

Mass : 20 ton
Dimensions : 12 m long, 2.7 m wide, 2.85 m high

4.7 Land Use (Reservoir and Construction Areas)

The Maung project area is located in Kabupaten (Regency) Banjarnegara as explained in succeeding Clause 4.9.

In the four Kecamatan (Districts) of Kab. Banjarnegara where reservoir floods Desas (Village) of Kecamatan partially or wholly, land use conditions are as table below.

(ha)

Name of Kecamatan	Paddy Area	Upland area					Total
		Farm	Forest	House yard	Pond	Others	
Banjarnegara	1,631	1,976	514	428	19	70	4,638
Wanayasa	419	5,147	2,227	221	34	153	8,201
Karangkoobar	553	2,529	581	151	13	77	3,904
Pagentan	345	3,323	-	139	-	42	3,849
Total	2,948	12,975	3,322	939	66	342	20,592

The proposed reservoir area at EL.597 m (Top water level) is 780 ha, which will flood ten Desas within the above-mentioned four Kecamatan.

Land use of submerged area (below EL.597 m) is estimated as the table below, on the basis of information from each Desa.

(ha)

Desa	Land Use				
	Paddy	Upland	Homeyards	Others	Total
Kec. Banjarnegara					
Kalilunjar	18.4	25.8	-	-	44.2
Sijeruk	35.8	8.2	-	-	44.0
Kec. Wanayasa					
Suidak	52.7	177.5	0.8	-	231.0
Karang Tengah	74.0	48.4	8.0	-	130.4
Kec. Karangobar					
Paweden	-	-	-	47.8	47.8
Kec. Pagentan					
Gumingsir	62.5	42.6	1.6	0.3	107.0
Nagasari	94.4	50.9	6.0	-	151.3
Kalitlaga	3.1	-	-	-	3.1
Kayuares	5.5	-	-	-	5.5
Alibaya	15.7	-	-	-	15.7
Total	362.2	353.4	16.4	48.1	780.0

Population, family number and building numbers in the submerged area and also in the whole area in each Desa are tabled in Table 4-9. Totally numbers of family (2,272 persons) will be submerged among the whole 2,201 families (10,316 persons). Data shows that the population in these Desas increased by only 2.6% or at an annual rate of 0.5% during five years from Mar. 1974 until Mar. 1979.

Besides the area to be submerged as stated above, certain area are also required for construction use such as for borrow sites, quarry sites, roads, quarters and so on, as shown on Figure 6-13. It is roughly estimated that total area is 400 ha and total family number is 150.

Present number of households and land area within the area to be acquired for the project implementation are summarized below.

Item	Reservoir Area (below EL. 595 m)	Construction Site	Total
Family (No.)	500	150	650
Land (ha)	780	400	1,180

Unit costs for transmigration of family and compensation of land are estimated as shown below.

Item	Unit cost	Source
Transmigration	Rp 3.3×10^6 /family	DEPNAKER TRANS - Jakarta
Compensation	Rp 2.5×10^6 /ha (II class)	Dinas Agraria-Banjarnegara

4.8 Irrigation Intakes

There are many simple (village) irrigation water intakes in the upstream of the Maung damsite. Total 60 numbers are registered in Dinas PU Province (Local irrigation office in Banjarnegara). Irrigable area of those intake is about 15 ha/number on an average, (max. 80 ha and min. 2 ha).

There is a technical irrigation intake at the Clangap damsite, which feeds water to a paddy field of 690 ha. According to the record in the above-mentioned irrigation office, monthly mean take during Jan. 1975 and Dec. 1978 was as tabulated below.

	Month												Average
	J	F	M	A	M	J	J	A	S	O	N	D	
Monthly Mean (m^3/s)	1.07	1.04	1.05	0.92	1.07	1.17	1.27	1.26	0.98	0.70	0.68	0.98	1.02

Note; In September and October, maintenance of irrigation system is performed.

Cropping (rice) is done two times a year; during Jan. and mid Apr. (160 days in wet season) and during mid Apr. and Aug. (140 days in dry season). In the dry season, some water shortage presently takes place caused by a malfunction of weir at the intake site.

A survey report, titled Geological Investigation Report at Clangap Irrigation Intake (1979), has been prepared by Irrigation Project Office of Serayu (Projek Irrigasi Serayu, Purwokerto, DPU) aiming at to give data for improving the existing weir at the Clangap intake. Time schedule of realizing the improvement works, however, has not yet been established.

4.9 Other Informations

Other environmental aspects at and around the Project site are summarily described below following to the informations given by local Government offices.

(1) Administrative division and the project area

Project area of the Maung project, its reservoir and construction areas, is located in Kabupaten Banjarnegara as shown on Figure 4-21. The reservoir will flood, partially or wholly, ten-villages within Banjarmangu, Wanayasa, Karangobar and Pagentan Kecamatans as shown on Figure 4-22.

(2) Statistics of Kab. Banjarnegara in April 1979

Population and profession

Population is 657,227 in total, 321,689 male and 335,538 female. Professions of persons aged more than 10 years are as follows.

Profession	Number	
Farmer (Owner)	152,972	(47.5)
- do - (Employed)	80,361	(25.0)
Fisherman	174	(0.0)
Office worker	7,926	(2.5)
Industry labour	9,010	(2.8)
Building labour	7,021	(2.2)
Merchant	11,496	(3.6)
Offic er (Government & Army)	10,630	(3.3)
Pensioner	1,837	(0.6)
Others	40,300	(12.5)
Total	321,727	(100 %)

Education and religion

Ninety three (93) per cent of population above 5 years old are educated or under education in schools. Religeon is overwhelmingly Islam, 99% of population.

Vegetation

Main vegetation is as listed below.

Kind	Harvested Area (ha)	Total production (ton/year)
Rice	2,940	8,969
Corn	9,245	1,680
Cassava	367	1,581
Potato	372	1,033
Peanut	209	294
Soybean	93	534
Other vegetables	-	75

Plantation and animals

Coconut (about 1.1 million numbers) and coffee (about 2 million numbers) are main plantation. Domestic fowls (hen, cock, duck etc., about 650 thousand numbers) and domestic animals (goat, cow etc., about 180 thousand numbers) are breded.

Industries (except fishing industry)

No remarkable industries, other than small scale coconut sugar (3,906 numbers), pantile (199 numbers), bamboo (1,836 numbers) factories etc., are developed.

Diseases

Respiratory tract infections, skin diseases and malaria are main diseases.

(3) Water quality of river at the damsite

Water quality test data at the Clangap site (15 numbers in total) can be referred to Volume 3B of Refs 4. Some figures, average of 15 numbers, are quoted from the above-mentioned data, as listed below.

Test Item	Average of 15 Nos.
Colour, Colour scale	10.5
Conductivity, μ mho/cm	173
Heavy metal, mg/l	Negative
pH	7.7

(4) Fishing industry

Statistic in 1977 (Dinas PERIKANAN - Semarang) shows the area and products of pond culture in the Central Java as below.

Area (ha)	Product (ton)	Income (x 10 ⁶ Rp)
1,544 (146.2)	2,104 (413.9)	774 (144.0)

Note: Figures between parenthesis are of Kab. Banjarnegara.

Cultivated fish production in the man-made lakes is a feasible proposition. The environment of the Serayu basin seems ideal for fish cultivation.

Though a reliable estimation should wait a detail survey on biological and ecological conditions for the fishery from limnological viewpoint, an attempt is made to estimate the feature of fishing industry in the Maung reservoir, on the basis of statistic stated above and suggestions given by the Dinas PERIKANAN-Semagang.

- . Nilem carp (Nilem), Tilapia (Nila, Mujau) and Puntius (Tawes) would be suitable kind for cultivation.
- . Maximum annual yield of about 350 kg/ha could be expected, namely about 270 ton per year. Sales value of the production is presently Rp/400 kg or \$640/t. Costs for the production is presently Rp 150/kg or \$240/t.

CHAPTER 5

PLAN FORMULATION

5.1 General

This chapter sets forth plan formulation of the Maung project under the considerations of:

- . Timing of the Maung project implementation which promises the most feasible development plan of power plant in Central Java (Clause 5.2)
- . Basic layout of the Maung project which enable the most promising use of the potential water head between the Maung and the Mrica projects (Clause 5.3)
- . Optimal scale of the Maung project which enable the most beneficial use of the runoff at the damsite (Clause 5.3)

5.2 Power Development Plan in Central Java

5.2.1 System Output Capacity in FY 1979/80 - FY 1982/83

The actual output capacity (see Table 3-1) in the Tuntang/Ketenger System and its extension is summarized in Table 5-1 according to the definite plan by PLN as described in CHAPTER 3, for FY 1979/80 - FY 1982/83 beyond which the power development plan subjects to study hereinafter. In preparing this table, the diesel power stations, either existing within the present system or isolated, are totally ignored, because it is PLN's principle that any diesel power station shall be removed to other place, if its service area comes under the transmission system.

The system's actual output capacity will increase from 172.5 MW in FY 1979/80 to 412.3 MW in FY 1982/83 by being added with 39.8 MW of hydro power (Sempor, Garung and Wonogiri) and 200 MW of steam power (Semarang No.3).

The actual output capacity of the Semarang East Gas Turbine Power Plant will maintain 11-26 % of the total actual output capacity of the system.

That will be enough to clip off the occasional peak, which has been assumed to be 7 % of the system load.

The capacity factor of hydro power plants will lower to a level of 34 - 35 % in the dry season. The typical load duration curve on Figure 3-5 shows that such a power station as having 34 - 35 % of capacity factor can meet 35 - 40 % of total load in the upper portion of the load duration curve if the actual output capacity is enough. The values of Hydro/(Hydro + Steam) maintained between 18 - 40 % in Table 5-1 suggest that the total actual output capacity (Hydro + Steam) can be fully utilized to meet the load though it might a little reduce in FY 1981/82.

5.2.2 Load and Supply Balance Between FY 1979/80 and FY 1988/89

Figure 5-1 illustrates the peak load projected in PLN's sales target and the actual output in accordance with the construction schedule in 5.2.1 between FY 1979/80 and FY 1988/89 in Central Java.

No failure in supply can be seen between FY 1979/80 and FY 1986/87, if the actual output capacity and load are compared on Figure 5-1.

The actual output will reduce if some generating unit is being overhauled. The system dependable capacity is hereinafter defined to be the total actual output capacity excluding one largest unit which is assumed to be under overhaul.

The system dependable capacity is plotted with dashed line on Figure 5-1. It is usually located below the load except in certain period in FY 1982/83. This shows that certain power shortage will be inevitable for the period that a largest generating unit (Semarang No.1 or No.2 upto FY 1981/82 and Semarang No.3 onward) is being overhauled.

The situation will be changed after FY 1983/84, if the interconnection between Central and West Java systems by a 500 kV EHV line is constructed as scheduled by PLN and accordingly a power swap is made possible between the two systems.

In order to examine the possibility to import power from the West Java system to the Central Java system during the time in which the largest unit is being overhauled, the actual output capacity and load in the West Java system is compared for FY 1984/85 - FY 1988/89, based on PLN's sales target in Table 5-2. It is found that there will be a surplus of more than 200 MW in the actual output capacity throughout FY 1985/86 - FY 1988/89. The largest units in the two systems in FY 1988/89 are 1 x 600 MW (Suralaya) in West Java and 1 x 200 MW (Semarang No.3) in Central Java. Therefore, power can be imported from the West Java system to the Central Java system during the time that Semarang No.3 is being overhauled, if the overhaul program of plants is reasonably scheduled.

Coming back to Figure 5-1, it is clear that the Central Java system will be regularly in short of power after FY 1986/87, if new power plant is not introduced. In the present plan of PLN, the Mrica hydro power station 3 x 60 MW will be commissioned by the end of FY 1986/87. The daily energy output of the Mrica power station is estimated to be 312 MWH in the dry season as will be described in 5.2.3. It is estimated that the Mrica power station, though it has a large installed capacity, can afford to 50 - 80 MW in actual output with the abovementioned energy output. In consequence, the Mrica power station can meet all the deficit only until FY 1987/88, even if it is commissioned as scheduled. It is recommended that the construction of the Mrica power station be delayed until the load condition will allow more effective operation of the Mrica power station and, instead, a new 200 MW steam power station be constructed to meet the deficit after FY 1986/87.

In summary, the projected load in the Central Java system can regularly be met between FY 1979/80 and FY 1988/89, if PLN's present construction schedule is implemented except that a new 200 MW steam plant is commissioned in FY 1987/88 instead of the Mrica hydro power station. Certain saving in power demand will be necessary during the time that a large generating unit is being overhauled in FY 1979/80 - FY 1983/84. On the other hand, in FY 1984/85 - 1988/89, there will be no power shortage owing to the power swap between the Central Java and West Java systems through a new 500 kV interconnection line, if the overhaul program of plants is reasonably scheduled.

5.2.3 Power Supply Plan for FY 1989/90 - FY 1995/96

The load in the Central Java system will grow from 500 MW to 1,330 MW between FY 1988/89 and FY 1995/96. In this stage, the occasional peak will be met by gas turbine plants as same as in the previous stage. The reserved power for overhaul will be effected by either constructing a stand-by generating unit or through power swap between the Central and West Java systems. The regular load except the occasional peak load must be met by the steam and hydro power, existing and additional.

(1) Alternative plans

In order to determine the optimum power development plan for FY 1989/90 - FY 1995/96, the following 5 alternative plans are compared.

- . Alternative I (Steam): Construction of 200 MW steam power plants
- . Alternative II (Maung + Steam): Construction of the Maung hydro plant (190 MW assumed) and subsequent 200 MW steam power plants
- . Alternative III (Maung + Mrica + Steam): Modification of Alternative II. The Mrica hydro plant (180 MW) is introduced in an appropriately later time.
- . Alternative IV (Mrica + Steam): Construction of the Mrica hydro plant (180 MW) and subsequent 200 MW steam plants
- . Alternative V (Mrica + Maung + Steam): Modification of Alternative IV. The Maung hydroplant (190 MW) is introduced in an appropriately later time.

(2) Assumptions

- . The load to be met by steam and hydro plants is as illustrated in Figure 3-6.
- . The daily load duration curve on Figure 3-5 is applicable for the load to be met by steam and hydro plants throughout the study period.
- . The installed capacity is herein defined to be the maximum output capacity of the power plant; the actual output capacity for the existing power plants and the installed capacity itself for the additional power plants.

- . The installed capacity of the Maung hydro plant is assumed to be 2 x 95 MW.
- . The installed capacity of the Mrica hydro plant is assumed to be 3 x 60 MW following to Ref. 4.
- . The energy outputs of the Maung and Mrica hydro plants are estimated by use of newly estimated run-off record. Irrigation take under the "Design Future" condition in Ref.4 is deducted in the river stretch between the Maung and Mrica sites.
- . The primary energy is herein defined to be the energy output under the most critical hydrological condition. It is first obtained as the daily value and then converted into the annual value by multiplying 365 days.
- . The secondary energy is herein defined to be the difference between the total energy output and the primary energy output.
- . The Semarang No.1 (50 MW), No.2 (50 MW) and No.3 (200 MW) steam plants, totally 300 MW in installed capacity are herein called the existing steam plants.
- . The Jelok, Timo, Ketenger, Sempor, Garung and Wonogiri hydropower plants are called the existing hydro plants. Their total actual capacity is 67.3 MW.
- . The ratio of the primary energy output to the total energy output for the existing hydro power plant is assumed to be equal to that of the Maung hydro power station.

The assumed installed capacity and energy output of hydro plants are summarized below:

Name	Installed Capacity (MW)	Annual Energy Output (GWh)			Daily Primary Energy (MWh)
		Primary	Secondary	Total	
Existing	67.3	204	62	266	560
Maung	2 x 95	277	87	364	760
Mrica					
- before Maung	3 x 60	114	486	600	312
- after Maung	3 x 60	184	416	600	504

(3) Alternative plans fitting to the load growth

In fitting the development schedule of each alternative plan, the total installed capacity at the beginning of a fiscal year is set to be minimum possible but to be enough to meet the load at the end of the fiscal year. Consideration is usually so made as to maximize the utilization of the installed capacity which is available at the time.

The primary energy only is assigned to the hydro power plant (to gauge the dependable peak power corresponded to load curve). Under this condition, the hydropower is operated with a low capacity factor and accordingly takes the peak portion of the daily load curve.

The hydro power is, in the first place, assigned to such a portion of the load as to utilize the installed capacity as much as possible and then the steam power to meet the remaining part of the load, because O & M cost of hydro power is lower than the steam power.

Among the hydro power plants the priority is set in the order of construction sequence. The hydro power plants which have been operated is first assigned to such a portion of the load as to utilize the installed capacity as much as possible and next the newcomer hydro power plant is assigned.

A new plant is commissioned at the beginning of a fiscal year so that the system dependable capacity meet the load in the whole period of that year.

Figure 5-2 shows the development schedules for the 5 alternative plans.

(4) Cost comparison of alternative plans

The present value of the economic cost of alternative plans are compared in terms of the capital cost, replacement cost and fixed O & M cost less the saving in variable O & M cost (fuel cost) in the steam power plant.

The evaluation period is fixed to be 50 years starting at the beginning of FY 1989/90 and a discount rate of 12 % is assumed. All the

economic costs are estimated at FY 1979/80 price level.

The economic construction cost is assumed to be \$250 x 10⁶ for the Maung hydro power plant, \$240 x 10⁶ for the Mrica hydropower plant and \$170 x 10⁶ for 200 MW steam power plant, respectively, and cost of fuel is estimated to be US\$30/barrel. The basis for the estimate of fixed and variable O & M costs are as described in CHAPTER 7.

The capital costs of all the power plants which are scheduled to commission between FY 1989/90 and FY 1995/96 are counted in estimating the present value of the capital cost. The steam plant to be commissioned in FY 1995/96 in each alternative plan does not be fully utilized. The capital cost of this plant is reduced by the ratio of the utilized capacity at the end of FY 1995/96 to the installed capacity.

The replacement cost is assumed at certain time intervals during the evaluation period.

The annual value of fixed O & M cost of a power plant is estimated based on the capital cost of the plant and it is capitalized for the evaluation period.

The saving in fuel cost owing to the operation of existing and proposed hydro power plants in a year is estimated based on the primary and secondary energy outputs which are utilized in the year. The saving in cost beyond FY 1995/95 was assumed to be equal to that calculated at the end of FY 1995/96.

The present values of cost and saving of the alternative plans are referred to Table 5-3 and summarized below.

Alternative Plan	Unit \$10 ⁶ capitalized				
	I	II	III	IV	V
Capital, Replacement and Fixed O & M					
- Maung (1)	-	313	313	-	178
- Mrica (2)	-	-	169	298	298
- Steam Plants (3)	612	387	345	481	396
Saving in Fuel Cost (4)	-	187	325	244	350
Total (1)+(2)+(3)-(4)	612	513	502	535	522

The abovementioned results show that the introduction of hydro power, either the Maung or Mrica is more advantageous than relying on new steam plant only (Alternative I). Regarding the hydro power plant to be commissioned at the beginning of FY 1989/90, the Maung is more economical than the Mrica. The best sequence is observed in Alternative III.

5.2.4 Recommended Power Development Plan

The need for the construction of a new 200 MW steam plant in FY 1987/88 has been disclosed in 5.2.2 and it has been made clear that Alternative III be selected for FY 1989/90 - FY 1995/96 in 5.2.3. Now the power development plan between FY 1980/81 and 1995/96 is proposed as shown in the following table and is also illustrated in Figure 5-3.

Operation start year	Plant	Capacity (MW)		Type ^{/1}	Status ^{/2}
		No.	MW		
FY 1980/81	Sempor	1	1 = 1.0	H	UC
81/82	Garung No.1 & No.2	2	13.2 = 26.4	H	UC
	Wonogiri No.1 & No.2	2	6.5 = 13.0	H	UC
82/83	Semarang No.3	1	200 = 200	S	UC
87/88	Steam	1	200 = 200	S	P
89/90	Maung No.1	1	95 = 95	H	P
90/91	Maung No.2	1	95 = 95	H	P
91/92	Gas	1	50 = 50	G	P
92/93	Steam	1	200 = 200	S	P
94/95	Mrica No.1 & 2	2	60 = 120	H	P
	Steam	1	200 = 200	S	P
95/96	Mrica No.3	1	60 = 60	H	P
	Steam	1	200 = 200	S	P

Remarks; /1: H = Hydro, S = Steam, G = Gas

/2: UC = Under construction, P = Under planning

Note (1) Geothermal power plants is an alternative way of supplying base power in place of steam power plants which are to be newly implemented as listed above.

(2) Gas power plant is possibly replaced by an alternative hydro-power plant.

In FY 1991/92, the estimated occasional peak will exceed over the capacity of the East Semarang gas turbine plant. Therefore, it is recommended to commission a new gas turbine of 50 MW in FY 1991/92.

The recommended power development schedule does not include the installation of a power plant to be reserved for the overhaul of any of plant in the Central Java system. In this connection, there may be certain power shortage between FY 1980/81 and FY 1983/84, but the power swap between the Central and West Java systems through a 500 kV interconnection line can meet such shortage between FY 1984/85 and FY 1988/89. If the reserved capacity in the West Java system would not be available for the Central Java system after FY 1988/89, a 200 MW steam power plant as a reserved unit should be introduced in the Central Java system in addition to the recommended plan.

5.3 Basic Layout

5.3.1 Introduction

In the pre-feasibility study report (Vol.6 of Ref.4) Maung project, after a primary consideration, was proposed as a hydroelectric power project which would be implemented by the year of 1988 after the development of the Mrica project and would have a power plant of installed capacity 170 MW and a reservoir having full supply level (FSL) at EL.588 m and minimum operating level (MOL) at EL.559 m^{/1}. Power house was designed to be located just downstream of the dam then tailrace water level was fixed at about EL.396.5 m. Full supply level of the Mrica project, after examining its optimal feature, was proposed at EL.231 m. No development plan which aims at to utilize remainder potential water head between the Maung and the Mrica project, namely 165.5 m (EL.396.5 m - EL.231 m), was presented.

^{/1}: In the Vol.6 of Ref.4. FSL and MOL are stated at EL.593 m and EL.564 m respectively. Topographical survey this time revealed the level being lowered by 5 meters at the Maung dams site, while no change at the Mrica dams site.

5.3.2 Alternatives

A reconnaissance and map study between the Maung damsite and the backwater end of the proposed Mrica reservoir revealed that the Merawu river stretches in a mountainous area for 8 km between the Maung damsite and Clangap and then enters the vast Serayu depression of deep alluvial deposit, as referred to location map on Figure 5-4. The river bed elevation at Clangap is EL.290 m which is 106.5 m below the proposed tail water level of the Maung power station.

This water head may be utilized for power generation, so far as the site condition suggests. A waterway may be constructed between the Maung damsite and Clangap and also the Clangap site is suitable for the construction of a dam though its height will be limited to be 80 m.

With the abovementioned considerations five alternative layouts are worked out. Their structural layouts and schematic waterway profiles are as shown on Figure 5-4. The feature of Alternatives are explained below:

- Original: The power station is located immediately downstream of the dam. No downstream development. Layout proposed in the prefeasibility study is followed with some modifications.
- Alternative I: Original + the Clangap dam and power station. Water head increases by 80 m against Original.
- Alternative II: Modification of Alternative I. The Maung power station is moved to the backwater end of the Clangap reservoir. Additional water head is 106.5 m against Original.
- Alternative II': Modification of Alternative II. The headrace tunnel of the Clangap power station is constructed between the Maung power station and Clangap site and the Clangap dam is not constructed. Water head increase is 106.5 m against Original.
- Alternative III: The Maung power station is constructed underground and the tailrace tunnel is excavated to the Clangap site. No Clangap power station. The water head gain is 106.5 m against Original.

5.3.3 Selection of The Best Layout

To compare the Alternative layouts and to select the best one, power generation and construction cost are estimated for respective plan as shown in Table 5-4.

Comparison of Alternative layouts is summarized below.

Alternative	P (MW)	E (GWh)	C (\$/kW)	C (\$/kWh)	Technical comment	Other comment
Original	158	303	1,362	0.710	-	106.5 m potential loss
Alt. I	231	443	1,257	0.656	-	26.5 m potential loss
II	256	490	1,156	0.604	-	-
II'	253	485	1,082	0.564	Relatively long tunnel is needed.	Synchronous operation of M & C is obliged.
III	252	483	1,236	0.645	Big under- ground structures and long tunnel are needed.	Big initial investment is needed.

Note: P = Dependable power, E = Annual energy, C = Unit construction cost
M = Maung plant, C = Clangap plant

Both Original and Alternative I utilize the potential water head to limited extents, and therefore power generations are less than those of other layouts, and also these layouts require higher unit costs.

Alternative III will offer technical difficulties in constructing huge underground structures in a tuff breccia layer of relatively young era at this site. The saving in the initial development by staging is impossible.

Alternative II and II' will produce almost same amount of power. Alternative II' shows an advantage over Alternative II in its unit costs. Operation of the power plants both the Maung and Clangap plants in Alternative layout II' is, however, compelled to be synchronous since no regulating pond can be provided for the Clangap project. Moreover, some difficulty might take place in constructing relatively long tunnel in case Alternative layout II'.

Through the considerations stated above, Alternative II is selected as the best layout at this stage of study. Alternatives II and II' have no essential difference between them so far as the layout of the Maung project itself is concerned except a minor part; the terminal part of the tailrace of Maung project. Therefore final selection between Alternative II and II' can be made in the stages of detailed design of the Maung project or of feasibility study for the Clangap project.

5.4 Optimal Scale

5.4.1 Methodology and Examined Cases

Reservoir operation studies were made to find the annual average energy and the installed capacity for each reservoir scale. A computer program was prepared for the simulation. The procedures are summarized as follows:

The difference between inflow I to the reservoir and the outflow O from the reservoir is the rate of change of storage. The equation of continuity is expressed as follows.

$$\frac{dS}{dt} = I - O - E \quad (1)$$

where S is the storage, t is the time and E is the evaporation from the reservoir.

Monthly mean discharge in Table 4-3 is used as inflow I in Equation (1) above. A period of simulation is 75 years between 1904 and 1978. Evaporation from the reservoir surface is assumed to be 3 mm/day. Initial water level for the simulation is Full Supply Level (FSL).

In the computer program for the simulation, it was assumed that storage is zero at FSL. If the accumulation of difference between inflow and outflow is negative, water level stays between FSL and MOL. If water level is between FSL and MOL, the outflow is kept constant such as 10, 16 or 18 m³/sec. This constant outflow is defined as the firm discharge.

If the accumulation of difference between inflow and outflow is positive, namely while water level stays at FSL, the storage water is released as much as possible through the waterway to produce secondary energy and to minimize the spillout. The deepest trough or the largest negative value is the effective storage needed for the given outflow. If MOL is arbitrarily selected, FSL is given from the reservoir storage curve. Discharge through the waterway is determined dividing firm discharge by the capacity factor of the power plant. Storage in the reservoir is numerically ordered and the water level corresponding to 90 % storage from the top is multiplied to discharge through the waterway to find dependable power. Firm energy is defined as the energy which is produced by the constant discharge through the waterway. Secondary energy is defined as the energy which is produced by the surplus discharge while water level stays at FSL. Firm energy is calculated multiplying discharge through the waterway by the water head corresponding to the average storage. Secondary energy is calculated multiplying discharge through the waterway by the water head corresponding to the FSL. The annual average energy is the summation of firm energy and secondary energy.

For the evaluation of evaporation, the first simulation using the Equation above was made to find the average reservoir area assuming zero evaporation. In the second simulation, evaporation is subtracted amounts multiplied the average reservoir area by the evaporation rate from the Equation above.

As it is adequate for the hydro-electric plant to share in peak load, the operation time a day is assumed to be four hours for the Maung hydroplant, referring the daily load curve shown on Figure 3-5. This means the capacity factor of the power plant being set at 0.167 (4/24). Operation time is extended more than four hours in case water level

stays at FSL and inflow is more than the amount required for four hours operation. Minimum operation level is assumed to be higher than EL.550 m by considering both the elevation filled with sediment for a hundred years (EL.539 m) and flow condition to the intake. Simulation studies were made for the cases of MOL 550, 555, 560 and 565 m.

5.4.2 Results of Reservoir Operation

The simulation studies are made for the case of MOL 550, 555, 560 and 565 m changing firm discharge from 6 m³/sec to 19.0 m³/sec. The relationship of three parameters, they are firm discharge, FSL and MOL is prepared as shown on Figure 5-5. The annual average energy and installed capacity of the plant calculated from these three parameters are also shown on Figure 5-5.

The annual average energy increase as MOL is getting higher for a certain FSL, because though firm energy decreases in accordance as the increase of MOL, the plant has capacity to absorb residual water into secondary energy generation if the operation time a day is four hours. There is no significant increase on the installed capacity when FSL is over EL.598 m.

5.4.3 Determination of Optimal Scale

The determination of the optimal project scale was made by the annual-cost method in which all benefits and costs are converted into equivalent uniform annual figures, at a discount factor 12 %.

The criteria and conditions applied for the economic analysis are the same as applied in the economic analysis described in the succeeding CHAPTER 7.

The results of economic analysis are depicted on Figure 5-6. FSL 593 m on the case of MOL 553 m is selected as the optimal project scale, since the annual net benefits are greatest. The installed plant capacity is 190 MW (2 x 95 MW) on that case.

CHAPTER 6

PRELIMINARY DESIGN AND COST ESTIMATES

6.1 General Description of the Proposed Facilities

The Project includes construction of the Maung dam of 179 m in height above riverbed, an intake, waterway of about 2.1 km in length including penstock line, an aboveground power station with installed capacity of 190,000 kW and about 16 km long 150 kV transmission line including a sub-station at the town Banjarnegara from the power station to connect with the Central Java system.

The general layout of the proposed facilities is as shown on Figure 6-3.

6.2 Preliminary Design of Project Works

6.2.1 The Maung Reservoir

The proposed damsite for the Maung dam is on the Merawu river about 9 km upstream from the confluence of the Serayu river and the Merawu river. The Maung reservoir will have a gross storage capacity of $384 \times 10^6 \text{ m}^3$ of which active storage capacity is $230 \times 10^6 \text{ m}^3$. FSL is at EL.593 m and MOL is at EL.553 m, the drawdown is 40 m, the area and storage capacity curves of the Maung reservoir are as shown on Figure 6-1. A map of the proposed reservoir area is shown on Figure 6-2. The flooded area is 7.8 km^2 at TWL.

6.2.2 The Maung Dam

(1) Dam axis and type

The plan of the Maung Dam can be seen on Figure 6-3. The dam axis is fixed to be the same as what proposed on the pre-feasibility study (Re. Vol. 6 of Ref. 4). There is no better alternative location of dam axis, as the vicinity topography indicates.

The Maung dam is designed as a zoned rockfill dam. The profile and cross section are shown on Figure 6-4. One may suggest a concrete gravity dam instead of a rockfill dam, because of steep slopes in the abutments.

It is, however, estimated that the foundation rock chiefly composed of tuff breccia of a relatively younger era in Upper Tertiary has 7.9 kg/cm^2 of cohesive strength and 38.3° of angle of internal friction, which are insufficient for the foundation of a 179 m high concrete dam, but enough for the rockfill dam foundation.

Facing type dam, concrete or asphalt concrete type, is considered competitive because the project site is located at relatively wet area and facing type will be less effected by rainfall compared to earth core type. The type, however, is rejected because the dam is as high as 179 m which is listed in the most highest figure among existing facing type dams in the world then it is too risky to construct such a big scale facing type dam in Indonesia where there has been no existing case of facing type dam and seismic effect is relatively big while there are many of earth center core type dams existing in this country.

A center core type of embankment is proposed based on the material availability and technical reliability considerations.

The groundwater table along the dam axis is shallow and parallel to the ground surface. This fact indicates that the rock surface is lower permeable. There are some high lagoon zone in andesite formation but the results of grout test show this zone can be successfully grouted. In consequence, the ground seepage can be reasonably controlled by an ordinarily planned grouting.

(2) Zoning

Core (Zone (1))

The core of the Maung dam is designed as a homogeneous embankment of earth material to be obtained from borrow sites No.E6 and E4. So far the samples taken from these sites were tested, the coefficient of permeability is sufficiently low as $1 \times 10^{-6} \text{ cm/sec}$ or less and the plasticity index is 30 % or more which indicates high resistivity against piping. Core is designed to have a width to be 50% of the reservoir water head based on a generally accepted consideration for water tightness and for quick dispersion of pore water pressure during the construction stage.

Filter (Zone (2))

The filter zones are provided, with varying thickness of 10% of the reservoir water head, on both upstream and downstream faces of the core zone. The filter material is supplied partly from the sand and gravel in the borrow site No.SP1 and partly from the excavated material from the spillway site.

Inner shell (Zone (3))

Excavated rocks, chiefly produced from the spillway, is used for the inner shell zone. The volume of this zone is determined to make maximum use of excavated rocks in the spillway.

Outer shell (Zone (4))

Quarried rock from the quarry site No. Q51 is used for the outer shell zone. Outside slopes of the zone, namely the dam slopes, are determined after stability analysis which is explained in 6.2.2 (4).

Crest height of the dam

The crest height of the dam is determined at EL.599 m, 6 m above FSL at EL.593 m. The freeboard is 2 m above the reservoir water surface when the design flood discharge ($2,900 \text{ m}^3/\text{s}$, see 6.2.3) passes the spillway. If PMF takes place the freeboard reduces to 0.5 m.

(3) Foundation treatments

At the core zone, excavation line is determined at the depth where appears durable, fresh and groutable rocks. All top soils is stripped at both the filter and shell zones.

Cement grout curtain, alignment of which is determined on the base of both the field grout test and water test, is constructed along the dam axis. Blanket grout is also applied for the whole area of the core bottom to enhance the cutoff effect and also the bearing strength of rocks at its shallow depth. An analysis of ground seepage is explained in 6.2.2 (4).

For the purpose of the inspection of the ground seepage after impounding water, an inspection gallery is constructed at a low level part beneath the core.

(4) Stability and seepage analysis

Stability analysis

Slope stability was examined by slice method. Conditions of analysis are set up as listed below.

Computation condition

Case	Computed Slope	Seismic Coefficient	Water Level	Pore Pressure
Reservoir full	U/S and D/S	Hh = 0.15 Hv = 0	U/S: FSL D/S: River bed	Steady seepage at FSL
Drawdown	U/S only	Hh = 0.075 Hv = 0	U/S: FSL to MOL D/S: River bed	Fully remained in core only

Note: U/S = Upstream, D/S = Downstream, Hh = Horizontal component of seismic coefficient
Hv = Vertical component of seismic coefficient

Material property

Zoon	Wet density (t/m ³)	Saturated density (t/m ³)	Cohesion (t/m ²)	Friction angle (degree)
(1) Core	1.65	1.75	1.5	25
(2) Filter	1.95	2.15	0	37
(3) Inner shell	1.85	2.10	0	39
(4) Outer shell	1.95	2.15	0	42.5

Note: The property assumed is referred to 4.5.

Safety factors computed and the corresponding critical slip circles are illustrated on Figure 6-8.

The safety factor against the surface plate sliding is also carried out assuming a horizontal seismic coefficient of 0.15.

The minimum safety factors obtained are summarized below.

	Upstream slope			Downstream slope		
	Normal	Seismic		Normal	Seismic	
	Circle ^{/1}	Circle	Surface ^{/2}	Circle	Circle	Surface
Reservoir full	2.34	1.21	1.21	1.74	1.23	1.28
Drawdown	2.34	1.63	1.63	-	-	-

Note: /1: Safety factor computed against the circular rupture by means of slice method.

/2: Safety factor computed against the surface plate sliding.

In all cases, minimum safety factors of slopes are more than 1.5 under the normal condition and more than 1.2 even the seismic force is taken into account; the safety factor is more than the allowable in all studied cases.

The stability analysis so far carried out by conventional means show that the proposed dam is structurally safe. The dam is, however, 179 m high and the abutment slopes along the dam axis are about 40° in the average gradient. These conditions indicates that, the static analysis by assuming a single coefficient of seismic acceleration to the whole dam body might be unapplicable and the shearing stress in the embankment near the abutment contact may be large. It is recommended that the dynamic stability analysis and stress analysis be performed in the detailed design.

Seepage analysis

The seepage through the proposed dam and its foundation is analysed by means of the finite element method. The seepage model assumed is illustrated on Figure 6-9. The flow-net resulted is as shown on Figure 6-10.

This analysis disclosed the following conclusions:

- . The total seepage through the dam and its foundation is estimated to be 45 l/s, if the reservoir water surface is maintained at FSL. Its annual value of $1.4 \times 10^6 \text{ m}^3$ corresponds to only 0.2 % of annual inflow, or, is equivalent to 0.6 % of the active storage capacity.
- . Residual pore water pressure in the downstream zone (inner shell zone) of the dam is so small that it does not affect the stability of dam.
- . Seepage velocity is too low to cause a piping failure.

6.2.3 River Diversion System

River diversion system, consisting of coffer dams and diversion tunnels as referred to Figures 6-3 and 6-5, is designed against 20-year flood which has a peak of $1,700 \text{ m}^3/\text{sec}$.

The main upstream coffer dam is so located as to be incorporated in the main dam body later on.

Height of the coffer dam, 55 m above riverbed, is determined so as to limit the volume of coffer dam within that can be constructed in a dry season and to retard the flood flow to an extent that the outflow can be discharged by the tunnel of an appropriate diameter for the construction.

Two lines of diversion tunnels is constructed in the right bank. Their profiles are shown on Figure 6-5. They pass chiefly through tuff breccia, tunneling through which might involve difficulties if the tunnel diameter is large. Therefore, not one-line of large diameter tunnel but two lines of 5 m diameter tunnels are adopted. Moreover two tunnels case has advantages that tunnel closing work is easier, security on discharge capacity is higher and emergency outlet, if determined to be constructed in the detail design stage, is easily added.

The downstream coffer dam, if required, will be very small, because the outlet of the diversion tunnel is located far downstream of the dam.

6.2.4 Spillway

Plan and profile of the spillway are shown on Figures 6-3 and 6-5. The spillway composes ungated crest with width 170 m, chute having a straight converging section from width 170 m to 30 m, flip bucket at the terminal of the chute and plunge pool in the downstream river. Total length from the crest to the flip bucket is 785 m.

The topography favours location on the right bank because it allows the best alignment of approach channel, ungated crest, chute, energy killers and construction access.

The spillway has a capacity to discharge the design flood, peak $2,900 \text{ m}^3/\text{sec}$ (1.2 x 200 years flood) as depicted on Figure 4-3, without considering any retarding effect of the reservoir (Inflow = Outflow), though the outflow peak would actually be reduced to so small as $1,000 \text{ m}^3/\text{sec}$ when the retarding effect is taken into account. Flood rise in the reservoir is 4 meters. There is no evidence of flooding in downstream areas to suggest that the flood mitigation effects of the reservoir are important. Plunge pool is designed for a flood with peak $1,700 \text{ m}^3/\text{s}$ (20 years flood to the reservoir).

The material from the spillway excavation is expected suitable for dam construction, chiefly for the inner shell zone. Because the dam fill requirements are much greater than the volume of excavation of the spillway, there is no advantage in reducing the spillway size so increasing the flood rise and the dam height.

The spillway will be excavated mainly through beds of moderately strong tuff breccia as explained in Clause 4.2. This will provide a good foundation for the spillway crest and chute structures. A cement grout curtain beneath the crest is provided to control the uplift to the downstream chute. Deep cut at the middle of the chute is protected by a shotcrete covering and a systematic drainage works.

6.2.5 Waterway

Plan and profile of the waterway are shown on Figures 6-3 and 6-6. The waterway, maximum discharge of which is $188.1 \text{ m}^3/\text{sec}$, composes gated intake with sill level at EL.540 m, 1,032 m long headrace tunnel with diameter 5.9 m, surge tank, 127 m long penstock tunnel and 912 m long diameter 5.9 m penstock which bifurcate 43.3 m long penstock with diameter 4.2 m - 3.0 m at the spherical branch near the power house.

Topograph and geology favours location of the waterway at the right bank.

Intake sill level is determined at EL.540 m by considering both 100 years silting level and MOL. Approach velocity at the entrance trash rack is 1.0 m/s at the maximum discharge. A roller gate, 5.9 m x 5.9 m, is equipped for maintenance purpose of the tunnel. Pressure tunnel is circular shaped and concrete lined. The diameter 5.9 m is determined by considering economic velocity 4 m/s in the current designs.

Surge tank is located at the end of pressure tunnel aiming at to mitigate big pressure changes caused by load fluctuations. A concrete lined shaft of 8.5 m diameter is constructed having a 21 m diameter and 8.5 m height upper chamber. Up and down surging water levels are calculated respectively at EL.601.5 m (Full load cut in case reservoir at FSL) and at EL.537.0 m (Half load increase in case reservoir at MOL). A roller gate is equipped in the shaft for maintenance purpose of the tunnel. This will contribute for the decrease of construction cost and also for the easiness of transportating metal works compared to the case of applying valves.

Diameter of penstock 5.9 m is determined by assuming the velocity at the maximum discharge being at 4 m/s under the consideration of effect of water hammer to the economy of penstock and generator. Maximum pressure rise is calculated at 50% of the water head at FSL.

Application of a pressure regulator would save the construction cost, though it is not taken into account for the design in this stage for the sake of conservative cost estimation. Penstock is mostly founded on rock bed in an open cut trench except at the upstream part where the penstock is embedded in the tunnel.

Total loss head at the maximum discharge is calculated at 4.3 meters, about 2 % of the gross head.

The waterway passes mainly through tuff breccia similar to that at the spillway. The geology will cause no serious difficulties on the structural conditions of the waterway.

6.2.6 Power House

Above ground type power house is constructed at a place about 2.3 km downstream from the dam by considering the topography and geology as shown on Figures 6-3 and 6-6. It houses two units of power generating equipments (2 x 95,000 kW). Outdoor switchyard is arranged at the right bank downstream of the power house.

(1) Civil Works

To make minimize the excavation volume, the power house is constructed at the river bed of existing river channel. The existing river channel is substituted for a new man-made channel.

The power house is founded on a rock bed of tuff breccia which has enough strength for bearing the structure.

The house has a dimension of 54.2 m in length, 31.5 m in width and maximum height is about 39.5 m, housing two units of turbine and generator (c to c 16 m) and other ancillary equipments such as inlet valves, tailrace gates, overhead crane, control floor etc.

Level of casing center of the turbine is set at EL.360 m which is 2.8 m lower than water level at the tailrace at its maximum discharge. Generator floor and erection bay floor have levels respectively at EL.366 m and EL.371.2 m.

Tailrace is an open channel with width 25 m and has a control point at its terminal with an level EL.361.5 m. Water levels at the maximum power discharge ($108.1 \text{ m}^3/\text{s}$) and the design discharge of spillway ($2,900 \text{ m}^3/\text{s}$) are respectively at EL.362.8 m and EL.367.4 m.

The channel joins with a new man-made channel at about 120 m downstream from the power house. Man-made channel has a width 25 m at its bottom, length about 300 m and slope 1:50.

(2) Station plant

Hydraulic turbine is of vertical shaft Francis type with an elbow type draft tube. By considering relatively high water head more than 200 m, a rotary valve is equipped at its inlet.

Effective head of the turbine will vary between 224.7 m and 208.1 m, 214.3 m in its average, which is taken as the design head. Rated speed is selected at 273 m by applying an experimental formula.

Alternating current generator is of vertical shaft-revolving field-semiumbrella type rated at 106,000 kVA, 13.8 kV, 3-phase, 50 Hz and 0.9 power factor.

Assembling and disassembling of the turbine and generator are performed by using 2 Nos. of 150 tons overhead travelling crane.

Main transformer is rated at 106,000 kVA, 50 Hz, 3-phase two windings, 13.8 kV delta to 150 kV star connected outdoor, fan-cooled type, having three separate single phase tanks in order to reduce the transportation weight.

Outdoor switchyard has a space 100 m by 60 m. A double circuit transmission line is connected to 150 kV double bus. The circuit breaker is rated at 168 kV, 1200 A, 5,800 MVA interrupting capacity and is suitable for synchronizing between Maung power plant and Tuntang system.

Connection diagram and plan of switchyard are shown on Figure 6-11.

(3) Transmission line and substation

Substation to switch the power from the Maung plant to the main transmission line is recommendably located in the outdoor switchyard of the Mri project to make minimize the total power transmitting cost for both Maung and Mrica projects.

A 16 km long double circuit 150 kV transmission line with 242 mm² ACS conductor is constructed between the outdoor switchyards of Maung and Mrica

6.2.7 Effects to The Upstream and Downstream Areas

(1) Land slide in the reservoir area

As described in the Clause 4.2, small scale land slidings are considered common occurrence in the reservoir area, because surface geology in the area is mainly sedimentary rocks. The largest conceivable slide on the reservoir area, however, would have an insignificant effect on the loss of storage capacity and would not displace sufficient water to produce wave action of any sequence, though further detailed investigation should be waited to conclude the effects of reservoir impounding in precise.

(2) Water level fluctuation on the downstream river reach

When the full peak power operation of the Maung plant is performed, water level at the end of the tailrace of power house will fluctuate at 1.3 m in depth between the peak and off-peak time.

Lay of the land along the river channel between the tailrace and Clangap site, at a distance 3.7 km, has a gorge where is expected scarce possibility of inhabitants and animals approaching to the river channel. The land appears flat and low in the downstream of Clangap where Serayu depression developes. Paddy field developes at that area and accesses to the river channel are found in many places. And also an irrigation intake is existing at the Clangap site as described in the Clause 4.5.

Retarding effect of the river channel between the tailrace and the Clangap site on mitigating the water level fluctuation at the tailrace may be small, because the river channel has rather steep slope of 1:50.

It would be required to provide some appropriate device by which warning is given to the downstream reach of the Clangap prior to the peak discharge and discharge change is formed to the Clangap intake for its intake gate control, though precise study should be performed in the detailed design stage.

6.3 Construction Plan and Cost Estimates

6.3.1 General

The implementation schedule of the Maung Project is expected as follows:

- Detailed design including : Jan. 1981 to Dec. 1982
preparation of tender documents
- Tender call and contract : Jan. to Dec. 1983
- Commencement of construction: Jan. 1984
- No. 1 unit commissioning : End of Mar. 1989
- No. 2 unit commissioning : End of Mar. 1990

Cost estimates were prepared for the Maung Project on the basis of a schedule of quantities derived from the preliminary design detailed in the foregoing Clause 6.2, using unit rates and the ruling exchange rate as of February 1980 (US\$1.00 = Rp 626 = ¥241).

It was assumed that the project works would be constructed under three major international competitive contracts:

- Civil contract : Civil works such as dam, diversion tunnels, spillway, waterway and power house including architectural works. (Improvement works of construction access from the port to the project site are not included).
- Metal contract : Metal works such as gates and penstock.
- Electrical contract : Electrical works such as plants including inlet valve at the casing, switchyard equipments and transmission line with a sub-station at Banjarnegara. (Transmission line between the sub-station of Banjarnegara to the load center is not included).

The estimates have been divided into foreign exchange and local currency costs. The division however is approximate only since the amount of foreign currency required will vary with different contractors, the amount of locally owned equipment that can be mobilized, the construction methods adopted and so on.

6.3.2 Construction Plan

Following preliminary design, schedules of quantities for the major items of work are given in Table 6-2.

Construction time schedule which is established after an overall assessment on the planning to develop a logical construction sequence is shown on Figure 6-12.

Location of work facilities like permanent roads, plants, quarters, borrow sites, quarry site and spoil banks is shown on Figure 6-13.

Major equipments and plants for construction use are listed in Table 6-1.

Distribution of excavated and embankment materials is illustrated on Figure 6-14.

(1) Preparatory works

Preparatory works are completed in two years from Jan. 1984 to Dec. 1985. Works for diversion tunnels should have been completed before Apr. 1984.

The following works are, however, recommended to be carried out by PLN with local currency at any time before the period said above.

- Construction of field office, field laboratory, clinic, and access road to/in the project area except the construction roads to be constructed by the Contractor
- Reconstruction of the bridges on the transportation road from Cilacap to the project site

Construction access road in the project area

Totally about 10 km long road for construction use is required. The road has 15 m width (3 lane - one for maintenance), 10% maximum grading and metaling with excavated rocks.

Buildings

Totally about 12,400 m² in floor area buildings is required for field offices (1,600 m²), quarters (7,000 m²), repair shop (2,000 m²) and others (1,800 m²).

Plants

Plants as listed below are required.

Plant	Capacity	Total processing amount (m ³)	Condition for determining capacity
• Aggregates plant for concrete	100 ton/hr	250,000	260 m ³ of sand & gravel for 10 hours a day.
• Filter plant for filter	200 ton/hr	692,000	570,000 m ³ of main dam filter zone for 18 months
• Batchter plant for concrete	30 m ³ /hr	152,000	260 m ³ for 10 hours a day

Water supply facility

Totally 6.8 m³/min in capacity water supply facility is required for plants (1.4 m³/min), buildings (1.5m³/min) work site (2.9m³/min) and others (1 m³/min).

Power supply facility

- A 20 kV power transmission line is required to be constructed between the project site (temporary substation) and the Garung project before the commencement of main work, by the hand of Government.
- Besides for the purpose of both temporary use before the completion of the above stated facility and a reserve capacity, 2 units of capacity 250 kW each diesel generator are prepared.

- Distribution of power at the project area is done by 2 km long-20 kV lines, 6 km long-3,000 V lines and 3 sets-500 KVA temporary substations.
- Total installed capacity is about 2,000 kW for plants (440 kW), building (290 kW), water supply facility (230 kW) and other use (990 kW). Assuming power demand factor at 0.6, peak load is about 1,200 kW.

Other facilities

- A telecommunication facility is required. A telephone system with 40 circuits is provided at the project area. Government will provide a telecommunication system between the Government field and main offices.
- A clinic with one doctor and two nurses and first aid posts are prepared for ordinal and emergent use.

(2) Main dam work

Main dam work, which includes 810,000 m³ excavation and 13,300,000 m³ embankment in total is done during 5 years from May 1984 to Nov. 1988, among which embankment work is done in 4 years between 1985 and 1988. The works are mainly done in dry seasons between May and October. Monthly workable day is assumed 20 days for excavation, 19 days for core embankment and 20 days for other embankments. Two shifts - 14 hours a day work is assumed. Average and peak monthly embankment volume will reach respectively to 440,000 m³ and 500,000 m³.

Foundation excavation is done in two years between 1984 and 1985. Abutment parts, which have rather steep slope as about 1 on 1, are excavated by 21 to 32 ton bulldozer with ripper. The excavated materials are disposed to the spoil bank by using 3.9 m³ wheel loader and 20 ton dump truck. At the core trench, the last one meter above the formation level is excavated by light equipments such as pick hammer and steel bar not to disturb the contact surface to the core.

Impervious core embankment

Core material is chiefly borrowed from E-6 located as referred to the Figure 4-16. Stripping and excavation at the borrow site is done by 32 ton class bulldozer. The excavated material is loaded by 3.9 m³ wheel loader to a 20 ton class dump truck and hauled to the dam, then spreaded by a 21 ton class back-rake bulldozer and compacted by a 30 ton class self-traveling tamping roller in a lift of 20 cm. At adjacent area to the bottom and abutment rock, compaction is done by a light compacter such as air-tamper, rammer and small vibrating roller.

Filter embankment

Filter material is sourced half from sand & gravel borrow site (S-1) and half from the excavated rocks at the spillway. All materials are processed through a filter plant. Excavation, hauling and spreading works are done by the manner as same as that for the impervious core, while the compaction is done by a 21 ton vibrating roller.

Inner shell (Random rock) embankment

The material, 4,220,000 m³ in total, is sourced from excavated materials, they are weathered rock from spillway (2,076,000 m³), fresh rock from spillway (1,056,000 m³), rocks from the dam (95,000 m³), rocks from other excavation sites (500,000 m³) and quarried rock (493,000 m³). Rocks are excavated by both ripping (32 to 44 ton ripper dozer for weathered rocks) and blasting (bench cut by crawler drill and jack hammer for fresh rocks). The excavated materials are loaded by 3.9 and 7.7 m³ wheel loaders, hauled by 20 and 32 ton dump trucks, spreaded at embankment site by 32 ton class bulldozer and compacted by 25 ton class vibrating roller at 60 cm lift.

Other shell (Quarried rock) embankment

The material, 6,930,000 m³ in total, is quarried from the quarry site (QS-1) by a 10 to 15 m high bench cut method. The blasted materials are gathered by 44 ton bulldozer, loaded by 7.7 m³ wheel loader, hauled by 32 ton dump truck and compacted by 25 ton class vibrating roller at 100 cm lift.

Inspection gallery and grouts

Inspection gallery is constructed in 1985 before the core embankment. Blanket and curtain grouts are commenced in Apr. 1985 and proceeded in parallel with the dam embankment works. Curtain grout at the part of inspection gallery is done after the completion of gallery work. Cement grout is applied by means of drilling by a 5.5 kW class boring machine and injecting by 3.7 to 7.5 kW class grout pumps.

(3) Other works

Diversion tunnels

Diversion tunnels, both No. 1 and No. 2, are constructed between May 1984 and Mar. 1985. Tunnel No. 1 is closed in the dry season of 1988, the final year of dam construction works, without using gate. Tunnel No. 2 is closed by gate in Oct. 1988 when the dam embankment work is really completed. Pluggings, located at the central part of the tunnel, succeeds to the closing works. Tunnel is excavated by full-face method fundamentally using crawler mounted drill jumbo, shovel and dump truck. Concrete lining except the invert is done by using sliding form with combination of 60 m³/hr class concrete pump and 3.2 m³ class agitator truck. Invert concrete is placed by using portable conveyer and agitator truck. Backfill grout between rock and lining concrete is performed after lining work.

Coffer dam

Coffer dam, 1,102,000 m³ in total volume, is embanked in one dry season of 1985. The manner of excavation and embankment is as same as that of in the main dam work.

Spillway

Spillway work is done in four years between 1985 and 1988, during which concrete placement is performed in the last two years. Excavation at the plunge pool is performed after the closure of diversion tunnels. Excavation volume is totally 3,600,000 m³, about 80% of which is used for the embankment in the inner shell zone of the dam. Weathered rock is excavated by 44 ton bulldozer with ripper and fresh rock is blasted

by bench cut method. Loading and hauling are done respectively by 7.7 m³ wheel loader and 32 ton dump truck. Concrete placement is done by using 4.5 m³ agitator truck and concrete pump or crane with bucket. Prior to placing concrete at the chuteway slab and wall, anchor bars are provided in the base rock. Excavated slope surface of the chuteway is protected by shot-concrete and drainage system.

Waterway

Construction of waterway is done in 5 years during 1984 and 1988. The sequence of the works is performed, as referred to Figure 6-14, under due considerations on smooth and systematic progress of construction in waterway as well as works at other sites. Headrace tunnel is constructed by the same method as applied for the diversion tunnels. Excavation of the shaft of surge tank is performed by pilot shaft enlargement method by using a 90 kW class large boring machine. Muck is hauled through the penstock tunnel. Concrete lining is done by using sliding form at 1.2 m lift and bucket handled with a crane. The work at the penstock line is affected chiefly by the pipe installation schedule. Excavation is all completed prior to the liner installation. Pipes, which are prefabricated at 6 m unit, are succeedingly installed by crane or rail mounted carrier in parallel with concrete works.

Power house

Power house construction is performed in 5 years during 1985 and 1989. Excavation work is completed in 1985 and 1986. Primary stage concrete at the substructure is finished by the end of 1986, then draft tubes are installed. All concrete placement except secondary concrete relating to the generating equipment installation is finished by the end of 1987. No. 1 and No. 2 units are completed respectively by the end of Mar. 1989 and by the end of Mar. 1990. Excavation work is done by using 32 ton class bulldozer with ripper, 3.9 m³ class wheel loader and 20 ton class dump truck. Concrete placement is done by using either concrete pump or bucket with crane and 4.5 m³ class agitator truck.

(4) Construction access from port to the project site

Load to be carried

In the assessment the following data have been taken as a basis for establishing the access requirements:

• Transporter

Mass : 16 t

Dimensions: 12 m long, 3.2 m wide, 0.7 m head load high

• Bulldozer

Mass without blade: 36 t (44 t with blade)

Dimensions: 5.6 m long, 3 m wide, 4 m high

• Penstock

Mass : 22.3 t

Dimensions: 3 m long, 5.2 m wide, 1.5 m high

• Gate

Mass : 25 t

Dimensions: 4 m long, 6.5 m wide, 1.7 m high

• Valve disc (with transition)

Mass : 30 t

Dimensions: 2.7 m long, 3.4 m wide, 5.3 m high

• Turbine runner

Mass : 22 t

Dimensions: 3.4 m diameter, 1.3 m high

• Stator (6 pieces)

Mass : 20 t

Dimensions: 3.3 m long, 1.9 m wide, 3.8 m high

Proposed access

Conditions of road and railway system are described in Clause 4.4.

- Railway system, from the Port of Cilacap to the Project site, is available for light weight goods having mass and dimensions respectively less than 20 t and 12 m x 2.7 m x 2.85 m, but is not feasible access for the heavy loads as listed above.

- Road system of the route from the Port Cilacap to the Project site is deemed the most recommendable access for the heavy loads since:
 - The port has the capacity to handle ships with a displacement of 15,000 t, although the unloading of heavy loads will have to be carried out by the ships own cranes as there will be no heavy lifting gear at the port.
 - The route has less numbers of bridges which have bearing to improvements compared to the route from the Port Semarang to the Project site.
- Bridges listed below are assumed to be reconstructed by Roads Department.
- Cilacap to Buntu: Slarang (L = 228 m) in case via Adipara or Serayu (L = 202 m) and Jajum (L = 60 m) in case via Sampang.
- Buntu to Banjarnegara: Gumelem (L = 45.5 m) and Sapi (L = 52 m).
- Banjarnegara to the Project site: Serayu (L = 45.5 m) and Merawu (L = 61 m).

6.3.3 Cost Estimates

Cost estimates were prepared following the basic conditions described in Sub-Clause 6.3.1 such as date of price base (February 1980), ruling exchange rate (US\$1.00 = Rp 626 = ¥241) and work system (three major international competitive contracts), etc.

(1) Present-day cost

Civil works

Cost of civil works was estimated on the base of unit price for each item of schedule of quantities. Unit prices were computed following the construction plan described in Sub-Clause 6.3.2 as well as the assumption stated below.

- Costs are divided into foreign and local currency portions assuming divisions in items as the following.

Foreign currency portion	Local currency portion
• Construction plants and equipments including spare parts	• Fuel, oils, lubricants
• Reinforcement bar and steel support	• Cement
• Salaries and expenses of foreign supervisory personnel employed by contractor	• Explosives
• Contractors' overhead and profit components	• Timber for construction purpose
• Miscellaneous architectural materials, special equipments, etc.	• Salaries and wages of construction supervisors and workmen employed by contractor

- Basic prices of materials and wages of labours are assumed as listed in Table 6-3.
- Costs of plants and equipments are broken down to unit prices for schedule of work quantities assuming that depreciation, maintenance repair and administration costs are inclusive in unit prices.
- Freight, insurance and inland transportation costs are gauged in costs for all materials, plants and equipments which are to be imported, while no import tax and duty are assumed in costs.

After computing the unit prices on the base of the construction program, current data of unit price in similar kinds of international contract works were referred, thenafter adjustment of computed prices were performed, when required.

Metal and Generating Equipments Works

The cost estimates for metal and generating equipment works were gauged from current contract prices for similar kinds of works.

Land Acquisition

The resettlement of population in the submerged and construction area is considered the responsibility of the relevant Civil and Administration authorities. Cost estimates for land acquisition, however, assume tentatively that all the population will transmigrate because this is considered the most costly alternative. Land acquisition cost then composes transmigration cost and land compensation cost, which are calculated by using the quantities and unit costs presented in Clause 4-5.

Engineering Service

Engineering service includes detailed design and supervision in the construction stage and is assumed to be done by an overseas consultant together with officers from PLN. A nominal figure of 7.5 % of contract construction costs is allowed for the engineering service costs.

Government Administration

An allowance of 2 % of the sum of contract construction costs and land acquisition cost is added for Government administration costs for the Project.

Physical Contingency

The cost estimates was prepared based on the informations available from the feasibility stage investigation work completed to date.

Allowance must be made for such unknown factors as:

- Degree of certainty of site investigations - aerial mapping, volume in borrow areas, hydrological records, etc.
- Changes in item quantities during detailed design studies
- Geological conditions encountered during construction varying from those now assumed

• Bidding climate at time of tendering

From an assessment of factors involved, a contingency loading of 15 % of the feasibility stage estimates is adopted to obtain the estimate of anticipated project cost.

A summary of present-day (February 1980) costs including an assessment of foreign and local currency requirement for the Project is given below.

Item	Cost (\$ Thousand)		
	Total	Foreign	Local
1. Land acquisition	8,139	-	8,139
2. Civil works			
(1) Dam works	114,467	90,754	23,713
(2) Power facility works	20,200	11,647	8,553
Sub-total 2	134,667	102,401	32,266
3. Metal and generating equipment works			
(1) Metal works	17,826	15,281	2,545
(2) Generating equipments works	28,832	26,256	2,576
Sub-total 3	46,658	41,537	5,121
4. Engineering service and Government administration			
(1) Engineering service ^{/1}	13,599	10,795	2,804
(2) Government administration ^{/2}	3,789	-	3,789
Sub-total 4	17,388	10,795	6,593
5. Physical contingency ^{/3}	29,807	23,210	6,597
Total:	236,659	177,943	58,716

/1 : 7.5 % of 2 + 3

/2 : 2 % of 1 + 2 + 3

/3 : 15 % of 2 + 3 + 4

(2) Project finance requirement

On the assumption that construction of the Maung dam and power station is undertaken in accordance with the construction program presented on Figure 6-12, estimated yearly finance requirement (present-day costs) are shown in Table 6-4.

Annual escalation rate is assumed at 6 % for both foreign and local currency during the whole implementation period. Annual interest rate of 8 % is assumed to be imposed on the foreign currency during the construction period.

Using these rates the present-day costs are extended to show escalated costs as in Table 6-5 and as summarized below.

	<u>Unit \$ Thousand</u>		
	Foreign currency	Local currency	Total
. Present-day construction cost	177,943	58,716	236,659
. Price contingency	94,895	29,625	124,520
. Interest during construction period	58,824	-	58,824
Total	331,662	88,341	420,003

(3) Operation and maintenance

Estimates on annuals costs of operation and maintenance of the Maung project are gauged from data on actual costs of similar schemes.

Allowance 0.5% (\$572 thousand) of dam works cost of civil works is assumed for the annual operation and maintenance cost of dam facilities. Allowance 2.5% (\$1,671 thousand) to the total of power facility works cost of civil works and metal and generating equipments costs is assumed for the annual cost of power facilities.

(4) Replacement cost

Life time of metal and generating equipments works is assumed at 40 years after installation. Replacement costs of these works are assumed sum of costs for installation cost of metal and generating equipment works as well as costs of civil works related to this replacement. Considering a salvage value, 90 % of the installation costs of metal and generating equipments works is gauged for the replacement cost while 10 % of the power facility cost of civil work is allowed for the replacement as a civil works cost component.

6.4 Organization for Construction and Operation and Maintenance

(1) Construction management and organization

Figure 6-15 presents overall construction organization chart. Ministry of Mines & Energy will have overall responsibility for the implementation of the Project. Design and construction of the Project will be executed by PLN. Resettlement in the project area will be cared by Government authorities concerned with the assistance of PLN.

For the execution of construction works, the field office of PLN tentatively named Maung Project Office will be required to be built. The construction works will be carried out by the contract basis with international/local contractors under the supervision of the Project. A technical assistances by foreign and/or local consulting engineers will be provided to the Project for successful performance of the construction work.

(2) Operation and Maintenance

Table 6-6 presents staffing required for operation and maintenance. After completing construction of the Maung Project by the Project Office, operation and maintenance will be transferred to and managed by the hand of Region XIII of PLN as referred to Figure 3-1 of Clause 3.1.

CHAPTER 7

ECONOMIC AND FINANCIAL ANALYSIS

7.1 The Project Output

The project output consists of the firm power, primary energy and secondary energy. The firm power is the maximum power output under the most unfavorable combination of the hydrologic condition and the load condition. The hydrologic condition affects the firm power in the regulated outflow and reservoir water level. The installed capacity is determined to generate the maximum power output which can be generated by utilizing the possible minimum outflow with an appropriate capacity factor if the reservoir water level is high enough to maintain the rated water head. The maximum output reduces if the reservoir water level lowers. In this connection, the firm power is herein defined that the maximum power output to be generated by use of the minimum outflow with a capacity factor appropriate for the operation of the plant under the load condition conceived, when the water head is at a level with a probability of exceedence of 90 %. The firm power of the Project has been estimated in the calculation for Clause 5.2 to increase from 86 MW in FY 1989/90 to 190 MW in FY 1995/96 onward.

The Maung power station generates 277 GWh/year or 760 MWh/day of primary energy evenly through the year, and 87 GWh/year of secondary energy, from time to time. The primary energy is utilized regularly to meet a certain portion of the load and the secondary output saves the variable operation cost of steam power plant.

In the earlier period of operation, the primary energy of the Maung power station is utilized to meet such a portion of load as having rather long duration. The daily operation hours gradually reduces and in FY 1995/96 onward the primary energy is totally utilized for the peaking operation of short duration.

The average rate of fuel consumption in the steam power station is high if the operation hours are short, and vice versa. Accordingly, the value of primary energy of a hydro power station would be set to

be higher for a short operation hours than for a long operation hours, if the hydro electric power should be evaluated based on the cost of a steam power plant. In other words the value of "peak energy" is higher than that of "base energy", in broad sense. In consequence it is herein assumed that the primary energy of the Maung power station is totally generated as the base energy in FY 1989/90 and as the peak energy in FY 1995/96 onward, and the proposition of peak energy is linearly increased between the two fiscal years.

The estimated build-up of the project output is as shown below.

	'89/90	'90/91	'91/92	'92/93	'93/94	'94/95	'95/96 onward
Firm Power (MW)	86	126	140	156	172	188	190
Primary Energy							
- Peak power (GWh)	-	46	92	138	185	231	277
- Base power (GWh)	277	231	185	139	92	46	-
Secondary Energy (GWh)	87	87	87	87	87	87	87

7.2 Economic Analysis

7.2.1 Criteria and Assumptions

An economic analysis of the Maung Hydroelectric Project was made for the development schedule, layout and size recommended in CHAPTER 5, based on the economic internal rate of return (EIRR) criteria. The evaluation period starts from FY 1981/82, which is the first year of the project implementation, and ends in FY 2032/33, 50 years from 1983/84, which is the first year of the project construction. All the cost and benefit are estimated at a constant price level at the end of FY 1979/80.

The cost incorporated in the analysis is the economic capital cost, replacement cost and O & M cost of the proposed project facilities.

The economic benefit is estimated based on the economic cost of the least-costly alternative facilities.

As the least-costly alternative facilities a 200 MW oil-fired steam plant is taken up, based on the following considerations.

- . In the Central Java system, 200 MW oil-fired steam plants will be prevailing in the foreseeable future.
- . Coal-fired steam plant has not been included in any power development plan in the Republic of Indonesia yet.
- . The oil-coal mixed steam plant is more costly than the oil-fired steam plant because of its high capital cost.
- . The economic size of gas turbine power plant is up to 50 MW and the oil consumption rate of this type of plant is high, seemingly only justified for clipping off a peak of very short duration.
- . Regarding the nuclear power plant, it is anticipated that the fuel cost consisting of four elements (refined uranium cost: 20 %, cost for enrichment: 20 %, formation treatment cost: 30 %, retreatment cost: 30 %) is going up sharply. The construction cost per kWh varies considerably by the type of nuclear reactors (BWR, PWR, GCR, AGR and HWR), but there is no definite idea about the type of reactor to be developed in late-1980's.

7.2.2 Economic cost

The economic cost of the project facilities is derived by subtracting the transfer payment which is assumed to be 20 % of the financial cost including tax and local contractor's profit. Economic cost of foreign currency is as same as the financial cost while the economic cost of local currency is 80 % of the financial cost.

The disbursement schedule of capital cost is as shown in Table 7-1.

The economic life of the project facilities is assumed to be 40 years for the metal work, generating equipment, switching equipment, transforming equipment and transmission facilities and 50 years for the civil work. The replacement cost excluding the salvage value is assumed to be 90 % of the capital cost. The replacement cost of metal works and generating equipments consists of $\$42,920 \times 10^3$ disbursed in 2 years starting from FY 2027/28.

The ratio of O & M cost to the investment of project facilities is estimated to be 2.5 % of the power generation and transmission facilities and 0.5 % of dam. The total of annual O & M cost is calculated to be $\$2,152 \times 10^3$.

7.2.3 Economic Benefit

The unit construction cost of 200 MW oil-fired steam power plant is estimated to be \$680/kW excluding the interest during the construction period at the price level of FY 1979/80.

The hydropower plant has a certain advantage against the thermal power plant in terms of loss and outage. The adjustment factors for the hydro advantage are calculated as shown in Table 7-2.

Annual costs during the service life of the power plant are divided in fixed and variable costs as shown below:

<u>Fixed cost</u>	<u>Variable cost</u>
a) Maintenance cost	a) Fuel cost
i) Salary and wages	b) Maintenance cost
ii) Repair	i) A portion of salary and wages
iii) Insurance and others	ii) A portion of repair cost
b) General administration cost	

Note: Duties and taxes to the assets and business activities are not considered.

The fixed and variable costs are obtained as shown in Table 7-3 taking into consideration the adjustment factor between hydro and thermal power plants.

The unit cash flow of alternative oil-fired thermal power plant is prepared in Table 7-4, based on the data in Table 7-3.

The annual equivalent cost of the alternative thermal power plant is calculated to be a composition of kW value and kWh value. The kWh value is estimated to be $\$66.2 \times 10^{-3}/\text{kWh}$ for the peak energy and $\$50.2 \times 10^{-3}/\text{kWh}$ for the base energy including the secondary energy (where the oil price is assumed at \$30/barrel (export price of crude oil of Indonesia as of February 1980)). The kW value is calculated, in accordance with the discount rate assumed, as shown below:

	<u>Unit \$/kW</u>		
	<u>Discount rate</u>		
	14 %	17 %	20 %
kW value	175.8	208.0	242.4

7.2.4 EIRR

The cash-flow of the project benefit is calculated as shown in Table 7-5.

The cash-flow of the economic costs and benefit is prepared as shown in Table 7-6. The present worths of the economic cost and economic benefit are plotted against varying discount rate on Figure 7-1. This figure shows that the value of EIRR is 16.5% under the normally conceivable condition.

The values of EIRR under the condition if the cost is unexpectedly high or the benefit is unexpectedly low can also be derived from Figure 7-1, as summarized below:

	<u>EIRR (%)</u>
A: Normal:	16.5
B: Benefit reduction by 15%:	13.5
C: Cost increase by 15 %:	13.9
D: Benefit delay by 1 year:	14.0
E: Benefit reduction by 15 % & cost increase by 15 %:	11.3

The value of EIRR under the normal condition shows a high economic viability. The project is not very sensitive to unfavorable change in the cost and benefit. The values of EIRR remaining within a feasible range under several unfavorable conditions assumed.

7.3 Financial Analysis

7.3.1 Pricing Structure

The average power charge in Central Java in FY 1977 is estimated to be \$0.0428/kWh including the charge for development as presented in Clause 3.2. It seems that this average power charge has become unapplicable to pay off the cost of power system, due to high fuel cost.

The power charge is established to be marginal to recover the cost of power system. In this connection the power tariff will be revised based on the cost of 200 MW oil-fired steam plant which will be prevailing in the Central Java system from now on.

The Asian Development Bank (ADB) loaned to Indonesia for the Extra High Voltage Transmission Project in Java on November 29, 1979. The loan is repayable in 20 years at an interest rate of 7.6 %. Assuming the same repayment condition, the fixed unit cost (kW cost) of a 200 MW oil-fired steam plant is estimated at the price level of FY 1979/80 as follows:

(1) Financial construction cost including interest during construction period of 3 years	\$789
(2) Capital recovery factor (17 years, 7.6 %)	0.106
(3) Annual repayment; (1) x (2)	\$83.6
(4) Fixed O & M (from Table 7-3)	\$27.8
(5) Sub-total; (3) + (4)	\$111.4
(6) Cost of stand-by capacity; 25 % of (5)	\$27.9
(7) Annual kW cost; (5) + (6)	\$139.3

The kWh cost is estimated by the same procedure as that for the economic kWh value described in 7.2.3; $\$16.2 \times 10^{-3}/\text{kWh}$ for the peak energy and $\$12.2 \times 10^{-3}/\text{kWh}$ for the base energy, where the fuel cost is assumed not by the export price but by the domestic price of C heavy oil ($\$0.0479/\ell$).

The average cost of power at the price level in FY 1979/80 is calculated, assuming that peak energy load is 20 % of the total energy load and the load factor is 73 %.

kW cost; \$139.3/(8,760 hr x 0.73)	= \$21.8 x 10 ⁻³
Peak energy cost; \$16.2 x 10 ⁻³ x 0.2	= \$3.2 x 10 ⁻³
Base energy cost; \$12.2 x 10 ⁻³ x 0.8	= \$9.8 x 10 ⁻³
Total cost/kWh of power	\$34.8 x 10 ⁻³

The average charge is derived from the above-mentioned cost of power at Rp 35-40/kWh, taking into account costs for transmission, distribution and administration and loss between the plant and the consumer. It is indicative that PLN's tariff for FY 1977/78 (average charge is Rp 26.79/kWh) is too low to recover all the cost of the power supply system, if it is applied in FY 1979/80 as it is.

With these considerations, the power charge of \$139.3/kW and \$16.2 x 10⁻³/kWh for the peak energy and \$12.2 x 10⁻³/kWh for the base energy at the price level in FY 1979/80 is attributed to the power generation in the present study.

The gross revenue of the project is calculated by applying the above-mentioned power charge to the project output described in Clause 7.1.

7.3.2 FIRR

A financial cash flow is prepared for 30 years starting from FY 1981/82 as shown in Table 7-7.

In preparing this table, an escalation rate of 6 % is assumed for both the cost and benefit until FY 1990/91 and beyond that year no escalation is assumed. The above 6% of price escalation for foreign currency portion is determined referring to the projection by the World Bank^{1/} which the practice in the ADB (Asian Development Bank) follows. The rate of price escalation for local currency portion is assumed to be the same (6%) as that for foreign currency portion considering the following:

^{1/}: "Price Prospects for Major Primary Commodities"
IBRD, June 1978, p. 20.

	<u>GDP Deflator for OECD Countries</u>	<u>Index of CIF US\$ prices of developed countries' manufactured exports to developing countries</u>
Projected:		
- 1980-1985	7.0%	6.0%
- 1985-1990	6.0%	5.0%

- (1) The domestic inflation in Indonesia is largely affected by the imported prices of manufactured goods from the developed countries, and
- (2) As the project cost is estimated in US dollars, the future increase in Rupiah cost of the Project may be absorbed by the future fluctuation of the exchange rate insofar as the exchange rate moves in proportion with the domestic inflation.

The project benefit is escalated until FY 1990/91 in the same manner as the project cost.

The value of financial internal rate of return (FIRR) of the project is calculated based on Table 7-7 to be 10.1 % for the evaluation period of 30 years, as referred to Figure 7-2.

This value of FIRR is higher than the interest charges of 9 % which is paid by PLN for the outstanding long-term debt nowadays.

7.3.3 Loan Repayability

To examine the Project feasibility from financial viewpoint, loan repayability of the Project is herein examined. Only the foreign component of the total capital cost is presumed to be financed by the loans with assumed conditions. The local component of the total capital cost and the interest during construction are assumed to be financed by PLN's own funds.

It is herein judged that the loan is successfully repaid only if the accumulated surplus which comprise net revenue (gross revenue less O & M cost), less local component of total capital cost, interest during construction and loan repayment, turns out to be positive at the end of the repayment period. It is noted that the replacement cost is estimated to be $\$84 \times 10^6$ to be disbursed in FY 2027/28 and FY 2028/29 and it can be financed from the net revenue of the Project after the repayment period.

As same as the case of FIRR calculation price escalation of 6 % is only assumed until FY 1990/91.

With the above-mentioned criteria, the marginal interest rate on loan is calculated for varying repayment period including a grace period of 8 years as shown below.

Repayment Period (Year)	20	25	30
Marginal Interest Rate (%)	8.6	13.2	15.4

Taking into consideration the likely terms of loans, though it is yet to be determined, the financial statement of the Project is examined in case that the Project is financed by a loan which is repayable over 30 years including 8 year grace period at a 8 % interest rate.

As shown in Table 7-8, the accumulated surplus is turned into positive figure only one year after the Project reaches its final development stage in 1995/96. Afterwards, the Project yields the profit of about US\$30 million after deducting the loan repayment from the net revenue. The accumulated surplus at the end of the repayment period, FY 2010/11, reaches about US\$428 million, which is well over the total capital cost, about US\$361 million.

From the viewpoint of loan repayability, the Project is justifiable.

7.4 Associated Benefit

Associated benefits will be expected to be contributed from the project such as fishing industry, transfer of knowledge and employment opportunity, flood control and water supply, etc.

(1) Fishing industry

An estimate of product of fishing industry is stated in the paragraph (4) of Clause 4-9 that annual net income would amount to about 100 thousand dollars per year by cultivating fishes such as Nile carp, Tilapia etc. in the reservoir.

(2) Transfer of knowledge and employment opportunity

At the stages of detail design and construction, many of local personnel will have chance knowledge transference on the manner and method of surveys and constructions from skilled firms who would work

jointly. Besides skilled and unskilled labours will be required to be employed for the project both in and after the construction stage.

(3) Flood control and water supply

At all flood times, mitigation effect of the flood will be contributed by the project, because the spillway of the project is of non-gate type then no artificial control will be made. Also the relatively big storage can contribute for the increase of irrigation water at dry-years and contribute for silting the fines (so called Wadas Lintan) in the reservoir which is said to have bad effect on the vegetable growth of the paddy fields.

(4) Other benefits

Municipal water supply, to the city Banjarnegara, is possibly made from the reservoir.

The reservoir will present a recreation and resort land located on midway between a sight-seeing route, Wonosobo-Dieng-Karangkobar-Banjarnegara.

Roads constructed in the vicinity of the dam will offer an easy access and communication among the persons living in and around the project area.

CHAPTER 8

FURTHER INVESTIGATIONS RECOMMENDED

8.1 Detailed Design for the Maung Project

8.1.1 Introduction

Detailed design work is required before the commencement of construction works, aiming at to prepare tender documents for construction after detailed investigations added to the feasibility investigation.

The work is assumed to be done by an overseas consultant working with officers from PLN.

The work is to be completed within two years after starting the investigation from possible earliest date in the year of 1981. The work schedule corresponding to main investigation items are expected as below assuming the service being started in January 1981.

- . Inception work: January 1981 through March 1981.
- . Detail investigation (Site): April 1981 through December 1981.
- . Detail design: November 1981 through December 1982.
- . Tender document: November 1981 through November 1982.
- . Implementation program: November 1981 through December 1982.

8.1.2 Scope of Investigation

The scope of investigation is expectedly termed as the followings after due considerations on the results of feasibility investigations and implementation program.

Inception works

- . To review the feasibility report and to prepare work plan on the detail design
- . To perform tender and mobilization of local contract works executed at the site in cooperation with PLN

Detail investigations

- . To perform detail geological investigations in the project area chiefly for the local contract works in cooperation with PLN
- . (Geological investigation will include those items as same as on the feasibility study such as seismic prospecting (about 5 km), core borings (about 300 m) accompanied by water tests, grout test (about 100 m), test aditting (about 400 m) accompanied by rock tests etc.)
- . To carry out detail material investigations chiefly for local contract works in cooperation with PLN
- . To perform hydraulic model tests
- . To perform seismic stability analysis both in case of dynamic approach and static approach
- . To perform detail topographical survey, local contract work, of the structure area and reservoir area in cooperation with PLN
- . To perform additional collection and analysis of hydrologic data in cooperation with PLN and to study reservoir operation
- . To collect information on construction planning in cooperation with PLN
- . To discuss principal conditions on preparing tender documents with PLN
- . To perform detail investigations on transmission line route and sub-station area and local contract works in cooperation with PLN
- . To assist PLN performing detail investigation on land acquisition
- . To prepare documentary film of picturing manner and progress of the investigation works

Detail design

- . To perform detail design of civil structures, that is, dam and appurtenant structures
- . To perform basic design of electrical works
- . To perform basic design of metal works
- . To establish construction plan
- . To prepare Bill of Quantity and Engineering cost estimate
- . To refine the Project feasibility

Tender documents

- . To prepare tender documents for civil works, electrical works (probably of two packages) and metal works

Implementation program

- . To prepare draft Implementation Program for construction to sustain the appraisal of the Project by a fund creditor

In accordance with the progress of investigations, the following reports will be prepared.

- . Work progress report: To report progress of work every month
- . Inception report: To report fruits of inception work after finishing inception works
- . Design criteria report: To submit design criteria report preceding to the detail design work to obtain PLN agreement on it.
- . Tender documents: To prepare tender documents for civil works, electrical works (two packages) and metal works
- . Design report: To prepare fruits of detail design works (including the detail investigation works)
- . Implementation program: To prepare implementation program for construction
- . It is also recommended to install seismograph at the damsite in the earliest chance, because dynamic access on the dam stability will be required in the detail design stage by taking into account of seismic characteristic of the proposed damsite. Further the apparatus will contribute for gauging seismicity after project completion.
- . Man-month required is roughly estimated at about 160 M/M for site works and about 270 M/M for home works respectively, about 430 M/M in total.

8.2 Feasibility Study for the Clangap Project

8.2.1 Introduction

The riverbed slope of the upper reaches of the Merawu river is very steep topographically (1/20 - 1/40) and water head between the Maung dam-site (EL.402 m) and F.S.L. of the Mrica reservoir (EL.231 m) is about 170 m.

But nothing had been planned to make the best of this water head even if availability of water head of 60 m out of 170 m at the lower reaches of clangap metro-hydrological station site (EL.290 m) seems almost scarce due to the topographical and geological conditions.

Therefore, from a viewpoint of the most effective overall development of the river, study on the maps available and field reconnaissance for the Clangap project were carried out during the site survey for the Maung project. And as a result of scrutiny on the various

cases of combination of a dam and power station, as shown on the Figure 5-4, taking into account topography, geology, operation method of the power station and a using purpose of generated electric power, a case, in which the Maung power station is located at 2 km downstream site (EL.361.5m) from the Maung dam and the Clangap dam and power station are constructed at about 3.5 km in direct distance further down the river, was selected as a most prospective plan to utilize remaining water head as effective as possible, as described in the foregoing Clause 5.3.

8.2.2 Outline and Merits of the Clangap Project

The envisaged general features of Clangap dam and power station are as follows:

- . Dam foundation; tuff breccia overlapped by weathered yellowish clay partially
- . Dam, Type; rock fill with center core
 - Height; about 75 m
 - Volume; about 2,500,000 m³
- . FSL of reservoir; EL.363 m
- . Power station, Type; aboveground
- . Tailwater sill; EL.290 m
- . Installed capacity; 1 x 66 MW
- . Annual energy output; 126 GWh

The Clangap project has following merits besides effective use of remaining water head between Maung damsite and Clangap.

- . Generated electric power can be used for peak power demand in the Central Java as same as the case of Maung power station.
- . Outflow from Maung reservoir can be utilized effectively.
- . Power generation of Clangap power station can be controlled daily by Clangap reservoir.
- . When construction of the Clangap project is commenced in succession to the Maung and Mrica Projects, construction cost can be reduced remarkably owing to diversion of the existing roads,

buildings, facilities of quarry site and earth borrow area and heavy equipment, and employment of the skilled workers from the preceding projects directly.

8.2.3 Feasibility Study

As stated above, it is desirable to conduct early execution of feasibility study for the Clangap project.

For this purpose, preparation of the detailed topographic maps which covers the whole Clangap project area is indispensable to carry out the surveys, namely geological investigation and pre-design.

While, data and informations concerning hydrology, electric power condition, construction materials and environmental problems which have been collected for the Maung project will be applied for the study of the Clangap project effectively.

Necessary man-month for execution of the feasibility study is estimated roughly at 105 M/M including 55 M/M for the home works.

CHAPTER 9

SOME CONSIDERATIONS RELATED TO PLN'S NEW POLICIES PRESENTED IN OCTOBER 1980

9.1 General

In October 1980, discussion was made between PLN and JICA on the draft feasibility study report. PLN presented new policies which had been settled in the year of FY 1980/81.

This Chapter sets forth considerations made in relation to the PLN's new policies as described below.

- . New tariff base was settled in July 1980 as per attached Table 9-1. Average tariff is estimated at Rp 42.5/kWh, while the average in the year of 1977 was Rp 26.8/kWh as shown in the Clause 3.2.
- . PLN-Pusat prepared in August 1980 a power expansion plan in the whole Java as per attached Table 9-2. This plan grounds on an assumption that the whole Java will be integrated in an unit system through 500 kV extra high voltage power transmission lines. Maung project is listed to be realized in the year of FY 1990/91, one year behind the proposed schedule as shown on the Figure 5-3.
- . PLN-central Java office prepared in August 1980 two alternative power expansion plans in the region of Central Java as per attached Table 9-3. Alternative plan I proposes an implementation program as Mrica by FY 1988/89 and Maung by FY 1990/91, while alternative plan II proposes Maung by FY 1988/89 and Mrica by FY 1992/93.
- . Domestic price of C heavy oil was raised in May 1980 to Rp 45// from the former price of Rp 39//.
- . Thermal power plant which will be realized in the future will be mainly of coal-fired type which would be the least costly alternative to a hydro power plant .

9.2 Considerations Related to New Policies

Details of considerations made in relation to the PLN's new policies are explained in PART III of APPENDIX in separate volume. Conclusions only are briefed below.

9.2.1 Financial Feasibility of the Project in case Average Tariff being Rp 42.5/kWh

- . Average tariff, which is the power rate at the consumer side, is Rp 42.5/kWh (Re. Table 9-1). Assuming 45 % of the tariff is contributable to costs required for transmission, distribution and administration, Rp 23.5/kWh, or equivalentents \$0.0375/kWh, is estimated as the power rate at the plant side. This rate, \$0.0375/kWh, is about 1.08 times the estimated rate shown in the Clause 7.3.1.
- . It is apparent, if this new power rate is applied, the project will become financially more feasible. FIRR becomes at 10.8 % while it is 10.1 % in the Clause 7,3.2. Loan repayability is also justified.

9.2.2 Feasibility of the Project in case Implemented as Assumed in the Power Expansion Plan of PLN-Pusat

- . Power expansion plan in the whole Java assumed by PLN-Pusat is as refered to the Table 9-2, where, in the feasibility examination in this Clause, installed capacity and annual energy product of the Maung power plant are assumed as same as those presented in the preceding Chapters, namely 190 MW and 364 GWh/year, but completion of the project is assumed all at once by FY 1990/91.
- . It is also assumed that the plant will be operated as a peak power plant from the first year of operation with full peak power dependability of 190 MW.
- . EIRR is calculated at 25.8 % which proves high economical feasibility of the project.
- . FIRR is calculated at 17.0 % which also demonstrates financial soundness of the projects.
Loan repayability is justified.

9.2.3 A Review on Implementation Time of the Mrica Project in relation to Assumed Power Expansion Plan of PLN-Central Java

- . PLN-Central Java office presented an alternative power expansion plan in the Central Java as shown on the Table 9-3.
- . Study in this Clause is limitedly made for Maung and Mrica projects only, because projects other than the above listed on the table have not yet been well investigated and quantitative evaluation is difficult to be made.
- . Present values of cost and saving in each comparison cases are obtained as the table below, where the assumptions and calculation procedure are the same as adopted in the Clause 5.2.3-(4)

Case	/1 Cost (x 10 ⁶ US\$)
I ^{/2} All Thermal	937
III ^{/3} Maung FY 89/90 + Mrica FY 94/95 + Thermal	827
A - do - + Mrica FY 93/94 + - do -	830
B - do - + Mrica FY 92/93 + - do -	835
C - do - + Mrica FY 91/92 + - do -	839
D - do - + Mrica FY 90/91 + - do -	845
E - do - + Mrica FY 89/90 + - do -	849
F - do - + Mrica FY 88/89 + - do -	858
G - do - + Mrica FY 87/88 + - do -	971

Note /1: Cost and saving FY 1987/88 and afterward

/2: Same as Alternative Plan I of the Clause 5.2.3

/3: Same as Alternative Plan III of the Clause 5.2.3

As seen above, the most beneficial case among all comparison case is the case III which is as same as that proposed in the Clause 5.2.3, though it is also true that hydro-power plants are essentially advantageous compared to thermal power plant.

9.2.4 Financial Feasibility of the Project in case C Heavy Oil Price being Rp 45/ℓ

- . Domestic price of C heavy oil was raised from Rp 30/ℓ to Rp 45/ℓ, which will contribute for improving financial stability of the project.
- . FIRR will be increased 11.1 % from the former 10.1 %. Accumulated surplus following to the financial statement for 30 years after the start of detailed survey, will be also increased to US\$540,578,000 from the former US\$428,261,000.

9.2.5 Economical Feasibility of the Project in case Coal-Fired Plant being Least Costly Alternative

- . Economic values, kW and kWh values, are estimated as below.

Least Costly Alternative	kW value (\$/kW at discount rate of 14%)	kWh value (\$/kWh)
Coal-fired plant	193.7	0.0209
Oil-fired plant ^{/1}	175.8	0.0502
		0.0662

/1: Figures are the same as in the Clause 7.2.3.

- . EIRR is calculated at 11.2 % which is rather less than that (16.5 %) calculated in case oil-fired plant regarded as the least costly alternative due to relatively small kWh value as listed above.

Table 1-1 LIST OF FIELD SURVEY TEAM

<u>Assignment</u>	<u>Name</u>
Coordinator	M. Suemori
Team Leader	K. Nakamura
Deputy Team Leader	K. Sumikawa
Geologist	T. Moritani
Boring Engineer	T. Kodama
Boring Engineer	K. Matsuhashi
Geophysicist	T. Suzuki
Geophysicist	H. Ibaragi
Geophysicist	Y. Kawabe
Survey Engineer	F. Watanabe
Survey Engineer	K. Ishizuka
Soil Mechanical Engineer	M. Nagahara
Hydrologist	K. Kotani
Civil Engineer	T. Katayama
Electrical Engineer	Y. Tomiyama

Power System	Name of Power Station	Installed Capacity	Actual Output	Remarks
Tuntang System	Jelok	774 kW	680 kW **	
	Timo	672 kW	600 kW ***	
	Semarang ha	4,928 kW	4,000 kW ***	
	East Semara	836 kW	500 kW ***	
		1,202 kW	1,100 kW ***	
		672 kW	600 kW ***	
	Wirobrajan	1,036 kW	980 kW ***	
		100 kW	90 kW ***	
	Wirobrajan	100 kW	90 kW ***	
	Purwosari	60 kW	60 kW *	
	Kalisari	340 kW	310 kW ***	
	Kudus	280 kW	220 kW ***	
		1,208 kW		
	Ketenger System	Ketenger	124 kW) 945 kW ***
Cilacap		500 kW)	
		256 kW) 632 kW ***	
Tegal I		275 kW)	
		285.6 kW	235 kW ***	
Tegal II		332 kW	205 kW ***	
		208 kW	208 kW ***	
	6,020 kW	<u>3,500 kW</u> **		
		14,955 kW		

Source: PLN Region XIII , 1

* : PLN has decided

** : Presently out c

*** : Presently under
of the power sy

/1 : The maximum out

Table 3-1 POWER PLANT IN CENTRAL JAVA OWNED BY PLN

Power System	Name of Power Station	Type	Installed Capacity	Actual ^{/1} Output	Remarks	Power System	Name of Power Station	Type	Installed Capacity	Actual Output	Remarks
Tuntang System	Jelok	Hydro	4 x 5,120 kW	13,000 kW		Isolated Station	Tuban I	Diesel	774 kW	680 kW **	
	Timo	"	3 x 4,000 kW	10,500 kW			Tuban II	"	672 kW	600 kW ***	
	Semarang harbor	Steam	2 x 53,125 kW	100,000 kW			Cepu	"	4,928 kW	4,000 kW ***	
	East Semarang	Gas	1 x 14,400 kW	45,000 kW			Lasem	"	836 kW	500 kW ***	
			1 x 27,388 kW		Japara II		"	1,202 kW	1,100 kW ***		
			1 x 20,100 kW		Purwodadi		"	672 kW	600 kW ***		
	Wirobrajan I	Diesel	1 x 1,000 kW	2,100 kW **			Sragen	"	1,036 kW	980 kW ***	
			3 x 1,020 kW		Karanganyar		"	100 kW	90 kW ***		
	Wirobrajan II	"	3 x 2,150 kW	6,000 kW **			Sukoharjo II	"	100 kW	90 kW ***	
	Purwosari	"	2 x 1,160 kW	1,800 kW **			Wonogiri	"	60 kW	60 kW *	
Kalisari	"	4 x 1,000 kW	2,800 kW **		Wonosari	"	340 kW	310 kW ***			
Kudus	"	2 x 560 kW	400 kW **		Wates	"	280 kW	220 kW ***			
Ketenger System	Ketenger	Hydro	2 x 3,520 kW	4,000 kW		Wonosobo	"	1,208 kW	945 kW ***		
		Diesel	2 x 584 kW	2,500 kW**		(Kalianget)	Hydro	124 kW			
	Cilacap	"	3 x 1,000 kW		1,700 kW**		Banjarnegara	Diesel	500 kW	632 kW ***	
			3 x 1,000 kW	6,400 kW**				Hydro	256 kW		
	Tegal I	"	2 x 1,152 kW		1,684 kW*		Weleri	Diesel	275 kW		
			2 x 2,500 kW	14,955 kW			Bumiayu	"	285.6 kW	235 kW ***	
	Tegal II	"	1 x 304 kW		1,684 kW*		Majenang	"	332 kW	205 kW ***	
1 x 320 kW						Tonjong	Hydro	208 kW	208 kW ***		
1 x 688 kW						Semarang	Diesel	6,020 kW	3,500 kW **		
		1 x 372 kW									
				197,884 kW							

Source: PLN Region XIII , 1979

- * : PLN has decided to move to other power sectors in near future.
- ** : Presently out of operation because of high O & M cost and will be retired in future.
- *** : Presently under operation but will be retired in future after the well development of the power system.

^{/1} : The maximum output limited in PLN operation rule.

TABLE 3-2 POWER TRANSMISSION AND DISTRIBUTION
SYSTEM IN CENTRAL JAVA AS OF FY1978/79

Description	Quantity
Transmission line	
150 kV double circuit lines	329 km
150 kV single circuit lines	222
30 kV double circuit lines	112
30 kV single circuit lines	591
Main substation	
150 kV class	total 412 MVA in transformer capacity
30 kV class	total 83 MVA in transformer capacity
Distribution lines	
20 kV distribution lines	1,572 km
15 kV distribution lines	95
6 kV distribution lines	1,141
380/220 V low tension distribution lines	2,144 km
220/127 V low tension distribution lines	1,808
20 kV class distribution transformer	10,412 Nos - 219 MVA
6-15 kV class distribution transformer	2,519 Nos - 152 MVA

Source: PLN Pusat (figures are as of the end of FY 1978/79).

Table 3-3 HISTORICAL POWER DEMAND AND GENERATION IN PLN REGION XIII

	Year/ ¹	1969	1970	1971	1972	1973	1974	1975/76	1976/77	1977/78	1978/79
I. Sales Demand											
a) Household	(MWh)	117,497	120,476	119,754	122,628	126,253	128,219	134,479	142,281	152,270	177,014
b) Commercial	(MWh)	11,739	13,010	13,527	15,073	20,390	23,384	31,186	38,403	44,372	55,764
c) Industrial	(MWh)	51,237	54,603	59,730	62,697	67,921	66,212	70,488	73,272	86,897	116,515
d) Public	(MWh)	10,506	11,017	13,764	15,817	17,783	20,589	24,223	26,052	29,482	34,917
e) Total Demand	(MWh)	190,979	199,106	206,775	216,215	232,347	238,404	265,704	285,751	323,903	384,210
II. Generation											
a) Losses	(MWh)	61,107	67,753	71,536	72,850	90,137	95,636	89,463	90,970	104,823	111,987
	(%)	24.2	25.4	25.7	25.2	28.0	28.6	25.2	24.1	24.4	22.6
b) Gross Generation	(MWh)	252,086	266,859	278,311	289,065	322,484	334,040	355,167	376,721	428,726	496,197
c) System Peak	(MW)	41.6	44.2	45.5	47.3	51.5	53.6	57.9	65.9	78.6	95.0
d) System L.F.	(%)	69.1	68.9	69.8	69.8	71.5	71.1	70.0	65.2	62.3	59.6

Source: PLN Region XIII

¹: Calendar year until 1974 but Fiscal year after 1975/76.

Table 3-4 TARIFF BASE (PLN)

Tariffs & Purposes		Used Capacity		Consumer Payment per Month		Tariffs & Purposes		Used Capacity		Consumer Payment per Month	
I. Non-Metered, Flat											
Rate Tariff											
	<u>Capacity</u>	<u>Flat Rate</u>	<u>Max. T.B.E. /1</u>	<u>Rp/month</u>							
A-1. Small	60 VA	Rp 200	Rp	420							
	75 VA	Rp 250	Rp	525							
	100 VA	Rp 300	Rp	700							
	125 VA	Rp 400	Rp	875							
	150 VA	Rp 450	Rp	1,050							
	175 VA	Rp 500	Rp	1,225							
	200 VA	Rp 600	Rp	1,400							
II. Metered Tariff											
	<u>Capacity</u>	<u>Fixed Charge</u>	<u>Energy Charge etc.</u>								
A-2. Social agencies	min. 250 VA	Rp 6/every 25 VA	1. Rp 6/kWh	2. T.B.E. Rp 14/kWh							
B-1. Residential	min. 250 VA	Rp 12/every 25 VA	1. Rp 13/kWh, up to 200 hr/month	2. Rp 6/kWh, over 200 hr/month							
			3. T.B.E. Rp 14/kWh								
B-2. Commercial	min. 250 VA	Rp 27.50/every 25VA	1. Rp 20/kWh, up to 200 hr/month	2. Rp 8/kWh, over 200 hr/month							
			3. T.B.E. Rp 14/kWh								
C-1. Industrial	min. 13.5 kVA	Rp 160/every 0.5kVA	1. Consumption outside peak hours; Rp/10/kWh, up to 150 hr/month	2. ditto: Rp 6/kWh, over 150 hr/month							
			3. Rp 20/kWh for consumption during peak hours.	4. For every kVarh, /2 according to the PLN regulation							
			5. T.B.E. Rp 12.50/kWh day-time	Rp 14/kWh night							
						C-2. Office	min. 250 VA	Rp 8 every 25 VA	<u>Energy Charge etc.</u> 1. Rp 13/kWh, up to 200 hr/month 2. Rp 6/kWh, over 200 hr/month 3. T.B.E. Rp 14/kWh		
						D. Street Lighting			1. Rp 10/kWh 2. T.B.E. Rp 7.50/kWh		
						E. Large Consumers min. 100 kVA	1. Rp 460/kVA for the first 400kVA	2. Rp 420/kVA for 401-1,000 kVA	3. Rp 375/kVA for 1,001-2,000 kVA	4. Rp 275/kVA for over 2,000 kVA	1. Consumption outside peak hours: Rp 5/kWh 2. Consumption during peak hours: Rp 20/kWh 3. For every kVarh, according to the PLN regulation 4. T.B.E. Rp/12.50/kWh day-time: Rp/14/kWh night
						F. Special purpose	min. 500 VA	-	1. Rp 30/kWh, min. consumption 20 hr. 2. T.B.E. Rp 14/kWh		
						Note: /1 T.B.E. (Tambahan Biaya Eksploitasi), Exploitation charge Surcharges. /2 kVarh stands for kilovolt ampere reactive hours.					
						A-1: Non-metered, fixed tariff; for small consumers A-2: Social use; for special institutions like Church, Mosque, Schools, Student Houses, Hospitals and the like. B-1: Residential use; for household purposes and <u>not</u> use for business. B-2: Commercial use; for business purposes, like small shops, stores, restaurants, hair dressing salons, business offices, Companies; Govn. & Private Banks, Hotels etc. C-1: Industrial use; for production purposes. C-2: Office use; for office Government, State Enterprise, Government Services. Public Enterprise and Foreign Missions. D : Street lighting and traffic lighting E : Large Consumers F : Special use; for Special purpose, temporary connection.					

Table 3-5 PROSPECTIVE HYDROELECTRIC POWER PROJECTS

Name of Basin	Name of River	Name of Project	Installed capacity (MW)	Annual energy production (MWh)	Estimated Project cost (10 ³ US\$)
Serayu	Merawu	Maung	2x95MW =190 ^{/1}	364,000 ^{/1}	237,000 ^{/1}
"	"	Clangap ^{/2}	66	126,000	70,000
"	Lake Menjer	Garung ^{/4}	2x13.2MW=26.4	39,200	15,235
"	Main stem	Mrica ^{/4}	3x60MW =180	600,000	95,200
"	Begaluh	Selomerto	10	^{/5}	^{/5}
"	Tulis		27	-	-)
"	Pekacangan	Telogo	18	-	-)
"	Brukah		-	-	-) ^{/3}
"	Gintung		11	-	-)
"	Sapi	Kebanaran	-	-	-)
"	Tajum		6	-	-)
		Sub total	534.4		
Serang	Main stem	Ngrambat	4x14MW =56	70,000	55,460
Tuntang	Main stem	Glapan	4x3.5MW =14	32,000	75,530
Jrang	Main stem	Jragung	10	35,040	51,593
-	Sempor	Sempor ^{/4}	1x1MW = 1	-	47,559
Lukulo	Main stem	Karang Sambung	80	175,000	-
Bengawan Solo	Main stem	Jipang	18	70,000	80,100
"	"	Wonogiri ^{/4}	2x6.2MW =12.4	34,100	43,400
"	Madiun	Bendo	3.5	10,000	20,100
"	"	Badegan	6	18,800	40,300
Comal	Lumeneng	Watu Kumpul	21.4	81,300	25,270
"	Main stem	Karanganyar	3	23,400	5,700
Pemali	Gergunung	Bantarsari	13	97,100	23,800
"	Main stem	Bantarkawung	3.4	-	11,890
Oya	Main stem	Oya	25	181,000	-
Progo	Elo	Mendut	3.5	27,500	-
"	Kaloran	Kaloran/Setro	1.7	13,400	-
-	Serang	Serang	1.5	13,100	-
		Total	804.3		

Source: Principal Project Hydro Power, Central Jawa PLN, Aug. 1976

Remarks; ^{/1} : Revised by JICA
^{/2} : Proposed newly by JICA
^{/3} : Recommend in the Feasibility Report on Serayu basin, 1974
^{/4} : Listed in the development plan of generating facilities of PLN
^{/5} : Data is not available

Table 3-6 EXPANSION PLAN OF POWER TRANSMISSION
SYSTEM IN CENTRAL JAVA

Section	Voltage (kV)	Length (km)	No. of Circuit	Conductor Nos x size (mm ²)	Commis sioning Year / <u>1</u>	Status / <u>2</u>
Tegal - Sunyaragi	150	35	1	1 x 242	1979	UC
East Sala - New Madiun	150	120	2	1 x 242	1979	UC
Semarang Harbor - Kudus - Rembang	150	120	2	1 x 242	1982	UC
Rembang - Blora - Cepu - Bojonegoro	150	120	1	1 x 242	1982	UC
Bojonegoro - Babat	150	72	2	1 x 282	1982	UC
Semarang Harbor - Ungaran - West Semarang	150	54	2	2 x 400	1982	UC
Magelang - Wonosobo - Garung	150	70	1	1 x 242	1982	UC
Tuntang ring	150	238	1 (add.)	1 x 242	1984	P
Magelang - Wonosobo	150	60	1 (add.)	1 x 242	1984	P
Wonosobo - Rawalo	150	80	2	1 x 242	1984	P
Cilacap - Kebumen - South Yogyakarta	150	160	1	1 x 242	1984	P
- ditto -	150	160	1 (add.)	1 x 242	1985	P
Cirebon - Ungaran	500	238	1	4 x 280	1983	P

Source: PLN Pusat, 1979

/1 : Calendar year

/2 : UC = Under construction. P = Under planning.

Table 3-7 PROJECTED HOUSEHOLD DEMAND

Fiscal year	Population x10 ³	Number of households x10 ³	Electrification ratio %	Number of household consumers x10	Average energy consumption per household consumer kWh	Demand MWh
I. Urban Area						
1978	13,905	2,913	4.31	125.6	961	121,000
81	14,657	3,073	7.67	235.7	1,038	245,000
84	15,449	3,239	11.03	357.3	1,121	401,000
87	16,284	3,414	14.39	491.3	1,211	595,000
90	17,164	3,598	17.75	638.6	1,308	835,000
II. Rural Area						
1978	14,245	2,913	2.54	73.9	762	56,000
81	14,953	3,058	4.94	151.1	806	122,000
84	15,696	3,210	7.34	235.6	853	201,000
87	16,476	3,369	9.74	328.1	903	296,000
90	17,295	3,537	12.14	429.4	955	410,000

Table 3-8 PROJECTED COMMERCIAL DEMAND

Fiscal Year	Number of household consumers x 10 ³	Number of commercial consumers x 10 ³	Average energy consumption of commercial consumers kWh	Demand MWh
I. Urban Area				
1978	125.6	14.0	2,572	36,000
81	235.7	26.3	2,935	77,000
84	357.3	39.8	3,349	133,000
87	491.3	54.8	3,822	209,000
90	638.6	71.2	4,362	211,000
II. Rural Area				
1978	73.9	11.4	1,733	20,000
81	151.1	23.3	1,883	44,000
84	235.6	36.4	2,045	74,000
87	328.1	50.6	2,222	112,000
90	429.4	66.3	2,414	160,000

Table 3-9 (1) INDUSTRIAL DEMAND EXPECTED TO BE CONVERTED TO PLN SUPPLY

Proposed Year	Customer	Capacity kVA	Peak Load	Load Factor (working) %	Working hour per year	Demand MWH year
1979	PG. Rendeng; sugar	3,960	-	-	-	-
	Sukun Tex and Perc. Sukun; textile	3,350	2,150	75	8,640	13,932
	PT. Primatex; textile	2,000	1,058	75	8,640	6,855
	PT. Nissin Biscuit; biscuit	1,662.5	1,147.5	100	2,496	2,864
	Puro Pulp; zinc	1,250	1,000	36	8,640	3,110
	Pabrik Karung; canvas	1,635	981	36	8,640	2,644
	Jaya Cold Storage; prawn	1,110	666	100	8,640	5,754
	PT. Petro Kimia; quarters	1,700	594	83	8,640	4,259
	Pusdik Migas; quarters	1,700	594	83	8,640	4,259
	Sub-total					43,677 ≅ 44,000
1980	PG. GKBI; cambric	4,000	2,400	89	8,640	18,455
	PT. Indojati; sawing industry	2,457	1,474	38	2,808	1,572
	PTP. XV Jatibarang; sugar	1,683.8	-	-	-	-
	PTP. XV Banjaratma; sugar	2,070	884	80	8,640	6,110
	PTP. XV Pangkah; sugar	1,190	323	80	8,640	2,232
	Texmaco Jaya; pertemuan	1,855	931	73	8,640	5,872
	PT. Famous Shoes; shoes	1,035	392	100	4,056	1,589
	PT. Central Java Marine; prawn	1,050	390	100	8,640	3,369
	ISTW. Pengecoran Baja;	1,065	220	100	5,760	1,267
	Sub-total					40,466 ≅ 40,000

Table 3-9 (2) INDUSTRIAL DEMAND EXPECTED TO BE CONVERTED TO PLN SUPPLY

Proposed Year	Customer	Capacity kVA	Peak Load kW	Load Factor (working) %	Working hour per year	Demand MWH year
1981	PG. Madukismo; sugar	4,790	639	80	8,640	4,416
	PT. Primatex and Co.; textile	6,375	3,825	75	8,640	24,786
	PT. Kamaltex; textile	4,090	2,454	75	8,640	15,901
	PT. Batam; textile	3,100	1,860	75	8,640	12,052
	PT. Dan Liris; textile	1,250	750	75	8,640	4,860
	Sub-total					62,015 ≈ 62,000
1982	General Iron Work Steel;	6,450	3,870	100	1,920	9,659
	PN. Jantra; tenum	6,272.5	3,763.5	54	8,640	17,558
	Texin; textile	6,300	3,024	75	8,640	19,595
	Tay Fun Tex; textile	4,250	2,550	75	8,640	16,524
	PTP. XV Sumberharjo; sugar	3,675	456	80	8,640	3,151
	Sub-total					66,487 ≈ 66,000
1983	PT. Semen Nusantara; cement	32,310	24,731	26	3,600	23,148
	Oil Refining Pertamina; refinery	24,000	14,400	36	8,640	44,789
	Sub-total					67,937 ≈ 68,000
Total						280,582 ≈ 280,000 x MWH

Table 3-10 DEMAND BY NEW INDUSTRY EXPECTED AS OF FY 1990/91

No.	Planned Industry	Installed Capacity 10 ³ kW	Peak Load 10 ³ kW	Load Factor (working)	Working hour per day	Working day per month	Demand MWH /year
1.	I.E. Karanganyar	30	18	36	24	30	55,987
2.	I.E. West Semarang	30	18	36	24	30	55,987
3.	I.E. East Semarang	30	18	36	24	30	55,987
4.	I.Z. Kudus	25	15	38	9	26	16,005
5.	I.Z. Demak	15	9	38	9	26	9,603
6.	I.Z. Kendal	15	9	38	9	26	9,603
7.	I.Z. Batang	20	12	38	9	26	12,804
8.	I.Z. Pekalongan	20	12	38	9	26	12,804
9.	I.Z. Tegal	25	15	38	9	26	16,005
10.	Pamotan Glass factory	15	10	60	24	30	51,840
11.	Notog Paper factory	5	3	70	24	30	18,144
12.	Cement Manufactories (14 - one million ton complex)						
			14 x 10 ⁶ (ton)	x 130 (kWh/ton)			
			x 56 % operation	x 30 % reliability			= 305,760

Total

620,529
± 621,000

Source: Provincial Government (BKPM-D)

MWH/year

Note: I.E. = Industrial Estate (Combination)

I.Z. = Industrial Zone

Table 3-11 POWER DEMAND FORECAST IN CENTRAL JAVA

Description	FY 1978/79	1981/82	1984/85	1987/88	1990/91
I. Sales Demand					
Household (GWh)	177	366	602	891	1,245
Commercial (GWh)	56	121	208	322	471
Industrial (GWh)	117	211	382	690	1,247
Public (GWh)	35	70	105	137	172
Total (GWh)	385	768	1,297	2,040	3,135
II. Losses					
(GWh)	112	217	353	552	848
(%)	22.6	22.0	21.4	21.3	21.3
III. Gross Generation (GWh)					
	496	985	1,650	2,592	3,983

Table 4-1 COORDINATE AND HEIGHT OF CONTROL POINTS

Point	North, m (X)	East, m (Y)	Height of Mark, m
PT-1	9,191,288.41	357,846.76	730.80
PT-2	9,189,735.66	358,124.36	753.64
PT-3	9,189,409.99	360,388.46	900.3
PT-4	9,192,007.61	360,476.69	844.3
PT-5	9,191,932.44	362,274.09	819.7
PT-6	9,192,417.14	364,687.57	726.5
P -7	9,190,310.04	363,964.85	737.7
P -8	9,189,303.77	362,685.16	802.3
PT-9	9,190,009.99	359,484.85	774.4
PT-10	9,190,455.61	358,027.58	628.145
PT-11	9,190,058.25	358,455.36	692.04
PT-12	9,190,121.55	358,642.03	641.310
T-13	9,191,264.13	358,986.91	592.4
T-14	9,190,869.23	358,525.00	631.86
T-15	9,190,564.80	358,953.76	539.509
T-16	9,187,917.75	358,561.19	530.62
T-17	9,188,857.54	359,485.20	593.91
T-18	9,188,543.66	358,261.57	487.69
T-19	9,189,370.16	358,769.02	453.43
T-20	9,188,043.97	358,137.60	481.7
T-21	9,188,161.92	357,344.09	460.7
T-22	9,189,119.68	357,305.18	589.070

Note: All points are of concrete mark.

Table 4-2 ELEVATION AND LOCATION OF
NEW BENCH MARKS

Mark	Elevation, m	Location
BM 1	450.568	600 m upstream of dam axis, right bank side and near the confluence of Merawu and Urang.
BM 2	411.636	600 m downstream of dam axis, left bank.
BM 3	425.067	River gauging site, right bank.
BM 4	425.042	Bridge site, right bank 10 m upstream of BM3.
DO	611.823	Abutment at dam axis, right bank.
T 15	539.509	Control point, right bank upstream of dam axis.
T 22	589.070	Mid point of bench marks 11/BM and 12/BM, right bank.
BMC 1	295.490	Clangap dams site, right bank several meters higher than the river water level.

Table 4-3 MONTHLY MEAN DISCHARGE

Year	Unit m ³ /sec (1/3)													Year	Unit m ³ /sec (2/3)												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1904	29.5	37.8	32.3	33.1	27.1	21.2	17.3	11.0	18.3	33.5	31.0	37.2	329.3	1936	42.0	34.4	32.9	37.6	24.5	15.6	10.5	5.5	8.7	15.1	33.3	27.1	287.2
1905	38.3	44.0	43.3	37.1	23.4	15.8	13.8	8.5	6.7	20.5	25.0	30.4	306.8	1937	44.2	30.6	32.8	35.6	28.3	18.7	9.3	4.9	9.2	16.9	18.2	38.0	286.7
1906	41.5	23.9	27.5	26.8	17.4	15.0	11.3	16.4	25.7	27.5	29.8	44.2	307.0	1938	35.8	30.3	32.3	25.9	23.9	18.7	18.4	13.3	8.3	10.7	36.8	32.5	286.9
1907	44.4	30.0	37.0	32.1	26.4	16.6	9.5	15.3	15.5	20.4	27.8	49.0	324.0	1939	31.1	32.1	35.2	25.3	16.2	16.5	15.3	16.3	9.1	16.2	26.7	25.2	265.2
1908	35.7	39.1	42.4	35.6	22.5	16.6	17.8	12.3	14.2	26.0	41.9	31.6	335.7	1940	33.4	27.1	29.2	31.4	25.1	14.3	8.6	4.8	4.2	7.3	15.0	28.5	228.9
1909	33.8	34.2	33.3	26.3	26.8	25.7	19.0	11.2	13.2	20.8	26.0	24.2	294.5	1941	33.8	27.5	32.5	26.9	27.6	20.7	11.1	5.3	4.4	12.9	14.5	36.8	254.0
1910	33.6	37.0	31.7	30.5	23.8	17.1	12.2	14.2	21.4	24.6	33.1	35.7	314.9	1942	40.3	35.7	37.5	25.4	17.3	14.7	14.7	8.2	6.7	21.1	32.2	19.0	272.8
1911	32.1	33.2	29.4	23.4	23.1	21.3	13.7	7.6	7.3	19.3	30.0	38.7	279.1	1943	34.0	35.1	23.0	28.6	23.4	14.9	9.8	3.7	2.1	3.5	13.8	30.3	222.2
1912	40.9	45.0	40.0	26.3	15.3	10.6	8.6	6.2	4.9	21.8	34.4	32.3	286.3	1944	29.7	32.8	30.0	32.5	17.5	8.1	5.4	6.4	6.5	29.8	30.5	25.6	254.8
1913	31.5	25.7	27.5	27.0	19.7	10.1	5.6	4.3	5.5	17.4	29.8	31.0	235.1	1945	29.6	36.7	32.3	30.5	21.6	14.8	7.6	5.9	6.0	7.4	27.4	25.5	245.3
1914	26.4	22.2	34.6	22.2	20.4	12.9	6.9	4.1	3.5	5.2	22.0	33.2	213.6	1946	29.5	37.9	35.5	30.6	20.1	12.2	9.2	5.7	8.9	5.7	17.4	25.5	238.2
1915	36.3	38.5	38.8	30.0	24.7	14.7	8.4	4.7	7.3	12.2	23.9	25.3	264.8	1947	43.9	41.7	29.3	30.1	18.3	16.5	19.0	12.0	7.8	20.4	29.8	49.8	318.6
1916	38.5	36.6	37.0	32.4	15.3	13.8	14.0	8.6	20.3	26.2	29.6	40.5	312.8	1948	39.4	35.4	38.8	28.0	18.5	12.9	9.0	5.9	3.3	5.5	19.7	25.3	241.7
1917	40.7	43.1	28.0	39.1	19.4	11.9	10.5	10.6	17.8	19.9	33.8	33.1	307.9	1949	40.7	33.4	32.2	34.5	29.3	14.6	10.7	10.9	9.6	6.4	26.3	37.3	285.9
1918	33.5	61.9	36.6	26.9	23.2	14.7	8.2	6.4	4.7	4.7	38.3	29.4	288.5	1950	39.9	42.5	44.4	31.8	31.0	13.2	13.2	9.2	10.3	10.8	31.4	27.1	304.8
1919	27.3	28.9	25.4	35.7	33.9	19.8	11.1	5.3	6.1	6.3	27.7	39.9	267.4	1951	38.3	35.1	33.3	28.8	21.9	16.5	10.0	9.2	4.9	10.9	23.2	28.3	260.4
1920	41.0	23.4	27.0	35.3	18.5	16.4	8.8	11.4	20.5	32.0	28.0	37.2	299.5	1952	34.0	30.7	29.4	31.3	24.0	17.6	8.6	6.6	4.4	7.6	14.6	25.2	234.0
1921	25.0	34.0	33.5	35.9	14.2	13.6	13.2	7.5	9.2	23.9	33.2	28.6	271.8	1953	33.0	32.1	30.9	25.3	23.0	12.7	5.3	3.2	5.2	9.3	25.2	41.1	246.3
1922	45.8	41.4	40.1	32.6	29.9	22.8	11.2	7.6	5.0	24.8	32.3	42.1	335.6	1954	29.2	31.4	26.0	29.3	25.5	17.9	10.8	11.9	12.8	13.1	34.0	43.0	284.3
1923	40.5	42.3	44.1	25.9	27.7	18.1	29.5	11.1	5.3	6.3	17.4	39.0	307.2	1955	28.7	29.6	27.5	29.3	27.2	17.4	22.4	17.5	12.9	20.1	43.5	28.5	303.6
1924	32.9	31.4	28.8	30.3	21.5	13.4	7.7	5.1	5.2	16.1	31.3	36.3	260.0	1956	38.0	40.7	28.8	22.9	19.7	21.5	19.0	17.6	13.7	18.0	27.7	33.1	300.0
1925	25.6	39.5	36.2	26.9	16.7	8.1	4.6	4.0	3.5	3.2	7.5	25.5	201.3	1957	31.7	24.1	40.5	32.0	22.8	14.3	17.2	12.0	7.9	7.0	16.5	39.7	266.1
1926	32.7	29.4	34.5	20.4	29.8	12.1	5.3	3.4	3.2	5.9	20.3	33.4	230.4	1958	33.0	38.0	33.4	29.9	29.9	16.9	17.4	18.1	11.9	16.9	29.7	44.1	318.6
1927	50.0	32.5	35.2	30.5	22.9	16.1	11.4	6.3	4.7	12.1	29.6	34.9	286.2	1959	36.1	31.6	36.8	28.1	28.0	18.1	12.2	6.9	5.1	7.9	15.8	22.3	248.4
1928	38.7	41.0	38.5	30.5	15.4	12.7	8.8	8.4	7.1	17.1	32.2	44.4	294.8	1960	35.8	34.8	30.0	34.4	26.6	14.8	8.6	4.8	4.9	8.9	32.5	37.5	273.0
1929	44.0	38.7	43.0	28.9	14.9	10.2	5.7	4.2	3.6	8.1	17.6	35.1	254.0	1961	44.5	30.8	31.3	26.7	20.1	10.8	5.5	4.1	3.5	4.2	12.9	23.5	217.2
1930	26.5	26.7	38.1	30.9	23.4	13.1	8.0	4.3	4.6	19.0	29.8	49.3	272.7	1962	26.0	29.1	29.9	44.5	23.2	12.3	13.4	10.8	5.5	11.5	20.0	35.0	260.4
1931	38.9	34.1	41.8	35.8	32.4	16.6	9.7	7.9	6.5	21.0	22.0	25.2	291.9	1963	28.3	27.3	25.2	20.2	14.0	6.9	3.9	3.2	2.7	2.3	20.9	23.3	177.6
1932	28.9	28.2	28.7	35.2	17.3	16.4	11.1	5.4	5.0	15.5	20.7	36.2	248.6	1964	23.8	29.1	25.8	21.0	22.5	12.3	7.2	6.9	7.8	23.9	26.9	23.6	230.4
1933	28.0	42.5	43.0	32.7	27.5	18.5	10.9	12.2	17.6	20.4	32.3	42.5	328.1	1965	39.7	36.5	36.0	22.2	10.3	6.5	4.1	3.4	2.9	3.8	12.2	28.2	204.9
1934	39.4	40.1	31.5	38.9	27.4	13.1	8.2	6.2	4.7	19.7	33.1	35.1	297.4	1966	26.7	30.7	41.2	26.5	18.0	13.6	5.3	3.3	3.4	20.2	21.7	27.9	237.8
1935	33.8	29.8	28.3	26.1	16.8	14.4	8.3	4.8	4.2	15.6	32.0	29.4	243.5														

- To be continued -

- To be continued -

													Unit m ³ /sec (3/3)
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1967	45.7	32.3	25.6	28.2	17.9	7.1	3.7	3.1	2.6	4.2	22.0	23.3	214.7
1968	41.1	37.5	33.6	28.4	25.2	19.2	18.8	14.0	15.4	15.2	23.5	36.6	308.1
1969	33.0	29.4	31.0	38.1	19.3	14.4	8.2	4.5	3.9	10.1	17.9	21.2	230.1
1970	28.7	29.9	38.0	27.6	24.9	14.9	8.9	5.8	4.9	9.2	26.2	34.5	252.0
1971	32.1	45.9	37.3	30.9	20.9	14.4	8.1	5.6	4.2	19.8	30.9	38.1	286.4
1972	38.2	25.9	27.2	24.0	17.3	8.5	4.3	3.7	3.3	3.2	18.4	31.8	382.0
1973	31.7	31.8	31.4	30.4	29.3	21.7	17.6	10.1	17.0	20.5	36.0	29.4	306.3
1974	18.6	29.3	33.8	30.7	20.2	10.2	7.5	13.1	19.6	34.5	34.5	29.0	280.8
1975	26.4	28.4	39.9	35.2	31.7	15.3	8.7	6.0	14.9	26.2	32.0	31.9	310.8
1976	37.0	27.3	42.7	26.9	14.6	7.2	4.8	3.8	2.9	16.3	32.6	28.0	243.6
1977	25.6	39.4	32.1	27.3	14.7	14.6	7.6	2.9	4.2	4.1	9.6	26.2	208.8
1978	38.0	39.1	33.8	16.9	22.7	23.4	22.8	16.3	20.3	16.7	19.2	26.4	290.4
Total													
Annual mean discharge												22.7	

- Note: (1) Values from 1975 to 1978 show observed discharge.
- (2) Values from 1904 to 1942 and 1954 to 1974 show estimated discharge by tank model methods.
- (3) Values from 1943 to 1953 show estimated discharge by synthesis method.

Table 4-4 ITEM AND NUMBER OF MATERIAL SURVEY

Material	Survey quantity
(1) Earth (for core)	<ul style="list-style-type: none"> . Test pit <ul style="list-style-type: none"> E1: 4 Nos - 11.5 m in total E3: 4 Nos - 13.5 m in total E4: 8 Nos - 24.6 m in total E5: 3 Nos - 8.0 m in total E6: 4 Nos - 18.5 m in total . Laboratory tests <ul style="list-style-type: none"> Standard physical & mechanical tests for 6 samples by applying ASTM.
(2) Sand & gravel (for filter and concrete aggregates)	<ul style="list-style-type: none"> . Test pit <ul style="list-style-type: none"> S1: 5 Nos - 9.25 m in total S2: 1 No - 2 m . Laboratory tests <ul style="list-style-type: none"> Specific gravity, gradation, soundness and abration tests for 2 samples by applying ASTM
(3) Tuff breccia at spillway (for inner shell zone)	<ul style="list-style-type: none"> . Boring <ul style="list-style-type: none"> At spillway: 9 Nos - 460 m in total . Seismic prospecting <ul style="list-style-type: none"> At spillway: 4 lines - 1,915 m in total . Laboratory tests <ul style="list-style-type: none"> Specific gravity, soundness, abrasion and unconfined compression tests for 2 samples by applying ASTM
(4) Andesite at quarry site-G. Lawe (for outer shell zone)	<ul style="list-style-type: none"> . Boring <ul style="list-style-type: none"> At G. Lawe: 3 nos - 96 m in total . Seismic prospecting <ul style="list-style-type: none"> At G. Lawe: 5 lines - 1,562 m in total . Laboratory tests <ul style="list-style-type: none"> Test as same as of tuff breccia for 2 samples and peterographic analysis for 4 samples

Note: Survey for tuff breccia is the same as for the geological survey explained in Clause 4.3.

Table 4-5 SUMMARY OF LABORATORY TEST RESULTS

Sample Depth (m)	Class	Gradation, (% passing)									Atterbergs		Gs	Compaction			Shear				Permeability (cm/s)			Consolidation		Soundness	Abrasion	Unconfined compression (kg/cm ²)			
		MS	4.76	2.00	0.84	0.42	0.25	0.105	0.074	0.002	W _L	Ip		W _n	OMC	MDD	Cu	φ _u	C _{cu}	φ _{cu}	C'	φ'	OMC-2%	OMC	OMC+2%				Cc	% at 7kg/cm ²	
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(%)	(%)	(%)	(%)	(t/m ³)	(t/m ³)	(°)	(t/m ³)	(°)	(t/m ³)	(°)										
Earth (for core)																															
E15	0.75-1.75	CH	9.52	87.9	86.2	84.4	82.4	80.5	75.6	73.6	26	58	32	2.67	31.3	38.4	1.27	21.9	2.9	20.0	7.6	20.0	7.2	6.7 ⁻⁷	3.3 ⁻⁷	3.4 ⁻⁷	0.33	24.3			
E32	2.0 -3.0	CL	0.84			99.8	98.2	92.3	90.0	32	29	14	2.67	16.4	13.8	1.90	13.9	7.3	1.30	2.9	9.9	8.8	5.5 ⁻⁷	2.2 ⁻⁷	2.2 ⁻⁷	0.30	47.7				
E43	0.5 -1.5	MH	2.00			99.7	95.0	90.0	79.6	76.4	31	77	30	2.68	56.0	43.3	1.20	16.0	4.3	13.2	6.9	10.1	9.5	1.7 ⁻⁷	1.7 ⁻⁷	1.7 ⁻⁷	0.39	20.3			
E51	1.0-2.0	MH-OH	0.84			98.9	91.4	77.4	74.0	7	119	18	2.57	116.9	75.0	0.83	10.9	10.9	19.0	11.3	21.0	10.3	7.8 ⁻⁷	5.6 ⁻⁷	4.5 ⁻⁷	0.46	13.4				
E63	3.0-4.0	MH	4.76		96.6	93.0	88.3	82.8	74.3	72.8	29	76	40	2.65	62.0	21.0	1.57	13.2	18.9	8.0	14.3	5.5	17.1	4.1 ⁻⁶	1.7 ⁻⁶	0.9 ⁻⁶	0.30	34.3			
E64	1.0-2.0	MH-OH	0.84			99.7	97.8	93.5	92.5	44	108	52	2.64	81.4	51.6	1.07	14.0	14.0	15.0	16.9	15.0	16.9	1.2 ⁻⁶	2.3 ⁻⁶	3.2 ⁻⁶	0.41	18.3				
Sand and gravel (for filter and concrete aggregates)																															
												Absorption																Legend:			
																												1.2 ⁻⁶ = 1.2 x 10 ⁻⁶			
S12	0.15-1.75		100	36.0	26.5	17.9	11.5	7.5	4.9	4.4			2.62 (1.53)																Sand Gravel		
																												40&56 24			
S14	0.2 -2.0		100	47.7	37.9	26.0	15.1	9.4	6.4	6.1			2.67 (1.28)																Sand Gravel		
																												56&44 25			
Grains more than 100 mm, MS 40-80 cm, are excluded. Big grains content is about 30%.																															
Tuff breccia at spillway-G. Situk (for inner shell zone)																															
																												Gravel Gravel			
												2.12 (11.6)																71 68			
																												134*			
												2.02 (13.3)																151*			
																												147*			
																												103*			
Andesite at quarry site - G. Lawe (for outer shell zone)																															
																												Gravel Gravel			
												2.35 (5.7)																60 43			
																												672*			
												2.34 (4.9)																574*			
																												1,012*			
* Saturated																															
** Air dried																															

Table 4-6 ENGINEERING PROPERTY OF EMBANKMENT MATERIALS

Description	Earth for core	Sand & Gravel for filter	Excavated Rocks for inner shell zone	Quarried Rock for outer shell zone
Classification	MH	Sand & gravel	Tuff breccia	Andesite
Specific gravity, Gs	2.65	2.65	2.10	2.35
Field water content, W_f (%)	50	-	-	-
Field wet density, γ_d (t/m^3)	1.65	1.95	1.85	1.95
Field saturated density, γ_{sat} (t/m^3)	1.75	2.15	2.10	2.15
Permeability, k (cm/s)	3×10^{-6}	Free drain	1×10^{-3}	Free drain
Cu (t/m^2)	14	0	0	0
Shear strength C' (t/m^2)	1.5	0	0	0
ϕ_u (°)	14	-	-	-
ϕ' (°)	25	37	39	42.5

Table 4-7 GEOMETRIC PLANNING STANDARDS FOR ROADS

DESIGN STANDARDS	MAIN HIGHWAY				SECONDARY HIGHWAY				CONNECTING ROAD				
	CLASS I TERRAIN		CLASS IIA TERRAIN		CLASS IIB TERRAIN		CLASS IIC TERRAIN		CLASS III TERRAIN				
	F	M	F	R	F	M	F	R	F	M	F	R	M
Average daily traffic volume	20,000		6,000 - 20,000		1,500 - 8,000		2,000						
Design speed (km/h)	120	100	80	80	60	60	80	60	40	30	60	40	30
Right-of-way width (m)	60	60	60	40	40	40	30	30	30	30	30	20	20
Width of paved surface (m)	Min.2 (2 x 3.75)		2 x 3.50 or 2 (2 x 3.50)		2 x 3.50		2 x 3.0		2 x 3.0		3.50 - 6.00		
Min. width of median (m)	10		1.50**										
Shoulder width (m)	3.50	3.00	3.00	2.50	2.50	2.50	3.00	2.50	2.50	2.50	1.50	1.50	1.50 - 2.50*
Pavement crossfall (%)	2%		2%				2%		2%	3%		4%	
Shoulder crossfall (%)	4%		4%				6%		6%	6%		6%	
Maximum superelevation (%)	10%		10%				10%		10%	10%		10%	
Minimum curve radius (m)	560	350	210	210	115	115	210	115	50	115	50	115	50
Maximum grade (%)	3%	5%	6%	6%	7%	7%	5%	7%	8%	6%	8%	6%	8%
Type of surface	Bituminous Concrete		Bituminous Concrete		Bituminous Penetration Macadam (double)		Bituminous Penetration Macadam (single)		Bituminous Penetration Macadam		Single Bituminous Seal		

NOTES: * = according to local conditions
 ** = for four lanes

F = flat terrain - side slopes 0% to 9.9%

R = rolling terrain - side slopes 10% to 24.9%

M = mountainous terrain - side slopes 25% and over

Source: 'Standard Specifications for Geometric Design of Rural Highways'
 Direktorat Jenderal Bina Marga

Table 4-8 MAJOR BRIDGES ON ROAD ACCESS

(1/3)

NO.	NAME OF BRIDGE	LOCATION (km)	LOADING CLASSIFICATION	CLEARANCES WIDTH	CLEARANCES HEIGHT	SPAN NO.	LENGTH	TOTAL LENGTH	TYPE OF BRIDGE	CONDITION OF BRIDGE
1	2	3	4	5	6	7	8	9		
A CILACAP ROUTE :										
<u>C-1 Banyumas - Banjarnegara</u>										
1	Gumelem bridge	12.850	III	5.00m	-	3	15.15m	45.45m	Steel girder	Broken
2	Kali Sapi bridge	16.300	III	6.70	-	3	10.00	52.00	Steel girder	Good
<u>Banyumas - Buntu - Sampang - Adipala</u>										
3	Slarang bridge	28.44	III	3.65	-	1	228	228.00	Steel girder	Broken
<u>C-2 Sampang - Menganti - Slarang - Cilacap</u>										
1	Serayu at Rawalo	17.60	II	5.50	-	5	39.00	202.00	Concrete	
2	Tajum/Menganti bridge	23.60	-	-	-	1	7.00	60.00	Timber	Was destroyed by flood in 1968
B SEMARANG ROUTE :										
<u>S-1 Semarang - Basen - Secang</u>										
1	Kali Panjang bridge	37.980	II	7.80	-	1	22.50	22.50	Concrete/masonry	Rather good
2	Kali Ketekan bridge	43.155	II	6.00	-	1	24.90	24.90	Concrete/steel-girder	Rather good

To be continued

Loading capacity : CLASS II ; 5 ton
 III ; 3.5 ton
 III A ; 2.75 ton
 IV ; 2 ton

Source DPU DROP. DATI I. JATENG
 SEMARANG

1	2	3	4	5	6	7	8	9
	<u>Secang - Temanggung</u>							
3	Progo bridge	18.110	III	5.70	1	51.50	51.50	Steel truss Good
	<u>Temanggung - Parakan through Kedu</u>							
4	Galeh bridge	31.721	III	4.50	1	41.50	41.50	Steel truss Rather good
	<u>Parakan - Kledung</u>							
5	Lodukuh bridge	39.763	III	4.20	1	21.00	21.00	Steel girder Broken
6	Sigandul bridge	40.315	III	7.10	1	24.10	24.10	Steel girder Good
	<u>Kledung - Wonosobo</u>							
7	Semagung bridge	60.620	III	4.60	1	38.90	38.90	Steel girder Good
	<u>Wonosobo - Banjarnegara</u>							
8	Begaluh bridge	69.375	III	7.56	1	47.29	47.29	Masonry Good
	<u>Banjarnegara - Kalilunjar</u>							
1	Serayu bridge	2.00	IIIA	3.00	1	64.50	64.50	Steel truss Broken
2	Merauri bridge	5.00	IIIA	4.00	1	61.00	61.00	Steel truss/1 Broken concrete

To be continued

	1	2	3	4	5	6	7	8	9	
		<u>SEMARANG ROUTE</u>								
S-2		<u>Semarang - Kendal</u>								
1		Blorong bridge	25.489	II	6.00	-	1	66.50	66.50	Steel girder Rather good
		<u>Kendal - Weleri</u>								
2		Kali Bodri bridge	33.600	II	6.50	--	1	80.00	80.00	Steel truss Broken
3		Kali Jengah bridge	37.600	II	9.25	-	1	28.00	28.00	Composite Good
4		Kali Damar bridge	45.210	II	6.00	-	1	20.50	20.50	Steel girder Good
		<u>Weleri - Sukorejo</u>								
5		Kali Desa bridge	56.640	III	4.00	-	1	50.00	50.00	Steel girder Good
6		Kali Damar bridge	59.230	III	3.50	-	1	23.00	23.00	Steel girder Good
7		Kali Butuh bridge	66.307	III	4.50	-	1	28.00	28.00	Steel girder Rather good
8		Kali Jeguru bridge	70.580	III	3.60	-	1	34.00	34.00	Steel girder Rather good
		<u>Parakan - Sukorejo</u>								
9		Kali Hutut bridge	48.085	III	4.20	-	1	42.00	42.00	Concrete Good

Table 4-9 POPULATION AND BUILDINGS IN DESA RELATED TO INUNDATION

VILLAGE (DESA)	SUB-VILLAGE (KAMPUNG)	POPULATION				HOUSES		SCHOOLS		MOSQUES		OTHER BUILDING	
		WHOLE		INUNDATED		WHOLE	INUNDATED	WHOLE	INUNDATED	WHOLE	INUNDATED	WHOLE	INUNDATED
		F	P	F	P								
KALILUNJAR	KALILUNJAR	182	815	-	-	145	-	1	-	1	-	-	-
	KALIARUS	190	837	-	-	145	-	-	-	-	-	-	-
	SIWERU	67	309	-	-	70	-	1	-	1	-	-	-
SIJERUK	SIJERUK JURAG	26	100	-	-	300	-	2	-	2	-	-	-
	SIJERUK GUNUNG	200	1200	-	-	-	-	-	-	-	-	-	-
	GUNUNG RAJA	105	348	-	-	-	-	-	-	-	-	-	-
PAWEDEN	KASIMPAR	42	178	-	-	35	-	-	-	1	-	-	-
	JOJOGAN	96	316	-	-	56	-	1	-	1	-	-	-
	KALIAMIS	69	292	-	-	54	-	-	-	1	-	-	-
SUIDAK	BUANA	30	107	30	167	27	27	1	-	6	1	3	-
	WANASARI	40	192	-	-	37	-	-	-	-	-	-	-
	SUIDAK	105	526	-	-	105	-	-	-	-	-	-	-
	JETIS	68	318	-	-	64	-	-	-	-	-	-	-
	NGALIAN	30	259	-	-	37	-	-	-	-	-	-	-
	KROBOKAN	47	154	10	56	43	10	-	-	-	-	-	-
KARANG TENGAH SILENGKONG	BEJI	322	1397	181	860	290	181	1	1	5	3	11	6
	KARANG TENGAH												
	LEKSANA												
GUMINGSIR	KALIGLAGAH	27	142	27	142	29	29	-	-	-	-	-	-
	TEGARON	53	228	53	228	60	60	-	-	-	-	1	1
	GUMINGSIR	76	377	-	-	84	-	-	-	-	-	1	-
	KALIKIDANG	145	786	-	-	156	-	-	-	-	-	-	-
	KWENI	21	102	-	-	21	-	-	-	-	-	-	-
NAGASARI	SEPRIH	107	520	45	224	110	46	-	-	2	1	-	-
	NAGASARI	93	466	93	466	95	95	1	1	1	1	2	2
	KERTAYASA	45	207	45	207	46	46	-	-	1	1	-	-
	TIMBANG	15	82	15	82	15	15	-	-	-	-	1	1
KALITLAGA	-	-	-	-	-	-	-	-	-	-	-	-	-
KAYUARES	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL		2,201	10,316	499	2,272	2,024*	509**	8*	2**	22*	7**	19*	10**

Note:

F: FAMILIES
P: PERSON
*: WHOLE BUILDINGS
**: INUNDATED BUILDINGS

Table 5-1 ACTUAL OUTPUT CAPACITY DEVELOPMENT
IN TUNTANG/KETENGER SYSTEM
BASED ON DEFINIT PLAN BY PLN

	FY 79/80	FY 80/81	FY 81/82	FY 82/83
Gas				
Semarang East (MW)	45	45	45	45
Hydro				
Jelok (MW)	13	13	13	13
Timo (MW)	10.5	10.5	10.5	10.5
Ketenger (MW)	4	4	4	4
Sempor (MW)		1	1	1
Garung (MW)			26.4	26.4
Wonogiri (MW)			12.4	12.4
Sub-total; Hydro (MW)	27.5	28.5	67.3	67.3
Steam				
Semarang No.1 (MW)	50	50	50	50
Semarang No.2 (MW)	50	50	50	50
Semarang No.3 (MW)				200
Sub-total Steam (MW)	100	100	100	300
Sub-total; Hydro + Steam (MW)	127.5	128.5	167.3	367.3
Total	172.5	173.5	212.3	412.3
Gas/Total (%)	26	26	21	11
Hydro/(Hydro + Steam) (%)	22	22	40	18

Remarks: Diesel is not taken into account, because it is PLN's principle to remove diesel plant of which service area has been covered by transmission system

Table 5-2 BALANCE OF LOAD AND SUPPLY IN WEST JAVA

<u>Power Plant</u>	<u>Unit</u>	<u>'84/85</u>	<u>'85/86</u>	<u>'86/87</u>	<u>'87/88</u>	<u>'88/89</u>	<u>'89/90</u>	<u>'90/91</u>
Hydro								
Lamajan	3 x 6.4 - 1	18						
Benkok/Dago	1 x 0.7 + 3 x 1.05 - 1	3						
Plengan	3 x 1.05 + 1 x 2.0 - 1	4						
Cikalong	3 x 6.4 - 1	18						
P. Kondang	4 x 2.5 - 1	9	-	-				
Kracak	3 x 5.5 - 1	12	as					
Ubrug	2 x 5.4 + 1 x 6.3 - 5	12	left					
Jatiluhur	6 x 25 - 6	144						
Curug	1 x 6.0	6						
Saguling	No.1 - 8	0	350	700	700	700	700	875
Jatigede	No.1 & 2	0	0	0	0	200	200	400
		226	576	926	926	1,126	1,126	1,501
Steam								
Priok	2 x 25 + 2 x 50	150	-	same				
Muara Karang	3 x 100 + 2 x 200	700		as				
				left				
Suralaya	No.1 - 4	400	800	800	1,400	2,000	2,000	2,000
		1,250	1,650	1,650	2,250	2,850	2,850	2,850
Geo Thermal								
Kamojang	No.1 - 3	30	60	90	90	90	90	90
Darejat	No.1 - 3	0	0	0	30	60	90	90
		30	60	90	120	150	180	180
Gas Turbine								
T. Priok	1 x 20 + 2 x 25 + 4 x 50	442	-	same				
P. Gadung	6 x 20 + 2 x 25		-	as				
Sunyaragi	2 x 20		-	left				
Actual Output (MW)		1,948	2,728	3,108	3,738	4,568	4,598	4,973
Overhaul (MW)		400	400	400	600	600	600	600
Peak Load (MW)		1,592	1,868	2,202	2,538	2,919	3,356	3,860
kW Balance (MW)		-44	460	506	600	1,049	642	513

Table 5-3 COMPARISON OF COST OF ALTERNATIVE INSTALLATION PLAN
(Costs equivalent to all Alternatives are excluded)

(x10⁶ US\$)

Cost Item	Capitalized Cost for				
	Alternative I All Thermal	Alternative II Maung + Thermal	Alternative III Maung + Mrica + Thermal	Alternative IV Mrica + Thermal	Alternative V Mrica + Maung + Thermal
1. Hydro power plant ^{/1}					
. Maung	-	313	313	-	178
. Mrica	-	-	169	298	298
Sub total	-	313	482	298	476
2. Thermal power plant ^{/2}					
Operation Start Year: FY 1990/91	231	-	-	-	-
1991/92	-	-	-	206	206
1992/93	184	184	184	-	-
1993/94	-	-	-	165	165
1994/95	147	147	147	-	-
1995/96	50	56	14	110	25
Sub total	612	387	345	481	396
3. Thermal O/M saving ^{/3}					
. Attributable to Maung	-	-187	-187	-	-106
. Attributable to Mrica	-	-	-138	-244	-244
Sub total	-	-187	-325	-244	-350
Total	612	513	502	535	522

^{/1}: Cost of capital, fixed O/M and replacement.

^{/2}: Cost of capital, fixed O/M and replacement

^{/3}: Variable O/M cost of thermal power plant

Table 5-4 POWER OUTPUT AND CONSTRUCTION COST OF ALTERNATIVE LAYOUT
(Economic Cost)

Item	Alternatives								
	Original		Alternative I		Alternative II		Alternative III		
	Maung	Cilangap	Maung	Cilangap	Maung	Cilangap	Maung	Cilangap	
1. Power generation									
Installed capacity (MW)	158	158	73	190	66	190	63	252	
Annual energy output (GWh)	303	303	140	364	126	364	121	483	
2. Construction cost (10 ³ US\$)									
i) Compensation	5,160	5,160	2,320	6,510	2,000	6,510	740	6,200	
ii) Civil work	122,310	122,310	40,600	128,210	37,300	128,210	22,900	203,000	
iii) M/W & G/E	44,350	44,350	17,300	45,630	16,900	45,630	14,700	39,300	
iv) Engineering service & Government Administration ^{/1}	15,936	15,936	5,547	16,645	5,189	16,645	3,587	23,143	
v) Physical contingency ^{/2}	27,389	27,389	9,517	28,573	8,908	28,573	6,178	39,816	
		(215,145)	(75,284)	(225,568)	(70,297)	(225,568)	(48,105)		
Total	215,145	290,429	290,429	295,865	273,673	295,865	311,459		
3. Unit cost (\$/kW)	1,362	1,257		1,156		1,082		1,236	
(\$/kWh)	0.710	0.656		0.604		0.564		0.645	

^{/1}: Engineering service: 7.5 % of (ii) + (iii)
Government administration: 2 % of (i) + (ii) + (iii)

^{/2}: 15 % of (ii) + (iii) + (iv)