Growth Rate and Energy Demand of Public Lighting in Kapit

Year	1986	1990	2000	2010
Growth rate	-	5%	4%	3%
Energy Demand (MWh)	64	78	115	155

4.4.5 Results of examinations

This subsection describes the results of examinations on the power demand forecast made 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 power demands are also projected considering the uncertainties involved in the assumed values.

(1) Results of demand forecast (Normal)

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

Results of Demand Forecast (Normal)

Year	Energy Consumption (MWh)	Energy Generation (MWh)	Maximum Power Demand (kW)	Annual Load Factor (%)
1984	3,689	4,209	948	50.7
1985	4,611	5,038	1,184	48.6
1986	5,045	5,528	1,358	46.5
1987	5,410	6,150	1,430	49.0
1988	5,760	6,545	1,490	50.0
1989	6,130	6,970	1,590	"
1990	6,520	7,410	1,690	"
1995	8,710	9,900	2,260	"
2000	11,260	12,800	2,810	52.0
2005	13,840	15,730	3,450	"
2010	17,080	19,410	4,260	"

System loss and station use are counted in estimating the required energy generation. A value of 12%, 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 for the electrification ratio in domestic sector and growth rate of power consumption 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	10	10	10
2000	12	15	11
2010	14	20	12

(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	10	12	8
2000	8	10	7
2010	6	8	6

Power demand in the high and low cases are projected applying the procedure used in the normal case. Figs. 4.12 and 4.13 show the summary of the projection giving 23% and 32% higher power consumption in 2000 and 2005 respectively in the comparison of high and normal cases, whilst 13% and 16% lower power consumption 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 is a previous study for the power demand forecast of the proposed load centre, Kapit; that is, the projection by SESCO in 1986. The comparison between the previous and present studies was made on the power requirement and maximum demand.

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	4.9	6.6	3.4	5.6
1990 - 2000	5.0	5.6	5.0	5.2
2000 - 2010	5.0	4.3	5.0	4.2

Moderate growth in the power demand is projected for the Kapit area, even taking into account the implementation of rural electrification.

4.5 Power Balance Study

According to the power demand forecast discussed in the previous section, power demand in the Kapit system is expected to increase from 1.4 MW in 1986 to 1.7 MW in 1990, 2.3 MW in 1995, 2.8 MW in 2000 and 4.3 MW in 2010, whilst 5.5 GWh/yr in 1986 to 7.4 Gwh/yr in 1990, 9.9 GWh/yr in 1995, 12.8 GWh/yr in 2000 and d19.4 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 required will reach 2.3 MW in 1990, 2.9 MW in 1995, 3.4 MW in 2000 and 5.1 MW in 2010 on the sent-out basis.

The present power supply capacity in the Kapit system stays at 2.4 MW and will increase by 2.7 MW in 1991. An addition of new plants will be required for meeting the growing demand after 1994. The Mukoh hydropower project is a promising scheme to be added to the Kapit 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 Mukoh project 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 Mukoh site itself, but also the system requirement. Namely, a power balance on the load curve or estimate of saleable energy of Mukoh 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 Mukoh 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 Mukoh. 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 Mukoh 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. In this case the runoff data of 1975 is applied.

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 : 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 daily load duration curve applied to the investing horizon of the Kapit 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	: 49%
1988 to 1999	: 50%
2000 to 2010	: 52%

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 Kapit 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 1.35 MW in 1986 to 4.26 MW in 2010 in the Kapit 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 Mukoh 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 Mukoh, if guaranteed power of it is far big compared with the demand growth in the Kapit power system.

The lead time required prior to construction is assumed to be five years from the beginning of year 1987(refer to Figure 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	: 18 months (June to 1989 to November 1990)
Tendering and contract for construction	: 13 months (December 1990 to December 1991).

The construction of Mukoh is assumed to start in 1992 following the pre-activities of construction and to complete with the construction period of 3 years. Thus, in-service year of Mukoh is assumed to be at the beginning of 1995.

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 12.0%, 53.6% and 34.3% in the first stage.

In searching the optimal development scale of Mukoh, the installation timing of its first stage is fixed in 1995. The optimal installation timing of Mukoh 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%, 12% and 14% besides the prime test discount rate of 10%,
- Low and high demand forecasts,
- 10% capital cost up for Mukoh,
- 10% fuel cost up and down for diesel plant, and
- 1987 constant fuel cost for diesel plant.

5.1.3 Development alternatives

The Mukoh project was originally conceived as a run-of-river project using head harnessing several rapids. The reservoir created by the proposed dam has been found to have an impounding capacity (a reservoir storage curve is referred to Figure 5.2) necessary for the seasonal regulation of flow in the survey of this investigation stage. Thus, the project is contemplated to develop as the reservoir type besides the run-of-river type with a daily regulating pondage.

Three alternatives are conceived for the hydropower development of Mukoh 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 hydropower generation with a dam and to have a powerhouse just behind the dam

Alt-2 : A plan to utilize head of some 13 m created by rapids with a 1,120 m long headrace tunnel besides head created by the dam

Alt-3 : A plan to make the headrace longer (1,740 m) and to increase available head.

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

Unit : m

Alternatives	Alt-1	Alt-2	Alt-3
Full supply level	89 to 110	89 to 110	89 to 110
Minimum operating level	87	87	87
Tailrace level	73	60	56
Headrace tunnel length	0	1,120	1,740
Penstock length	50	50	70

Minimum operating level, MOL, is set at El. 87 m with the operation of flush gates.

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 II). Figure 5.4 shows the relationship between the required active storage and firm discharge at the project site of the Mukoh 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 Mukoh.

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, head 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 rate 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 per cent of direct cost and 15 per cent of sum of direct and engineering services and administration costs, respectively.

5.2 Optimum Development Plan and Installation Timing

The study results to search the optimal developemnt scale of Mukoh are given in Table 5.4 and Figure 5.5. Maximum net benefit of M$1.7 million and economic internal rate of return, EIRR, of 11.3% are obtained in case of giving plant discharge of 18.8 m^3/sec and setting full supply level at El. 90.0 m in Alt-1. Thus, this development is proposed as the optimal scale of Mukoh. The development features of it are:

Alternative plan	:	Alt-1
Full supply level	:	90.0m
Minimum operating level	:	87.0m
Tailrace water level	:	73.0m

Type of dam	:	Concrete gravity
Penstock length	:	50 m
Plant discharge	:	18.8 m^3/sec
Firm discharge	:	6.3 m^3/sec
Peaking operation hours for firm discharge	:	8 hours
Rated net head	:	14.98 m
Maximum output	:	2.32 MW
Annual energy generation	:	13.0 GWh
Construction cost	:	M$27.5 million
Net benefit (capitalized)	:	M$1.7 million
EIRR	:	11.3%.

Cash flow diagrams for the optimal development scale and all diesel are given in Table 5.5 and 5.6, respectively. The construction cost required for the optimal development case is M$27.5 million as referred in subsequent Table 7.1.

Figures 5.6 and 5.7 show the optimal installation sequence given by the combination of Mukoh and diesel plant so that power and energy requirements of the Kapit system can be met in the time period of 1987 to 2010. Two units of turbine and generator are simultaneously installed in 1995 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 Mukoh was made by shifting the installation year for the scale determined to be optimal; that is, 2.32 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,%
1995	1.74	11.3
1996	2.13	11.9
1997	2.22	12.1
1998	2.17	12.3

The installation of Mukoh in 1997 gave the maximum net benefit of M$ 2.22 million. The variation of net benefit is, however, insensitive for the shift of installation year.

The reasons why the maximum net benefit for the Mukoh project was obtained in the installation of 1997 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 optimization study involve uncertainties and that Mukoh 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 sufficed.

The verification of earliest installation for the Mukoh 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 financed by SESCO itself and that foreign costs are funded 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$)
1995	2008	6,866,370
1996	2009	5,891,348
1997	2011	4,809,960
1998	2013	3,617,710

The accumulation of balance, revenue minus cost, for the maturity peroid is highest in case that the Mukoh project is installed in 1995. 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 Mukoh is assumed to be at the beginning of 1995 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 Mukoh project is also assessed in case that some pre-activities are accelerated by carrying out in parallel; that is, installation year of 1993 and 1994. In case that Mukoh is installed in 1993 and 1994, the EIRR is revealed to be 10.5% (net benefit of M$0.76) and 10.9% (net benefit of M$1.35) respectively. Thus, Mukoh 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 1995, earliest installation year. Following are the tested cases:

- Variation of discount rates; 4%, 5%, 8%, 12% and 14% besides the prime test discount rate of 10%,

- High and low demand forecasts,

- 10% capital cost up for Mukoh,

- 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	27.6
5	19.6
8	6.0
10	1.7
12	-0.7
14	-2.0

The net benefit of Mukoh increases from M$1.7 million in the discount rate of 10% to M$27.6 million in 4%, M$19.6 million in 5% and M$6.0 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	3.0	12.4
Medium	1.7	11.3
Low	0.9	10.7

Mukoh shows high viability for the high demand with EIRR of more than 12%. On the other hand, Mukoh keeps EIRR of 10.7% for the low demand.

In case that the capital cost of Mukoh is increased by 10%, the EIRR is reckoned to be 10.4%. On the other hand, in case of 10% fuel cost up for diesel plant, the EIRR is improved at 12.2%. On the contrary, even if fuel cost for diesel plant is down by 10%, the EIRR is maintained at 10.5%. Mukoh gains the EIRR of 7.5%, 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 Mukoh is a promising hydropower project to be developed.

CHAPTER 6 BASIC DESIGN

6.1 General

This chapter describes the preliminary design of major structures on the proposed Mukoh hydroelectric project. 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 5:

- Full supply level of intake pond : El. 90.0 m
- Minimum operation level of intake pond : El. 87.0 m
- Firm discharge : 6.3 m^3/sec
- Plant peak discharge : 18.8 m^3/s
- Tailwater level at plant peak discharge : El. 73.0 m
- Gross head at plant peak discharge : 17.0 m
- Installed power capacity (2 units) : 2.32 MW.

The project involves the construction of a 23 m high gated intake dam on the Mukoh River in which an intake structure is incorporated, a 44 m long penstock line, a power plant with 2.32 MW installed capacity, for which the number of units was selected to be two considering system reliability and maintenance of turbines and generators. The project also includes the construction of a 35 km long 33 kV transmission line to deliver power to the Kapit substation and a 7 km long access road between the existing road and the site.

6.2 Design of Main Structures

6.2.1 Site conditions

The dam site is located about 120 m upstream from a gorge, where the river width is about 40 m and the elevation of riverbed is about El.72.0 m. At the site, the slope of the original ground is about 40 on the left bank and 30 to 50 on the right bank. There exist two rapids; one about 40 m upstream and the other are 60 m downstream from the dam axis.

The foundation of main structures such as the intake dam, powerhouse and so on consists of shale intercalated with thin layers of sandstone which is covered with an overburden about 10 m deep on the left bank and 5 m deep on the right bank. This geological condition is considered to be similar in the section between the gorge and the rapid upstream of the dam. The shale rocks for foundation is in good condition as slightly weathered to fresh. Consequently there will be no serious problem in the construction from viewpoint of geology.

6.2.2 Intake dam

The intake dam has the function to store water of the Mukoh River for daily power generation. The location of the intake dam was determined to afford the gently-sloped area of the left bank for the power station. The spillway section is provided almost in the natural river course so that the rapid flow from the spillway will not cause any damage such as slope failure of the river bank. Curtain and consolidation groutings are taken into account for foundation treatment.

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 the following concepts:

(a) All the structural foundations are hard and watertight,

(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 of 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, and

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

Intake dam

FSL. 90.0m was determined on the basis of the study results of the pond storage capacity of 360,000 m^3 necessary for peak operation of 2.32 MW for 8 hours discussed in Section 5.2.

Gated weir was adopted for the spillway, since it gives an economical structure of the intake dam as compared with no-gated weir.

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

a) Gate top elevation	:	FSL + 0.5 m = El. 90.5 m
b) Dam crest elevation	:	FSL + 2.0 m = El. 92.0 m
c) Spillway gates	:	12.5m wide x 8.5m high x 2 Nos.

The above dam crest elevation has a freeboard of about 1.4 m above FWL. 90.601, when the design flood of 1,135 m^3/sec with a 200-year recurrence interval (refer to Appendix III of Volume II) is released through the spillway.

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 endangar 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 g 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 be kept as low as possible by periodical flushing of the silt through the orifice of the dam.

The floor level of the intake is set at El. 79.0 m to have enough depth of water in avoiding air entrainment into the penstock, when water level drops at MOL 87.0 m.

River diversion

The first stage river diversion is made by encircling the left side work area with embankment of cofferdam. The remaining right side section of the river is used as the diversion channel.

The second stage river diversion is made through the orifice opening of the dam constructed in the first stage by encircling the right side work area with concrete and embankment cofferdams. The partition wall on the apron is used as the part of second stage cofferdam.

The river diverison was planned against the design flood of 273 m^3/s with a 2-year recurrence interval (refer to Appendix III of Volume II) taking into consideration the small scale concrete structure.

6.2.3 Penstock

The penstock is 44 m in total length between the intake and the turbine centre. A distance of 9 m is provided between the centre line of penstock and the left side guide wall of spillway. Concrete encasement is provided to support and protect the penstock which feeds two units of turbines with total discharge of 18.8 m^3/s.

The diameter of penstock was determined by an economic comparison in which the following components were taken into account:

a) construction cost,
b) energy loss value due to head loss in the penstock line,

and

c) operation and maintenance cost.

As the result of comparison, the economic diameter was determined to be 3.0 m for the design discharge of 18.8 m^3/s.

The plate thinkness of the penstock is governed by the required minimum plate thickness, which is not the function of internal water pressure, but the restriction to avoid deformation by erection and conveyence, since the maximum water pressure including the pressure rise is as small as 26 m at the turbine centre. SM class is used for the penstock, and the plate thickness is 10 mm for the penstock of 3.0 m in diameter.

6.2.4 Power station

The power station is located on the left bank immediately downstream from the intake dam. The switchyard is provided on the backfilled area behind the power house. The powerhouse accomodating two units of generating equipment of 2.32 MW in total capacity is a semi-underground type of reinforced concrete structure. After construction of the concrete structure, the generating equipment will be installed by monorail hoists. The tailrace channel is a box culvert with a partition wall at the centre and embedded underground.

The general layout of the power station is shown in Fig. 6.1, while further detail of the powerhouse is depicted in Fig. 6.2.

6.3 Design of Metal Work

6.3.1 Gate and trashrack

A fixed-roller type is basically selected for the gates of the project in this feasibility study, becuase 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 and trashrack and valve:

<u>Spillway gate</u>

Type	:	fixed-roller gates
Set numbers	:	2 sets
Dimension	:	8.5 m high x 12.5 m wide
Hoist type	:	stationary type wire rope hoist

<u>Sand flush gate</u>

Type	:	fixed-roller gate
Set number	:	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	:	3.0 m high x 3.0 m wide
Hoist type	:	stationary type wire rope hoist

Draft tube gate

Type	:	slide gate
Set number	:	1 set
Dimension	:	2.1 m high x 2.5 m wide
Hoist type	:	travelling type monorail hoist

Trashrack

Type	:	fixed type
Set number	:	1 set
Dimension	:	12 m high x 6 m wide
Bar pitch	:	50 mm.

Inlet valve

Type	:	butterfly valve
Set number	:	2 sets
Diameter	:	1.75 m
Hoist type	:	hydraulic cylinder type hoist

6.3.2 Penstock

One (1) complete lane of the penstock will be provided from the intake to the turbine centre of two (2) turbine units. The penstock with 44.0 m long in total consists of shell proper, reducing pipes, bifurcation, bend pipes, manholes, seepage and thrust collars and so on.

The principal features are as follows:

Type	:	steel penstock with concrete encasement including Wai (Y) type bifurcation
Quantity	:	One (1) lane
Diameter	:	3.0 m (2.1 m to 1.75 m after bifurcation)
Length	:	44.0 m.

6.4 Design of Generating Equipment

6.4.1 Generating equipment and its auxiliaries

The basic design conditions of generating equipment are summarized below:

(1) Full supply water level : El. 90.00 m
(2) Minimum operating water level : El. 87.00 m

(3) Plant peak discharge : 18.8 m^3/sec
(4) Tailrace water level at plant peak discharge : El. 73.00 m
(5) Rated head : 14.98 m

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

(1) Water turbine

In general, a propeller type turbine, which is classified into two types such as Kaplan and Tubular types, will meet the given conditions. In addition, the Tubular type turbine is also divided into two types; i.e. S-type Tubular and Bulb type. Judging from the cost of equipment as well as easiness of maintenance, following were selected:

(a) Type : Horizontal shaft, S-type Tubular
(b) Number of units : 2
(c) Rated output : 1,210 kW
(d) Rated Speed : 429 rpm

(2) Generator

(a) Type : Horizontal shaft, revolving-field type
(b) Number of units : 2
(c) Rated output : 1,160 kW
(d) Rated capacity : 1,500 kVA
(e) Rated voltage : 6.6 kV

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

- Three (3) sets of 10-tone monorail hoist, and
- One (1) set of diesel engine generator for emergency power supply to the auxiliary equipment and the gates in the dam.

6.4.2 Outdoor switchyard

One (1) set of 3,000 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 arrester will also be provided.

6.5 Transmission Line and Substation

6.5.1 Transmission line

The power system in Kapit is at present isolated from other systems. Power generated by diesel plant is supplied with a 11 kV distribution line, which extends only in the urban area of Kapit.

A 33 kV transmission line will newly be constructed between the Mukoh power station and the substation newly constructed near Rumah Tajok (name of longhouse) located 5 km south from Kapit as shown in Fig 6.3. A diagram of power system is depicted in Fig 6.4. The transmision line runs 35 km distance, out of which a first 15 km from the Mukoh power station passes along the Mukoh River and goes across the Janan River. A remaining 20 km from R. Nyelang to the substation has a route in the plains extended at the foot of north of Bt. Goram. The highest point of the transmission line will be El. 600 m.

Timber poles called Belian (iron wood) are considered to be used for supporting the transmission line of 33 kV. 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, and aerial cable will be adopted considering the route of transmission line passing through the forest areas.

A voltage of 33 kV is selected to transmit power of 2,320 kW for the distance of 35 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 the longhouses nearby from the transmission line.

6.5.2 Substation

A site located 5 km south from Kapit is selected as the place to construct a new substation.

A new 11 kV distribution line will be extended to the substation for receiving the power generated at the Mukoh power station.

The substation will be equipped with the following:

- One (1) 3,000 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 feeder, and
- One (1) lot of control boards including DC supply.

An equipment layout of the substation is shown in Fig. 6.5.

CHAPTER 7 CONSTRUCTION PLAN AND COST ESTIMATE

7.1 Construction Plan and Schedule

7.1.1 General

All the works of the Mukoh project will be executed by the contractors selected through an international competitive tender including prequalification except for the engineering services. The following are modes of construction for the project works;

- Civil works (River diversion, dam and intake, penstock line, power station including building works, tailrace, drainage channel, 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 seven years. First four years are required for the arrangement of construction finance, the selection of engineering consultant, the detailed engineering services and the tendering. Latter three years are required for the construction work of the project. The arrangement of construction finance shall be made by the 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) Financial 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 : 15 months from September 1989 to November 1990

(d) Pre-qualification for tender and contract : 3 months from December 1990 to February 1991

(e) Tender and contract : 9 months from March 1991 to December 1991

(f) Main construction works : Commencement in January 1992 to completion in December 1994, within 36 months

(g) Commissioning of commercial operation : Beginning of January 1995

The overall construction schedule of the project is shown in Figs 7.1 and 7.2. It is noted that the compensation to be claimed for the construction of the project will be settled by SESCO in advance of the commencement of construction.

2. Outline of work execution by year

(a) First year of construction (January to December 1992)

Preparatory works such as construction of access roads and camp facilities, installation of a diesel generator and so on are to be carried out in a period of approximately 6 months.

Immediately after preparation works, excavation for the right bank of dam is to start in order to enlarge the river bed for diversion. Upper part of the left bank of the dam is to be excavated at the same time.

(b) Second year of construction (Janaury to December 1993)

After enlarging the river bed, coffer dams and concrete walls for river diversion are to be constructed. Excavation for the left bank of dam and the base of other structures such as penstock lines, powerhouse and tailrace is to be completed in the first 9 months. Concrete of the left side of the dam and other structures is to be placed in succession. Steel penstock, an intake gate and a sand flush gate are to be installed following concrete placing.

After completing the left side of the dam, new coffer dams for river diversion are constructed to enclose the right side of the dam and to divert river flow to left side of the river through the sand flush orifice.

Excavation for the right bank of dam is to be completed by 11th month of the second year (November, 1993). Concrete placement for the right side of the dam is to start in succession.

Works on generating equipment, transmission line and substation are to start from 11th month of the second year (November, 1993).

(c) Third year of construction (January 1994 to December 1994)

The right side of dam is to be completed by 5th month of the third year (May, 1994). Coffer dams are to be removed in succession.

Generating equipment, transmission line and substation are to be completed by 10th month of the third year (October, 1994).

Impounding of water in the head pond to be started in 11th month of the third year (November, 1994). Following this, discharge from the waterway and wet tests are to be completed by the end of third year. Commercial operation is to be started from the beginning of January, 1995.

7.1.3 Construction plan and method

1. Access road

There is a shipping port for timber about 10 km upstream of Song town along the Rajang River. It is possible to transport construction material, machine and equipment for the project upto the port by navigation.

A logging road extends from the port to 6 km far from the project site. The logging road has enough width for conveying construction material, machine and equipment and are well maintenanced, so that the road will be able to be used as transportation road of the project without any improvement except for 1.5 km near the the project site.

An access road of 7 km long is to be constructed from the logging road to the project site:

- Access road to be constructed : 4 m wide x 7 km long
- Existing road to be improved : 6 m wide x 1.5 km long
- Bridges to be constructed : 20 m long x 1
  10 m long x 2.

2. Construction plant

The total concrete volume is approximatley estimated at 25,000m^3. Considering the amount and schedule of concrete placement, following facilites will be adequate as the aggregate and concrete plant:

Name of plant	Capacity	Quatity
Aggregate plant	30 ^{t}/hour	1 unit
Concrete plant	24 m^3/hour	1 unit

3. River diversion

River diversion during construction will be made by a two-stage diversion, 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 a coffer dam 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 by a coffer dam.

During the close of the right bank, the river flow is to be diverted through the orifice of sand flush gate.

The volume of excavation is approximately 30,000 m^3. The work for this amount is to be completed in about 11 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 17,000 m^3, the work for which is to be completed in about 12 months. Concrete for the main dam and other structures is planned to be placed by a 20 ton class truck crane and 60 m^3/hr class concrete pump, respectively.

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 20 ton class truck crane.

5. Penstock line

Excavation of the penstock line is to be done by the same equipment used in dam excavation. Concrete is to be placed by a 60 m^3/hr class concrete pump.

The installation of steel liner for the penstock line is to be carried out together with concrete work, and is to be completed in about 3 months.

6. Powerhouse

Excavation of the powerhouse is to be done by the same equipment used in dam excavation.

Foundation and side wall concrete are to be placed by a 60 m^3/hr class concrete pump in advance, while an open space is to be secured in the vicinity of the powerhouse to facilitate delivery of power generating equipment. Colum 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 Mukoh project was estimated under the condition that the current construction technique will be applied, and furthermore the geological conditions at the project site, construction scale and construction schedule are also taken into account.

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, 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 cost, engineering services and administration cost.

- Land acquisition costs are not considered, but compensation costs for native customary rights are estimated for all the project area. Furthermore, costs of right-of-way are also counted for the transmission line.

b) Cost estimates

(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 contracts 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 quaters.

- Field investigation

  The costs for geological investigation and topographical survey necessary for the definite design were estimated by referring to the costs for boring, topographical mapping and seismic prospesting, etc. 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 and Mini Hydro Projects which had been constructed or under construction in Sarawak were mainly referred to estimate costs of civil works. In case of adopting construction costs of these projects to Mukoh 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 cost 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

Domestic products are to be used for the equipment of transmission line and substation.

c) Construction costs

The construction costs for the project are estimated at M$ 27,478,060 in total, consisting of M$18,255,497 in foreign currency portion and M$9,222,563 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$)
1992	2,227,777	2,433,139	4,660,916
1993	9,185,620	4,270,468	13,456,088
1994	6,842,100	2,518,966	9,361,066
Total	18,255,497	9,222,563	27,478,060

CHAPTER 8 PROJECT EVALUATION

8.1 Economic Analysis

8.1.1 Methodology of economic evaluation

The evaluation method of the Mukoh Small Hydropower Project puts its basis on the future power expansion programme in the Kapit 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 Kapit 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 Mukoh project are formulated so as to meet power and energy demand requirement in the Kapit 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 Mukoh 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 Mukoh 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 Mukoh project is economically viable justifies the reason for the Mukoh project to be incorporated into the future Kapit system. Economic feasibility of the system with the Mukoh 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 Mukoh 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 potion 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 statistics applied to Ibans of ethnic group which are mostly identified around site of the Mukoh project.

Economic sense of compensation costs to be outlaid to local people or entities due to the Mukoh 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 Mukoh 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 Mukoh 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$6 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 Mukoh 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 Mukoh project

Since evaluation of benefits and costs are based on the Kapit 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 1992 to 1994 during three years. As a result, the operation of the Mukoh hydro project is assumed to start in 1995.

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	1989	0.3 MW
2	1991	0.4 MW
3	1994	0.5 MW
4	1996	0.5 MW
5	1997	0.5 MW
6	2001	0.5 MW 3 diesel
7	2003	0.5 MW
8	2004	0.5 MW
9	2006	0.5 MW
10	2007	0.5 MW
11	2009	0.5 MW
12	2010	0.5 MW

Plant No of 1 and 2 are committed power plant in the Kapit 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 Kapit 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$38.18 million at 10% of discount rate.

8.1.4 Cost analysis

Costs are evaluated by cost streams of the least cost sequence with the Mukoh hydropower project. Since the commissioning year of the Mukoh project is physically conceivable from 1995, 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 Kapit system. Time span of searching optimal installation time are four years from 1995 to 1998. Installation programmes of power supply system with the project during investment horizon by installation time from 1995 to 1998 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$36.44 million in case of 1995 installation time, M$36.05 million in 1996, M$35.96 million in 1997, and M$36.01 million in 1998. 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 either 1996 or 1997. Consequently, the second or 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 Mukoh 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 (%)
1995	1.74	11.3	1997	2.22	12.1
1996	2.13	11.9	1998	2.17	12.3

Installation year indicated above means input time of the Mukoh hydro into the Kapit system. The results that net benefits in all cases turn out to be positive proves the justification that the Mukoh project should be incorporated into the Kapit system. In other words, it is proved that the Kapit system with the project is economically more viable than the same system will all diesel plants. Optimal installation time of the Mukoh project determined by an indication of maximum net benefit is identified to be the year of 1997 since present worth of supply system with the project proves to be the minimum cost in 8.1.4 when the Mukoh hydropower project is scheduled to be installed in that year. Consequently, installation programmes of the Kapit system with the Mukoh Project is identified to be the least cost sequence when the project is incorporated into the system in 1997.

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 Mukoh 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 Kapit system with the project at its installation time of 1995 is not precisely the least cost sequence, economic feasibility of this installation programme is viable since EIRR of 11.3% 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 1995.

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 substantial portion out of total costs in benefits streams, as shown in Table 8.4, economic feasibility of the Kapit 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%	60.2	45.1	50.8	44.1
8%	51.1	38.8	50.0	39.6
9%	43.9	33.8	40.3	35.8
10%	38.2	29.8	36.4	32.7
11%	33.5	26.5	33.1	30.0
12%	29.8	23.8	30.4	27.7
13%	26.6	21.5	28.1	25.8

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 unfavourable effect to the Kapit system with the project in terms of economic feasibility. The result of EIRR under a senario of constant fuel price is calculated to be 7.5%.

8.2 Financial Analysis

8.2.1 Objective of financial analysis

Financial analysis put its primal purpose on financial viability of the Mukoh hydro project itself and manageable ability 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 Mukoh 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 (1995). As a result, total financial costs of the Mukoh project are estimated to be M$30,687,420 consisting of M$27,478,060 of construction cost, and M$3,209,360 of pirce contigency. Foreign and local currency portions are estimated to be M$21,040,990 and M$9,646,430 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 Kapit and entire Sarawak is shown in the following table:

Unit: M$/kWh

	1980	1981	1982	1983	1984	1985	1986
Kapit	0.29	0.34	0.34	0.34	0.34	0.34	0.32
Sarawak	0.23	0.29	0.29	0.29	0.29	0.30	0.28

Average tariff in Kapit and Sarawak in the first five years of 1980's kept the constant price of M$0.34/kWh and M$0.29/kWh respectively. Regional feature of tariff level is appeared in Kapit in comparison to tariff level in Sarawak. The fact that tariff in Kapit region has been higher by 5 cent per kWh than in Sarawak is partly because diesoline 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 Kapit region. Owing to these reasons assumed, average cost per kWh of sold energy in Kapit 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 Kapit region is introduced in order to clarify average tariff covering all project costs of Kapit system. The cost covering prices are calculated as the ratio of present value of all project costs of Kapit 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	89,759,210	249,744,226	0.36
6	65,022,290	168,109,712	0.39
8	49,894,956	120,388,307	0.41
10	39,997,210	90,805,538	0.44

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$0.44/kWh, FIRR of the Mukoh 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 Mukoh project, tariff in the future is calculated to be M$0.44/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$0.44/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$0.32/kWh) in proportion to the increase rate of oil prices and domestic CPI. Forecast focuses on the future tariff in the commissioning year (1995) of the Mukoh project. The simple estimation by methods of oil price and CPI turns out to be M$0.42/kWh, and M$0.34/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 ROR 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$0.44/kWh or M$0.42/kWh determined by cost covering prices at the discount rate of 10% 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$0.34/kWh estimated by CPI method. The future tariff in standard case is assumed to be equivalent to present price (M$0.32/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 Mukoh 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 only about M$30.7 million consisting of foreign cost of M$21.0 million, and local cost of M$9.7 million, it would not be necessary to project financing plan for the Mukoh project. Local cost of M$9 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 the amount of foreign currency portion is negligibly small, 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 Mukoh 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 (12%) from energy output. Revenue is to be generated from 1995 where the estimated tariff of M$0.32/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 6.7%. 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 marginally lower than local interest rate (7.5%) and higher than foreign interest rate (4%). From an overall point of view, FIRR of 6.7% would be justifiable in terms of financial viability since combined rate of interest on both foreign and local loan is around 5.2% per annum. 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$0.34/kWh	7.2%
Case II	Cost increase by 10%	5.9%

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

(2) Loan repayability and financial manageability

Three financial statements shown in Table 8.7, 8.8 and 8.9 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 8.2.2. The clear result can be seen in net cash flow which would be continuously negative figure within maturity period except for a few years of grace period. As a result, accumulation of net cash flow will not turn to be positive within the maturity period. Although negative net cash flow amount is considered to be negligibly small, condition of loan repayability is not satisfactorily identified.

A statement shwon in Table 8.8 demonstrates net cash flow and its accumulation during the same maturity peiod with the following assumption that local cost is to be financed by SESCO, and foreign cost is to be funded by soft loan. Liquidity problem of whether or not local cost and interest on foreign loan can be financed by SESCO will be no serious matter from the viewpoints of the implementing agency since internal cash generation even at present level seen in Table 8.5 would be large enough to cover local cost and interest on foreign loan. Balance would turn to be positive in the commission year (1995) of the project. Accumulation of net cash amount is simulated to turn to be positive in around 2004. So the implementing agency will enjoy favourable financial position under operation of the Mukoh hydro project within the maturity period.

A statement given in Table 8.9 is prepared under the assumption that local cost is to be funded by SESCO and that foreign cost is to be financed by hard loans (8%). Negative figures continue in net cash flow for the maturity period except for two years of grace period, resulting in negative accumulation of net cash flow within the maturity period. Thus, condition of loan repayability is not satisfactorily identified.

Furthermore, financial statements for entire Kapit system during investment horizon are also demonstrated in order to make a comparison study of net cash flow and its accumulation between all diesel and the Mukoh project with diesel. The following financial case studies shown in Table 8.10 through 8.13 are 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 Mukoh in case of oil price increase.
Table 8.13 ; The system with the Mukoh under constant price of oil.

A slight modification of tariff setting from M$ 0.31 to 0.33/kwh does not make any difference since the reduction of negative net cash flow on an annual base is negligibly small. What is more important is, despite of assumptionsabout oil price, that comparison studies result in favourable condition in the system with the Mukoh financially in terms of net cash flow and its accumulation. This is mostly attributed 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 items in case Kapit 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 is to be funded by SESCO and soft loan respectively. The maximum amount of fund required to finance local cost plus interest on foreign loan is estimated to be about M$4.8 million at annual base, which is to be completely under financial manageability of SESCO itself. Under such financing scheme, accumulation of net cash amount would reach to a substantial amount of about M$11 million at the end of the maturity period.

Financial viability of the project is sustainable since the project's rate of return (6.7%) represented by FIRR is over interest rate (about 4%) on foreign loan. Although FIRR of the project is considered to be lower than ROR indicating overall SESCO's profitability, the implementation of the Mukoh project would not undermine financial position of SESCO since project costs of the Mukoh is quite small.

The implementation of the Mukoh project is proved to be preferrable to all diesel since simulation results of financial condition for Kapit 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 Mukoh hydropower development project was evaluated to be economically and financially viable. The project is recommended to commission at the beginning of 1995 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 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 study and detailed design are discussed hereinafter.

9.2 Post-feasibility Study Investigation

A staff gauge to estimate river runoff was established near the project site. 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.

For reinforcing hydrological measurements and accumulating 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 extenting the reliable range of the rating curve.

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

It is expected that the detailed design will be carried out in a relatively short time period. Considering this, topographic maps of 1 to 10,000 scale are recommended to be prepared prior to the detailed design with photogrammetry along the proposed transmission line route. A shooting scale of aerial photographs will be 1 to 25,000.

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, since the required quantity is relatively small, detailed investigation and study with regard to 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 Mukoh project should be initiated. The objectives of the engineering services for D/D would be as follows:

(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 specifications, pre-qualification and tender documents, cost estimate and detail implemetation programme for construction of the Mukoh 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 investigation

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 samplings 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 estimates include the work as follows:

(a) To prepare design criteria for detailed design of all 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, penstock, 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, and

(f) To confirm economic viability of the project.

(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, dam, intake, penstock line, powerhouse with tailrace, switchyard, etc., including 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, and

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

(7) Preparation of tender documents

Tender documents are prepared for the following work items:

(a) Documents of pre-qualification questionaire,

(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, and

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

(8) Documents to be prepared

Following reports and documents are 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, and

(f) Cost estiamte.

(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 constractors.

REFERENCES

The following are a list of literatures mainly referred through the study:

1. Malaysian Meteorological Service, Mirco-seismic of Malaysia and Adjacent Areas, 1983

2. Wolfenden, E. B., The Geology and Mineral Resources of Lower Rajang and Adjoining Area, Sarawak Memoir II, Geological Survey Department, British Territories in Borneo, 1960

3. Drainage and Irrigation Department, Sarawak Hydrological Year Book, 1962 - 1982

4. Drainage and Irrigation Department Department, Estimation of the Design Rainstorm (Hydrological Procedure No. 1), 1973

5. Drainage and Irrigation Department, Estimation of Design Rainstorm in Sabah and Sarawak (Hydrological Procedure No. 26), 1982

6. ENEX Mini-Hydro Consultants, Final Report on Hydrological Study in Sarawak, March 1982

7. M+R International, Prefeasibility Study Limbang River Basin, January 1980

8. SAMA Consortium, Feasibility Report on Bakun Hydro-electric Project, November 1983

9. Snowy Mountains Engineering Corporation, Feasibility Report on Batang Ai Hydroelectric Project, December 1978

10. Toshio Takenouchi (JICA), Hydrological Charcteristics of Sarawak, October 1982

11. WMO, Manual for Estimation of Probable Maximum Precipitation (Operational Hydrology Report No.1), WMO-No. 322, 1973

12. M. Sugawara, On the Analysis of Runoff Stucture about Several Japanese Rivers, Japanese Journal of Geophysics Vol. 2 No. 4, March 1961

13. Department of Environment, A Handbook of Environment Impact

14. Annual Report of the Forest Department, Sarawak (1980 to 1985)

15. Kapit District Annual Report (1978 to 1980 and 1985)

16. Land Code (Sarawak Chapter 81)

17. Annual Statistical Bullentin, Sarawak

18. SAMA Consortium, Pelagus/Bakun Hydro-electric Project, Ecological Impact, July 1982

19. SESCO, 21st Annual Report, 1983

20. SESCO, 22nd Annual Report, 1984

21. SESCO, Data and Information on Small-scale Hydroelectric Power Project in Sarawak, Malaysia September 1986

22. SAMA Consortium, Master Plan for Power System Development, April 1981

23. SAMA Consortium, Recommendation for Sarawak Hydropower Development, February 1983

24. Snowy Mountains Engineering Corporation, Ulu Ai Hydroelectric Project, Feasibility Report, July 1985

25. SAMA Consortium, Bakun Hydroelectric Project Detailed Design, August 1986

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			Value in General
	Mukoh River (TMK-6)	Tekalit River (TMK-1 - TMK-7)	Quarry (TMK-7)	
a. Fineness Modulus of Gravel (F.M.)	8.29	8.00	-	6.5 - 9.0
Fineness Modulus of Sand (F.M.)	2.95	3.10	-	2.3 - 3.5
b. Specific Gravity of Gravel	2.484	2.529	2.500	2.5 - 2.7
Specific Gravity of Sand	2.602	2.516	-	2.5 - 2.7
c. Absorption of Gravel (%)	3.53	1.34	2.49	less than 3.0
Absorption of Sand (%)	4.02	1.35	-	less than 3.0
d. Organic Impurities of Sand	passed	passed	-	
e. Scratch Hardness of Gravel (%)	38.1	7.8	2.4	less than 5.0

TABLE 3.1 RESULT OF LABORATORY TESTS (2/2)

Item of tests	Places: Mukoh River (TMK-6)	Places: Tekalit River (TMK-1 - TMK-7)	Places: Quarry (TMK-7)	Value in General
f. Soundness of Gravel (%)	15.3	6.4	1.9	less than 12.0
Soundness of Sand (%)	16.6	8.1		less than 10.0
g. Abrasion of Gravel (%)	35.4	24.1	25.1	less than 40.0
h. Unit weight of Gravel (t/m^3)	1.759	1.775	-	1.5 - 1.9
Unit weight of Sand (t/m^3)	1.761	1.590	-	1.4 - 1.8

TABLE 3.2 PLACES OF TEST PITTING AND SAMPLING MUKOH

Sampling No.	Distance from the dam site (km)	Volume of River Deposit (m^3)	Maximum Size of particles (cm)	Type of rock	Sampling weight (Kg)
TMK-1	Down 15 Left bank	600 (400)1/	10 - 20	Shale and Sandstone	90
TMK-2	Down 22 Right bank	2,000 (1,500)	10 - 20	Shale and Sandstone	180
TMK-3	Down 25 Right bank	1,200 (800)	10 - 20	Shale and sandstone	180
TMK-4	Down 27 Left bank	1,500 (6,000)	10 -20	Shale and Sandstone	90
TMK-5	Down 32 Right bank	1,500 (7,000)	10 -20	Shale and Sandstone	90
TMK-6	Down 25 Right bank	3,000 (1,500)	30 - 50	Shale and Sandstone	180
	Total Volume of River Deposits	9,800 (6,200)			
TMK-7 (Rock samples from Quarry)	Left bank of damsite			Shale and sandstone	50

Note: 1/ Figures in parenthesis show the estimated volume of gravel with the grain 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.	O
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 so far as compensation for native customary rights is properly transacted.	-L
Economic activities and social welfare	large construction labour demand is expected. Electricity will be supplied to the longhouses.	+H
Public health	It is not predicted that a vector of malaria will increase due to the creation of pondage.	O
Sedimentation	Sediment deposited in the pondage 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

(Unit:kW)

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)

Station / Year	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 KAPIT

(Unit:MWh)

Year	1980	1981	1982	1983	1984	1985	1986
Domestic	305	360	451	560	575	685	799
Commercial	1,605	1,948	2,249	2,433	2,691	3,352	3,407
Industrial	187	215	279	350	362	510	775
Lighting	55	61	60	55	61	64	64
Total	2,152	2,584	3,039	3,398	3,689	4,611	5,045

Table 4.7 DETAILS OF POWER CONSUMPTION BY DOMESTIC AND COMMERCIAL SECTORS IN KAPIT

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	458	346	42,252	188,109	547	417	53,996	296,078	638	433	59,240	300,074
February	462	344	47,837	195,465	545	408	61,699	284,236	639	430	62,547	261,317
March	461	347	42,238	196,535	560	410	45,820	244,991	637	430	59,101	266,304
April	466	347	48,080	222,006	562	417	56,985	303,251	637	431	59,682	267,998
May	468	376	47,057	226,534	560	414	58,226	302,252	633	430	69,928	290,002
June	506	392	48,216	222,481	574	416	54,600	278,830	682	432	67,500	284,849
July	513	387	46,071	222,730	573	427	54,911	269,604	690	432	69,408	283,718
August	517	390	52,944	267,284	606	436	60,144	300,848	701	428	72,309	295,515
September	536	394	50,097	238,755	618	431	62,514	284,712	705	431	72,042	290,023
October	547	396	49,857	245,827	626	433	58,853	270,095	709	431	71,878	291,153
November	546	397	52,061	256,148	629	432	57,672	269,425	711	430	71,220	294,387
December	546	397	48,172	209,591	625	432	59,512	248,043	723	431	64,036	281,957
Total			574,882	2,691,465			684,932	3,352,365			798,891	3,407,297

Note: D = Domestic and C = Commercial

Table 4.8 ANNUAL POWER CONSUMPTION PER CONSUMER IN MAJOR DISTRICTS

(1) Domestic Sector

(unit : kWh)

Year	1980	1981	1982	1983	1984	1985	1986	Average Growth Rate (1980 - 1986)
Kuching	1,428	1,541	1,476	1,660	-	1,686	1,736	3.3%
Sibu	1,429	1,510	1,559	1,808	-	1,782	1,874	4.6%

(2) Commercial Sector

(unit : kWh)

Year	1980	1981	1982	1983	1984	1985	1986	Average Growth Rate (1980 - 1986)
Kuching	12,137	12,166	12,706	13,100	-	13,617	14,567	3.1%
Sibu	9,650	10,183	10,753	11,373	-	11,595	10,736	1.8%

Remarks: Data for the year 1984 not available.

Table 4.9 CALCULATION OF POWER CONSUMPTION FOR KAPIT

Sectors / Year	DOMESTIC (MWh)	COMMERCIAL (MWh)	INDUSTRAIL (MWh)	PUBLIC LIGHTING (MWh)	TOTAL (MWh)
1980	305 (358)	1,605 (291)	187 (3)	55 (14)	2,152 (666)
1981	360 (389)	1,948 (367)	215 "	61 "	2,584 (713)
1982	451 (409)	2,249 (315)	279 (4)	60 "	3,039 (742)
1983	560 (454)	2,433 (347)	349 "	56 (12)	3,398 (817)
1984	575 (546)	2,691 (397)	362 "	61 (11)	3,689 (958)
1985	685 (625)	3,352 (432)	511 (5)	64 (12)	4,612 (1,074)
1986	799 (723)	3,407 (431)	775 "	64 (13)	5,045 (1,172)
1987	1.25MWh x 734=918	8.17MWh x 437=3,570	775MWh x (1+0.1)=853	64MWh x (1+0.05) = 67	5,408
1988	1.31MWh x 760=996	8.50MWh x 442=3,757	775MWh x $(1+0.1)^2$ = 938	64MWh x $(1+0.05)^2$ = 71	5,762
1989	1.38MWh x 785=1,083	8.83MWh x 446=3,938	775MWh x $(1+0.1)^3$ =1,032	64MWh x $(1+0.05)^3$ = 74	6,127
1990	1.45MWh x 810=1,175	9.19MWh x 450=4,136	775MWh x $(1+0.1)^4$ =1,135	64MWh x $(1+0.05)^4$ = 78	6,524
1995	1.79MWh x 1,000=1,790	10.86Mwh x 475=5,159	1,135MWh x $(1+0.08)^5$ =1,668	78MWh x $(1+0.04)^5$ = 95	8,712
2000	2.10MWh x 1,230=2,583	12.22MWh x 500=6,110	1,135MWh x $(1+0.08)^{10}$ =2,450	78MWh x $(1+0.04)^{10}$ = 115	11,258
2005	2.32MWh x 1,500=3,480	13.23MWh x 525=6,946	2,450MWh x $(1+0.06)^5$ =3,279	115MWh x $(1+0.03)^5$ = 133	13,838
2010	2.56MWh x 1,820=4,659	14.32MWh x 550=7,876	2,450MWh x $(1+0.06)^{10}$ =4,388	115MWh x $(1+0.03)^{10}$ = 155	17,078

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

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

No.	Type	Installed Cap.,kW	Unit	Inst. Year	Designated Retirement	Annual Max. Operation Rate,%
1.	Diesel	75	1	-	1987	60
2.	"	144	1	1977	1988	"
3.	"	144	1	1977	1988	"
4.	"	200	1	1979	-	"
5.	"	200	1	1980	-	"
6.	"	200	1	1981	-	"
7.	"	200	1	1982	-	"
8.	"	600	1	1985	-	"
9.	"	600	1	1985	-	"
10.	"	300	1	1988	-	"
11.	"	400	1	1990	-	"

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/	0.18/0.12 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 of Kapit used diesoline, whilst M$0.12/kWh is for the diesel plant of Limbang used 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 1/

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

Unit: M$

Work Item	Unit	Price
1. Civil Works		
a. Excavation in common	m^3	5.0
b. Excavation in rock	"	18.0
c. Concrete in dam	"	210.0
d. Concrete in structure	"	290.0
e. Concrete in powerhouse	"	350.0
f. Reinforcement	ton	1,900.0
g. Access road, new	km	160,000.0
h. Access road, improvement	"	65,000.0
2. Metal Works		
a. Gates	ton	12,000.0
b. Penstock	"	6,800.0

Table 5.4 Economic Evaluation for Mukoh Project

Case	FSL (El;m)	Plant Discharge (cms)	Installed Capacity (MW)	Construction Cost (million M$)	B/C	Net Benefit (million M$)	EIRR (%)
Alt-1							
ROR-1	88.900	12.1	1.44	21.278	1.026	0.982	10.885
ROR-2	89.500	18.5	2.25	23.521	1.040	1.464	11.156
ROR-3	89.800	25.0	3.06	25.126	1.039	1.445	11.022
4	90.000	25.1	3.10	25.838	1.030	1.111	10.790
5	90.000	18.8	2.32	23.825	1.048	1.738	11.345
6	90.000	12.5	1.55	21.789	1.034	1.245	11.077
7	100.000	29.0	4.77	33.851	0.981	-0.727	9.655
8	100.000	21.7	3.57	31.231	1.033	1.216	10.712
9	100.000	14.5	2.38	28.504	1.039	1.424	10.910
10	100.000	9.7	1.59	26.361	1.014	0.538	10.414
11	110.000	16.9	3.47	43.352	0.937	-2.565	8.910
12	110.000	11.2	2.31	40.804	0.940	-2.416	8.885
Alt-2							
1	90.000	25.1	5.62	41.364	0.939	-2.471	8.949
2	90.000	18.8	4.19	35.958	1.015	0.547	10.293
3	90.000	12.5	2.77	33.582	1.032	1.182	10.655
4	90.000	8.4	1.83	30.272	1.020	0.743	10.482
5	100.000	21.7	5.75	45.769	0.949	-2.044	9.228
6	100.000	14.5	3.81	40.435	1.010	0.390	10.189
7	100.000	9.7	2.52	37.922	1.009	0.336	10.179
Alt-3							
1	90.000	25.1	6.38	47.210	0.895	-4.487	8.330
2	90.000	18.8	4.75	41.971	0.959	-1.646	9.346
3	90.000	12.5	3.13	36.339	1.029	1.066	10.550
4	90.000	8.4	2.05	32.648	1.025	0.931	10.553
5	100.000	21.7	6.40	51.008	0.905	-4.027	8.634
6	100.000	14.5	4.23	44.424	0.990	-0.402	9.862
7	100.000	9.7	2.78	40.770	1.013	0.486	10.238

Table 5.5 Cash Flow for Mukoh (1/2)

ALT.1-5

Description	Unit	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Demand, peak power	MW	1.40	1.48	1.57	1.65	1.75	1.86	1.98	2.09	2.20	2.32	2.42	2.53	2.64	2.76
, energy	GWh	5.76	6.23	6.70	7.17	7.66	8.16	8.65	9.15	9.65	10.19	10.77	11.35	11.93	12.51
Annual load factor		.47	.48	.49	.50	.50	.50	.50	.50	.50	.50	.51	.51	.51	.52
Reserve capacity	MW	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60
Required total capacity	MW	2.00	2.08	2.17	2.25	2.35	2.46	2.58	2.69	2.80	2.91	3.03	3.13	3.24	3.36
Diesel retirement	MW	.00	-.08	-.29	.00	.00	.00	.00	.00	-.20	-.20	-.20	-.20	.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	2.32	.00	.00	.00	.00	.00
, diesel	MW	.00	.00	.30	.00	.40	.00	.00	.50	.00	.00	.00	.00	.00	.00
System capacity, installed	MW	2.36	2.28	2.30	2.30	2.70	2.70	2.70	3.20	5.32	5.12	4.92	4.72	4.72	4.72
, guaranteed	MW	2.36	2.28	2.30	2.30	2.70	2.70	2.70	3.20	3.87	3.75	3.62	3.45	3.50	3.52
(hydro, guaranteed)	MW	.00	.00	.00	.00	.00	.00	.00	.00	.88	.96	1.02	1.05	1.11	1.12
(diesel, H.S.D.unit)	MW	2.36	2.28	2.30	2.30	2.70	2.70	2.70	3.20	3.00	2.80	2.60	2.40	2.40	2.40
(diesel, cold reserve)	MW	.00	.00	.00	.00	.00	.00	.00	.00	1.09	.79	.55	.28	.21	.12
Installation cost, hydro	m.M$	.00	.00	.00	.00	.00	2.67	12.48	8.67	.00	.00	.00	.00	.00	.00
, diesel	m.M$	.23	.69	.31	.92	.00	.38	1.15	.00	.00	.00	.00	.00	1.15	3.44
Power generation, hydro	GWh	.00	.00	.00	.00	.00	.00	.00	.00	7.83	8.04	8.26	8.46	8.64	8.79
, diesel	GWh	5.76	6.23	6.70	7.17	7.66	8.16	8.65	9.15	1.82	2.15	2.51	2.89	3.29	3.72
Hydro OM cost	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.19	.19	.19	.19	.19	.19
Diesel OM cost, fixed	m.M$	.19	.18	.18	.18	.21	.21	.21	.25	.15	.16	.16	.17	.17	.18
, variable	m.M$	.12	.12	.13	.14	.15	.16	.17	.18	.04	.04	.05	.06	.07	.07
, fuel(HSD)	m.M$	.92	.99	1.07	1.21	1.36	1.51	1.67	1.84	.38	.48	.60	.74	.90	1.07
, fuel (LO)	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Total cost	m.M$	1.45	1.99	1.69	2.45	1.72	4.93	15.69	10.95	.76	.87	1.00	1.15	2.47	4.96

Table 5.5 Cash Flow for Mukoh (2/2)

ALT.1-5

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Demand, peak power	MW	2.87	3.00	3.13	3.26	3.39	3.53	3.69	3.86	4.02	4.18
, energy	GWh	13.09	13.68	14.26	14.85	15.44	16.10	16.83	17.57	18.31	19.04
Annual load factor		.52	.52	.52	.52	.52	.52	.52	.52	.52	.52
Reserve capacity	MW	.60	.60	.63	.65	.68	.71	.74	.77	.80	.84
Required total capacity	MW	3.47	3.60	3.76	3.91	4.06	4.24	4.43	4.63	4.82	5.01
Diesel retirement	MW	-1.20	.00	.00	-.30	.00	-.40	.00	.00	-.50	.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	1.50	.00	.00	.50	.00	.50	.00	.50	.00	.50
System capacity, installed	MW	5.02	5.02	5.02	5.22	5.22	5.32	5.32	5.82	5.32	5.82
, guaranteed	MW	3.90	3.89	4.00	4.22	4.28	4.48	4.53	5.10	4.84	5.16
(hydro, guaranteed)	MW	1.20	1.19	1.30	1.33	1.39	1.49	1.53	1.60	1.84	1.67
(diesel, H.S.D.unit)	MW	2.70	2.70	2.70	2.90	2.90	3.00	3.00	3.50	3.00	3.50
(diesel, cold reserve)	MW	.39	.34	.18	.28	.16	.21	.06	.41	.03	.17
Installation cost, hydro	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	m.M$	.00	.38	1.15	.38	1.15	.38	1.15	.38	1.15	.00
Power generation, hydro	GWh	8.92	9.01	9.09	9.15	9.21	9.27	9.33	9.39	9.44	9.50
, diesel	GWh	4.17	4.67	5.18	5.70	6.23	6.83	7.50	8.18	8.86	9.55
Hydro OM cost	m.M$	.19	.19	.19	.19	.19	.19	.19	.19	.19	.19
Diesel OM cost, fixed	m.M$	.18	.18	.20	.21	.21	.22	.23	.24	.23	.26
, variable	m.M$	.08	.09	.10	.11	.12	.14	.15	.16	.18	.19
, fuel(HSD)	m.M$	1.20	1.35	1.49	1.64	1.80	1.97	2.17	2.36	2.56	2.75
, fuel (LO)	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Total cost	m.M$	1.66	2.20	3.13	2.53	3.47	2.90	3.88	3.34	4.30	3.40

Table 5.6 Cash Flow by All Diesel in the Kapit System (1/2)

Description	Unit	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Demand, peak power	MW	1.40	1.48	1.57	1.65	1.75	1.86	1.98	2.09	2.20	2.32	2.42	2.53	2.64	2.76
, energy	GWh	5.76	6.23	6.70	7.17	7.66	8.16	8.65	9.15	9.65	10.19	10.77	11.35	11.93	12.51
Annual load factor		.47	.48	.49	.50	.50	.50	.50	.50	.50	.50	.51	.51	.51	.52
Reserve capacity	MW	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60
Required total capacity	MW	2.00	2.08	2.17	2.25	2.35	2.46	2.58	2.69	2.80	2.91	3.03	3.13	3.24	3.36
Diesel retirement	MW	.00	-.08	-.29	.00	.00	.00	.00	.00	-.20	-.20	-.20	-.20	.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	.00	.30	.00	.40	.00	.00	.50	.00	.50	.50	.00	.00	.00
System capacity, installed	MW	2.36	2.28	2.30	2.30	2.70	2.70	2.70	3.20	3.00	3.30	3.60	3.40	3.40	3.40
, guaranteed	MW	2.36	2.28	2.30	2.30	2.70	2.70	2.70	3.20	3.00	3.30	3.60	3.40	3.40	3.40
(hydro, guaranteed)	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
(diesel, H.S.D.unit)	MW	2.36	2.28	2.30	2.30	2.70	2.70	2.70	3.20	3.00	3.30	3.60	3.40	3.40	3.40
(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$	.23	.69	.31	.92	.00	.38	1.15	.38	1.53	1.15	.00	.00	1.15	3.44
Power generation, hydro	GWh	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	GWh	5.76	6.23	6.70	7.17	7.66	8.16	8.65	9.15	9.65	10.19	10.77	11.35	11.93	12.51
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$	.19	.18	.18	.18	.21	.21	.21	.25	.24	.26	.28	.27	.27	.27
, variable	m.M$	.12	.12	.13	.14	.15	.16	.17	.18	.19	.20	.22	.23	.24	.25
, fuel(HSD)	m.M$	.92	.99	1.07	1.21	1.36	1.51	1.67	1.84	2.02	2.29	2.59	2.91	3.25	3.61
, fuel (LO)	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Total cost	m.M$	1.45	1.99	1.69	2.45	1.72	2.27	3.20	2.66	3.97	3.90	3.09	3.41	4.91	7.57

Table 5.6 Cash Flow by All Diesel in the Kapit System (2/2)

Description	Unit	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Demand, peak power	MW	2.87	3.00	3.13	3.26	3.39	3.53	3.69	3.86	4.02	4.18
, energy	GWh	13.09	13.68	14.26	14.85	15.44	16.10	16.83	17.57	18.31	19.04
Annual load factor		.52	.52	.52	.52	.52	.52	.52	.52	.52	.52
Reserve capacity	MW	.60	.60	.63	.65	.68	.71	.74	.77	.80	.84
Required total capacity	MW	3.47	3.60	3.76	3.91	4.06	4.24	4.43	4.63	4.82	5.01
Diesel retirement	MW	-1.20	.00	.00	-.30	.00	-.40	.00	.00	-.50	.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	1.50	.00	.50	.50	.00	.50	.50	.00	.50	.50
System capacity, installed	MW	3.70	3.70	4.20	4.40	4.40	4.50	5.00	5.00	5.00	5.50
, guaranteed	MW	3.70	3.70	4.20	4.40	4.40	4.50	5.00	5.00	5.00	5.50
(hydro, guaranteed)	MW	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
(diesel, H.S.D.unit)	MW	3.70	3.70	4.20	4.40	4.40	4.50	5.00	5.00	5.00	5.50
(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$	.38	1.53	1.15	.38	1.53	1.15	.38	1.53	1.49	1.38
Power generation, hydro	GWh	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
, diesel	GWh	13.09	13.68	14.26	14.85	15.44	16.10	16.83	17.57	18.31	19.04
Hydro OM cost	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Diesel OM cost, fixed	m.M$	.29	.29	.33	.35	.35	.35	.39	.39	.39	.43
, variable	m.M$	.26	.27	.29	.30	.31	.32	.34	.35	.37	.38
, fuel(HSD)	m.M$	3.78	3.95	4.12	4.29	4.46	4.65	4.86	5.07	5.28	5.50
, fuel (LO)	m.M$	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Total cost	m.M$	4.71	6.04	5.88	5.31	6.64	6.47	5.97	7.34	7.19	6.31

Table 7.1 Construction Cost

(Unit:M$)

Description	Foreign Currency	Local Currency	Total
1. PREPARATORY WORKS			
1.1 Access road	594,500	741,000	1,335,500
1.2 Field investigation	7,000	133,000	140,000
1.3 Camp facilities	84,000	336,000	420,000
Sub-total	685,500	1,210,000	1,895,500
2. CIVIL WORKS			
2.1 River diversion	208,639	259,291	467,930
2.2 Intake dam	2,588,024	2,247,006	4,835,030
2.3 Penstock line	121,829	98,681	220,510
2.4 Powerhouse	894,528	752,322	1,646,850
2.5 Tailrace	295,819	226,721	522,540
2.6 Drainage channel	52,528	41,072	93,600
Sub-total	4,161,367	3,625,093	7,786,460
3. METAL WORKS	2,598,000	650,200	3,248,200
4. GENERATING EQUIPMENT	4,708,000	721,000	5,429,000
5. TRANSMISSION LINE AND SUBSTATION	1,643,740	704,460	2,348,200
6. LAND COMPENSATION	0	70,000	70,000
7. DIRECT CONSTRUCTION COST	13,796,607	6,980,753	20,777,360
8. ENGINEERING SERVICES	2,077,740	0	2,077,740
9. ADMINISTRATIVE COST	0	1,038,870	1,038,870
10. PHYSICAL CONTINGENCY	2,381,150	1,202,940	3,584,090
11. TOTAL CONSTRUCTION COST	18,255,497	9,222,563	27,478,060

Table 7.2 Detailed Construction Cost (1/3)

(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	7,000	70	490,000	90	630,000	160	1,120,000
Improved road	m	1,500	29	43,500	36	54,000	65	97,500
New bridge	L.S.			61,000		57,000		118,000
1.2 FIELD INVESTIGATION	L.S.			7,000		133,000		140,000
1.3 CAMP FACILITIES	L.S.			84,000		336,000		420,000
Total of 1				685,500		1,210,000		1,895,500
2. CIVIL WORKS								
2.1 RIVER DIVERSION								
Earth embankment	cub.m	9,470	1.6	15,152	2.4	22,728	4	37,880
Concrete wall	cub.m	378	151.0	57,078	139.0	52,542	290	109,620
Reinforcemant	ton	12	1,463.0	17,556	437.0	5,244	1,900	22,800
Gabion protection	sq.m	2,280	35.0	79,800	65.0	148,200	100	228,000
Removal of embankment	cub.m	9,470	2.9	27,463	2.1	19,887	5	47,350
Others	L.S.			11,590		10,690		22,280
Sub total of 2.1				208,639		259,291		467,930
2.2 INTAKE DAM AND INTAKE								
Excavation in common	cub.m	11,910	2.9	34,539	2.1	25,011	5	59,550
" weathered rock	cub.m	14,960	5.4	80,784	5.6	83,776	11	164,560
" rock	cub.m	3,040	9.5	28,880	8.5	25,840	18	54,720
Concrete in dam body	cub.m	13,944	109.0	1,519,896	101.0	1,408,344	210	2,928,240
" pier and intake	cub.m	3,210	151.0	484,710	139.0	446,190	290	930,900
Reinforcement	ton	163	1,463.0	238,469	437.0	71,231	1,900	309,700
Drilling grout hole	m	792	40.0	31,680	50.0	39,600	90	71,280
Cement in grouting	ton	79	590.0	46,610	410.0	32,390	1,000	79,000
Backfill, random material	cub.m	1,710	1.6	2,736	2.4	4,104	4	6,840
Others	L.S.			119,720		110,520		230,240
Sub total of 2.2				2,588,024		2,247,006		4,835,030

Table 7.2 Detailed Construction Cost (2/3)

(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 PENSTOCK LINE								
Excavation in common	cub.m	1,840	2.9	5,336	2.1	3,864	5	9,200
" weathered rock	cub.m	1,150	5.4	6,210	5.6	6,440	11	12,650
" rock	cub.m	1,650	9.5	15,675	8.5	14,025	18	29,700
Concrete	cub.m	476	151.0	71,876	139.0	66,164	290	138,040
Reinforcement	ton	14	1,463.0	20,482	437.0	6,118	1,900	26,600
Others	L.S.			2,250		2,070		4,320
Sub total of 2.3				121,829		98,681		220,510
2.4 POWERHOUSE								
Excavation in common	cub.m	1,440	2.9	4,176	2.1	3,024	5	7,200
" weathered rock	cub.m	1,390	5.4	7,506	5.6	7,784	11	15,290
" rock	cub.m	3,710	9.5	35,245	8.5	31,535	18	66,780
Concrete above generator floor	cub.m	1,038	182.0	188,916	168.0	174,384	350	363,300
below generator floor	cub.m	1,141	151.0	172,291	139.0	158,599	290	330,890
in switchyard	cub.m	285	182.0	51,870	168.0	47,880	350	99,750
Reinforcement	ton	86	1,463.0	125,818	437.0	37,582	1,900	163,400
Superstructure	cub.m	1,438	151.0	217,138	139.0	199,882	290	417,020
Backfill, random material	cub.m	7,730	1.6	12,368	2.4	18,552	4	30,920
Others	L.S.			79,200		73,100		152,300
Sub total of 2.4				894,528		752,322		1,646,850
2.5 TAILRACE								
Excavation in common	cub.m	770	2.9	2,233	2.1	1,617	5	3,850
" weathered rock	cub.m	2,870	5.4	15,498	5.6	16,072	11	31,570
" rock	cub.m	2,340	9.5	22,230	8.5	19,890	18	42,120
Concrete	cub.m	1,165	151.0	175,915	139.0	161,935	290	337,850
Reinforcement	ton	51	1,463.0	74,613	437.0	22,287	1,900	96,900
Others	L.S.			5,330		4,920		10,250
Sub total of 2.5				295,819		226,721		522,540
2.6 DRAINAGE CHANNEL								
Concrete	cub.m	264	151.0	39,864	139.0	36,696	290	76,560
Reinforcement	ton	8	1,463.0	11,704	437.0	3,496	1,900	15,200
Others	L.S.			960		880		1,840
Sub total of 2.6				52,528		41,072		93,600
Total of 2				4,161,367		3,625,093		7,786,460

Table 7.2 Detailed Construction Cost (3/3)

(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	150	9,600	1,440,000	2,400	360,000	12,000	1,800,000
Sand flushing gate	ton	55	9,600	528,000	2,400	132,000	12,000	660,000
Intake gate	ton	9	9,600	86,400	2,400	21,600	12,000	108,000
Draft gate	ton	10	9,600	96,000	2,400	24,000	12,000	120,000
Intake trashrack	ton	18	4,600	82,800	1,100	19,800	5,700	102,600
Raking equipment	ton	12	16,000	192,000	4,000	48,000	20,000	240,000
Steel penstock	ton	32	5,400	172,800	1,400	44,800	6,800	217,600
Total of 3				2,598,000		650,200		3,248,200
4. GENERATING EQUIPMENT	L.S.			4,708,000		721,000		5,429,000
5. TRANSMISSION LINE AND SUBSTATION								
Transmission line	L.S.			1,302,840		558,360		1,861,200
Substation	L.S.			340,900		146,100		487,000
Total of 5				1,643,740		704,460		2,348,200
6. LAND COMPENSATION	L.S.			0		70,000		70,000
7. DIRECT CONSTRUCTION COST				13,796,607		6,980,753		20,777,360
8. ENGINEERING SERVICES				2,077,740				2,077,740
9. ADMINISTRATION COST						1,038,870		1,038,870
10. PHYSICAL CONTINGENCY				2,381,150		1,202,940		3,584,090
11. TOTAL CONSTRUCTION COST				18,255,497		9,222,563		27,478,060

Table 7.3 Disburcement Schedule for Mukoh Project (1/3)

(Unit:M$)

Description	TOTAL F.C.	TOTAL L.C.	1992 F.C.	1992 L.C.	1993 F.C.	1993 L.C.	1994 F.C.	1994 L.C.
1. PREPARATORY WORKS								
1.1 ACCESS ROAD								
New road	490,000	630,000	490,000	630,000				
Improved road	43,500	54,000	43,500	54,000				
New bridge	61,000	57,000	61,000	57,000				
1.2 FIELD INVESTIGATION	7,000	133,000	7,000	133,000				
1.3 CAMP FACILITIES	84,000	336,000	84,000	336,000				
Total of 1	685,500	1,210,000	685,500	1,210,000				
2. CIVIL WORKS								
2.1 RIVER DIVERSION								
Earth embankment	15,152	22,728	1,515	2,273	13,637	20,455		
Concrete wall	57,078	52,542	5,708	5,254	51,370	47,288		
Reinforcemant	17,556	5,244	1,756	524	15,800	4,720		
Gabion protection	79,800	148,200	7,980	14,820	71,820	133,380		
Removal of embankment	27,463	19,887	2,746	1,989	4,119	2,983	20,597	14,915
Others	11,590	10,690	1,159	1,069	8,693	8,018	1,739	1,604
Sub total of 2.1	208,639	259,291	20,864	25,929	165,439	216,843	22,336	16,519
2.2 INTAKE DAM								
Excavation in common	34,539	25,011	24,177	17,508	10,362	7,503		
" weathered rock	80,784	83,776	56,549	58,643	24,235	25,133		
" rock	28,880	25,840	20,216	18,088	8,664	7,752		
Concrete in dam body	1,519,896	1,408,344	151,990	140,834	835,943	774,589	531,964	492,920
" pier and intake	484,710	446,190	48,471	44,619	266,591	245,405	169,649	156,167
Reinforcement	238,469	71,231	23,847	7,123	131,158	39,177	83,464	24,931
Drilling grout hole	31,680	39,600	3,168	3,960	17,424	21,780	11,088	13,860
Cement in grouting	46,610	32,390	4,661	3,239	25,636	17,815	16,313	11,337
Backfill, random material	2,736	4,104	547	821	1,094	1,642	1,094	1,642
Others	119,720	110,520	29,930	27,630	65,846	60,786	23,944	22,104
Sub total of 2.2	2,588,024	2,247,006	363,556	322,465	1,386,952	1,201,581	837,516	722,960

Table 7.3 Disburcement Schedule for Mukoh Project (2/3)

(Unit:M$)

Description	TOTAL F.C.	TOTAL L.C.	1992 F.C.	1992 L.C.	1993 F.C.	1993 L.C.	1994 F.C.	1994 L.C.
2.3 PENSTOCK LINE								
Excavation in common	5336.0	3,864	2,668	1,932	2,668	1,932		
" weathered rock	6210.0	6,440	3,105	3,220	3,105	3,220		
" rock	15675.0	14,025	7,838	7,013	7,838	7,013		
Concrete	71876.0	66,164	7,188	6,616	64,688	59,548		
Reinforcement	20,482.0	6,118	2,048	612	18,434	5,506		
Others	2,250	2,070	788	725	1,463	1,346		
Sub total of 2.3	121,829	98,681	23,634	20,117	98,195	78,564		
2.4 POWERHOUSE								
Excavation in common	4,176	3,024	2,088	1,512	2,088	1,512		
" weathered rock	7,506	7,784	3,753	3,892	3,753	3,892		
" rock	35,245	31,535	17,623	15,768	17,623	15,768		
Concrete above generator floor	188,916	174,384	18,892	17,438	151,133	139,507	18,892	17,438
below generator floor	172,291	158,599	17,229	15,860	137,833	126,879	17,229	15,860
in switchyard	51,870	47,880	5,187	4,788			46,683	43,092
Reinforcement	125,818	37,582	12,582	3,758	88,073	26,307	25,164	7,516
Superstructure	217,138	199,882	21,714	19,988	21,714	19,988	173,710	159,906
Backfill, random material	12,368	18,552	1,237	1,855	9,894	14,842	1,237	1,855
Others	79,200	73,100	15,840	14,620	47,520	43,860	15,840	14,620
Sub total of 2.4	894,528	752,322	116,144	99,479	479,630	392,555	298,755	260,288
2.5 TAILRACE								
Excavation in common	2,233	1,617	1,117	809	1,117	809		
" weathered rock	15,498	16,072	7,749	8,036	7,749	8,036		
" rock	22,230	19,890	11,115	9,945	11,115	9,945		
Concrete	175,915	161,935	17,592	16,194	158,324	145,742		
Reinforcement	74,613	22,287	7,461	2,229	67,152	20,058		
Others	5,330	4,920	1,865	1,722	3,465	3,198		
Sub total of 2.5	295,819	226,721	46,899	38,934	248,920	187,787		
2.6 DRAINAGE CHANNEL								
Concrete	39,864	36,696	3,986	3,670	35,878	33,026		
Reinforcement	11,704	3,496	1,170	350	10,534	3,146		
Others	960	880	96	88	864	792		
Sub total of 2.6	52,528	41,072	5,253	4,107	47,275	36,965		
Total of 2	4,161,367	3,625,093	576,349	511,032	2,426,412	2,114,295	1,158,606	999,766

Table 7.3 Disburcement Schedule for Mukoh Project (3/3)

(Unit:M$)

Description	TOTAL		1992		1993		1994	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.
3. METAL WORK								
Spillway gate	1,440,000	360,000	144,000	36,000	576,000	144,000	720,000	180,000
Sand flushing gate	528,000	132,000	52,800	13,200	475,200	118,800		
Intake gate	86,400	21,600	8,640	2,160	77,760	19,440		
Draft gate	96,000	24,000	9,600	2,400			86,400	21,600
Intake trashrack	82,800	19,800	8,280	1,980	74,520	17,820		
Raking equipment	192,000	48,000	19,200	4,800	172,800	43,200		
Steel penstock	172,800	44,800	17,280	4,480	155,520	40,320		
Total of 3	2,598,000	650,200	259,800	65,020	1,531,800	383,580	806,400	201,600
4. GENERATING EQUIPMENT	4,708,000	721,000			1,883,200	288,400	2,824,800	432,600
5. TRANSMISSION LINE AND SUBSTATION								
Transmission line	1,302,840	558,360			1,042,272	446,688	260568.0	111672.0
Substation	340,900	146,100			272,720	116,880	68180.0	29220.0
Total of 5	1,643,740	704,460			1,314,992	563,568	328,748	140,892
6. LAND COMPENSATION		70,000		70,000				
7. DIRECT CONSTRUCTION COST	13,796,607	6,980,753	1,521,649	1,856,052	7,156,404	3,349,843	5,118,554	1,774,858
8. ENGINEERING SERVICES	2,077,740		415,548		831,096		831096.0	
9. ADMINISTRATION COST		1,038,870		259,718		363,605		415,548
10. PHYSICAL CONTINGENCY	2,381,150	1,202,940	290,580	317,370	1,198,120	557,020	892,450	328,560
11. TOTAL CONSTRUCTION COST	18,255,497	9,222,563	2,227,777	2,433,139	9,185,620	4,270,468	6,842,100	2,518,966

TABLE 8.1 LIST OF CONVERSION FACTORS

Type of goods	Conversion Factor		
	Imports	Exports	Combined
Tradeable goods			
1. Petroleum (refined)	0.47	1.13	0.67
2. Petroleum (crude oil)	0.84	1.13	0.86
3. Construction material	0.82	1.12	0.88
4. Investment goods	0.82	1.12	0.85
Non-tradeable goods/ service			
5. Construction	-	-	0.77
6. Government services	-	-	0.88

Source : National Parameters for Project Appraisal
Malaysian Data (EPU) 1977

TABLE 8.2 ECONOMIC CONSTRUCTION COST OF THE MUKOH

Unit:M$

	Work Item	Financial cost	Economic cost	Ratio of E/F (%)
1.	Preparatory Works	1,895,500	1,384,970	73
2.	Civil Works			
2.1	River diversion	467,930	350,960	75
2.2	Intake dam	4,835,030	3,734,920	77
2.3	Penstock line	220,510	171,790	78
2.4	Powerhouse	1,646,850	1,286,740	78
2.5	Tailrace	522,540	404,290	77
2.6	Drainage channel	93,600	72,480	77
	Total of 2	7,786,460	6,021,180	77
3.	Metal Works	3,248,200	2,871,630	88
4.	Generating Equipment	5,429,000	5,297,050	98
5.	Transmission Line and Substation	2,348,200	2,234,000	95
6.	Land Acquisition	70,000	-	-
	Direct Cost	20,777,360	17,808,830	86
7.	Engineering Service	2,077,740	2,077,740	100
8.	Administration	1,038,870	831,100	80
9.	Physical Contigency	3,584,090	3,107,650	87
	Total cost	27,478,060	23,825,320	87

TABLE 8.3 INSTALLATION PROGRAMMES WITH THE MUKOH

Unit : MW

Year	Installation year of the Mukoh							
	1995 (First)		1996 (second)		1997 (Third)		1998 (Fourth)	
	Diesel	Hydro	Diesel	Hydro	Diesel	Hydro	Diesel	Hydro
1989	0.30		0.30		0.30		0.30	
1990								
1991	0.40		0.40		0.40		0.40	
1992								
1993								
1994	0.50		0.50		0.50		0.50	
1995		2.32						
1996				2.32	0.50		0.50	
1997						2.32	0.50	
1998								2.32
1999								
2000								
2001	1.50		1.50		1.00		0.50	
2002								
2003								
2004	0.50		0.50		0.50		0.50	
2005								
2006	0.50		0.50		0.50		0.50	
2007								
2008	0.50		0.50		0.50		0.50	
2009								
2010	0.50		0.50		0.50		0.50	

TABLE 8.4 CASH FLOW OF BENEFITS AND COSTS (1/2)

Unit : Million M$

Year	Benefit streams				Costs streams			
	Capital	Fuel	O&M	Total	Capital	Fuel	O&M	Total
1987	0.230	0.919	0.301	1.449	0.230	0.919	0.301	1.449
1988	0.689	0.994	0.304	1.987	0.689	0.994	0.304	1.987
1989	0.306	1.069	0.315	1.690	0.306	1.069	0.315	1.690
1990	0.918	1.213	0.324	2.455	0.918	1.213	0.324	2.455
1991	-	1.356	0.365	1.721	-	1.356	0.365	1.721
1992	0.382	1.509	0.375	2.266	2.990	1.509	0.375	4.874
1993	1.148	1.670	0.385	3.202	12.839	1.670	0.385	14.893
1994	0.382	1.839	0.434	2.656	7.509	1.839	0.434	9.782
1995	1.530	2.016	0.428	3.974	-	0.381	0.359	0.740
1996	1.148	2.291	0.463	3.901	-	0.483	0.373	0.856
1997	-	2.593	0.498	3.091	-	0.603	0.384	0.987
1998	-	2.914	0.494	3.408	-	0.742	0.397	1.139
1999	1.147	3.253	0.506	4.906	1.147	0.898	0.410	2.456
2000	3.443	3.610	0.517	7.570	3.443	1.072	0.426	4.940
2001	0.382	3.779	0.552	4.713	-	1.205	0.437	1.642
2002	1.530	3.948	0.564	6.042	0.382	1.348	0.451	2.181
2003	1.148	4.117	0.615	5.879	1.148	1.494	0.474	3.115
2004	0.382	4.286	0.642	5.311	0.382	1.644	0.492	2.518
2005	1.530	4.455	0.654	6.639	1.148	1.797	0.512	3.456
2006	1.148	4.646	0.675	6.469	0.382	1.971	0.528	2.881
2007	0.382	4.858	0.729	5.970	1.148	2.165	0.553	3.866
2008	1.530	5.071	0.744	7.345	0.382	2.361	0.579	3.322
2009	1.492	5.283	0.759	7.189	1.148	2.558	0.583	4.288
2010	1.377	5.495	0.813	6.308	-	2.755	0.624	3.379
2011	1.033	5.495	0.813	7.341	-	2.755	0.624	3.379
2012	-	5.495	0.813	6.308	-	2.755	0.624	3.379
2013	-	5.495	0.813	6.308	-	2.755	0.624	3.379
2014	1.033	5.495	0.813	7.341	1.033	2.755	0.624	4.412
2015	3.098	5.495	0.813	9.406	3.098	2.755	0.624	6.478

TABLE 8.4 CASH FLOW OF BENEFITS AND COSTS (2/2)

Unit : Million M$

Year	Benefit streams				Costs streams			
	Capital	Fuel	O&M	Total	Capital	Fuel	O&M	Total
2016	0.344	5.494	0.813	6.652	-	2.755	0.624	3.379
2017	1.377	5.495	0.813	7.685	0.344	2.755	0.624	3.724
2018	1.033	5.495	0.813	7.341	1.033	2.755	0.624	4.412
2019	0.344	5.495	0.813	6.652	0.344	2.755	0.624	3.724
2020	1.377	5.495	0.813	7.685	1.033	2.755	0.624	4.412
2021	1.033	5.495	0.813	7.341	0.344	2.755	0.624	3.724
2022	0.344	5.495	0.813	6.652	1.033	2.755	0.624	4.412
2023	1.377	5.495	0.813	7.685	0.344	2.755	0.624	3.724
2024	1.377	5.495	0.813	7.685	1.033	2.755	0.624	4.412
2025	1.377	5.495	0.813	7.685	-	2.755	0.624	3.379
2026	1.033	5.495	0.813	7.341	-	2.755	0.624	3.379
2027	-	5.495	0.813	6.308	-	2.755	0.624	3.379
2028	-	5.495	0.813	6.308	-	2.755	0.624	3.379
2029	1.033	5.495	0.813	7.341	1.033	2.755	0.624	4.412
2030	3.098	5.495	0.813	9.406	3.098	2.755	0.624	6.478
2031	0.344	5.495	0.813	6.652	-	2.755	0.624	3.379
2032	1.377	5.495	0.813	7.685	0.344	2.755	0.624	3.724
2033	1.033	5.495	0.813	7.341	1.033	2.755	0.624	4.412
2034	0.344	5.495	0.813	6.652	0.344	2.755	0.624	3.724
2035	1.033	5.495	0.813	7.341	1.033	2.755	0.624	4.412
2036	-	5.495	0.813	6.308	-	2.755	0.624	3.379

Table 8.5 Financial Performance of SESCO in the Past and the Year of 1995

Item	1978	1979	1980	1981	1982	1983	1984	1985	1986	1995
Energy sales (GWh)	223	275	305	344	383	445	474	535	569	1,342
Revenue (M$$10^6$)	47	57	71	101	112	132	140	159	161	375
Tariff (M$/kWh)	0.20	0.21	0.23	0.29	0.29	0.29	0.29	0.30	0.28	0.28
Expenses (M$$10^6$)	33	38	55	79	89	97	103	108	92	220
Net income (M$$10^6$)	14	19	16	22	23	35	37	51	69	155
Fixed assets (M$$10^6$)	168	176	191	210	239	305	326	825	867	2,294
Acc. Deprecition (M$$10^6$)	50	58	66	76	86	100	117	144	173	693
Net assets (M$$10^6$)	118	118	125	134	153	205	209	681	694	1,601
ROR (%)	12	16	13	16	15	17	18	7	10	9.7
Peak demand (MW)	61	69	74	84	101	107	116	133	141	331

Note: Acc. Depreciation means accumulated depriciation
Net fixed assets is equal to fixed assets minus accumulated depreciation.

ROR is expressed by the ratio of net income to net fixed assets on annual basis.

Table 8.6 Financial Cash Flow of the Mukoh

Unit:M$

No	Year	Cost		Revenue
		Foreign	Local	
1	1987			
2	1988			
3	1989			
4	1990			
5	1991			
6	1992	2,458,770	2,519,460	
7	1993	10,492,850	4,466,200	
8	1994	8,089,370	2,660,770	
9	1995		221,690	2,204,800
10	1996		221,690	2,264,000
11	1997		221,690	2,326,020
12	1998		221,690	2,382,340
13	1999		221,690	2,433,020
14	2000		221,690	2,475,260
15	2001		221,690	2,511,870
16	2002		221,690	2,537,220
17	2003		221,690	2,559,740
18	2004		221,690	2,576,640
19	2005		221,690	2,593,540
20	2006		221,690	2,610,430
21	2007		221,690	2,627,330
22	2008		221,690	2,644,220
23	2009		221,690	2,658,300
24	2010		221,690	2,675,200
			:	:
50	2036		221,690	2,675,200

Table 8.7 Financial Statement

(Unit : M$)

No	Year	Local Currency Portion			Foreign Portion		Revenue	Balance	Accumulated Balance
		O&M	Interest	Repayment	Interest	Repayment			
1	1992		188,960		98,350			-283,310	-287,310
2	1993		523,960		518,060			-1,042,202	-1,329,330
3	1994		723,480		841,640			-1,565,120	-2,894,450
4	1995	221,690	723,480		841,640		2,204,800	417,990	-2,476,460
5	1996	221,690	723,480		841,640		2,264,000	477,190	-1,999,270
6	1997	221,690		946,510	841,640		2,326,020	316,180	-1,683,090
7	1998	221,690		946,510	841,640		2,382,340	372,500	-1,310,590
8	1999	221,690		946,510		1,662,030	2,433,020	-397,210	-1,707,800
9	2000	221,690		946,510		1,662,030	2,475,260	-354,970	-2,062,770
10	2001	221,690		946,510		1,662,030	2,511,870	-318,360	-2,381,130
11	2002	221,690		946,510		1,662,030	2,537,220	-293,010	-2,674,140
12	2003	221,690		946,510		1,662,030	2,559,740	-270,490	-2,944,630
13	2004	221,690		946,510		1,662,030	2,576,640	-253,590	-3,198,220
14	2005	221,690		946,510		1,662,030	2,593,540	-236,690	-3,434,910
15	2006	221,690		946,510		1,662,030	2,610,430	-219,800	-3,654,710
16	2007	221,690		946,510		1,662,030	2,627,330	-202,900	-3,857,610
17	2008	221,690		946,510		1,662,030	2,644,220	-186,010	-4,043,620
18	2009	221,690		946,510		1,662,030	2,658,300	-171,930	-4,215,550
19	2010	221,690		946,510		1,662,030	2,675,200	-155,030	-4,370,580
20	2011	221,690		946,510		1,662,030	2,675,200	-155,030	-4,525,610
21	2012	221,690		946,510		1,662,030	2,675,200	-155,030	-4,680,640
22	2013	221,690		946,510		1,662,030	2,675,200	-155,030	-4,835,670
23	2014	221,690		946,510		1,662,030	2,675,200	-155,030	-4,990,700
24	2015	221,690		946,510		1,662,030	2,675,200	-155,030	-5,145,730
25	2016	221,690		946,510		1,662,030	2,675,200	-155,030	-5,300,760

Table 8.8 Financial Statement

No	Year	Cost	Interest	Repayment	Revenue	Balance	Accumulation
1	1992	2,519,460	98,350			-2,617,810	-2,617,810
2	1993	4,466,220	518,060			-4,984,260	-7,602,070
3	1994	2,660,770	841,640			-3,502,410	-11,104,480
4	1995	221,690	841,640		2,204,800	1,141,470	-9,963,010
5	1996	221,690	841,640		2,264,000	1,200,670	-8,762,340
6	1997	221,690	841,640		2,326,020	1,262,690	-7,499,650
7	1998	221,690	841,640		2,382,340	1,319,010	-6,180,640
8	1999	221,690		1,662,030	2,433,020	549,300	-5,631,340
9	2000	221,690		1,662,030	2,475,260	591,540	-5,039,800
10	2001	221,690		1,662,030	2,511,870	628,150	-4,411,650
11	2002	221,690		1,662,030	2,537,220	653,500	-3,758,150
12	2003	221,690		1,662,030	2,559,740	676,020	-3,082,130
13	2004	221,690		1,662,030	2,576,640	692,920	-2,389,210
14	2005	221,690		1,662,030	2,593,540	709,820	-1,679,390
15	2006	221,690		1,662,030	2,610,430	726,710	-952,680
16	2007	221,690		1,662,030	2,627,330	743,610	-209,070
17	2008	221,690		1,662,030	2,644,220	760,500	551,430
18	2009	221,690		1,662,030	2,658,300	774,580	1,326,010
19	2010	221,690		1,662,030	2,675,200	791,480	2,117,490
20	2011	221,690		1,662,030	2,675,200	791,480	2,908,970
21	2012	221,690		1,662,030	2,675,200	791,480	3,700,450
22	2013	221,690		1,662,030	2,675,200	791,480	4,491,930
23	2014	221,690		1,662,030	2,675,200	791,480	5,283,410
24	2015	221,690		1,662,030	2,675,200	791,480	6,074,890
25	2016	221,690		1,662,030	2,675,200	791,480	6,866,370