other load centre, if the diesel plant is not used for more than three years successively by the addition of the Medamit-2 project and furthermore the system still remains the capacity to meet the demand even under malfunction of one unit of the project. The transfer of diesel plant is counted as the negative cost on the least cost sequence with the project, the value of which is assumed at 80% of installation cost.

On the other hand, the diesel plant, which will be used again within three years, will be kept as a cold-reserve unit, in which fixed O & M costs are saved in the evaluation.

(viii) Two-stage development is considered for the development candidates of Medamit-2, if guaranteed power of it is far big compared with the demand growth in the Limbang power system.

The lead time required prior to construction is assumed to be almost five years from the beginning of year 1987 (refer to Fig. 7.1), the breakdown of which is as follows:

Feasibility study	: 17 months (up to May 1988)
Financing of detailed design and construction	: 12 months (June 1988 to May 1989)
Detailed design including the selection of consultant	: 19 months (June 1989 to December 1990)
Tendering and contract for construction	: 10 months (January 1991 to October 1991).

The construction of Medamit-2 is assumed to start in November 1991 following the pre-activities of construction and to complete by December 1995 (4 years and 10 months). Thus, in-service year of Medamit-2 is assumed to be at the beginning of 1996.

The costs of all the civil works are assumed to be incurred in the first stage; that is, the costs on the second stage are incurred from the installation of generating equipment. The economic cost used in the planting-up study is assessed to be 0.85 of the construction cost based on the study of subsequent Chapter 8. Furthermore, outlay of construction costs is assumed to be 1.5%, 16.6%, 26.1%, 35.0% and 20.8% in the first stage.

In searching the optimal development scale of Medamit-2, the installation timing of its first stage is fixed in 1996. The optimal installation timing of Medamit-2 is searched by shifting the installation year of each stage for the scale determined to be optimal.

Sensitivity tests are carried out for assessing uncertainties involved in the future costs and assumptions applied to the planting-up study. Following are selected as the cases to perform the sensitivity tests:

- Variation of discount rates; 4%, 5%, 8% and 12% besides the prime test discount rate of 10%,

- Low and high demand forecasts,

- 10% capital cost up for Medamit-2,

- 10% fuel cost up and down for diesel plant, and

- 1987 constant fuel cost for diesel plant.

5.1.3 Development alternatives

The proposed damsite of Medamit-2 is located at the narrow gorge of the Medamit River where a series of rapids starts. Besides this topographic favour, not only the proposed damsite creates an impounding reservoir with a capacity of 11 million m^3 to make possible seasonal regulation of river flow when full supply level is set at El.150 m (refer to Figure 5.2), but also the diversion length to the Limbang River is shortest, creating head of some 94 m when full supply level is set at El. 150 m.

Three alternatives are conceived for the hydropower development of Medamit-2 as depicted in Figure 5.3. The basic development idea of those three alternatives is as follows:

Alt-1: A plan to create head for power generation with a dam and to have a powerhouse just behind the dam

Alt-2: A plan to increase head by shortening the river course largely meandered with a 300 m long headrace

Alt-3: A plan to divert water of the Medamit River to the Limbang River with a 4,550 m long headrace for creating head of 75 to 95 m.

The principal dimensions of these three alternatives are summarized as follows:

Unit:m

Alternatives	Alt-1	Alt-2	Alt-3
Full supply level	130.5 to 150	130.5 to 150	130.5 to 150
Minimum operating level	130	130	130
Tailrace level	114	110	56
Headrace tunnel length	0	300	4,550
Penstock length	40	40	230

Minimum operating level, MOL, is set at El. 130m with the operation of sand flush gates. Maintenance flow of 0.5 m^3/sec to the Medamit River is secured for Alternative 3, which is the river diversion plan from the Medamit River to the Limbang River.

Reservoir simulation was carried out for finding the relationship between the required active storage and firm discharge. Runoff data estimated with Tank Model are used for simulation (refer to Appendix III of Volume V). Figure 5.4 shows the relationship between the required active storage and firm discharge at the project site of the Medamit River.

Plant discharge, one of parameters to be optimized, is varied in the range of 1.33 times (18-hour peaking operation) to 4 times (6-hour peaking operation) of firm discharge.

Daily turbinable flow, the maximum of which is plant discharge, is estimated by simulating 365-day inflow data with the reservoir. Computation of power generation for 365 days is based on the turbinable flow estimated above. Combined efficiency of the turbine and generator is assumed to be 0.84 for Medamit-2.

Construction costs are estimated based on the results of simulation study. The major information transferred from the simulation study to the cost estimate is plant discharge, dam height and so on for each alternative. The work quantities of hydraulic structures are estimated through the optimization of those structures.

The construction cost for each component is estimated based on the unit costs given in Table 5.3. The price level to estimate the construction cost is set at December 1987, and the ruling exchange applied is

US$1.00 = M$2.50.

Besides direct construction cost, engineering services and administration costs and physical contingency are counted as the necessary cost to implement the project and are assumed to be 15% of direct cost and 15% of sum of direct, engineering services and administration costs, respectively.

5.2 Optimum Development Plan and Installation Timing

The study results to search the optimal development scale of Medamit-2 are given in Table 5.4 and Figure 5.5. Maximum net benefit of M$4.4 million and internal rate of return of 11.7% are obtained in case of giving plant discharge of 8.9 m^3/sec and setting full supply level at El. 131.5 m in Alt-3. Thus, this development is proposed as the optimal scale of Medamit-2. The development features of it are:

Alternative plan	:	Alt-3
Full supply level	:	131.5 m
Minimum operating level	:	130.0 m
Tailrace water level	:	56.0 m
Type of dam	:	Concrete gravity
Headrace tunnel length	:	4,550 m
Penstock length	:	230 m
Plant discharge	:	8.9 m^3/sec
Firm discharge for power generation	:	4.5 m^3/sec
Maintenance flow to the Medamit River	:	0.5 m^3/sec
Peaking operation hours for firm discharge	:	12 hours
Rated net head	:	69.27 m
Maximum output	:	5.1 MW
Annual energy generation	:	36.1 GWh
Construction cost	:	M$59.0 million
Net benefit (capitalized)	:	M$4.4 million
EIRR	:	11.7%.

Since Alt-3 is the diversion scheme from the Medamit River to the Limbang River, maintenance flow of 0.5 m^3/sec is secured to the Medamit River. In fact, there exist four longhouses and a logging camp in the river reaches between the damsite and the confluence with the Limbang River, and then they rely on the Medamit River as a source of drinking water.

Cash flow diagrams for the optimal development scale and all diesel are given in Tables 5.5 and 5.6. The construction cost required for the optimal development case is M$59.0 million as referred in subsequent Table 7.1.

Figures 5.6 and 5.7 show the optimal installation sequence given by the combination of Medamit-2 and diesel plant so that power and energy requirements of the Limbang power system can be met in the time period of 1987 to 2010. Two units of turbine and generator are simultaneously installed in 1996 for securing guaranteed power as large as possible. Figures 5.8 and 5.9 depict the power and energy balance by all diesel plant.

The search for the optimal installation timing of Medamit-2 was made by shifting the installation year of each stage for the scale determined to be optimal; that is, 5.1 MW. The study results to search the optimal installation timing are summarized as follows:

Installation year	Net benefit in 10% discount rate, M$ million	EIRR,%
1996	4.37	11.7
1997	4.63	11.9
1998	5.09	12.4
1999	5.02	12.7

The installation of Medamit-2 in 1998 gave the maximum net benefit of M$5.09 million. The variation of net benefit is, however, insensitive for the shift of installation year.

The reasons why the maximum net benefit for the Medamit-2 project was obtained in the installation of 1998 would be due to applying the increasing fuel price in the study; that is, there is a tendency that the optimal installation year moves backward in case of applying the increasing fuel price.

It can therefore be said that the optimal installation timing will be greatly influenced by the assumptions and conditions set up in the optimization study, since the variation of net benefit is insensitive for the shift of installation year. Considering that the assumptions and conditions in the optimization study involve uncertainties and that Medamit-2 keeps high viability in spite of shifting the installation year, the earliest installation is recommended as far as the time period required for lead time, which is such pre-construction activity as financing and detailed design, and construction is suifficed.

The verification of earliest installation for the Medamit-2 project is studied from the financial viewpoint by preparing financial statements as the endorsement of the above study. As discussed in the subsequent Section 8.2.3, Financial analysis, the financial statements to assess the loan repayability and financial manageability are prepared under the condition that local costs are funded by the federal government loan and that foreign costs are financed by soft loan. Variation of financial statements by shifting installation year is summarized as follows:

Installation year	Year to turn positive in accumulation of net cash flow	Accumulated amount in the maturity period (M$)
1996	2004	11,840,720
1997	2005	9,475,640
1998	2008	6,777,710
1999	2012	3,573,610

The accumulation of balance, revenue minus cost, for the maturity period is highest in case that the Medamit-2 project is installed in 1996. Thus, earliest installation is endorsed from the financial viewpoint.

As discussed in conditions and input data for the planting-up study, the earliest in-service year of Medamit-2 is assumed to be at the beginning of 1996 by taking into consideration that pre-activities such as financing, detailed design, and tendering and contract for construction are in principle carried out in series.

The variation of viability for the Medamit-2 project is also assessed in case that some pre-activities are accelerated by carrying out in parallel; that is, installation year of 1994 and 1995. In case that Medamit-2 is installed in 1994 and 1995, the EIRR is revealed to be 10.8% (net benefit of M$2.59) and 11.1% (net benefit of M$3.48), respectively. Thus, Medamit-2 is judged to keep viability, even if the installation of project is accelerated.

5.3 Sensitivity Tests

The sensitivity tests were carried out by setting the installation year at year 1996, earliest installation year.

Following are the tested cases:

- Variation of discount rates; 4%, 5%, 8% and 12% besides the prime test discount rate of 10%,
- High and low demand forecasts,
- 10% capital cost up for Medamit-2,
- 10% fuel cost up and down for diesel plant, and
- 1987 constant fuel cost for diesel plant.

The results of sensitivity tests by varying the discount rate are summarized as follows:

Discount rate, %	Net Benefit M$ million
4	59.2
5	42.1
8	13.4
10	4.4
12	-0.8

The net benefit of Medamit-2 increases from M$4.4 million in the discount rate of 10% to M$59.2 million in 4%, M$42.1 million in 5% and M$13.4 million in 8%.

The results of sensitivity tests for the uncertainties involved in the demand forecast are summarized as follows:

Demand forecast	Net benefit in 10% discount rate, M$ million	EIRR,%
High	5.2	12.0
Medium	4.4	11.7
Low	2.9	11.0

Medamit-2 shows high viability for the high demand with EIRR of more than 12%, whilst EIRR of 11.0% for the low demand showing high viability.

In case that the capital cost of Medamit-2 is increased by 10%, the EIRR was 10.7%. On the other hand, in case of 10% fuel cost up for diesel plant, the EIRR was improved at 12.4%. On the contrary, even if fuel cost for diesel plant is down by 10%, the EIRR of Medamit-2 was maintained at 10.9%. Medamit-2 gained the EIRR of 8.2%, applying the 1987 constant fuel cost for diesel plant.

It is concluded as the results of sensitivity tests for the uncertainties involved in the future costs and assumptions that Medamit-2 is promising hydropower project to be developed.

CHAPTER 6. BASIC DESIGN

6.1 General

This chapter describes the preliminary design for major structures of the plan selected as the optimum of the Medamit-2 project, in which the Medamit River water is diverted to the Limbang River for power generation. The design was made at a feasibility study level, to the extent required for the purpose of estimating construction cost.

The following basic dimensions have been worked out for the project through the optimization study discussed in the previous chapter:

- Full supply level of intake pond	:	El.131.5 m
- Minimum operation level of intake pond	:	El.130.0 m
- Plant peak discharge	:	8.9 m^3/sec
- Tailwater level at plant peak discharge	:	El.56.0 m
- Gross head at plant peak discharge	:	75.5 m
- Installed power capacity (2 units)	:	5.1 MW (2.55 MW x 2)
- Bypass for water release to downstream of the Medamit River	:	0.5 m^3/sec in capacity

The project involves the construction of a 19.5 m high gated intake dam on the Medamit River, intake structure feeding 8.9 m^3/sec into the waterway, a 4,554 m long headrace tunnel, a surge tank, a 227 m long penstock line, and a power plant with 5.1 MW installed capacity, for which the number of units was selected to be two units considering system reliability and maintenance of turbines and generators. The project would also include the construction of a 58 km long 33 kV transmission line to deliver the generated power to the Limbang substation.

6.2 Design of Main Structures

6.2.1. Intake dam

The intake dam has the functions to divert the Medamit River water to the Limbang River and to create storage required for daily operation. The dam is located at the entrance of a gorge where the river width is about 20 m and the elevation of riverbed is El.114.0 m.

The geology at the dam site consists of hard sandstone distributed in the left bank to the riverbed of the right bank and the shale on the right bank. These rocks will have enough bearing capacity as the dam foundation. However, the sandstone at the site has numerous downward joints and will present a high permeability. To improve this situation, foundation treatment by means of grouting will be applied.

Fig. 6.1 shows the general layout of the intake dam and its associated structures.

Design concepts:

The intake dam and related structures were designed on the basis of following concepts:

a) Curtain and consolidation groutings are applied to the dam foundation to obtain firm and watertight foundation.

b) The intake dam is provided with gated orifice, and its sill elevation is set at the present riverbed level to keep the siltation level in the created pond as low as possible.

c) Sediments to be deposited in the intake pond are flushed out by opening the gates during flood periods.

d) Large floods are to be evacuated through the overflow spillway.

Intake dam

FSL.131.5 m was determined on the basis of the study results of the pond storage capacity of 190,000 m^3 necessary for peak opeation of 5.1 MW for 12 hours as discussed in preceding Section 6.1.

Gated-weir was adopted for the spillway, since it gives an economical structure of the intake dam as compared with non-gated weir.

On the basis of above results, the intake dam was designed to have the following dimensions:

a) Gate top elevation : FSL + 0.5 m = El.132.0 m

b) Dam crest elevation : FSL + 2.0 m = El.133.5 m

c) Spillway gates : 7.5 m widex 7.5 m high x 2 Nos.

The above dam crest elevation has a freeboard of about 1.2 m above FWL.132.322 when the design flood of 648 m^3/s with a 200-year recurrence interval (refer to Appendix III of Volume V) is released through the spillway. Water to warrant livings of riparians in the downstream reaches will be released through the steel pipe with a diameter of 50 cm equipped in the dam body.

In addition, the riverbed downstream of the intake dam is protected with concrete apron against being scoured by the flow from the spillway which will endanger the dam stability.

Stability of intake dam

Stability of intake dam was examined against overturning, sliding and bearing of the foundation. The stability of overturning was checked, so that the resultant force would fall within the middle third of the dam base. Furthermore, the intake dam was designed to have an adequate resistance against sliding. In these stability checks, horizontal seismic coefficient of 0.05 was taken into account.

Intake

The intake is located on the left bank just upstream of the intake dam, so that the silt around the intake is kept as low as possible by periodical flushing of the silt through the orifice opening of the dam.

The floor level of the intake is set at El.123.0 m to have enough depth of water in avoiding air entrainment into the headrace tunnel, when the water level drops to MOL.130.0 m.

River diversion

An open channel is provided on the right bank for the first stage river diversion. The channel has the flow capacity of a 2-year flood, 277 m^3/s.

The second stage river diversion is made through the orifice opening of the dam constructed in the first stage. The design flood for the second river diversion is set at 130 m^3/s which has the occurrence probability of about 4 times a year, taking into account the small work quantity of the concrete dam during the second stage construction.

The coffer dam for each of above river diversion is laid out making use of the permanent structure; that is, the right side guide wall of the spillway for the first stage coffer dam and the partition wall for the second stage coffer dam.

6.2.2 Waterway

The route of the waterway was selected to have the shortest length connecting the Medamit and Limbang rivers where they approach the nearest to each other. The waterway has a horizontal length of 4,761 m and is divided into two by the surge tank; a headrace tunnel of 4,554 m and a penstock of 207 m as shown in Fig. 6.2, whilst further detail of the penstock is depicted in Figs. 6.3 and 6.4.

The headrace tunnel has a straight alignment except for two horizontal curves; one just downstream from the intake and the other just upstream from the surge tank. The original ground of the headrace tunnel has enough rock cover for tunnelling. The location of the surge tank was selected so that the tank is seated in sound rock and structurally stable. For the penstock, an open-air type was designed for saving construction cost except for the upstream tunnel section. The open-air type penstock is routed along the ridge.

There will be no serious geological difficulties in the construction of the waterway. The route of the headrace tunnel is mostly composed of Setap shale which is characterized by the numerous thin layers of sandstone intercalated in shale. This rock strata is judged to be good for tunnelling, even though there are some minor faults. Geology in the penstock line consists of shale in the higher portion and limestone in the lower portion, and the boundary line runs across about the middle of the penstock line. A band of weak zone with about 70 m in width is accompanied by the boundary line. Therefore the anchor blocks are provided outside of the weak zone.

<u>Design of headrace tunnel</u>

An economic comparison was made to determine the diameter of the headrace tunnel including concrete lining construction taking into account the following components:

a) construction cost
b) energy loss value due to head loss in the tunnel, and
c) operation and maintenance costs.

To achieve an economical structure, further cost comparison was made between the concrete lining construction determined in the above and the shotcrete lining construction.

As the result of these comparisons, the concrete lining construction was adopted with the diameter of 2.5 m for the design discharge of 8.9 m^3/s. The cross section of headrace tunnel is shown in Fig. 6.2.

Design of surge tank

The surge tank was determined to be a simple-type, since the orifice-type gives a water pressure rise of 55% at the turbine which far exceeds the normal range up to 40% adopted in the design of a turbine with the effective head lower than 100 m.

The surge tank is of a reinforced concrete mostly built underground.

The principal features of the surge tank are shown in Fig. 6.4 and described below:

Shaft diameter	:	5.5 m
Shaft height	:	34.5 m
High surging water level	:	El.146.8 m (FSL + 15.3 m)
Low surging water level	:	El.118.2 m (MOL - 11.8 m)

Design of penstock

The penstock is divided into two types; a tunnel portion of 67 m long and an open-air steel pipe of 160 m long as shown in Fig. 6.4.

For the erection of tunnel portion, a working space of 60 cm was kept between the steel shells and the excavated faces supported by rock bolts if required as shown in Fig. 6.4. After installation of steel shells, this space is filled with concrete.

The open-air type penstock is supported with anchor blocks and ring girder supports. The anchor blocks are provided at the bend of penstock and the ring girder supports at an interval of about 15 m.

Design concepts and assumptions applied to determine the economic diameter of penstock at this feasibility study stage were as follows:

a) Diameters of the penstock were estimated using the same method applied to determine the economic diameter of the headrace tunnel.

b) In design of its plate thickness, dynamic pressure due to water hammer was computed on the following assumptions:

- "Jaeger's formula" is applied to analyse water hammer in the penstock with the simple type surge tank.

- The closing time of the turbine is limited to 2.0 seconds.

c) SM class steel is used for the penstock. The allowed maximum and minimum plate thickness would be 25 mm and 6 mm.

Based on the aforesaid concepts and assumptions, economic comparison was carried out and consequently the penstock diameters vary from 2.3 m to 1.0 m.

6.2.3 Power station

The above-ground type powerhouse is located on the right bank of the Limbang River where the river course turns its direction to the left almost with right angle. The powerhouse accommodating two units of generating equipment of 2.55 MW each is a reinforced concrete structure. The ground level of the powerhouse is set at El.62.0 m providing about 2 m freeboard above FWL.59.9 m of the Limbang River for a 100-year probable flood.

The foundation of the powerhouse would be limestone which is covered with an overburden of more than 10 meters depth and descends with steep slope towards the riverbed. The limestone is hard but will have a high permeability due to cracks developed in the rock. However, the power station site does not have any serious problem for the construction.

Fig. 6.5 shows the general layout of the powerhouse.

6.3 Design of Metal Work

6.3.1 Gate, trashrack and valve

A fixed-roller type is basically selected for the gates of the project in this feasibility study, because this type is the most popular and is typical for medium sized gate and its cost is little different from that of other types such as radial and flat gates. The following are the type and dimensions of gates, trashrack and valve:

Spillway gate

Type	:	fixed-roller gates
Set numbers	:	2 sets
Dimension	:	7.5 m high x 7.5 m wide
Hoist type	:	stationary type wire rope hoist

Sand flush gate

Type	:	fixed-roller gate
Set numbers	:	1 set
Dimension	:	6 m high x 5 m wide
Hoist type	:	stationary type wire rope hoist

Intake gate

Type	:	fixed-roller gate
Set number	:	1 set
Dimension	:	2.5 m high x 2.5 m wide
Hoist type	:	stationary type wire rope hoist

Draft tube gate

Type	:	slide gate
Set number	:	1 set
Dimension	:	1.5 m high x 2.4 m wide
Hoist type	:	travelling type monorail hoist

Trashrack

Type	:	fixed type
Set number	:	1 set
Dimension	:	9.5 m high x 6.0 m wide
Bar pitch	:	50 mm

Inlet valve

Type	:	butterfly valve
Set numbers	:	2 sets
Diameter	:	1.0 m
Hoist type	:	hydraulic cylinder type hoist.

6.3.2 Penstock

One (1) complete lane of the penstock will be provided from the surge tank to the inlet valve of two (2) turbine units. The penstock with 221 m in total consists of shells proper, reducing pipes, bifurcation, expansion joints, ring girder assemblies, bend pipes, manholes, seepage and thrust collars and so on.

The penstock was designed to have sufficient strength for the critical loading conditions of internal and external pressure, axial force and, earthquake or wind loads.

The principal features are as follows:

Type	:	Exposed and embedded type steel penstock including Wai (Y) type bifurcation
Quantity	:	One (1) lane
Diameter	:	2.3 m to 2.0 m (1.4 m to 1.0 m after bifurcation
Length	:	221.0 m.

6.4 Design of Generating Equipment

6.4.1 Generating equipment and its auxiliaries

Basic design conditions of the generating equipment are summarized below:

1)	Full supply water level	:	EL.131.50
2)	Minimum operating water level	:	EL.130.00
3)	Plant peak discharge	:	8.9 m^3/sec
4)	Tailrace water level at plant peak discharge	:	EL.56.00
5)	Rated head	:	69.27 m

The turbines and generators were designed based on the abovementioned conditions as follows:

1. Water turbine

From the given basic conditions, both vertical and horizontal type Francis turbines are applicable to this project, and its selection was made in consideration of cost of equipment and construction cost of the powerhouse as follows:

a) Type : Vertical shaft, Francis

b) Number of unit : 2

c) Rated output : 2,650 kW

d) Rated speed : 750 rpm

2. Generator

a) Type : Vertical shaft, revolving-field type

b) Number of unit : 2

c) Rated output : 2,550 kW

d) Rated capacity : 3,000 kVA

e) Rated voltage : 6.6 kV

Major auxiliary equipment of the power station would include the following:

- One (1) set of 10-ton overhead travelling crane, and
- Two (2) set of Butterfly type inlet valve with diameter of 1.0 m (maximum static head : 75.5 m).

6.4.2 Outdoor Switchyard

One (1) set of 6,000 kVA main transformer will be provided for two (2) generators as a central system.

In addition, necessary 33 kV switchyard equipment such as circuit breaker, line switch with earthing switch and lightning arrestors will also be provided.

6.5 Transmission Line and Substation

6.5.1 General

Power in Limbang, which is the demand centre of Medamit-2, is supplied with a 11 kV distribution line, which extends to Kubong village through Berawan village as shown in Fig. 6.6. On the other hand, a diagram of power system is depicted in Fig. 6.7.

The Sungai Saliban mini-hydropower station is under construction in the Saliban River, a tributary of the Limbang River, near Medamit village. The construction of a new 11 kV distribution line is under way as a part of the Sungai Saliban mini-hydropower project to connect to the existing 11 kV dustribution line running between Limbang and Kubong. The newly constructed distribution line runs along the Medamit to Limbang highway.

There exist many villages along the Limbang River between Medamit village and Limbang. Power generated from Medamit-2 will be supplied to those villages besides Limbang by extending the distribution line from the 11 kV transmission line currently under construction.

In this circumstance, transmission facilities including a substation will be constructed to supply power generated at the Medamit-2 hydropower station to Limbang.

6.5.2 Transmission line

A 33 kV transmission line will be newly be constructed between the Medamit-2 power station and the substation newly constructed at the suburb of Limbang (refer to Figure 6.6). The transmission line runs 58 km distance, out of which a first 28 km from the power station passes along the logging road constructed in the jungle with undulation, while remaining 30 km of the transmission line runs along the highway between Medamit village and Limbang. Pole arrangement with various spans besides tree-cutting will be required for the first 28 km. On the other hand, any obstacle is not foreseen for the construction of remaining 30 km.

Timber poles (iron wood or Belian in the local language) are considered to be used for supporting the transmission line of 33 kV with aerial cable. Belian poles which will endure for the use of more than 100 years can locally be produced and are easy to erect. Poles with 11 m high will stand every 100 m in standard.

A voltage of 33 kV is selected to transmit power of 5,100 kW for the distance of 58 km, taking into account the following:

(1) 11, 33, 132 and 275 kV are selected as the standard of the transmission and distribution line systems in SESCO.

(2) Direct branching from 33 kV to 11 kV is possible by pole transformer for customers along the transmission line.

(3) If 66 kV, which would be one of adequate voltages to transmit power of 5,100 kW for the distance of 58 km, is selected as the voltage of transmission line, all the equipment will not conform to the standard of SESCO, resulting in trouble in finding parts of equipment in case of breakdown.

Power supply to the dam and telecommunication cable between the power station and the dam will also be provided.

6.5.3 Substation

A site located 10 km south from Limbang is selected as the place to construct a new substation (refer to Figure 6.6). The existing 11 kV distribution line between Limbang and Kubong is passing this point.

The substation will be equipped with the following:

An equipment layout of the substation are shown in Fig. 6.8.

- One (1) 6,000 kVA stepdown transformer,
- One (1) lot of 33 kV equipment such as CB, DS and LA,
- One (1) lot of 11 kV outdoor cubicle for feeders, and
- One (1) lot of control boards including DC supply.

CHAPTER 7. CONSTRUCTION PLAN AND COST ESTIMATE

7.1 Construction Plan and Schedule

7.1.1 General

All the works of the Medamit-2 project will be executed by the contractors selected through the international competitive tender including prequalification except for engineering services. The following are modes of construction for the project works:

- Civil works (River diversion, dam and intake, waterway, power station including building works, tailrace, drainage channel and road construction)	: International competitive tender
- Metal works (Dam, intake and penstock line)	: International competitive tender
- Generating equipment	: International competitive tender
- Transmission line and substation	: International competitive tender
- Engineering services (Detailed design and construction supervision)	: Direct order

7.1.2 Construction schedule

1. Construction period

The construction period of the project is scheduled to extend over eight years. First four years are required for the arrangement of construction finance, selection of engineering consultant, detailed engineering services and tendering. Latter four years are required for the construction work of the project.

The arrangement of construction finance shall be made by Economic Planning Unit of Prime Minister's Department/Sarawak Electricity Supply Corporation. In order to secure the target, the following basic schedule shall be kept for the implementation of the project;

a) Finance arrangement	:	12 months from June 1988 to May 1989
b) Contract for engineering services	:	3 months from June 1989 to August 1989
c) Engineering services for detailed design	:	16 months from September 1989 to December 1990
d) Pre-qualification for tender and contract	:	3 months from October 1990 to December 1990 (during engineering services for detailed design)
e) Tender and contract	:	10 months from January 1991 to October 1991
f) Construction works	:	Commencement in November 1991 and completion in December 1995 within 50 months
g) Commissioning of power generation	:	Beginning of January 1996.

The overall construction schedule and general layout of the project are shown in Figs. 7.1 and 7.2.

2. Outline of work execution by year

a) First year of construction (November 1991 to October 1992)

Preparatory works such as construction of access roads and camp facilities, installation of diesel generators and so on are to be carried out in a period of approximately 5 months.

Immediately after preparatory works, two work adits of the headrace tunnel, one at the dam site and the other at the powerhouse site, are to be excavated. After the completion of work adits, the main tunnel is to be excavated from both dam and powerhouse sites.

For the intake dam, excavation is to start at the right bank in order to enlarge the river channel for diversion. Upper part of the left bank of dam is to be excavated at the same time. After enlarging the river channel, coffer dams and concrete walls for river diversion are to be constructed.

For the penstock line, major part of surface excavation is to be completed.

b) Second year of construction (November 1992 to October 1993).

Excavation of the headrace tunnel is to continue all the second year.

For the intake dam, excavation of the left bank is to be completed by 7th month of the second year (May, 1993). Concrete of the left side of the dam is to be placed in success. An intake gate and a sand flush gate are to be installed. After completing the left side of the dam, new coffer dams for river diversion are to be constructed to enclose the right side of the dam and to divert flow to left side of the river through the sand flush orifice.

Excavation of penstock line is to be finished by 2nd month of the second year (December, 1992). Concrete of anchor blocks is to be placed in succession.

Surface excavation of the surge tank is to start after excavation of the penstock line. Excavation for the shaft of surge tank is to start in succession and to be completed by 10th month of the second year (August, 1993). Lining concrete for the shaft of surge tank is to be placed in two months.

Works on the drainage channel are to be done in two months and to be completed before starting works on powerhouse.

Surface excavation of the powerhouse is to start after completion of drainage channel.

c) Third year of construction (November 1993 to October 1994).

Excavation of the headrace tunnel is to be completed by 4th month of the third year (February, 1994). Concrete lining of the tunnel is to start in succession.

Excavation and concrete placement for the right bank of intake dam are to be finished by 5th month of the third year (March, 1994).

All excavation and most of concrete placement are to be completed for the powerhouse. Works on tailrace are to be finished by 5th month of the third year (March, 1994).

Installation of spillway gates and steel penstock is to be completed by the end of third year.

d) Fourth year of construction (November 1994 to October 1995).

Concrete lining of the headrace tunnel is to be completed by 10th month of the fourth year (August, 1995).

Consolidation and backfill grouting are to start in succession and to be completed by the end of fourth year.

Concrete placement around such equipment as draft tubes and casings in the powerhouse is to be completed. All civil works are to be completed by the end of fourth year.

All works on generating equipment, transmission line and substation are to start at the beginning of fourth year and to be completed by the end of fourth year.

e) Fifth year of construction (November 1995 to December 1995).

Impoundment of water in the intake pond is to be started in the first month. Following this, discharge from the waterway and wet tests are to be completed by the end of the 2nd month. Commercial operation is to be started from the beginning of January, 1996.

7.1.3 Construction plan and method

1. Access road

Logging roads extend to both the dam and powerhouse sites from Limbang city where construction materials and equipment are unloaded. Most of the logging roads do not need improvement, but 19 km long parts near both sites are to be improved because of roughness and narrow width from the view point of transportion of construction materials and equipment.

The new roads of 1.1 km long is to be constructed as access roads connecting logging roads to the dam and powerhouse sites.

The access roads and bridges to be constructed are summarized below:

- Access road to be constructed : 1.1 km
- Existing road to be improved : 19.0 km
- Bridges to be counstructed : 20 m x 1
  10 m x 5.

2. Construction plant

The total concrete volume required at the dam and the powerhuse sites will approximately be estimated at 22,000 m^3 and 15,000 m^3, respectively. Considering the amount and schedule of concrete placement, following facilities will be adequate as the aggregate and concrete plant;

Site	Plant	Capacity	Quantity
Dam	Aggregate plant	20 t/hr	1 unit
	Concrete plant	$24m^3/hr$	1 unit
Powerhouse	Aggregate plant	15t/hr	1 unit
	Concrete plant	$24m^3/hr$	1 unit

3. River diversion

River diversion during construction will be made by two stage diversion method, taking into account the size of the intake dam and topographical condition of the river.

The plan for the river diversion is shown in Fig. 7.3.

4. Intake dam

The sequence for the construction of intake dam is shown in Fig. 7.3.

The right bank of the dam site is to be excavated in order to use as a river diversion. After closing the left bank by coffer dams and concrete walls and diverting flow to the right side, all excavation work and most of concrete work in the left side are to be done. Then, excavation and concrete works in the right side are to be done by closing the right bank with coffer dams. During the works on the right bank, the river flow is to be diverted through the orifice of sand flush gate.

The volume of excavation is approximately 55,000 m^3. The work for this amount is to be completed in about 16 months. The heavy equipment required for this work will be 21 ton class bulldozers with ripper, 0.7 m^3 class backhoe, 10 m^3 class crawler drills and leg hammers.

The concrete volume of intake dam is approximately 11,000 m^3, the work for which is to be completed in about 8 months. Concrete for the main dam and other structures is planned to be placed by a 20 t class truck crane and 6o m^3/hr class concrete pump, respectively.

Some of the sound rock excavated is to be used for aggregate of concrete.

Dam blocks are to be 10 m wide and with lifts of 1 to 2 m as standard.

The installation of gates is to be done during concrete work by a 20 t class truck crane.

5. Headrace tunnel

Construction for the headrace tunnel of approximately 4.6 km long is to be done by the rail method from both intake and surge tank sides; that is, work adits are to be provided at both portals.

Excavation of headrace tunnel is to be made by the full-face attack method and to be performed in 24 months. Drilling is to be carried out by leg hammers, and drilled rocks are to be hauled by a 0.4 m^3 muck loader and 2.0 m^3 muck car with a 8 ton battery locomotive. The driving progress speed is planned to be 220 m per month (110 m per set x 2 faces). After completing tunnel excavation, lining concrete is to be placed using the sliding forms of 12 m in span and to be performed in 18 months. Concrete is to be transported and placed by 6.0 m^3 prescretes with the 6 ton battery locomotive. The concrete - lining progress is planned to be 300 m per month (150 m/set x 2 sets).

After concrete lining, backfill and consolidation grouts are to be performed in succession.

6. Surge tank

Open cut excavation for surge tank is to be performed by a 0.7 m^3 class backhoe, 21 ton class bulldozer with ripper and leg hammers. After surface excavation for surge tank and excavation of tunnel below surge tank, the pilot shaft is to be excavated at the centre of shaft upward from the bottom. The excavated muck is to be hauled from the penstock tunnel. After the pilot shaft is through, enlarging to full shaft diameter is to be made by drilling with leg hammers. Drilled rocks are to be dropped into the pilot shaft using a 0.1 m^3 class backhoe.

All excavation works for the surge tank are to be performed in 7 months.

Concrete lining work is to be made upward from the shaft bottom after the completion of shaft enlargement.

7. Penstock line

Excavation of the penstock tunnel is to be executed in a similar way to the headrace tunnel and is planned to be completed prior to headrace tunnel excavation work.

Open cut excavation is to be carried out downward from the portion of high elevation using a 21 ton class bulldozer with ripper, a 0.7 m^3 class backhoe, leg hammers and a 2.2 m^3 class crawler type loader. Concrete of anchor blocks is to be placed by a 20 ton class truck crane with a 1 m^3 bucket after completion of excavation. Backfill concrete is to be placed where the installation of penstock pipe has been completed.

Excavation and concrete works are to be performed in 12 months. Installation of penstock pipe is to be carried out in 7 months.

8. Powerhouse

Excavation for powerhouse is to be carried out using a 21 ton class bulldozer with ripper, a 0.7 m^3 class backhoe, leg hammers and a 2.2 m^3 class crawler type loader. Foundation and side-wall concrete are to be placed in advance, while an open space is to be secured in the vicinity of the powerhouse to facilitate delivery of power generating equipment. Column and slab concrete are to be placed later.

The power generating facilities such as turbine and generator are installed by using an overhead travelling crane.

7.2 Cost Estimates

7.2.1 Construction cost

1. General

The construction cost for Medamit-2 project was estimated under the condition that the current construction technique will be applied besides the geological conditions at the project site, project scale and construction schedule.

Batang Ai Project (108 MW, 1982), Mini Hydro Projects (50 to 1,000 kW 1982 - 1989) and other projects in Malaysia were referred to the construction cost estimate.

2. Construction cost

a) Criteria for estimate

The following criteria were adopted for the cost estimates:

- The cost estimation date was taken in December 1987. A foreign currency exchange rate is taken to be US$1.00 = M$2.50, prevailing rates in Malaysia in December 1987.

- The construction costs are divided into local and foreign currencies. Portions in local currency are mainly composed of labour wages, domestic material, inland transportation and installation costs. On the other hand, costs in foreign currency are mainly composed of the ones for imported materials, equipment and machines and engineering services.

- Import tax on hydraulic equipment, electro-mechanical equipment, etc. is to be free.

- Engineering services and administration costs are to be 10% and 5% of the direct costs respectively.

- Physical contigencies are estimated at 15% of sum of the direct, engineering services and administration costs.

- Land acquisition costs and compensation costs are not considered, but right-of-way cost for the transmission line is included.

b) Cost estimation

(1) Preparatory works

- Access road

Costs for the improvement of existing roads and for the construction of new roads were estimated by referring to the contract for the construction of new roads in Sarawak.

- Camp facilities

Costs of camp facilities for SESCO's staff and the consulting engineers were estimated by referring to the contracts for building new quarters.

- Field investigation

The costs for geological investigation and a topographical survey necessary for the definite design were estimated by referring to the costs for boring, topographical mapping and seismic prospesting and so on carried out in this feasibility study.

(2) Civil works

After reviewing the construction costs of similar projects in Malaysia, the construction costs of the Batang Ai Project and Mini Hydro Projects which had been constructed or under construction in Sarawak were mainly referred to estimate the costs of civil works. In case of adopting construction costs of these projects to Medamit-2 project, the site conditions, the construction conditions, labour costs, material costs and machine costs were taken into consideration.

Costs for the main items of civil works were calculated on the basis of quantity. Those of other unknown items at the preliminary design stage were added up as a lump sum.

(3) Hydraulic Equipment

All hydraulic equipment such as gates, trashracks, raking equipment and steel penstock is to be imported and the costs of providing these equipment were estimated by quantity and unit price of each equipment. Unit prices include all costs of materials, processing, transportation and installation.

(4) Electro mechanical equipment

Turbines and generators are to be imported and these equipment costs include all costs of transportation, insurance and installation. On the other hand, domestic products for transformers and auxiliary equipment are to be used.

(5) Transmission line and substation

The various pieces of equipment for transmission line and substation are to be in use of domestic products.

c) Construction costs

The construction costs for the project are estimated at M$58,959,260 in total, consisting of M$36,153,853 in foreign currency portion and M$22,805,407 in local currency portion. The construction cost and its detailed estimates are shown in Tables 7.1 and 7.2, respectively.

7.2.2 Annual disbursement of construction cost

The annual disbursement of construction cost for foreign and local currencies is estimated on the basis of the construction schedule. The disbursement schedule is shown in Table 7.3 and summarized as follows:

Year	Foreign currency (M$)	Local currency (M$)	Total (M$)
1991	337,180	674,452	1,011,632
1992	6,445,770	5,478,892	11,935,662
1993	8,790,400	6,094,969	14,885,369
1994	12,711,271	6,741,478	19,452,887
1995	7,869,222	3,804,478	11,673,700
Total	36,153,853	22,805,407	58,959,260

CHAPTER 8 PROJECT EVALUATION

8.1 Economic Analysis

8.1.1 Methodology of economic evaluation

The evaluation method of the Medamit-2 Small Hydropower Project puts its basis on the future power expansion programme in the Limbang system. The advantage of evaluating the proposed project in the framework of power supply system rather than in conventional method using alternative plant lies in the following setting that economic benefits and costs are evaluated based on the entire Limbang system. By considering that benefits are equivalent to cost saving of the supply system with all diesel plants if the system with the proposed hydro project is implemented, they are counted as costs incurred from the least cost sequence of supply systems with all diesel plants. Costs are derived from the least cost sequence of supply system with the proposed hydro project.

As stated in an optimum development plan of Chapter 5, power expansion programmes with and without the Medamit-2 project are formulated so as to meet power and energy demand requirement in the Limbang system during investment horizon from 1987 to 2010. Since evaluation period is required to extend to time span of project life of the proposed project, economic benefits and costs are evaluated during planning horizon ranging from 1987 to 2036. The least cost sequence of supply systems with all diesel plants is formulated by the system to meet the requirement of minimizing investment costs, O & M costs including fuel costs of power plants, and replacement cost. The least cost sequence of supply systems with the Medamit-2 project is formulated by the system giving the net benefit maximum among systems with the project by simulating an optimal scale of the project and varying input time of it into the system. The net benefit is defined as the difference of costs incurred from least cost sequence in both cases of with and without the Medamit-2 project.

Since costs and benefits are evaluated by cost streams of the least cost sequence in cases of with and without the project respectively, the proof that the proposed supply system with the Medamit-2 project is economically viable justifies the reason for the Medamit-2 project to be incorporated into the future Limbang system. Economic feasibility of the system with the Medamit-2 project is assessed by a comparison of economic internal rate of return (EIRR) to opportunity cost of capital (OCC), assuming the OCC is 10%.

Since conditions and assumptions for calculating benefits and costs, and the results of economic evaluation including sensitivity analyses based on benefits and costs are fully discussed and analysed in Plan Formulation of Chapter 5, this chapter demonstrates the fundamental viewpoints related to economic evaluation.

8.1.2 Conditions and assumption required for evaluation

(1) Guideline for valuation of goods in economic sense

Valuation of goods forming cost components of the Medamit-2 project and diesel plants is assessed at accounting price in economic sense. Value of equipments and some materials to be categorized as foreign currency potion is assessed at c.i.f Kuching being border prices, on condition that they have to be imported according to current domestic production capability of producing them.

As to local currency portion of investment costs, some of construction materials which are partially traded and partially non-traded are categorized as tradeable goods since economic sense of valuing any goods is based on the assumption that a country is trading to its own best advantage. As a result, non-traded goods are treated as goods being neither exportable nor importable.

By adopting the method of conversion factor approach, a full list of conversion factors to be applied to the Malaysian economy shown in Table 8.1 is utilized to convert market price to economic one. The market price is defined as price less the internal transfer payment like tax portion. Economic labour cost of unskilled labour assessed by its real earning power is valued at income level covering monthly household expenditure for food, assuming that if foods being normally given to unpaid family labour have to be purchased for their subsistence life, income equivalent to expenditure for food must be earned. According to Annaual Statistical Bulletin of Sarawak, monthly household expenditure is referred to the average figures of all ethnic groups in Sarawak.

Economic sense of compensation costs to be outlaid to local people or entities due to the Medamit-2 project focuses on value of materials to be sacrificed by land acquisition. Nevertheless, any marketable things such as crops and forest product, and houses to be made up for are not identified according to the reconnaissance survey. Therefore, economic compensation costs are decided to be nil.

(2) Conversion from financial cost to economic cost

Cost items of the Medamit-2 hydro project broadly consist of equipment like machine, construction materials and labour cost. As far as the tax portion to be deducted from market prices are concerned, construction materials are divided into specific ones which shares a substantial portion of material costs, and others. Tax rates of the former are individually counted, whereas tax rate of others is represented by the average rate. The kind of tax is mostly confined to sales tax.

Cost categories of the Medamit-2 project evaluated in previous Chapter 7 are direct, land acquisition, engineering service, administration, and physical contingency. Construction costs by cost catergory is further broken down by cost item in order that the concept discussed in "Valuation of goods in economic sense" should be applied to project costs of the project for the purpose of estimating economic costs. The estimation of economic cost by cost item is made in the following way.

- Costs of equipments for economic evaluation is the same as the corresponding costs evaluated in Chapter 7 since value of them is measured at c.i.f Kuching.

- All of construction materials are considered to be tradeable goods. As to some of specific construction materials, conversion factors to be applied to them are classified into import or export cases by referring to statistics of import and export in Sarawak. As to the rest of materials, a combined conversion factor of 0.88 is used for evaluation.

- As far as equipments belonging to local currency portion are concerned, a combined conversion factor (0.85) of "Investment goods" in Table 8.1 is used.

- Economic labour cost per man-day is estimated to be M$7 which is approximately 20% of financial wage of unskilled labour.

- With respect to the rest of labour cost other unskilled labour, a conversion factor of 0.77 shown in "Construction" of non-traded good/service in Table 8.1 is used.

- A conversion factor to be applied to administration cost is 0.80.

- Operation and maintenance costs are simply assumed to be 1% of direct economic construction cost.

The results of economic construction costs of the Medamit-2 project is shown in Table 8.2.

Conversion factors to be applied to diesel plants are summarized as follows:

- A conversion factor of capital cost is decided to be 0.85 which corresponds to combined conversion factor of "investment goods",

- A conversion factor of fuel costs is assumed to be 0,86 shown in the columm of "petroluem (crude)" in Table 8.1.

- A conversion factor to be applied to operation and maintenance costs are assumed to be 0.97 by considering cost share of labour, spare parts and lubricating oils required for operation and maintenance, and respective conversion factor.

Economic construction costs are evaluated at 1987 price level. As far as fuel price is concerned, the augment of real value in crude oul price is taken into an account in order to estimate the future price of fuel by referring to "Price Prospect for Commodities" issued by IBRD. In this case, fuel price is valued at 1987 constant price.

(3) The lead time and construction period of the Medamit-2 project

Since evaluation of benefits and costs are based on the Limbang power supply system, the year when the proposed hydro project is physically capable of being installed is necessary to be searched in particular. Installation year is subject to the lead time and construction period.

The lead time prior to construction is defined as the pre-construction period required for conducting feasibility study, financing of detailed design, detailed design and tendering plus contract for construction. Subsequently, construction period after the lead time is assumed to be from 1991 to 1995 during five years. As a result, the operation of the Medamit-2 hydro project is assumed to start in 1996.

8.1.3 Benefit analysis

As stated in 8.1.1, benefit are evaluated by cost streams of the least cost sequence with all diesel plants. The installation programme of selected system during investment horizon (1987-2010) is shown in the following way:

No.	Installation year	Scale of diesel plant
1	1988	1.6 MW
2	1992	1.0 MW
3	1993	1.0 MW
4	1994	1.0 MW
5	1996	1.0 MW
6	1997	1.0 MW
7	1999	1.0 MW
8	2001	1.0 MW 2 diesel
9	2003	1.0 MW 3 diesel
10	2005	1.0 MW 2 diesel
11	2007	1.0 MW 2 diesel
12	2008	1.0 MW 2 diesel
13	2009	1.0 MW
14	2010	1.0 MW

Plant No of 1 and 2 are committed power plant in the Limbang system under the plan of SESCO. The setting for formulating installation programme being the least cost sequence with all diesel plants considers the retirement of diesel plants, assuming that plant life is 15 years. Plants whcih would be retired during investment horizon are the existing plants, plant under construction, and some plants shown in the above installation programme. Installation programme is formulated in such a way that the newly plant is added to the Limbang system so as to meet the requirement of power balance after the retirement of the plant.

Since evaluation period is extended to planning horizon from 1987 to 2036, replacement cost of newly installed plants is considered after 2010. The replacement cost is assumed to be 90% of the initial cost. Present worth of the least cost sequence with all diesel plants during planning horizon is estimated to be M$85.62 million at 10% of discount rate.

8.1.4 Cost analysis

Costs are evaluated by cost streams of the least cost sequence with the Medamit-2 hydropower project. Since the commissioning year of the Medamit-2 project is physically conceivable from 1996, studies to search the optimal development scale of the project is conducted in optimization study of Chapter 5. Subsequently this chapter focues on the further analysis of identifying optimal installation time. This study is simulated by varying input time of an optimal development scale of the project into the Limbang system. Time span of searching optimal installation time are four years from 1996 to 1999. Installation programmes of power supply system with the project during investment horizon by installation time from 1996 to 1999 are shown in Table 8.3.

All installation programmes shown in Table 8.3 are formulated so as to meet the requirement of power and energy demand. Present worth of supply system corresponding to the said four installation programmes at 10% of discount rate are calculated to be M$81.25 million in case of 1996 installation time, M$80.99 million in 1997, M$80.52 million in 1998, and M$80.60 million in 1999. Present worth of the supply system with the project is estimated to be the minimum cost when the installation time of the project is assumed to be in 1998. Consequently, the third instllation programme shown in Table 8.3 is identified to be the least cost sequence among systems with the project.

8.1.5 Economic evaluation

The net benefit being equal to B-C is, to be more precis, defined as the cost difference of present worth of supply systems with all diesel plants and with the Medamit-2 project. The results of net benefit at 10% of discount rate are summarized as below:

Installation year	Net Benefit (M$ million)	EIRR (%)	Installation year	Net Benefit (M$ million)	EIRR (%)
1996	4.37	11.7	1998	5.09	12.4
1997	4.63	11.9	1999	5.02	12.7

Installation year indicated above means input time of the Medamit-2 hydro into the Limbang system. The results that net benefits in all cases turn out to be positive proves the justification that the Medamit-2 project should be incorporated into the Limbang system. In other words, it is proved that the Limbang system with the project is economically more viable than the same system will all diesel plants. Optimal installation time of the Medamit-2 project determined by an indication of maximum net benefit is identified to be the year of 1998 since present worth of supply system with the project proves to be the minimum cost in 8.1.4 when the Medamit-2 hydropower project is scheduled to be installed in 1998. Consequently, installation programmes of the Limbang system with the Medamit-2 Project is identified to be the least cost sequence when the project is incorporated into the system in 1998.

Nevertheless, the variation of net benefit is insensitive for the shift of installation year since the difference of net benefit among four cases is negligibly small. Considering that the Medamit-2 keeps an economic viability in term of EIRR in spite of shifting the installation year, the earliest installation is recommended for the proposed project. Although the Limbang system with the project at its installation time of 1996 is not precisely the least cost sequence, economic feasibility of this installation programme is viable since EIRR of 11.7% is higher than opportunity cost of capital (10%). Cash flow of benefit and costs are shown in Table 8.4. In this case, cash flow of costs corresponds to cost streams of installation programme with the project at its installation time of 1996.

So far, the increase of fuel cost in the future is taken into account as one of assumptions required to discuss economic analysis. Since full cost shares a sunstantial portion out of total costs in benefits streams, as shown in Table 8.4, economic feasibility of the Limbang system with the project would be much influenced by the following assumption that fuel cost will continue to be present level. Present worth of benefit and cost streams under increase of fuel price and constant fuel price is shown as below:

unit: M$ Million

Discount rate	Benefit		Cost	
	Increase	Constant	Increase	Constant
7%	136.8	106.7	116.5	102.0
8%	115.6	91.2	102.1	90.5
9%	98.9	78.9	90.6	81.2
10%	85.6	69.1	81.2	65.5
11%	74.9	61.2	73.5	67.1
12%	66.2	54.6	67.0	61.6
13%	59.0	49.2	61.5	57.0

The clear result is that benefit decrease is much larger than the cost decrease in money terms. Consequently, the assumption of constant fuel price brings an unfovourable effect to the Limbang system with the project in terms of economic feasibility. The result of EIRR under a senario of constant fuel price is calculated to be 8.2%.

8.2 Financial Analysis

8.2.1 Objective of financial analysis

Financial analysis put its primal purpose on financial viability of the Medamit-2 hydro project itself and manageability of the implementing agency (SESCO) to repay foreign and local portion of investment costs or to finance local portion of them if local cost is to be entirely funded by SESCO. As far as the aspect of financial viability is concerned, analytical viewpoint focuses on financial rate of return to all resources engaged if the project is implemented. Its analysis usually put an emphasis on FIRR being equalizing discount rate based on present worth of investment costs and projected revenue amount. Concerning to financial manageability of the implementing agency, analyses are based on financial impact of the project to the implementing agency.

For the purpose of fulfilling objectives of financial analyses, conditions and assumptions to be applied to evaluation items has to be clarified. Evaluation items required for financial analysis are project costs including price contigency, forecast on electricity tariff for estimating revenue amount, and terms of repaying foreing loan plus financial performance of the implementing agency to finance local cost. Conditions and assumptions to conduct the appropriate estimate of evaluation items are discussed in the next section.

8.2.2 Conditions and assumptions for evaluation items

(1) Project cost

Financial costs of the Medamit-2 project evaluated in cost estimate of Chapter 7 are estimated at the price level of 1987. Operation and maintenance cost is assumed to be simply 1% of direct construction cost. Price contigency is added to financial cost of the project at 1987 price level by applying annual inflation rate for foreign and local currency portion of investment costs respectively. Price escalation rates for foreign and local costs are shown as below.

Unit:%

	1988	1989	1990	1991	1992	1993	1994	1995	1996
Foreign	1.0	1.0	1.0	3.5	3.5	3.5	3.5	3.5	3.5
Local	0.5	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0

An escalation rate for foreign cost is derived from the weighted average of price indexes of major manufacture goods in industrial countries, which is estimated by IBRD. As far as price escalation rate for local cost is concerned, the recent movement of consumer price index (CPI) in Sarawak and factors affecting CPI are taken into account. As general circumstance of the Malaysian economy, an unfavourable condition surrounding oil sector featured by the decline of oil price worsened public revenue and expenditure, resulting in contraction of the money supply leading to stabilization of CPI. Assuming that CPI is primarily correlated to public expenditure to be boosted by oil revenue, forecast on price escalation for local cost is roughly estimated by referring to forecast on oil price movement.

Time range to which price escalation is applied is up to the commissioning year of the project (1996). As a result, total financial costs of the Medamit-2 project are estimated to be M$66,103,240 consisting of M$58,959,250 of construction cost, and M$7,143,990 of pirce contigency. Foreign and local currency portions are estimated to be M$42,172,860 and M$23,930,380 respectively.

(2) Study on electricity tariff

Electricity tariff in the future has much influence on financial viability of power projects in terms of FIRR since projection of power revenue to be generated entirely depends on tariff setting. Prior to the estimation of future tariff, historical movement of the average electricity tariff in load centre of Limbang and entire Sarawak is shown in the following table:

Unit: M$/kWh

	1980	1981	1982	1983	1984	1985	1986
Limbang	0.27	0.33	0.33	0.33	0.33	0.33	0.31
Sarawak	0.23	0.29	0.29	0.29	0.29	0.30	0.28

Average tariff in Limbang and Sarawak in the first five years of 1980's kept the constant price of M$0.33/kWh and M$0.29/kWh respectively. Regional feature of tariff level is appeared in Limbang in comparison to tariff level in Sarawak. The fact that tariff in Limbang region has been higher by 4 cent per kWh than in Sarawak is partly because light fuel oil being fairly expensive oil is used as fuel for operation of diesel plants, and parlty because economy of scale is not workable due to small consumption centre characterized by Limbang region. Owing to these reasons assumed, average cost per kWh of sold energy in Limbang has been a bit higher than tariff in Sarawak.

The future electricity tariff is estimated by a few methods concervable. At first, the method of cost covering prices to be paid by consumers in Limbang region is introduced in order to clarify average tariff covering all project costs of Limbang system. The cost covering prices are calculated as the ratio of present value of all project costs of Limbang system over present value of electricity sales for various discount rate. The results of present value of project costs and electricity sales by discount rate are shown as below:

Discount rate (%)	PV of Costs (M$)	PV of E. sales (kWh)	Costs (M$)/kWh
4	212,990,706	721,240,547	0.30
6	151,114,628	473,686,211	0.32
8	113,836,437	330,883,193	0.34
10	89,868,150	243,687,662	0.37

Note: PV Present value

Understanding obtained from the above table demostrates that, for instance, if average tariff according to cost covering price method is M$0.37/kWh, FIRR of the Medamit-2 project is calculated to be 10%.

As one of finaincial guidelines, SESCO aims at minimum annual rate of return of 10% on the average net fixed assets in operation. This rate called ROR is equivalent to FIRR in terms of rate of return to all resources engaged. If this guideline of minimum rate of return is applied to the FIRR of the Medamit-2 project, tariff in the future is calculated to be M$0.37/kWh. Neverthless, cost covering price determined by the approach of minimum rate of return tends to disregard general trend or performance of tariff at present and in the future. Therefore tariff of M$0.37/kWh is reviewed and checked by another methods shown in the next.

The second approach being a conventional method is to escalate present tariff (M$0.31/kWh) in proportion to the increase rate of oil prices and domestic CPI. Forecast focuses on the future tariff in the commissioning year (1996) of the Medamit-2 project. The simple estimation by methods of oil price and CPI turns out to be M$0.41/kWh, and M$0.33/kWh respectively.

However, the further judgement whether electricity prices estimated so far are the appropriate tariff setting applicable to the proposed project, or not is required by the method reflecting financial conditions of supply side (SESCO) assessed by future financial performance. Financial performance of SESCO in the past and the selective year of 1995 is shown in Table 8.5.

The prediction of financial performance in 1995 is based on the simulation results of System Planning Division in SESCO. Tariff setting in 1995 is assumed to be the same tariff level as present one (1986). Since the targets of key financial ratios such as ROS or Debt-service ratio are more than 10 % or more than 1.5 times, financial performance of SESCO in 1995 based on present tariff level satisfies financial requirement SESCO aims.

It is reminded that an important assumption used for predicting financial performance is the exclusion of Bakun-Hydro project from future projects. Since the simulation results meet with financial targets satisfactorily, the possibility that tariff will soar more than present level is hardly expected.

Consequently, tariff setting at M$0.37/kWh determined by cost covering prices at the discount rate of 10% or 0.41 M$/KWh estimated by the method of oil prices would not be the appropriate tariff due to reasons stated above. In the conservative way of estimation, an upper limit of tariff is fixed at M$0.33/kWh estimated by CPI method. The future tariff in standard case is assumed to be equivalent to present price (M$0.31/kWh).

(3) Financial sources and conditions of project financing

Financial sources of power projects committed so far by SESCO normally take the form of grant from federal govenment and external plus internal loans from the various institutions and banks. Grants usually supplied to rural electrification programme rather than individual project is sometimes extended to a big project like Batang Ai hydro power project to finance local currency portion of investment costs.

The major national sources for financing power projects are derived from loans from federal government and non-bank financial institution like the Employee's Provident Fund Board (consisting of pension and social security fund). As to external loans, financial sources of external borrowing by SESCO are a multilateral financing agency like ADB, a financial institution like OECF, and various banks supplying syndicate loans and Yen credit. The list of financial sources and loan conditions is shown in the following table.

Financial sources	Loan condition			
	Interest rate (%)	Grace period (year)	Repayment (year)	Maturity (year)
Local fund				
Federal Government	7.5	5	20	25
Non-bank institution	8.0	5	15	20
External fund				
International Ins. (ADB)	8.0	5	15	20
Financial Ins. (OECF)	4.0	7	18	25
Commercial (Yen credit)	5.8	2	6	8
Commercial (Other loan)	5.5	2.5	5	7.5

Loan conditions shown in the above table indicates terms of fund requirement prevailing in 1987. Although loan conditions depend on type or scale of projects, loan conditons applicable to the Medamit-2 project are chosen among many terms. It is assumed that these conditons will continue and be extended to the proposed project.

Since project costs including price contigency is estimated to be about M$66 million consisting of foreign cost of M$42 million, and local cost of M$24 million, it would not be necessary to project the detailed financing plan for the Medamit-2 project. Local cost of M$24 million is surely under financing manageablity of federal government or the Employee' Provident Fund (EPF) and might be capable of being financed by SESCO's intenal cash generation. Since foreign currency portion (M$40 million) of the Medamit-2 project would be the amount to be finacnced by a single fund resource, many sources do not have to be considered. Soft loans being OECF fund could be the most appropriate financial source among them. As a result, any manageable issues of financing local or foreign costs can not be observable.

8.2.3 Financial analysis

(1) Financial internal rate fo return

Cost stream of the Medamit-2 project in financial term is based on conditions of financial requirement with advance payments. Saleable energy is calculated as the amount after deducting station use and transmission loss (13%) from energy output. Revenue is to be generated from 1996 where the estimated tariff of M$0.31/kWh is assumed to continue up to 2036. Evaluation period is decided to be time range from 1987 to 2036, which is the same duration as evaluation period in economic analysis. Based on cash flow of revenue and cost shown in Table 8.6, FIRR is calculated to be 8.4%. If local and foreign cost is financed by federal government loan and soft loan from OECF respectively, this result of FIRR turns out to be higher than local interest rate (7.5%) and foreign interest rate (4%). If local cost is financed by SESCO's internal cash generation, financial viability of the project is satisfactorily assured.

Sensitivity analysis is also conducted with the following cases:

Case I	Projected tariff of M$0.33/kWh	8.9%
Case II	Cost increase by 10%	7.6%

Even if project costs increase by 10%, it is clarified that financial viability of the project is sustainable.

(2) Loan repayability and financial manageability

Two financial statements shown in Tables 8.7 and 8.8 are demonstrated in order to clarify loan repayability of the implementing agency. The condition of loan repayability is searched by net cash flow between revenue and interest plus repayment to be outlayed. A statement shown in Table 8.7 is made with the following assumption that local cost is to be funded by federal government, and foreign cost is to be financed by soft loans. Terms of loan are already mentioned in the preceding subsection, 8.2.2. The clear result can be seen in net cash flow which would turn to be positive in the commissioning year (1996) of the Medamit-2 project. Payment of interest during the first five years from 1991 to 1995 will be the amount order under financial manageability of SESCO, which is to be entirely covered by internal cash generation. Accumulation of net cash flow would turn to be positive within the maturity period, to be precise, in ten years after construction. So, the implementing agency will enjoy the favourable financial position under operation of the Medamit-2 project within the maturity period.

A statement shown in Table 8.8 demonstrates net cash flow and its accumulation during the same maturity period with the following assumption that local cost is to be financed by SESCO, and foreign cost is to be funded by soft loans. Liquidity problem of whether or not local cost and interest on foreign loan can be financed by SESCO would be a bit controversial matter from the viewpoints of the amount order of internal cash generation at present level, or would present no serious constraint to SESCO if cash generation will grow as shown in Table 8.5. Although net cash flow would turn to be positive in the commissioning year (1996) of the project which means that repayability of foreign loan is in fairly good condition, accumulated amount of local cost and interest on foreign loan will reach to about M$27 million in 1995.

A statement given in Table 8.9 is prepared under the assumption that local cost is to be funded by federal government and that foreign cost is to be financed by hard loans (8%). Net cash flow turns to be positive in year 2011, however, the accumulation of net cash amount is negative within the maturity period. Thus, condition of loan repayability is not satisfactorily identified.

Furthermore, financial statements for entire Limbang system during investment horizon are also demonstrated in order to make a comparison study of net cash flow and its accumlation between all diesel and the Medamit-2 with diesel. The following financial case studies shown in Table 8.10 through 8.13 made on assumptions that oil price would be constant at 18 US$ per barrel or is expected to increase according to the IBRD's forecast.

Table 8.10 ; All diesel in case of oil price increase.
Table 8.11 ; All diesel with oil price constant.
Table 8.12 ; The system with the Medamit-2 in case of oil price increase.
Table 8.13 ; The system with the Medamit-2 under constant price level.

A slight modification of tariff setting from M$0.32 to 0.34/KWh does not make any difference since the reduction of negative cash flow on annual base is negligibly small. What is more important is, despite of assumptions about oil price, that comparison studies result in favourable conditions in the system with the Medamit-2 financially in terms of net cash flow and its accumulation. This is mostly ascribed to the difference of fuel consumption between the system with all diesel and hydro project. It is expected that fuel cost would become the major expenditure item in case Limbang system is formulated with all diesel.

(3) Conclusion of financial analysis

Based on the simulation results of loan repayability and financial manageability, financing plan is recommended in such a way that local and foreign cost are to be financed by federal government and soft plan respectively. The results of net cash flow at annual base and its accummulated amount during construction period would bring no financial burden on the implementing agency. Whereas, the financial statement in which local cost is to be funded by SESCO would cast doubt on self-financing capability of the implementing agency, especially if a big project like Bakun hydropower project comes into the future power programme. Increase of interest payment on loans of other projects will squeeze internal cash generation, resulting in that financing of local cost would be more difficult than expected.

Financial viability of the project is sustainable since the project's rate of return (8.4%) represented by FIRR is over interest rate (7.5%) on local loan and interest rate (4%) on foreign loan.

The implementation of the Medamit-2 project to be prefferable to all diesel since simulation results of financial condition for Limbang system turn out to be favourable outcome in the system with the proposed hydro project.

CHAPTER 9. FURTHER INVESTIGATION AND STUDIES

9.1 General

As discussed in the preceding chapters, the Medamit-2 hydropower development project was evaluated to be economically and financially viable. The project is recommended to be developed at the earliest time. It is possible to commission the project at the beginning of 1996 according to the study of construction plan and schedule.

It is desirable for keeping the commissioning year of the project to start the detailed design by September of 1989 with the financial arrangement. Post-feasibility study investigation is recommended prior to the detailed design for smoothly carrying out it. Further investigation and studies in the post-feasibility and detailed design are discussed hereinafter.

9.2 Post-feasibility Study Investigation

A staff gauge to estimate river runoff was established at 8 km downstream from the proposed damsite. Regular readings of stage height are continued since installation. Furthermore, discharge measurements to establish a reliable rating curve are regularly carried out by a task force of DID and SESCO.

Reinforcing hydrological measurements and accummulating reliable runoff data, it is recommended to install an automatic stream recorder close to the staff gauge. Stage records of the automatic stream recorder will be endorsed with staff reading twice a day. Furthermore, discharge measurements are desired to successively be carried out especially during high flow seasons for extending the reliable range of the rating curve.

A manual rain gauge was installed near the staff gauge. Considering that tropical rainfall is erratic, two more automatic rain gauges are recommended to be installed in the Medamit River basin upstream from the project site.

Establishment of quarry is proposed as the source of concrete aggregate material in the Study taking into account the quantity, hauling distance and physical condition of riverbed deposits and quarry. However, the required quantity is relatively small, detailed investigation and study with regard to the commercial supply source will be required to be carried out.

9.3 Detailed Design

9.3.1 Objective

Subsequent to the completion of this feasibility study, detailed design (D/D) for the development of Medamit-2 should be initiated. The objectives of the engineering services for D/D would be as follow:

(i) To collect updated additional data and information and to review and analyse the findings and recommendation for optimization of the project,

(ii) To conduct additional field investigation for obtaining essential data for design,

(iii) To prepare design drawings, design report, technical specification, pre-qualification , tender documents, cost estimate and detailed implementation programme for construction of the Medamit-2 hydropower project, and

(iv) To transfer technology to the SESCO staff concerned during the period of services.

9.3.2 Scope of work

The engineering services for D/D would be carried out in close cooperation with assigned SESCO counterparts. The services would include but not necessarily be limited to the following:

1. Review of available data

The review of available data is to obtain updated information, to review the feasibility study report and, if necessary, to revise the development scheme, scale and principal features of the project.

2. Preparation of Inception Report

The Inception Report will cover the following discussions:

a) Work schedule with study and survey methods for this engineering service, and

b) Review of the feasibility study.

3. Preparation of tender documents for field investigations

The tender documents for the field investigation carried out by local contractors are prepared. Field investigation covers following work:

a) Test boring and grouting,

b) Seismic exploration,

c) In-situ rock shear tests,

d) Shear test for rock materials on a large scale,

e) Concrete tests including sampling and test pits in aggregate quarries,

f) Topographic surveys, and

g) Boring and penetration test.

4. Field investigation and tests for detailed design

The field investigation and test work of the above items 3(a) through (g) are executed by the local contractors under the supervision and technical guidance of the Consultant.

5. Basic design and cost estimate

Basic design and construction cost estimates include the work as follows:

a) To prepare design criteria for detailed design of all the major components with respect to methodology, analysis and computation criteria, etc.,

b) To make a final review and revision of layouts and optimum scale of the plant based on the investigation results of item (4),

c) To review the design of main structures including the dam, intake, waterway, surge tank, powerhouse, generating equipment with switchyard facilities, metal works of gates and penstocks, and transmission lines,

d) To study construction schedules at the basic design level,

e) To estimate construction costs at the basic design level,

f) To confirm economic viability of the project, and

g) To conduct hydraulic model tests for the spillway.

6. Detailed design

Detailed design, construction schedule and cost estimate include the work as follows:

a) To make a plan for preparatory works including layout of camp, workshops, warehouses, etc., and supply of electric power and water.

b) To design access roads including bridges.

c) To design in detail the structures including the diversion channel, intake dam, intake, headrace tunnel, surge tank, penstock line, powerhouse with tailrace, switchyard, etc., including a flood warning system to the downstream reaches of the dam.

d) To design in detail generating equipment and auxiliary facilities.

e) To design in detail the metal work such as gates, penstocks and valves.

f) To design in detail the transmission line including poles and a substation including electric equipment.

g) To make detailed construction schedules/networks.

h) To estimate construction cost in detail.

i) To study on environmental and other aspects, if necessary.

7. Preparation of tender documents

Tender documents are prepared for the following work items:

a) Documents of pre-qualification questionnaire.

b) Tender documents for civil works.

c) Tender documents for generating equipment.

d) Tender documents for metal works.

e) Tender documents for a transmission line and substation.

f) Tender documents for preparatory works, access roads and bridges.

8. Documents to be prepared

a) Inception Report,

b) Tender documents for field investigation of the above item (3),

c) Reports with data books on field investigation,

d) Report on design criteria,

e) Design report with drawings,

f) Cost estimate,

g) Tender documents for the works of the above item (7), and

h) Quarterly progress reports.

9. Transfer of technology

The Consultant will make efforts on transfer of technology to SESCO's staff and local contractors during the service period.

10. Assistance in pre-qualification

The Consultant will assist SESCO in the pre-qualification of contractors.

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TABLES

TABLE 1.1 INSTALLED CAPACITY, GENERATED ENERGY AND CONSUMPTION OF ELECTRICITY IN SARAWAK

Year	Installed Capacity (KW)	Generated Energy (MWh)	Number of Consumer	Consumption (GWh)			
				Domestic	Industrial	Street	Total
1975	80,885	199,924	46,631	41,662	125,450	2,924	170,034
1976	86,602	228,555	50,138	47,337	142,415	3,432	193,183
1977	102,184	258,155	53,477	53,137	164,217	3,271	220,625
1978	138,362	301,193	61,433	56,458	198,411	3,412	258,280
1979	147,387	343,178	65,722	69,034	227,240	3,688	299,962
1980	152,755	383,319	73,212	93,270	232,502	4,194	329,965
1981	156,002	429,201	83,358	107,655	259,026	4,396	371,077
1982	189,246	483,059	94,200	120,788	286,658	4,807	412,253
1983	203,499	551,852	106,102	147,464	328,066	5,408	408,938
1984	228,508	601,987	116,107	148,295	356,279	5,806	510,379

Source : Annual Statistical Bulletin Sarawak, 1984

TABLE 3.1 RESULT OF LABORATORY TESTS (1/2)

Item of Tests	Places: Medamit River (TME-1-TME-2)	Places: Limbang River (TME-3-TME-7)	Value in General
a. Fineness Modulus of Gravel (F.M.)	8.18	8.61	6.5-9.0
Fineness Modulus of Sand (F.M.)	3.68	2.96	2.3-3.5
b. Specific Gravity of Gravel	2.553	2.588	2.5-2.7
Specific Gravity of Sand	2.438	2.361	2.5-2.7
c. Absorption of Gravel (%)	1.54	1.20	less than 3.0
Absorption of Sand (%)	2.438	2.361	less than 3.0
d. Organic Impurities of Sand	passed	not passed	
e. Scratch Hardness of Gravel	5.6	4.6	less than 5.0
f. Soundness of Gravel (%)	1.8	4.2	less than 12.0
Soundness of Sand (%)	-	19.1	less than 10.0
g. Abrasion of Gravel (%)	13.6	15.7	less than 40.0
h. Unit Weight of Gravel (t/m^3)	1.54	1.20	1.5-1.9
Unit Weight of Sand (t/m^3)	2.438	2.361	1.4-1.8

TABLE 3.1 RESULT OF LABORATORY TESTS (2/2)

Item of Tests	Quarry Samples	Acceptable Values
a. Specific Gravity	2.635	2.5-2.7
b. Absorption (%)	0.77	less than 3.0
c. Scratch Hardness	0.3	less than 5.0
d. Soundness (%)	1.09	less than 12.0
e. Abrasion (%)	17.8	less than 40.0
f. Aggregate Impact Value (%)	18	less than 45.0
g. Aggregate Crushing Value (%)	19	less than 45.0

TABLE 3.2 PLACES OF TEST PITTING AND SAMPLING (MEDAMIT-2) (1/2)

Sampling No.	Distance from Dam or Power House Site (km)	Volume of River Deposit (m^3)	Maximum Size of Particles (m)	Type of Rock	Sampling Weight (kg)
Quarry sample QME-1	0.2 upstream from damsite (left bank)	more than required	50x20	Sandstone and Shale	120
TME-1	From damsite up 0.85 (Middle of River)	1,000 (250)	30-50	Shale and Sandstone	120
TME-2	From damsite up 0.60 (Right Bank)	600 (150)	30-50	Shale and Sandstone	90

TABLE 3.2 PLACES OF TEST PITTING AND SAMPLING (MEDAMIT-2) (2/2)

Sampling No.	Distance from Dam or Power House Site (Km)	Volume of River Deposit (m^3)	Maximum size of particles (m)	Type of rock	Sampling weight (Kg)
TME-3	From Power House up 2.50 (Left Bank)	9,000 (3,000)	30 - 50	Shale, Sand-stone and lime-stone	90
TME-4	From Power House up 1.70 (Right Bank)	18,000 (6,000)	30 - 50	Shale, Sand-stone and lime-stone	180
TME-5	From Power House up 0.70 (Left Bank)	21,000 (7,000)	30 - 50	Shale, Sand-stone and lime-stone	90
TME-6	From Power House Down 1.80 (Right Bank)	7,800 (2,600)	20 - 30	Shale, Sand-stone and lime-stone	90
TME-7	From Power House Down 2.20 (Left Bank)	10,000 (5,000)	20 - 30	Shale, Sand-stone and Lime-stone	180
	Total Volume	67,400 (24,000)			

Note: Figures in parenthesis show the estimated volume of gravel with the size under 10 cm

Table 3.3 Results of Environmental Impact Assessment (1/2)

Item	Prediction	Evaluation
Settlement	No submergence is expected in the project area due to no inhabitants in the upstream from the damsite.	0
Land issues and compensation	About 40,000 m^2 will have to be secured for the construction of such major facilities as dam, powerhouse and access road in the forest. Land issues are not foreseen, since the land is reserved to the Government and nobody may claim native customary rights.	0
Economic activities and social welfare	A large construction labour demand is expected. Electricity will be supplied to the villages from Medamit village to Limbang.	+H
Public health	It is not predicted that a vector of malaria will increase due to the creation of reservoir.	0
Sedimentation	Sediment deposited in the reservoir will be flushed out by the sand flush gate. Thus, the sedimentation problem is less affected.	-L

Table 3.3 Results of Environmental Impact Assessment (2/2)

Item	Prediction	Evaluation
Vegetation	Since only a limited area of forest is opened, the effect to the vegetation is minimal. However, afforestation will be necessary at the opened areas after construction.	-L
Wildlife	Wildlife will not be affected, since the project area is only limited.	-L
Fish and fisheries	The migration of river fish is affected with the construction of dam. Thus, a fish ladder will be provided.	-L

TABLE 4.1 INSTALLED CAPACITY IN SARAWAK

Station / Year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1. Kuching	42,758	42,758	42,758	77,414	77,414	77,414	77,414	77,414	91,548*	103,324*	210,908*	212,264*
2. Sibu	15,794	15,794	31,560	31,560	31,560	31,560	31,560	31,560	31,560	31,560	47,560	47,564
3. Miri	10,680	10,680	10,680	10,680	14,550	14,550	14,550	32,150	31,050	41,950	41,950	41,200
4. Bintulu	1,154	1,611	1,611	1,811	3,811	11,551	11,551	22,991	20,664	20,376	19,776	30,890
5. Sarikei	1,775	2,575	2,575	2,575	2,575	2,575	2,575	3,295	4,415	4,415	4,415	6,415
6. Sri Aman	2,095	1,949	2,024	2,078	1,478	1,874	2,474	2,474	2,534	2,534	4,184	4,184
7. Limbang	1,734	1,734	1,735	1,735	1,735	1,935	2,535	2,535	2,310	2,535	3,585	3,585
8. Kapit	437	385	529	529	729	729	654	1,054	1,254	1,164	2,363	2,363
9. Marudi	607	607	607	607	804	804	754	954	879	943	1,280	1,313
10. Lawas	223	367	381	381	536	492	548	655	786	1,775	1,775	1,775
Whole Sarawak	80,435	81,956	98,174	133,575	139,255	148,055	151,102	183,646	196,599	221,518	348,699	364,624

Remarks:
(1) * Inclusive of Batang Ai.
(2) These readings do not include generating units which have been retired.
(3) Source: As per SESCO Annual Reports (Commercial Office) and the answers to the Questionaire

TABLE 4.2 ENERGY GENERATED IN SARAWAK

(Unit : MWh)

Year / Station	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1. Kuching	94,998	111,746	127,026	149,736	174,426	189,720	207,674	230,048	261,034	295,458*	344,975*	377,408
2. Sibu	39,666	43,720	48,188	55,002	60,894	67,017	73,100	80,217	88,018	91,941	101,412	104,842
3. Miri	20,793	24,550	29,255	38,474	44,231	52,338	60,688	70,224	78,053	81,186	92,343	98,901
4. Bintulu	2,678	3,141	4,161	5,618	7,930	13,299	18,631	24,996	33,615	37,908	53,481	52,240
5. Sarikei	3,580	3,962	4,745	5,655	6,418	6,996	7,910	9,016	9,718	10,234	13,375	15,607
6. Sri Aman	3,332	3,713	4,861	5,289	6,092	6,724	7,706	8,372	9,294	9,546	10,223	11,090
7. Limbang	3,253	3,679	3,965	4,526	5,033	5,567	5,993	7,506	8,781	9,462	10,609	11,596
8. Kapit	1,071	1,167	1,475	1,679	2,053	2,454	2,936	3,465	3,838	4,209	5,038	5,528
9. Marudi	1,343	1,465	1,663	1,960	2,198	2,603	2,830	3,091	3,192	3,312	3,614	4,478
10. Lawas	648	814	1,004	1,297	1,288	1,491	1,719	2,024	2,619	2,855	3,544	3,933
Whole Sarawak	176,322	203,425	232,697	277,024	317,540	355,261	398,923	451,242	513,397	563,317	656,593	706,560

Remarks: (1) * 1984, 1985, 1986 for Kuching inclusive of Batang Ai Hydropower Station
(2) Source: SESCO Annual Reports and the answers to the Questionaire

TABLE 4.3 ENERGY SOLD IN SARAWAK

(Unit : MWh)

Year / Station	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1. Kuching	77,676	91,590	105,226	125,261	150,888	159,334	175,329	191,954	220,586	239,067	268,351	279,878
2. Sibu	32,347	36,793	40,945	46,216	51,897	57,215	63,401	68,528	78,238	78,597	84,326	86,830
3. Miri	16,938	20,022	25,163	32,749	37,293	44,700	51,737	56,168	65,802	66,403	67,707	78,973
4. Bintulu	2,339	2,733	3,639	4,947	7,237	12,002	16,161	21,441	29,572	32,849	47,845	45,584
5. Sarikei	2,654	3,143	4,120	4,893	5,592	6,436	6,931	8,291	8,863	9,672	10,890	11,908
6. Sri Aman	2,647	3,019	4,053	4,455	5,106	5,554	6,585	7,222	7,966	8,170	8,776	9,460
7. Limbang	3,007	3,137	3,419	3,818	4,265	4,753	5,247	6,331	7,499	8,083	9,239	10,212
8. Kapit	906	987	1,259	1,453	1,779	2,152	2,584	3,038	3,398	3,689	4,611	5,045
9. Marudi	1,070	1,190	1,396	1,620	1,826	2,155	2,350	2,584	2,737	2,834	3,117	3,724
10. Lawas	548	632	776	1,018	1,076	1,254	1,422	1,688	2,175	2,338	2,835	3,058
Whole Sarawak	146,431	168,054	195,496	233,151	274,833	304,952	343,964	382,604	445,518	473,806	535,342	568,562

Source: SESCO Annual Reports and the answers to the Questionaire

TABLE 4.4 MAXIMUM DEMAND IN SARAWAK

(Unit : kW)

Station / Year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1. Kuching	19,110	24,270	26,990	33,170	38,900	39,500	43,200	54,140	55,600	60,500	68,500	72,800
2. Sibu	8,240	9,300	10,250	11,600	12,490	14,000	15,800	17,050	18,050	19,320	20,450	20,950
3. Miri	4,140	4,840	5,560	7,860	8,210	9,380	11,100	12,350	13,810	15,300	16,500	17,700
4. Bintulu	735	940	1,240	1,468	1,955	3,080	4,197	5,409	6,532	7,200	11,500	11,650
5. Sarikei	884	826	1,000	1,270	1,325	1,505	1,617	1,910	2,060	2,480	3,030	3,260
6. Sri Aman	833	1,025	1,070	1,275	1,210	1,365	1,964	1,751	1,993	1,960	1,971	2,197
7. Limbang	963	759	877	936	1,110	1,098	1,276	1,541	1,659	1,912	2,006	2,502
8. Kapit	258	242	419	362	476	529	612	738	796	948	1,184	1,358
9. Marudi	317	319	428	413	439	499	529	800	589	661	782	925
10. Lawas	173	200	244	295	340	275	435	430	582	585	820	800
Whole Sarawak	37,325	44,693	50,048	61,053	69,070	73,635	84,147	100,580	107,194	116,939	133,507	141,408

Source: SESCO Annual Reports and the answers to the Questionaire.

TABLE 4.5 NUMBER OF CONSUMERS IN SARAWAK

Year / Station	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1. Kuching	20,386	21,644	23,008	26,751	27,828	30,198	32,519	36,737	40,136	44,261	48,874	49,316
2. Sibu	9,534	10,097	11,153	12,371	13,262	14,496	15,509	16,574	17,923	18,790	19,835	20,610
3. Miri	4,645	5,104	5,543	6,197	6,771	7,580	8,310	8,939	10,234	11,386	12,673	13,690
4. Bintulu	1,141	1,268	1,398	1,656	1,849	2,097	2,454	3,018	4,027	4,756	5,827	6,822
5. Sarikei	1,443	1,555	1,662	1,791	2,065	2,218	2,505	2,760	2,860	3,161	3,522	3,674
6. Sri Aman	1,421	1,568	1,631	1,742	1,878	2,184	2,386	2,637	2,801	2,966	3,203	3,307
7. Limbang	881	973	1,029	1,063	1,168	1,232	1,493	1,753	1,960	2,109	2,289	2,558
8. Kapit	432	461	492	568	649	713	742	742	817	958	1,074	1,172
9. Marudi	714	755	813	856	881	958	1,006	1,032	1,079	1,141	1,193	1,251
10. Lawas	278	311	344	395	407	443	460	595	733	764	787	1,060
Whole Sarawak	45,808	49,315	52,654	60,610	64,899	72,862	82,358	93,200	105,102	115,106	128,949	136,041

Source: SESCO Annual Reports and the answers to the Questionaire.

Table 4.6 POWER CONSUMPTION BY CATEGORY IN LIMBANG

(Unit:MWh)

Year	1980	1981	1982	1983	1984	1985	1986
Domestic	1,001	1,232	1,508	2,019	2,181	2,507	2,922
Commercial	3,650	3,908	4,108	4,381	4,727	5,463	6,014
Industrial	67	75	681	1,052	1,123	1,215	1,206
Lighting	35	32	34	47	52	54	70
Total	4,753	5,247	6,331	7,499	8,083	9,239	10,212

TABLE 4.7 DETAILS OF POWER CONSUMPTION BY DOMESTIC AND COMMERCIAL SECTORS IN LIMBANG

Year	1984				1985				1986			
Items	No. of Consumers		Sold (kWh/month)		No. of Consumers		Sold (kWh/month)		No. of Consumers		Sold (kWh/month)	
Month	D	C	D	C	D	C	D	C	D	C	D	C
January	1,475	486	168,985	386,016	1,599	497	186,820	531,810	1,779	523	229,030	515,586
February	1,515	493	183,334	372,022	1,611	501	191,514	432,772	1,778	524	215,221	433,632
March	1,511	493	164,075	327,091	1,616	502	213,003	399,056	1,782	527	212,063	405,819
April	1,548	488	185,034	412,042	1,629	504	193,534	457,050	1,784	534	240,763	516,314
May	1,530	491	187,289	389,987	1,624	498	208,615	475,906	1,779	538	230,317	494,570
June	1,547	498	180,982	377,635	1,615	501	214,585	450,701	1,720	614	270,398	542,307
July	1,600	501	189,136	451,900	1,730	501	231,130	427,175	1,800	546	263,588	534,889
August	1,629	500	183,533	393,821	1,738	499	221,958	482,338	1,797	556	234,542	554,743
September	1,609	503	194,988	468,455	1,295	850	212,118	456,310	1,948	557	257,749	498,887
October	1,589	495	188,929	383,104	1,745	508	221,297	479,750	1,950	559	259,137	512,497
November	1,569	480	173,380	411,941	1,761	513	190,874	479,191	1,956	623	259,790	533,946
December	1,606	500	181,431	353,338	1,771	515	221,556	391,238	1,983	572	249,328	471,255
Total	18,728	5,928	2,181,096	4,727,352	19,734	6,389	2,507,004	5,463,297	22,056	6,673	2,921,926	6,014,445

Note: D = Domestic and C = Commercial

TABLE 4.8 ANNUAL POWER CONSUMPTION PER CONSUMER IN MAJOR DISTRICTS (1/2)

(1) Domestic Sector

Year	Kuching		Sibu	
	Annual Power Consumption per consumer, kWh	Growth Rate %	Annual Power Consumption per consumer, kWh	Growth Rate %
1980	1,428		1,429	
		7.9		5.7
1981	1,541		1,510	
		4.2		3.2
1982	1,476		1,559	
		12.5		16.0
1983	1,660		1,808	
		-		-
1985	1,686		1,782	
		3.0		5.2
1986	1,736		1,874	
Average Growth Rate		3.3		4.6

Remarks : Data for the year 1984 not available.

TABLE 4.8 ANNUAL POWER CONSUMPTION PER CONSUMER IN MAJOR DISTRICTS (2/2)

(2) Commercial Sector

Year	Kuching: Annual Power Consumption per consumer, kWh	Kuching: Growth Rate %	Sibu: Annual Power Consumption per consumer, kWh	Sibu: Growth Rate %
1980	12,137		9,650	
		0.2		5.5
1981	12,166		10,183	
		4.4		5.6
1982	12,706		10,753	
		3.1		5.8
1983	13,100		11,373	
		-		-
1985	13,617		11,595	
		7.0		7.4
1986	14,567		10,736	
Average Growth Rate		3.1		1.8

Remarks: Data for the year 1984 not available.

TABLE 4.9 CALCULATION OF POWER COMSUMPTION FOR LIMBANG

Sector / Year	DOMESTIC	(MWh)	COMMERCIAL	(MWh)	INDUSTRIAL	(MWh)	PUBLIC LIGHTING	(MWh)	TOTAL	(MWh)
1980	1,001	(898)	3,650	(332)	67	(1)	35	(1)	4,753	(1,232)
1981	1,232	(1,131)	3,908	(360)	75	"	32	"	5,247	(1,493)
1982	1,508	(1,285)	4,108	(465)	681	(2)	34	"	6,331	(1,753)
1983	2,019	(1,472)	4,381	(485)	1,052	"	47	"	7,499	(1,960)
1984	2,181	(1,606)	4,727	(500)	1,123	"	52	"	8,083	(2,109)
1985	2,507	(1,771)	5,463	(515)	1,215	"	54	"	9,239	(2,289)
1986	2,922	(1,983)	6,014	(572)	1,206	"	70	"	10,212	(2,558)
1987	1.62MWh x 2,057= 3,394		11.13MWh x 590=6,567		1,206MWh x (1+0.12) =1,351		70MWh x (1+0.1)= 77		11,389	
1988	1.70MWh x 2,207=3,752		11.46MWh x 630=7,220		1,206MWh x $(1+0.12)^2$ =1,513		70MWh x $(1+0.1)^2$ = 85		12,570	
1989	1.78MWh x 2,333=4,153		11.80MWh x 660=7,788		1,206MWh x $(1+0.12)^3$ =1,694		70MWh x $(1+0.1)^3$ = 93		13,728	
1990	1.86MWh x 2,462=4,579		12.15MWh x 690=8,384		1,206MWh x $(1+0.12)^4$ =1,898		70MWh x $(1+0.1)^4$ =102		14,963	
1995	2.07MWh x 3,200=6,624		14.09MWh x 905=12,751		1,898MWh x $(1+0.10)^5$ =3,057		102MWh x $(1+0.08)^5$ =150		22,582	
2000	2.52MWh x 3,780=9,526		16.33MWh x 1,020 =16,657		3,057MWh x $(1+0.09)^5$ =4,704		102MWh x $(1+0.08)^{10}$ =220		31,107	
2005	2.73MWh x 4,460=12,176		18.48MWh x 1,180 =21,806		4,704MWh x $(1+0.08)^5$ =6,912		220MWh x $(1+0.06)^5$ =294		41,188	
2010	2.95MWh x 5,270=15,547		20.38MWh x 1,370 =27,921		4,704MWh x $(1+0.08)^{10}$ =10,156		220MWh x $(1+0.06)^{10}$ =394		54,018	

Note: ( ) shows the number of consumers at the end of year from 1980 to 1986.

TABLE 5.1 LIST OF EXISTING, UNDER-CONSTRUCTION AND COMMITTED POWER PLANT IN THE LIMBANG SYSTEM

No.	Type	Installed Cap.,kW	Unit	Inst. Year	Designated Retirement	Annual Max. Operation Rate,%
1.	Diesel	225	1		-	60
2.	"	225	1		-	"
3.	"	225	1		-	"
4.	"	460	1		-	"
5.	"	600	1	1975	-	"
6.	"	600	1	1981	-	"
7.	"	200	1	1980	-	"
8.	"	1,050	1	1985	-	"
9.	"	600	1	1987	-	"
10.	"	1,000	1	1987	-	"
11.	Hydro	150	2 (75x2)	1987	-	-

TABLE 5.2 CONSTRUCTION AND O & M COSTS OF DIESEL CANDIDATES

Class, kW	Annual Max. Operation rate, %	Lead Time year	Construction Time Period, year	Life Time, year	Construction Cost, M$/kW	O & M Fixed, % 1/	O & M Variable, M$/kWh	Fuel Cost M$/kWh
500 to 1,000	60	0	1	15	2,700	3	0.02/0.03 2/	0.12/0.18 3/
1,000 to 2,000	"	"	"	"	2,200	"	"	"
2,000 to 3,000	"	"	"	"	1,900	"	"	"

Notes: 1/ Annual fixed O & M cost is expressed by percentage of construction cost.

2/ Variable O & M cost of M$0.02/kWh is for the Kapit system, whilst M$0.03/kWh for Limbang.

3/ Fuel cost of M$0.18/kWh is for the diesel plant in Kapit using diesoline, whilst M$0.12/kWh is for the diesel plant in Limbang using light fuel oil.

The increase rates of future fuel costs to the price in 1987 are assumed on the basis of the projection of World Bank as follows:

Year	1987	1988	1989	1990	1995	2000	2010
Ratio to 1987 price	1.00	1.00	1.00	1.06	1.31	1.81	1.81 4/

4/ Fuel price is assumed to be constant after 2000 onward, since no projection is given for the crude oil price after that time.

TABLE 5.3 UNIT PRICES FOR MAJOR WORKS

Work Item		Unit	Price
1.	Civil Works		
a.	Excavation in common	m3	5.0
b.	" in rock	"	18.0
c.	Concrete in dam	"	210.0
d.	" in structures	"	290.0
e.	" in powerhouse	"	350.0
f.	Reinforcement	ton	1,900.0
g.	Access road, new	Km	160,000.0
h.	" " , improve	"	65,000.0
2.	Metal Works		
a.	Gates	ton	12,000.0
b.	Penstock	"	6,800.0

Table 5.4 ECONOMIC EVALUATION FOR MEDAMIT-2 PROJECT

Case	FSL (El;M)	Plant Discharge (cms)	Installed Capacity (MW)	Construction Cost (million M$)	B/C	Net Benefit (million M$)	EIRR (%)
Alt-1							
1	140.000	25.3	4.26	40.618	0.943	-5.219	7.402
2	140.000	18.9	3.19	37.584	0.952	-4.353	7.646
3	140.000	12.6	2.13	33.381	0.940	-5.509	6.450
4	140.000	8.4	1.42	33.926	0.914	-8.020	4.906
5	150.000	32.9	6.91	52.127	0.937	-5.746	7.815
6	150.000	24.7	5.18	48.225	0.954	-4.117	8.315
7	150.000	16.5	3.45	43.964	0.955	-4.009	8.128
8	150.000	11.0	2.30	42.841	0.925	-6.952	6.600
Alt-2							
1	140.000	25.3	5.01	45.585	0.940	-5.441	7.559
2	140.000	18.9	3.75	41.903	0.951	-4.382	7.873
3	140.000	12.6	2.50	37.747	0.944	-5.127	7.150
4	140.000	8.4	1.66	36.820	0.914	-8.039	5.259
5	150.000	32.9	7.90	57.940	0.928	-6.614	7.759
6	150.000	24.7	5.92	53.239	0.949	-4.574	8.323
7	150.000	16.5	3.94	47.994	0.953	-4.258	8.215
8	150.000	11.0	2.62	46.083	0.926	-6.833	6.894
Alt-3							
ROR-1	130.500	5.8	3.21	43.293	1.012	0.989	10.484
ROR-2	131.500	8.9	5.10	49.881	1.054	4.369	11.652
ROR-3	131.839	13.5	7.86	58.449	1.038	3.139	10.959
ROR-4	132.000	18.1	10.63	65.802	1.002	0.189	10.058
5	135.000	19.8	11.88	72.158	0.971	-2.534	9.410
6	135.000	14.8	8.84	63.775	1.016	1.343	10.410
7	135.000	9.9	5.80	54.073	1.035	2.891	10.966
8	135.000	6.6	3.79	46.604	1.026	2.169	10.911
9	140.000	17.4	10.80	72.193	0.982	-1.560	9.652
10	140.000	11.6	7.11	61.911	1.029	2.407	10.729
11	140.000	7.8	4.66	53.771	1.030	2.505	10.890
12	140.000	5.8	3.44	53.262	0.921	-5.674	9.125
13	150.000	23.2	15.41	90.858	0.939	-5.578	8.883
14	150.000	15.5	10.18	76.628	1.020	1.719	10.442
15	150.000	10.3	6.70	71.788	1.023	1.908	10.527
16	150.000	7.7	4.96	64.609	1.024	2.030	10.632

Table 5.5 Evaluation of Project - Cash Flow Schedule (1/2) Alt. 3.2

Description	Unit	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Demand, peak power	MW	2.61	2.84	3.06	3.28	3.56	3.91	4.25	4.59	4.94	5.33	5.76	6.20	6.64	7.07
, energy	GWh	12.30	13.70	15.10	16.50	18.08	19.83	21.58	23.33	25.08	26.93	28.89	30.85	32.81	34.77
Annual load factor		.54	.55	.56	.57	.58	.58	.58	.58	.58	.58	.57	.57	.56	.56
Reserve capacity	MW	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.07	1.15	1.24	1.33	1.41
Required total capacity	MW	3.61	3.84	4.06	4.28	4.56	4.91	5.25	5.59	5.94	6.39	6.92	7.44	7.96	8.49
Diesel retirement	MW	.00	.00	.00	.00	-.60	-.68	.00	-.46	.00	-.20	-.60	.00	.00	.00
Diesel transferred	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Power addition, hydro	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	5.10	.00	.00	.00	.00
, diesel	MW	.00	1.60	.00	.00	.00	1.00	1.00	1.00	.00	.00	.00	.00	.00	.00
System capacity, installed	MW	3.60	5.20	5.20	5.20	4.60	4.92	5.92	6.46	6.46	11.36	10.76	10.76	10.76	10.76
, guaranteed	MW	3.60	5.20	5.20	5.20	4.60	4.92	5.92	6.46	6.46	8.74	8.39	8.69	8.84	8.99
(hydro, guaranteed)	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.48	2.73	3.02	3.18	3.33
(diesel, L.O.unit)	MW	3.60	5.20	5.20	5.20	4.60	4.92	5.92	6.46	6.46	6.26	5.66	5.66	5.66	5.66
(diesel, cold reserve)	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.31	1.42	1.03	.67	.31
Installation cost, hydro	m.M$	.00	.00	.00	.00	.73	8.23	12.73	17.44	10.75	.00	.00	.00	.00	.00
, diesel	m.M$	3.67	.00	.00	.76	3.06	3.06	2.30	.00	.00	.00	.00	.00	1.53	4.59
Power generation, hydro	GWh	.00	.00	.00	.00	.00	.00	.00	.00	.00	24.07	24.67	25.08	25.35	25.53
, diesel	GWh	12.30	13.70	15.10	16.50	18.08	19.83	21.58	23.33	25.08	2.86	4.22	5.77	7.46	9.24
Hydro OM cost	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.39	.39	.39	.39	.39
Diesel OM cost, fixed	m.M$	.28	.41	.41	.41	.36	.39	.47	.51	.51	.31	.33	.36	.39	.42
, variable	m.M$	.36	.40	.44	.48	.53	.58	.63	.68	.73	.08	.12	.17	.22	.27
, fuel(HSD)	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, fuel (LO)	m.M$	1.31	1.46	1.60	1.86	2.13	2.44	2.77	3.12	3.49	.43	.68	.99	1.36	1.78
Total cost	m.M$	5.62	2.26	2.45	3.51	6.81	14.70	18.89	21.75	15.48	1.22	1.53	1.91	3.89	7.45

Table 5.5 Evaluation of Project - Cash Flow Schedule (2/2) Alt. 3-2

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Demand, peak power	MW	7.53	8.00	8.47	8.94	9.41	9.95	10.55	11.15	11.76	12.36
, energy	GWh	36.91	39.23	41.54	43.86	46.18	48.82	51.76	54.72	57.67	60.61
Annual load factor		.56	.56	.56	.56	.56	.56	.56	.56	.56	.56
Reserve capacity	MW	1.51	1.60	1.69	1.79	1.88	1.99	2.11	2.23	2.35	2.47
Required total capacity	MW	9.03	9.60	10.16	10.73	11.30	11.94	12.66	13.39	14.11	14.83
Diesel retirement	MW	-1.05	.00	-1.60	.00	.00	.00	-1.00	-1.00	-1.00	.00
Diesel transferred	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Power addition, hydro	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	MW	2.00	.00	2.00	.00	1.00	.00	1.00	2.00	2.00	1.00
System capacity, installed	MW	11.71	11.71	12.11	12.11	13.11	13.11	13.11	14.11	15.11	16.11
, guaranteed	MW	10.09	10.27	10.90	11.20	12.23	12.61	12.73	14.11	15.11	16.11
(hydro, guaranteed)	MW	3.48	3.66	3.89	4.19	4.22	4.59	4.72	5.10	5.10	5.10
(diesel, L.O.unit)	MW	6.61	6.61	7.01	7.01	8.01	8.01	8.01	9.01	10.01	11.01
(diesel, cold reserve)	MW	.87	.60	.64	.25	1.00	.58	.04	.43	.71	.98
Installation cost, hydro	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	m.M$	1.53	4.59	.76	2.30	.76	3.83	6.12	5.36	2.30	.00
Power generation, hydro	GWh	25.74	25.97	26.15	26.29	26.41	26.50	26.57	26.60	26.60	26.60
, diesel	GWh	11.17	13.26	15.40	17.57	19.78	22.32	25.20	28.12	31.06	34.01
Hydro OM cost	m.M$	.39	.39	.39	.39	.39	.39	.39	.39	.39	.39
Diesel OM cost, fixed	m.M$	.45	.47	.50	.53	.55	.58	.63	.67	.73	.79
, variable	m.M$	.33	.39	.45	.51	.58	.65	.73	.82	.90	.99
, fuel(HSD)	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, fuel (LO)	m.M$	2.15	2.55	2.96	3.38	3.80	4.29	4.85	5.41	5.98	6.54
Total cost	m.M$	4.85	8.39	5.07	7.11	6.09	9.75	12.72	12.65	10.30	8.72

Table 5.6 Evaluation of Project - Cash Flow Schedule (1/2) All Diesel

Description	Unit	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Demand, peak power	MW	2.61	2.84	3.06	3.28	3.56	3.91	4.25	4.59	4.94	5.33	5.76	6.20	6.64	7.07
, energy	GWh	12.30	13.70	15.10	16.50	18.08	19.83	21.58	23.33	25.08	26.93	28.89	30.85	32.81	34.77
Annual load factor		.54	.55	.56	.57	.58	.58	.58	.58	.58	.58	.57	.57	.56	.56
Reserve capacity	MW	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.07	1.15	1.24	1.33	1.41
Required total capacity	MW	3.61	3.84	4.06	4.28	4.56	4.91	5.25	5.59	5.94	6.39	6.92	7.44	7.96	8.49
Diesel retirement	MW	.00	.00	.00	.00	-.60	-.68	.00	-.46	.00	-.20	-.60	.00	.00	.00
Diesel transferred	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Power addition, hydro	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	MW	.00	1.60	.00	.00	.00	1.00	1.00	1.00	.00	1.00	1.00	.00	1.00	.00
System capacity, installed	MW	3.60	5.20	5.20	5.20	4.60	4.92	5.92	6.46	6.46	7.26	7.66	7.66	8.66	8.66
, guaranteed	MW	3.60	5.20	5.20	5.20	4.60	4.92	5.92	6.46	6.46	7.26	7.66	7.66	8.66	8.66
(hydro, guaranteed)	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
(diesel, L.O.unit)	MW	3.60	5.20	5.20	5.20	4.60	4.92	5.92	6.46	6.46	7.26	7.66	7.66	8.66	8.66
(diesel, cold reserve)	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Installation cost, hydro	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	m.M$	3.67	.00	.00	.76	3.06	3.06	2.30	.76	3.06	2.30	.76	2.30	1.53	4.59
Power generation, hydro	GWh	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	GWh	12.30	13.70	15.10	16.50	18.08	19.83	21.58	23.33	25.08	26.93	28.89	30.85	32.81	34.77
Hydro OM cost	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Diesel OM cost, fixed	m.M$	.28	.41	.41	.41	.36	.39	.47	.51	.51	.57	.60	.60	.68	.68
, variable	m.M$	.36	.40	.44	.48	.53	.58	.63	.68	.73	.78	.84	.90	.95	1.01
, fuel(HSD)	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, fuel (LO)	m.M$	1.31	1.46	1.60	1.86	2.13	2.44	2.77	3.12	3.49	4.04	4.64	5.28	5.96	6.69
Total cost	m.M$	5.62	2.26	2.45	3.51	6.08	6.47	6.16	5.08	7.79	7.69	6.84	9.07	9.13	12.97

Table 5.6 Evaluation of Project - Cash Flow Schedule (2/2) All Diesel

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Demand, peak power	MW	7.53	8.00	8.47	8.94	9.41	9.95	10.55	11.15	11.76	12.36
, energy	GWh	36.91	39.23	41.54	43.86	46.18	48.82	51.76	54.72	57.67	60.61
Annual load factor		.56	.56	.56	.56	.56	.56	.56	.56	.56	.56
Reserve capacity	MW	1.51	1.60	1.69	1.79	1.88	1.99	2.11	2.23	2.35	2.47
Required total capacity	MW	9.03	9.60	10.16	10.73	11.30	11.94	12.66	13.39	14.11	14.83
Diesel retirement	MW	-1.05	.00	-1.60	.00	.00	.00	-1.00	-1.00	-1.00	.00
Diesel transferred	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Power addition, hydro	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	MW	2.00	.00	3.00	.00	2.00	.00	2.00	2.00	1.00	1.00
System capacity, installed	MW	9.61	9.61	11.01	11.01	13.01	13.01	14.01	15.01	15.01	16.01
, guaranteed	MW	9.61	9.61	11.01	11.01	13.01	13.01	14.01	15.01	15.01	16.01
(hydro, guaranteed)	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
(diesel, L.O.unit)	MW	9.61	9.61	11.01	11.01	13.01	13.01	14.01	15.01	15.01	16.01
(diesel, cold reserve)	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Installation cost, hydro	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	m.M$	2.29	6.89	1.53	4.59	1.53	6.12	5.36	3.06	2.98	2.75
Power generation, hydro	GWh	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	GWh	36.91	39.23	41.54	43.86	46.18	48.82	51.76	54.72	57.67	60.61
Hydro OM cost	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Diesel OM cost, fixed	m.M$	.76	.76	.87	.87	1.02	1.02	1.10	1.18	1.18	1.26
, variable	m.M$	1.07	1.14	1.21	1.28	1.34	1.42	1.51	1.59	1.68	1.76
, fuel(HSD)	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, fuel (LO)	m.M$	7.10	7.55	7.99	8.44	8.89	9.39	9.96	10.53	11.09	11.66
Total cost	m.M$	11.23	16.33	11.60	15.17	12.78	17.95	17.92	16.36	16.25	14.68

TABLE 7.1 CONSTRUCTION COST

(Unit : M$)

	Description	Foreign Currency	Local Currency	Total
1.	Preparatory Works			
1.1	Access Road	719,000	867,000	1,586,000
1.2	Field investigation	10,000	190,000	200,000
1.3	Camp facilities	108,000	432,000	540,000
	Sub-total	837,000	1,489,000	2,326,000
2.	Civil Works			
2.1	River diversion	474,357	436,713	911,070
2.2	Intake dam	2,077,632	1,817,018	3,894,650
2.3	Headrace tunnel	9,955,398	8,509,552	18,464,950
2.4	Surge tank	804,001	648,329	1,452,330
2.5	Penstock line	911,923	772,757	1,684,680
2.6	Powerhouse	1,190,307	922,363	2,112,670
2.7	Tailrace	185,050	146,970	332,020
2.8	Drainage channel	136,695	107,105	243,800
	Sub-total	15,735,363	13,360,807	29,096,170
3.	Metal Work	2,387,600	603,200	2,990,800
4.	Generating Equipment	4,782,000	761,000	5,543,000
5.	Transmission line and Substation	3,238,000	1,387,700	4,625,700
6.	Direct Construction Cost	26,979,963	17,601,707	44,581,670
7.	Engineering Services	4,458,170	0	4,458,170
8.	Administration Cost	0	2,229,080	2,229,080
9.	Physical Contingency	4,715,720	2,974,620	7,690,340
10.	Total Construction Cost	36,153,853	22,805,407	58,959,260

TABLE 7.2 DETAILED CONSTRUCTION COST (1/4)

(Unit:M$)

Description	Unit	Q'ty	Foreign currency Unit	Foreign currency Amount	Local currency Unit	Local currency Amount	Equivalent cost Unit	Equivalent cost Amount
1. PREPARATORY WORKS								
1.1 ACCESS ROAD								
New road	m	1,100	70.0	77,000	90.0	99,000	160	176,000
Improved road	m	19,000	29.0	551,000	36.0	684,000	65	1,235,000
New bridge	L.S.			91,000		84,000		175,000
1.2 FIELD INVESTIGATION	L.S.			10,000		190,000		200,000
1.3 CAMP FACILITIES	L.S.			108,000		432,000		540,000
Total of 1				837,000		1,489,000		2,326,000
2. CIVIL WORKS								
2.1 RIVER DIVERSION								
Earth embankment	cub.m	6,760	1.6	10,816	2.4	16,224	4	27,040
Concrete wall	cub.m	1,859	156.0	290,004	144.0	267,696	300	557,700
Reinforcement	ton	56	1,463.0	81,928	437.0	24,472	1,900	106,400
Gabion protection	sq.m	1,450	35.0	50,750	65.0	94,250	100	145,000
Removal of embankment	cub.m	6,310	2.9	18,299	2.1	13,251	5	31,550
Others	L.S.			22,560		20,820		43,380
Sub total of 2.1				474,357		436,713		911,070
2.2 INTAKE DAM								
Excavation in common	cub.m	34,530	2.9	100,137	2.1	72,513	5	172,650
" weathered rock	cub.m	31,420	5.4	169,668	5.6	175,952	11	345,620
" rock	cub.m	15,380	9.5	146,110	8.5	130,730	18	276,840
Concrete in dam body	cub.m	7,382	114.0	841,548	106.0	782,492	220	1,624,040
" pier and intake	cub.m	2,741	156.0	427,596	144.0	394,704	300	822,300
Reinforcement	ton	101	1,463.0	147,763	437.0	44,137	1,900	191,900
Drilling grout hole	m	928	40.0	37,120	50.0	46,400	90	83,520
Cement in grouting	ton	186	590.0	109,740	410.0	76,260	1,000	186,000
Backfill, random material	cub.m	3,700	1.6	5,920	2.4	8,880	4	14,800
Others	L.S.			92,030		84,950		176,980
Sub total of 2.2				2,077,632		1,817,018		3,894,650

TABLE 7.2 DETAILED CONSTRUCTION COST (2/4)

(Unit:M$)

Description	Unit	Q'ty	Foreign currency Unit	Foreign currency Amount	Local currency Unit	Local currency Amount	Equivalent cost Unit	Equivalent cost Amount
2.3 HEADRACE TUNNEL								
Excavation in tunnel	cub.m	35,670	160	5,707,200	120.0	4,280,400	280	9,987,600
Concrete	cub.m	13,334	192	2,560,128	178.0	2,373,452	370	4,933,580
Reinforcement	ton	100	1,463	146,300	437.0	43,700	1,900	190,000
Formwork, steel form	sq.m	35,735	28	1,000,580	38.0	1,357,930	66	2,358,510
Drilling grout hole	m	1,800	40	72,000	50.0	90,000	90	162,000
Cement in grouting	ton	180	590	106,200	410.0	73,800	1,000	180,000
Backfill grout	cub.m	910	192	174,720	128.0	116,480	320	291,200
Others	L.S.			188,270		173,790		362,060
Sub total of 2.3				9,955,398		8,509,552		18,464,950
2.4 SURGE TANK								
Excavation in common	cub.m	17,690	2.9	51,301	2.1	37,149	5	88,450
" in weathered rock	cub.m	9,380	5.4	50,652	5.6	52,528	11	103,180
" in rock	cub.m	1,970	9.5	18,715	8.5	16,745	18	35,460
" in shaft, tunnel	cub.m	1,360	240	326,400	180.0	244,800	420	571,200
Concrete, above ground	cub.m	109	156	17,004	144.0	15,696	300	32,700
underground	cub.m	792	307	243,144	283.0	224,136	590	467,280
Reinforcement	ton	35	1,463	51,205	437.0	15,295	1,900	66,500
Drilling grout holes	m	312	40	12,480	50.0	15,600	90	28,080
Cement in grouting	ton	31	590	18,290	410.0	12,710	1,000	31,000
Others	L.S.			14,810		13,670		28,480
Sub total of 2.4				804,001		648,329		1,452,330
2.5 PENSTOCK LINE								
Excavation in common	cub.m	23,480	2.9	68,092	2.1	49,308	5	117,400
" weathered rock	cub.m	12,710	5.4	68,634	5.6	71,176	11	139,810
" rock	cub.m	790	9.5	7,505	8.5	6,715	18	14,220
" tunnel	cub.m	710	160	113,600	120.0	85,200	280	198,800
Concrete in backfill	cub.m	447	132	59,004	88.0	39,336	220	98,340
in anchor block, etc.	cub.m	1,266	156	197,496	144.0	182,304	300	379,800
Reinforcement	ton	28	1,463	40,964	437.0	12,236	1,900	53,200
Backfill grout	cub.m	19	192	3,648	128.0	2,432	320	6,080
Shotcrete	sq.m	4,600	73	335,800	67.0	308,200	140	644,000
Others	L.S.			17,180		15,850		33,030
Sub total of 2.5				911,923		772,757		1,684,680

TABLE 7.2 DETAILED CONSTRUCTION COST (3/4)

(Unit:M$)

Description	Unit	Q'ty	Foreign currency Unit	Foreign currency Amount	Local currency Unit	Local currency Amount	Equivalent cost Unit	Equivalent cost Amount
2.6 POWERHOUSE								
Excavation in common	cub.m	5,940	2.9	17,226	2.1	12,474	5	29,700
" weathered rock	cub.m	4,560	5.4	24,624	5.6	25,536	11	50,160
" rock	cub.m	640	9.5	6,080	8.5	5,440	18	11,520
Concrete above generator floor	cub.m	661	187	123,607	173.0	114,353	360	237,960
below generator floor	cub.m	1,282	156	199,992	144.0	184,608	300	384,600
in switchyard	cub.m	451	187	84,337	173.0	78,023	360	162,360
Reinforcement	ton	85	1,463	124,355	437.0	37,145	1,900	161,500
Superstructure	cub.m	3,021	168	507,528	122.0	368,562	290	876,090
Backfill, random material	cub.m	1,680	1.6	2,688	2.4	4,032	4	6,720
Others	L.S.			99,870		92,190		192,060
Sub total of 2.6				1,190,307		922,363		2,112,670
2.7 TAILRACE								
Excavation in common	cub.m	3,580	2.9	10,382	2.1	7,518	5	17,900
" weathered rock	cub.m	2,410	5.4	13,014	5.6	13,496	11	26,510
" rock	cub.m	120	9.5	1,140	8.5	1,020	18	2,160
Concrete	cub.m	633	156	98,748	144.0	91,152	300	189,900
Reinforcement	ton	32	1,463	46,816	437.0	13,984	1,900	60,800
Backfill, random material	cub.m	3,650	1.6	5,840	2.4	8,760	4	14,600
Rock riprap	cub.m	440	13	5,720	18.0	7,920	31	13,640
Others	L.S.			3,390		3,120		6,510
Sub total of 2.7				185,050		146,970		332,020
2.8 DRAINAGE CHANNEL								
Excavation in common	cub.m	2,964	2.9	8,596	2.1	6,224	5	14,820
Concrete	cub.m	627	156	97,812	144.0	90,288	300	188,100
Reinforcement	ton	19	1,463	27,797	437.0	8,303	1,900	36,100
Others	L.S.			2,490		2,290		4,780
Sub total of 2.8				136,695		107,105		243,800
Total of 2				15,735,363		13,360,807		29,096,170

TABLE 7.2 DETAILED CONSTRUCTION COST (4/4)

(Unit:M$)

Description	Unit	Q'ty	Foreign currency Unit	Foreign currency Amount	Local currency Unit	Local currency Amount	Equivalent cost Unit	Equivalent cost Amount
3. METAL WORK								
Spillway gate	ton	80	9,600	768,000	2,400	192,000	12,000	960,000
Sand flushing gate	ton	46	9,600	441,600	2,400	110,400	12,000	552,000
Intake gate	ton	5	9,600	48,000	2,400	12,000	12,000	60,000
Draft gate	ton	6	9,600	57,600	2,400	14,400	12,000	72,000
Intake trashrack	ton	20	4,600	92,000	1,100	22,000	5,700	114,000
Raking equipment	ton	12	16,000	192,000	4,000	48,000	20,000	240,000
Steel penstock with support	ton	146	5,400	788,400	1,400	204,400	6,800	992,800
Total of 3				2,387,600		603,200		2,990,800
4. GENERATING EQUIPMENT	L.S.			4,782,000		761,000		5,543,000
5. TRANSMISSION LINE AND SUBSTATION								
Transmission line	L.S.			2,836,480		1,215,620		4,052,100
Substation	L.S.			401,520		172,080		573,600
Total of 5				3,238,000		1,387,700		4,625,700
6. LAND COMPENSATION	L.S.							
7. DIRECT CONSTRUCTION COST				26,979,963		17,601,707		44,581,670
8. ENGINEERING SERVICES				4,458,170				4,458,170
9. ADMINISTRATION COST						2,229,080		2,229,080
10. PHYSICAL CONTINGENCY				4,715,720		2,974,620		7,690,340
11. TOTAL CONSTRUCTION COST				36,153,853		22,805,407		58,959,260

Table 7.3 Disbursement Schedule (1/4)

(Unit:M$)

Description	TOTAL F.C.	TOTAL L.C.	1991 F.C.	1991 L.C.	1992 F.C.	1992 L.C.	1993 F.C.	1993 L.C.	1994 F.C.	1994 L.C.	1995 F.C.	1995 L.C.
1. PREPARATORY WORKS												
1.1 ACCESS ROAD												
New road	77,000	99,000	7,700	9,900	69,300	89,100						
Improved road	551,000	684,000	275,500	342,000	275,500	342,000						
New bridge	91,000	84,000			91,000	84,000						
1.2 FIELD INVESTIGATION	10,000	190,000	10,000	190,000								
1.3 CAMP FACILITIES	108,000	432,000			108,000	432,000						
Total of 1	837,000	1,489,000	293,200	541,900	543,800	947,100						
2. CIVIL WORKS												
2.1 RIVER DIVERSION												
Earth embankment	10,816	16,224			5,408	8,112	5,408	8,112				
Concrete wall	290,004	267,696			232,003	214,157	58,001	53,539				
Reinforcement	81,928	24,472			65,542	19,578	16,386	4,894				
Gabion protection	50,750	94,250			25,375	47,125	25,375	47,125				
Removal of embankment	18,299	13,251			1,830	1,325	8,235	5,963	8,235	5,963		
Others	22,560	20,820			13,536	12,492	6,768	6,246	2,256	2,082		
Sub total of 2.1	474,357	436,713			343,695	302,789	120,172	125,880	10,491	8,045		
2.2 INTAKE DAM												
Excavation in common	100,137	72,513			60,082	43,508	40,055	29,005				
" weathered rock	169,668	175,952			101,801	105,571	67,867	70,381				
" rock	146,110	130,730			87,666	78,438	58,444	52,292				
Concrete in dam body	841,548	782,492			84,155	78,249	504,929	469,495	252,464	234,748		
" pier and intake	427,596	394,704			42,760	39,470	256,558	236,822	128,279	118,411		
Reinforcement	147,763	44,137			14,776	4,414	88,658	26,482	44,329	13,241		
Drilling grout hole	37,120	46,400			3,712	4,640	22,272	27,840	11,136	13,920		
Cement in grouting	109,740	76,260			10,974	7,626	65,844	45,756	32,922	22,878		
Backfill, random material	5,920	8,880			592	888	2,664	3,996	2,664	3,996		
Others	92,030	84,950			36,812	33,980	46,015	42,475	9,203	8,495		
Sub total of 2.2	2,077,632	1,817,018			443,330	396,784	1,153,305	1,004,545	480,997	415,689		

Table 7.3 Disbursement Schedule (2/4)

(Unit:US$)

Description	TOTAL F.C.	TOTAL L.C.	1991 F.C.	1991 L.C.	1992 F.C.	1992 L.C.	1993 F.C.	1993 L.C.	1994 F.C.	1994 L.C.	1995 F.C.	1995 L.C.
2.3 HEADRACE TUNNEL												
Excavation in tunnel	5,707,200	4,280,400			2,282,880	1,712,160	2,853,600	2,140,200	570,720	428,040		
Concrete	2,560,128	2,373,452			256,013	237,345			1,280,064	1,186,726	1,024,051	949,381
Reinforcement	146,300	43,700			14,630	4,370			73,150	21,850	58,520	17,480
Formwork, steel form	1,000,580	1,357,930			100,058	135,793			500,290	678,965	400,232	543,172
Drilling grout hole	72,000	90,000			7,200	9,000					64,800	81,000
Cement in grouting	106,200	73,800			10,620	7,380					95,580	66,420
Backfill grout	174,720	116,480			17,472	11,648					157,248	104,832
Others	188,270	173,790			37,654	34,758	56,481	52,137	56,481	52,137	37,654	34,758
Sub total of 2.3	9,955,398	8,509,552			2,726,527	2,152,454	-2,910,081	2,192,337	2,480,705	2,367,718	1,838,085	1,797,043
2.4 SURGE TANK												
Excavation in common	51,301	37,149			5,130	3,715	46,171	33,434				
" in weathered rock	50,652	52,528			5,065	5,253	45,587	47,275				
" in rock	18,715	16,745			1,872	1,675	16,844	15,071				
" in shaft, tunnel	326,400	244,800			32,640	24,480	293,760	220,320				
Concrete, above ground	17,004	15,696			1,700	1,570	15,304	14,126				
underground	243,144	224,136			24,314	22,414	218,830	201,722				
Reinforcement	51,205	15,295			5,121	1,530	46,085	13,766				
Drilling grout holes	12,480	15,600			1,248	1,560	11,232	14,040				
Cement in grouting	18,290	12,710			1,829	1,271	16,461	11,439				
Others	14,810	13,670			1,481	1,367	13,329	12,303				
Sub total of 2.4	804,001	648,329			80,400	64,833	723,601	583,496				
2.5 PENSTOCK LINE												
Excavation in common	68,092	49,308			68,092	49,308						
" weathered rock	68,634	71,176			68,634	71,176						
" rock	7,505	6,715			7,505	6,715						
" tunnel	113,600	85,200			113,600	85,200						
Concrete in backfill	59,004	39,336			5,900	3,934			53,104	35,402		
in anchor block, etc.	197,496	182,304			19,750	18,230	177,746	164,074				
Reinforcement	40,964	12,236			4,096	1,224	36,868	11,012				
Backfill grout	3,648	2,432			365	243			3,283	2,189		
Shotcrete	335,800	308,200			33,580	30,820	302,220	277,380				
Others	17,180	15,850			13,744	12,680	3,436	3,170				
Sub total of 2.5	911,923	772,757			335,266	279,530	520,270	455,636	56,387	37,591		

Table 7.3 Disbursement Schedule (3/4)

(Unit:MS)

Description	TOTAL F.C.	TOTAL L.C.	1991 F.C.	1991 L.C.	1992 F.C.	1992 L.C.	1993 F.C.	1993 L.C.	1994 F.C.	1994 L.C.	1995 F.C.	1995 L.C.
2.6 POWERHOUSE												
Excavation in common	17,226	12,474			1,723	1,247	15,503	11,227				
" weathered rock	24,624	25,536			2,462	2,554	22,162	22,982				
" rock	6,080	5,440			608	544	5,472	4,896				
Concrete above generator floor	123,607	114,353			12,361	11,435			98,886	91,482	12,361	11,435
below generator floor	199,992	184,608			19,999	18,461			159,994	147,686	19,999	18,461
in switchyard	84,337	78,023			8,434	7,802			75,903	70,221		
Reinforcement	124,355	37,145			12,436	3,715			105,702	31,573	6,218	1,857
Superstructure	507,528	368,562			50,753	36,856			228,388	165,853	228,388	165,853
Backfill, random material	2,688	4,032			269	403			2,419	3,629		
Others	99,870	92,190			9,987	9,219	34,955	32,266	44,942	41,486	9,987	9,219
Sub total of 2.6	1,190,307	922,363			119,031	92,236	78,092	71,372	716,233	551,930	276,952	206,825
2.7 TAILRACE												
Excavation in common	10,382	7,518			1,038	752			9,344	6,766		
" weathered rock	13,014	13,496			1,301	1,350			11,713	12,146		
" rock	1,140	1,020			114	102			1,026	918		
Concrete	98,748	91,152			9,875	9,115			88,873	82,037		
Reinforcement	46,816	13,984			4,682	1,398			42,134	12,586		
Backfill, random material	5,840	8,760			584	876			5,256	7,884		
Rock riprap	5,720	7,920			572	792			5,148	7,128		
Others	3,390	3,120			339	312			3,051	2,808		
Sub total of 2.7	185,050	146,970			18,505	14,697			166,545	132,273		
2.8 DRAINAGE CHANNEL												
Excavation in common	8,596	6,224			860	622	7,736	5,602				
Concrete	97,812	90,288			9,781	9,029	88,031	81,259				
Reinforcement	27,797	8,303			2,780	830	25,017	7,473				
Others	2,490	2,290			249	229	2,241	2,061				
Sub total of 2.8	136,695	107,105			13,670	10,711	123,026	96,395				
Total of 2	15,735,363	13,360,807			4,080,423	3,314,034	5,628,546	4,529,659	3,911,357	3,513,246	2,115,037	2,003,868

Table 7.3 Disbursement Schedule (4/4)

(Unit:M$)

Description	TOTAL F.C.	TOTAL L.C.	1991 F.C.	1991 L.C.	1992 F.C.	1992 L.C.	1993 F.C.	1993 L.C.	1994 F.C.	1994 L.C.	1995 F.C.	1995 L.C.
3. METAL WORK												
Spillway gate	768,000	192,000					76,800	19,200	691,200	172,800		
Sand flushing gate	441,600	110,400					441,600	110,400				
Intake gate	48,000	12,000					48,000	12,000				
Draft gate	57,600	14,400					5,760	1,440			51,840	12,960
Intake trashrack	92,000	22,000					92,000	22,000				
Raking equipment	192,000	48,000					192,000	48,000				
Steel penstock with support	788,400	204,400							788,400	204,400		
Total of 3	2,387,600	603,200					856,160	213,040	1,479,600	377,200	51,840	12,960
4. GENERATING EQUIPMENT	4,782,000	761,000							1,912,800	304,400	2,869,200	456,600
5. TRANSMISSION LINE AND SUBSTATION												
Transmission line	2,836,480	1,215,620							2,269,184	972,496	567,296	243,124
Substation	401,520	172,080							321,216	137,664	80,304	34,416
Total of 5	3,238,000	1,387,700							2,590,400	1,110,160	647,600	277,540
6. LAND COMPENSATION	0	0										
7. DIRECT CONSTRUCTION COST	26,979,963	17,601,707	293,200	541,900	4,624,223	4,261,134	6,484,706	4,742,699	9,894,157	5,305,006	5,683,677	2,750,968
8. ENGINEERING SERVICES	4,458,170				980,797		1,159,124		1,159,124		1,159,124	
9. ADMINISTRATION COST		2,229,080		44,582		512,688		557,270		557,270		557,270
10. PHYSICAL CONTINGENCY	4,715,720	2,974,620	43,980	87,970	840,750	716,070	1,146,570	795,000	1,657,990	879,340	1,026,420	496,240
11. TOTAL CONSTRUCTION COST	36,153,853	22,805,407	337,180	674,452	6,445,770	5,489,892	8,790,400	6,094,969	12,711,271	6,741,616	7,869,222	3,804,478