Roads (cont.)

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
Bridge	m^2	$60^m \times 6^m$	2,000	720,000	
Sub-Total				720,000	
Total				16,512,650	

Table 4.4 River Treatment

M$20,572,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Coffering (1st)					
Banking	m^3	27,500	5.0	137,500	
Sub-Total				137,500	
2. Coffering (2nd)					
Rock Embankment	m^3	234,800	15.5	3,639,400	
Filter Embankment	"	25,300	17.5	442,750	
Core Embankment	"	70,300	14.0	984,200	
Miscellaneous	set	1		151,650	3%
Sub-Total				5,218,000	
3. Diversion Tunnel					
Common Excavation	m^3	11,400	9.0	102,600	
Rock Excavation	"	46,300	22.5	1,041,750	
Tunnel Excavation					
Horizontal	"	56,000	86.5	4,844,000	
Back Fill	"	3,500	5.0	17,500	
Concrete Lining					
Horizontal	"	16,500	305.0	5,032,500	
Intake Concrete	"	5,700	250.0	1,425,000	

(to be continued)

River Treatment (cont.)

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
Plug Concrete	m3	2,800	225.0	630,000	
Reinforcement Bar	t	860	1,800.0	1,548,000	
Miscellaneous	set	1		438,650	3%
Sub-Total				15,080,000	
4. Grouting					
Contact Grouting	m3	500	265.0	132,500	
Miscellaneous	set	l.s. 1		4,000	
Sub-Total				136,500	3%
Total				20,572,000	

Table 4.5 Dam

M$59,976,000

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Dam					
Common Excavation	m^3	221,000	9.5	2,099,500	
Rock Excavation	"	221,000	23.0	5,083,000	
Rock Embankment	"	1,927,000	15.5	29,868,500	
Filter Embankment	"	255,000	17.5	4,462,500	
Core Embankment	"	534,000	14.0	7,476,000	
Riprap and Protection Rock	"	79,000	18.5	1,461,500	
Miscellaneous	set	l.s. 1		1,519,000	3%
Sub-Total				51,970,000	
2. Grouting					
Drilling	m	22,100	130	2,873,000	
Curtain Grouting	t	3,300	1,350	4,455,000	
Miscellaneous	set	l.s. 1		222,000	3%
Sub-Total				7,550,000	
3. Grout Tunnel (ℓ = 160 m)					
Tunnel Excavation	m^3	1,850	86.5	160.025	$11.54m^3/m$
Concrete	"	750	305	228.750	$4.71m^3/m$
Reinforcement Bar	t	30	1,800	54,000	$40kg/m^3$
Miscellaneous	set	l.s. 1		13,225	3%
Sub-Total				456,000	
Total				59,976,000	

Table 4.6 Spillway

M$21,200,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Spillway					
Common Excavation	m^3	70,000	9.0	630,000	
Rock Excavation	"	213,000	23.0	4,899,000	
Floor and Wall Concrete	"	2,240	255.0	571,200	
Pier Concrete	"	780	265.0	206,700	
Overflow Section Concrete	"	8,370	230.0	1,925,100	
Concrete for Shute	"	11,270	255.0	2,873,850	
Stilling Base Concrete	"	25,790	255.0	6,576,450	
Backfill	"	6,620	5.0	33,100	
Reinforcement Bar	t	1,450	1,800.0	2,610,000	
Anchor Bar	"	48	2,200.0	105,600	
Bridge	set	1		106,000	L = 37 m
Miscellaneous	set	1		663,000	
Total				21,200,000	

Table 4.7 Intake

M$3,512,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Intake					
Common Excavation	m^3	23,100	9.5	219,450	
Rock Excavation	"	9,900	23.0	227,700	
Embankment	"	5,300	5.0	26,500	
Retaining Wall Concrete	"	6,200	255.0	1,581,000	
Concrete in Intake Body	"	1,330	265.0	352,450	
Invert Concrete	"	723	250.0	180,750	
Slug Concrete	"	310	265.0	82,150	
Pier Concrete	"	482	265.0	127,730	
Reinforcement Bar	t	340	1,800.0	612,000	
Miscellaneous	set	1		102,270	3%
Total				3,512,000	

Table 4.8 Penstock

M$25,654,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Penstock					
Tunnel Excavation					
Horizontal Section	m^3	32,600	86.5	2,819,900	
Vertical Section	"	6,700	110.0	737,000	
Concrete Lining					
Horizontal Section	"	11,400	230.0	2,622,000	
Vertical Section	"	2,900	230.0	667,000	
Reinforcement Bar	t	46	1,800.0	82,800	
Miscellaneous	set	l.s. 1		208,300	3%
Sub-Total				7,137,000	
2. Grouting					
Contact Grouting	m^3	1,050	350.0	367,500	
Drilling	m	1,900	130.0	247,000	
Consolidation Grouting	t	285	1,350.0	384,750	
Miscellaneous		l.s. 1		7,750	
Sub-Total				1,007,000	

(to be continued)

Penstock (cont.)

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
3. Steel Penstock					
Steel Penstock	t	3,000	5,400.0	16,200,000	
Sub-Total				16,200,000	
4. Service Adit					
Tunnel	m	150	8,730.0	1,310,000	
Sub-Total				1,310,000	
Total				25,654,000	

Table 4.9 Power House

M$20,450,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Power House					
Common Excavation	m^3	58,400	9.0	525,600	
Rock Excavation	"	25,100	22.5	564,750	
Embankment	"	13,200	5.0	66,000	
Concrete for Side Wall	"	7,100	255.0	1,810,500	
Concrete for Foundation	"	8,300	250.0	2,075,000	
Barell Casing Concrete	"	4,800	255.0	1,224,000	
Slab Concrete	"	2,100	265.0	556,500	
Outlet Concrete	"	5,000	255.0	1,275,000	
Retaining Wall	"	2,700	255.0	688,500	
Reinforcement Bar	t	1,870	1,800.0	3,366,000	
Miscellaneous	set	l.s. 1		368,150	3%
Sub-Total				12,520,000	

(to be continued)

Power House (cont.)

Item	Unit	Quantity	Unit Cost	Cost (H$)	Remarks
2. Architectural Work					
Main Control Building	m^3	25,100	230.0	5,773,000	
Plumbing, Air Conditioning and Ventilation Works	"	35,000	55.0	1,925,000	
Miscellaneous	set	l.s. 1		232,000	3%
Sub-Total				7,930,000	
Total				20,450,000	

Table 4.10 Outdoor Switch Yard

M$1,330,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Outdoor Switch Yard					
Excavation	m^3	7,500	9.0	67,500	
Embankment	"	47,000	5.0	235,000	
Concrete for Retaining Wall	"	2,660	235.0	625,100	
Concrete for Foundation	"	630	255.0	160,650	
Reinforcement	t	85	1,800.0	153,000	
Bullast	m^3	970	49.0	47,530	
Miscellaneous	set	l.s. 1		41,220	3%
Total				1,330,000	

Table 4.11 Gate Screen

M$3,500,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Gate Screen					
Intake Gate	t	85	9,300.0	790,500	
Screen	"	150	5,000.0	750,000	
Outlet Gate	"	150	8,700.0	1,305,000	
Diversion Channel Gate	"	62	8,730.0	541,260	
Miscellaneous	set	1		113,240	3%
Total				3,500,000	

Table 4.12 Estimated Construction Cost for the Optimum Development Scheme

Lower Tekai

10^3 M$

1. Preparatory Works	3,930	
Access Road	103	
Temporary Facilities	3,827	
2. Civil Works	34,773	
Diversion and care of River	5,078	
Dam	16,000	
Spillway	4,950	
Intake Structure	920	
Penstock	810	
Power House	6,440	
Mechanical Equipment	575	
3. Generating Equipment	13,000	
4. Engineering Service	4,136	(1)+(2)+(3)x8%
5. Government Administration	1,551	(1)+(2)+(3)x3%
6. Contingency	4,591	(1)+ ... +(5)x8%
7. Grand Total	61,981	

Table 4.13 Roads

M$103,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
(2)~(6) 0.34km					
Common Excavation	m^3	2,300	9.0	20,700	
Rock Excavation	"	580	20.50	11,890	
Subbase Coursing	"	620	49.00	30,380	
Asphalt	m^2	2,040	16.30	33,252	
Drainage Appliance	set	1		6,778	
Sub-Total				103,000	
Total				103,000	

Table 4.14 River Treatment (Coffer Dam)

M$5,078,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Coffering (1st)					
Sheet Pile	m	590	4,475.0	2,640,250	
Fill Work	m^3	10,600	2.0	21,200	
Sub-Total				2,661,450	
2. Coffering (2nd)					
Sheet Pile	m	340	4,475.0	1,521,500	
Fill Work	m^3	8,200	2.0	16,400	
Excavation	"	500	5.6	2,800	
Concrete	"	2,400	142.0	340,800	
Gate	t	10	8,000.0	80,000	
Withdrawal Quantity	set	l.s. 1		455,050	
Sub-Total				2,416,550	
Total				5,078,000	

Table 4.15 Dam

M$16,000,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Dam Body					
Common Excavation	m^3	18,200	9.5	172,900	
Rock Excavation	"	24,100	23.0	554,300	
Concrete Class A	"	800	235.0	188,000	σck=270
Concrete Class B	"	45,700	190.0	8,683,000	σck=230
Concrete Class C	"	10,400	170.0	1,768,000	σck=170
Reinforcement Bar	t	58	1,800.0	104,400	
Miscellaneous	set	l.s. 1		349,400	3%
Sub-Total				11,820,000	
2. Foundation Treatment Tunnel (ℓ=70m)					
Tunnel Excavation	m^3	810	86.5	70,065	
Concrete	"	330	305.0	100,650	
Reinforcement Bar	t	13	1,800.0	23,400	
Miscellaneous	set	l.s. 1		5,885	3%
Sub-Total				200,000	
3. Grouting					
Drilling	m	12,500	130.0	1,625,000	
Curtain Grouting	t	1,425	1,350.0	1,923,750	
Consolidation	t	450	700.0	315,000	

(to be continued)

Dam (cont.)

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
Miscellaneous	set	l.s. 1		116,250	3%
Sub-Total				3,980,000	
Total				16,000,000	

Table 4.16 Spillway

M$4,950,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Spillway					
Common Excavation	m^3	22,500	9.0	202,500	
Rock Excavation	"	10,400	23.0	239,200	
Side Wall Concrete	"	7,700	255.0	1,963,500	
Invert Concrete	"	6,100	250.0	1,525,000	
Guide Wall Concrete	"	1,100	255.0	280,500	
Reinforcement Bar	t	331	1,800.0	595,800	
Miscellaneous	set	1		143,500	3%
Total				4,950,000	

Table 4.17 Intake

M$920,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Intake					
Common Excavation	m^3	1,100	9.5	10,450	
Rock Excavation	"	3,100	23.0	71,300	
Retaining Wall Concrete	"	1,200	255.0	306,000	
Concrete in Body Intake	"	750	265.0	198,750	
Invert Concrete	"	500	250.0	125,000	
Reinforcement Bar	t	100	1,800.0	180,000	
Miscellaneous	set	l.s. 1		28,500	3%
Total				920,000	

Table 4.18 Penstock

M$810,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Penstock					
Common Excavation	m^3	1,100	9.5	10,450	
Rock Excavation		2,500	23.0	57,500	
Foundation Concrete	"	1,150	250.0	287,500	
Reinforcement Bar	t	23	1,800.0	41,400	
Miscellaneous	set	l.s. 1		13,150	3%
Sub-Total				410,000	
2. Steel Penstock					
Steel Penstock	t	72	5,400.0	388,800	
Miscellaneous	set	l.s. 1		11,200	
Sub-Total				400,000	
Total				810,000	

Table 4.19 Power House

(Power House, Outlet)

M$6,440,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Power House					
Common Excavation	m^3	8,500	9.0	76,500	
Rock Excavation	"	12,700	22.5	285,750	
Concrete for Side Wall	"	2,470	255.0	629,850	
Concrete for Foundation	"	2,070	250.0	517,500	
Borrel Casing Concrete	"	1,000	255.0	255,000	
Slab Concrete	"	320	265.0	84,800	
Outlet Concrete	"	340	255.0	86,700	
Retaining Wall Concrete	"	2,280	255.0	581,400	
Reinforcement Bar	"	450	1,800.0	810,000	
Miscellaneous	set	1		102,500	3%
Sub-Total				3,430,000	
2. Architectural Work					
Power House Building	m^3	10,000	230.0	2,300,000	
Plumbing, Air Conditioning and Ventilation Work	"	11,400	55.0	627,000	
Miscellaneous	set	l.s. 1		83,000	3%
Sub-Total				3,010,000	
Total				6,440,000	

Table 4.20 Gate Screen

M$575,000.-

Item	Unit	Quantity	Unit Cost	Cost (M$)	Remarks
1. Gate, Screen					
Intake Gate	t	27	9,300.0	251,100	
Outlet Gate	"	18	8,700.0	156,600	
Screen	"	30	5,000.0	150,000	
Miscellaneous	set	l.s. 1		17,300	3%
Total				575,000	

4.6 Construction Planning and Implementation Schedule

4.6.1 General

Technical data for the Upper Tekai and Lower Tekai is shown in the table below.

Item	Unit	Dimension	
		Upper Tekai	Lower Tekai
Type	-	Rock Fill	Concrete Gravity
Height of Dam	m	101	38
Crest Length	m	350	160
Volume of Dam Embankment	m^3	3,125,000	56,900
Effective Depth	m	10	4.5
Generating Energy	MW	150	5.8

The Upper Tekai is located about 20 km upstream of the Lower Tekai. To expedite the completion of work, an access road will be completed prior to starting the primary work. Consequently, this work will be started immediately after conclusion of the work contract. Construction of the Upper Tekai power station is scheduled to be started in March 1986, followed by the start of filling in November (when the rainy reason begins) 1989 with operations scheduled to start in July 1991. To reduce construction costs by utilizing the flood control function of the Upper Tekai, the construction work of the Lower Tekai will be started with sluice diversion in April (during the dry season) 1989. Dam concrete will be placed two months after the start of filling of the Upper Tekai. The start of operations of the Lower Tekai power station will be in July 1991, the same as for the Upper Tekai power station.

The total construction period of principal work is about 6 (six) years.

4.6.2 Upper Tekai

(1) Schedule

The principal schedule for Upper Tekai is as follows:

a) Completion of access road and temporary road (road from the aggregate plant to spoil site) - February 1986
b) Start of excavation of diversion tunnel - June 1986
c) Start of excavation of diversion and dam - October 1987
d) Dam embankment start - July 1988
e) grouting of dam body - October 1989 (complete)
f) Spillway - July 1987
g) Penstock - May 1987
h) Power station - March 1988
i) Start of reservoir filling - November 1989
j) Start of operations - July 1991

(2) Construction

a) Access road

The construction of an access road will be started in February 1984, with the road completed to the Upper Tekai by February 1986.

The temporary road from the upper dam site to the aggregate plant and to the spoil site will be completed by February 1986 to enable commencement of the primary work immediately.

b) Temporary facilities

After concluding the contract, the erection of camp facilities, generator equipment, etc. will be started. At the same time, land preparation (excavation of about 75,000 m^3) of the aggregate plant site and the erection of such plant and batcher plant will be started because spray aggregate for the diversion tunnel will be required from August 1986 and lining concrete from October of the same year.

c) Diversion tunnel

Excavation will be started from both the inlet and outlet sites to shorten the construction period.

Concrete will be cast in parallel with excavation work while leaving the invert unconcreted. Invert concrete will be cast after completion of excavation.

d) Dam body

Dam excavation will be started on both banks after completion of diversion. Excavated soil will be transported by dump truck from the river bed to the spoil area.

Embankment work will be started from July 1988, at a rate of 6,290 m^3/day up to EL. 130 m and a mean 3,400 m^3/day up to 166.2m. Excavation and embankment work will be done only during the daytime.

e) Quarry site

Two quarry sites are selected on the right bank downstream of the Upper Tekai, for core, rock and filter materials. The aggregate plant will be erected on the right bank of the Upper Tekai, to produce concrete aggregate for the Upper and Lower Tekai and filter materials for the embankment.

f) Grouting

For dam foundation treatment, curtain grouting will be carried out, with an improved target of 2 Lu, up to the third grouting.

g) Spillway

Excavation at the over flow part will be started in July 1987. After diversion, the shute and stilling basin will be excavated from the upper section. Concrete placing will be done in parallel with excavation. (Completion schedule, December 1989)

h) Pressure tunnel

Excavation will be made by an access tunnel of 150 m length in order to avoid simultaneous work as power station construction. For the inclined section, excavation will be made by widening after excavating the pilot tunnel from the lower section. After completion of excavation, installation of steel pipe, concrete placing, and grouting will be carried out.

i) Power station

Excavation for the power station will be started after completion of dam excavation and completed in five months at an average excavation rate of 20,000 m^3/month, in accordance with the benched excavation. A part of the excavated soil and rocks will be re-used for land preparation of the switchyard. Concrete placing will be done in parallel with the installation of draft-tube, cashing and generation. After completion of power station concrete placing, architectural work will be carried out simultaneously with generating equipment.

4.6.3 Lower Tekai

(1) Schedule

The principal schedule for the Lower Tekai is as follows:

a) Start of temporary facilities erection - January, 1989
b) First coffering - April 1989
c) Dam excavation - August 1989
d) Start of concrete placing on the right bank - January 1990
e) Secondary coffering - June 1990
f) Start of concrete placement on the left bank - October 1990
g) Excavation of spillway and water intake - August 1989
h) Penstock - December 1989
i) Power station - August 1989
j) Start of operations - July 1991

(2) Construction

a) Access road

The access road to the Lower Tekai site will be a branch of the access road to the upper dam site and run over the crest of the Lower Tekai dam to the power station. For the temporary road to be used during construction, a temporary bridge will be built from the left to right bank to transport construction materials and equipment.

b) Temporary facilities

Camp facilities will be located at a flat area approximately 3 km upstream from dam site. Concrete aggregate plant will be installed at Quarry site D. Principal temporary facilities here include the batcher plant (30 m^3/H), cooling plant, cement silo and one-side travelling cable crane (6T) which will be located in the vicinity of dam site.

c) Diversion work

After comparing diversion tunnel and sluice diversion methods in terms of cost and construction period, the latter was selected. Because the reservoir filling of the Upper Tekai will be started in November 1989, the first stage of sluice diversion will be made in April (dry season). Discharge was estimated at 200 m^3/s from the remaining basin for a 10-year period. The second stage will be implemented in June 1990, when two diversion tunnels (B = 4.0 m, H = 4.0 m, and R = 2.0 m) are completed inside the embankment. In both the first and second stages of sluice diversion, sheet piles will be driven.

d) Dam excavation

Dam excavation will be started from August 1989. Upon completion of the first stage of sluice diversion, excavation of the right bank will be started. For the left bank, excavation will be started in March 1990, after completion of the second stage of sluice diversion. Excavation will be made from the top of the bank downward, in accordance with the benched excavation method. Excavated soil will be loaded onto dump trucks on the river bed and carried to the soil area.

e) Dam concrete

Placing of dam concrete will be started in January 1990 and completed in about 16 months. Concrete placing will be continued day and night, with an average volume of 160 m^3 a day. For concrete placing, the one-side travelling cable crane (6T) will be used. The batcher plant to be used will have a capacity of 30 m^3/h. The construction schedule is as follows: concrete of about 20,000 m^3 on the right bank in five months (up to EL. 65.0 m) during the first stage and concrete on the left bank above EL. 65.0 m after completion of the second stage of sluice diversion.

f) Grouting

For the dam foundation treatment, curiam grouting will be used, with an improved target of 10 Lu, up to the fourth grouting.

g) Spillway

Excavation and concrete work for the spillway will be made approximately parallel with work on the dam body. Excavated soil will be carried to the spoil area about 3 km downstream of the dam site. Concrete placing for the guide wall will be made simultaneously with that for the dam body, with one lift being 1.0 to 1.5 m.

h) Penstock

Excavation for the penstock will be made simultaneously with that of the dam body. After completion of excavation, installation of the penstock and concrete placing will be implemented.

i) Power station

Excavation for the power station will be started in August 1989, and completed in five months with an average volume of 5,000 m^3/month. Concrete placing will be completed in seven months, with an average volume of 1,600 m^3 per month. As in the case of the Upper Tekai, excavated soil will be utilized for land preparation of the switchyard.

5. ECONOMIC EVALUATION FOR POWER BENEFITS AND OTHER ASPECTS

5. Economic Evaluation for Power Benefit and Other Associated Aspects

5.1 Introduction

The purpose of this chapter is to identify and quantify the costs and benefits concerning the proposed Project in order to evaluate its economic viability. The criterion used in this appraisal is the Internal Rate of Return for the power benefit which is derived from the viewpoint of comparison of costs between the Project and an assumed alternative power generation scheme. The cash flow table of the Project is in accordance with the construction schedule presented in Figure X-III. Included in the analysis are several cases with varying assumptions for the yearly fuel costs of the alternative scheme; and IRRs and Net Present Values (NPV) are estimated for each of these cases.

Although the present Project is conceived as a single-purposed one, the subsequent sections deal not only with the main benefit but also other major aspects such as forestry, flood mitigation, irrigation and agriculture, tourism and others. For the main benefit, following a description on power generation and transmission in Peninsular Malaysia, the evaluation framework and the major parameters used in the present analysis are explained.

With respect to the other aspects, however, only forestry losses are estimated in terms of NPV. The effects of the Project on the otehr aspects - e.g. flood mitigation, irrigation and agriculture, tourism and others - are assessed qualitatively; since they are either expected to be small or subject to uncertainties and therefore not easily measurable. The results of the economic evaluation are presented in Section 5.8. With regard to the effects of the Project on natural environment, the results of the field survey carried out by the present study team are summarized in Appendix 2.

5.2 Power Benefits

5.2.1 Power Generation in the Peninsular Malaysia

During the fiscal years 1970 to 1980, total electricity sales in the Peninsular Malaysia increased at an average annual rate of about 13 percent, reflecting the economy's need for additional power (see Table 5.1). In April 1981, the NEB forecast the long-term power demand for the years up to 2000 using econometric models, with the assumption that the system load factor will not greatly change over the forecast period. As shown in Table 5.2, maximum demand and annual energy demand were forecast to be 4,154 MW and 25,254 GWH in 1990, and 9,135 MW and 55,550 GWH respectively in the year 2000. These figures are six to seven times greater than the corresponding present figures, and show an average annual increase rate of 9.8 percent.

The present installed capacity of NEB's generating plants amounts to approximately 2,480 MW with the composition shown in Table 5.3. The percentage of generating plants connected with the NEB integrated system (except diesel-engine generators for rural electrification) is 65 percent for thermal power stations, 26 percent for hydro power stations, 4 percent for gas turbines, and 5 percent for diesel generators. According to the plan established by the NEB based on the long-term power demand forecast, power stations with a total installed capacity of 3,262 MW are scheduled to be constructed by 1990 with hydro power stations accounting for 28 percent, gas turbines for 5 percent, and oil-fired thermal and combined cycle stations for 67 percent (see Table 5.4). Fig. 5.1 shows the generation development schedule with the nominal installed capacity and the forecast peak demand up to the fiscal year 1990.

In September 1981, the NEB published a report reviewing the generation development with alternative programmes including coal-fired thermal stations over the period from fiscal 1986 to 1990. In the report, it was concluded that the proposed hydro projects of Ulu Trengganu, Pergau, Tembeling and Tekai should be implemented. With the development of the Tembeling project presently suspended due mainly to environmental factors, the development of the Tekai project with the revision of installed capacity of 161 MW is now considered to be more important.

Regarding the system's load characteristics, the maximum demand, generated load factor and the load curve of January 4 (Monday), 9 (Saturday) and 10 (Sunday) in 1982 are presented in Table 5.5, Figs. 5.2, 5.3 and 5.4. As shown in these figures, thermal power stations run for the base load, and hydro power stations and gas turbine generators for the peak load. Fig. 5.5 shows the present weekday load duration curve converting the load curve of Fig. 5.2 on January 4, 1982 into equivalent linear. Based on this load duration curve and the NEB's forecast annual growth rate of 9.8 percent (1980 ∿ 2000 year, Table 5.2), the load duration curve with maximum and minimum demands are obtained for fiscal 1990, 1995 and 2000 (Fig. 5.6 and Table 5.6).

As is apparent in the forecast load duration curve in Fig. 5.6, Upper Tekai's installed capacity of 150 MW with a planned average daily operation time of 3.6 hours should be placed on the top of the system's load curve among the power stations which are to serve the system's peak demand. The actual weekday operation time of the Upper Tekai, however may become longer than the average figure suggested considering the substantially lower peak demand on Sundays and Saturdays.

5.2.2 Power Transmission

In parallel with the NEB's power generation development program established in April 1981, the expansion and reinforcement program for the existing 132 KV/275 KV transmission network is now under implementation. This program covers the whole west coast of the Peninsular Malaysia and a 275 KV loop transmission line which interconnects the west coast with the east coast, and the north and the central regions of the Peninsula. (See Fig. 5.7) The 275 KV loop transmission line consists of double circuits, each with ACSR 300 mm^2, carrying a maximum transmission capacity of 1,174 MVA (587 MVA x 2). The program is scheduled to be completed by 1985.

The NEB system is currently linked with the systems of Singapore (PUB) and Thailand (EGAT). The connection with the PUB system, currently using a 22 KV line, is planned to be upgraded to a new 230 KV cable line with a maximum capacity of 200 MVA to cope with emergency conditions. In the case of the EGAT, the connection was completed in February 1981 at the Bukit Ketri Substation using a 132 KV, 150 mm^2 line with a maximum capacity of 75 MVA. Here again, however, the interchange of electricity is made only under emergency conditions and is limited to 30 MVA to 50 MVA in practice.

The NEB's basic plan for the construction of transmission lines for the Tekai hydro power station is as follows. Construction of 132 KV x 2 double circuits is to be made over a distance of approximately 60 Km from the Upper Tekai station to the existing Jerantut Substation via the Lower Tekai station. The Jerantut Substation is connected to the Kg. Awah Substation by a 150 mm^2 transmission line with a capacity of 77 MVA. Therefore, because the output of the Tekai hydro power stations will exceed the capacity of the existing 132 KV transmission line, a new 132 KV transmission line of about 71 km in length should be constructed from the Jerantut Substation along the existing transmission line extended to Kg. Awah.

5.2.3 Evaluation Framework

The economic value of public funds invested in these power projects which aim at alleviating future shortages in the system's peak-load capacity or improving system reliability cannot be fully quantified and thus an estimate of return on investment cannot be expressed. In the absence of an established methodology for properly quantifying the benefits of power supply, an economic evaluation (especially for hydro projects) is usually carried out by comparing the costs attributable to the concerned project (net of duties and taxes) - including the cost of transmission - to the least costly alternative (thermal) program able to meet the same system demand.

It must be mentioned, however, that any evaluation made in this way implicity assumes that the demand for future peak-load power generation must be met either by the proposed project or by some alternative means, because the social loss of not meeting the power demand would be far larger than the net benefits accruing to any marginal non-power projects. Thus, the IRR (or more exactly, the discount rate, which equalize the present values of the costs of the two alternatives) calculated on this assumption is not relevant when making a choice between the proposed project and any marginal projects in other sectors of the economy, although it is relevant for evaluating projects within the power sector.

In general, a new project is evaluated not as an individual project but as a part of a comprehensive program in order to take account of the capabilities and load-follow operation characteristics of all existing as well as planned facilities. However, because of the relatively small size of the proposed project's capacity (161 MW compared with the system's forecast peak demand of more than 4,000 MW in 1990), it was suggested by NEB that the evaluation would be restricted to comparing the proposed project with an assumed single alternative project using gas turbine units, considering the load-follow operation for peak demand which is to be met by the proposed project.

Table 5.1 Energy Generated and Sold by NEB (GWH)

Fiscal Year	Energy generated & purchased (GWH)	Sending end energy (GWH)	Energy sold (GWH)	Rate of increase (%)
1970	2498.1	2406.3	2175.0	-
1971	2755.8	2645.8	2398.9	10.3
1972	3189.4	3057.4	2766.4	15.3
1973	3647.0	3491.8	3145.4	13.7
1974	4106.3	3929.5	3502.1	11.3
1975	4650.7	4441.9	3982.3	13.7
1976	5356.9	5103.2	4543.5	14.1
1977	6257.8	5953.6	5297.1	16.6
1978	6991.5	6651.4	5934.2	12.0
1979	7651.3	7302.4	6541.0	10.2
1980	8466	8071	7266	11.1

(Source ; NEB Annual Reports, 1969/70 - 1979/80)

Table 5.2 Long-Term Demand Forecast by NEB (1981 to 2000)

Fiscal Year	Annual Energy (GWH)	Peak Demand (MW)	Load Factor (%)
1980	8,610	1,397	70.38
1981	9,641	1,621	67.89
1982	11,034	1,614	69.44
1983	12,730	2,127	68.32
1984	14,595	2,388	69.77
1985	16,449	2,778	67.59
1986	18,906	3,110	69.40
1990	25,254	4,154	69.40
1995	36,976	6,082	69.40
2000	55,550	9,138	69.40

(Annual Growth Rate (%))

Fiscal Year	Energy	Peak Demand
1980 - 1985	13.8	14.7
1980 - 1990	11.4	11.5
1980 - 1995	10.2	10.3
1980 - 2000	9.8	9.8

(Source ; NEB System Development, 1981 - 2000 Part I : Load Forecasts)

Table 5.3 Power Generating Plant of NEB

(1) Hydro Power Stations

Temengor	4 units x 87 MW	348 MW
Sultan Idris II	3 x 50	150
Sultan Yusuf	4 x 25	100
Chenderoh	3 x 10	30 (PRHEC)
Others		15.4
	(Sub-total)	643.4 MW

(2) Thermal Power Stations

Pasir Gudang	2 units x 120 MW	240 MW
Connaught Bridge	4 x 20	80
Gelugor	4 x 10	40
Malaka	4 x 10	40
Sultan Ismail	3 x 10	30
	3 x 30	90
Perai	3 x 30	90
	3 x 120	360
Tuanku Jaafar (Port Dickson)	4 x 60	240
	3 x 120	360
Malim Navar	2 x 20	40 (PRHEC)
	(Sub-total)	1,610 MW

(3) Gas Turbines

Gelugor	1 unit x 20 MW	20 MW
Connaught Bridge	1 x 20	20
Tuanku Jaafar	1 unit x 20 MW	20 MW
Tanjong Gelang	1 x 20	20
Sultan Ismail	1 x 20	20
	(Sub-total)	100 MW

(4) Diesel-engine Generators

Lundang		37.95 MW
K. Trengganu		24.15
Kemaman		4.61
Dungun		3.145
Kuantan		11.73
Lemal		2.60
K. Rompin		2.85
Others		30.876
Diesel engine generators for rural electrification		6.300
	(Sub-total)	124.211 MW
	Total	2,477.611 MW

Table 5.4 Power Expansion Program

(1) Power Stations Committed

				completion scheduled
Connaught Bridge (G/T)	2 units	x 80 MW	160 MW	1983
Bersia (H)	3	x 24	72	1983
Kenering (H)	3	x 40	120	1983/4
Paka (C/C)	9	x 100	900	1984/5
Port Kelang (O)	2	x 300	600	1985
Kenyir (H)	4	x 100	400	1985
		Total	2,252 MW	

where, (O) : Heavy oil burning

(G/T) : Gas turbine heavy oil burning

(H) : Hydro power station

(C/C) : Combined cycle, natural gas burning

(2) Power Stations Planned (as of 1982)

Port Kelang (O)	2 units	x 300 MW	600 MW	1986/7
Ulu Trengganu (H)	2	x 100	200	1988
Pergau (H)	2	x 50	100	1988
Tembeling (H)	4	x 27.5	110	1988
		Total	1,010 MW	

Fig. 5.1 Generation Development 1981-1990

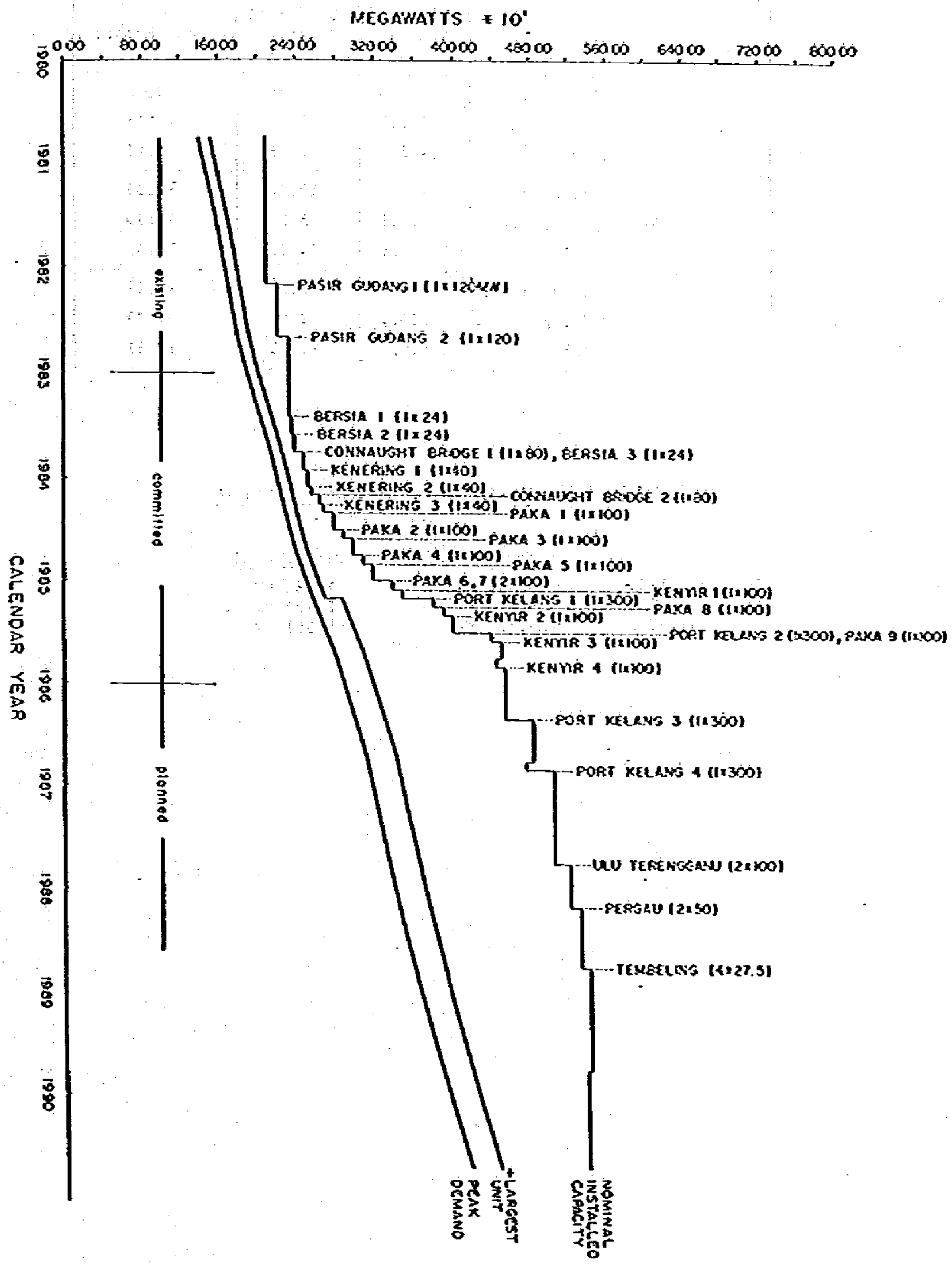


Table 5.5 Maximum Demand and Load Factor

		Maximum Demand (KW)	Generated Power (GWH)	Load Factor
	Thermal power	1,037.0	22.21	89.23
1982 Jan. 4th	Hydro power	398.2	4.12	43.15
	Total	1,435.2	26.33	76.45
	Thermal power	944.0	19.72	87.06
" 9th	Hydro power	426.6	5.11	49.90
	Total	1,370.6	24.83	75.49
	Thermal power	852.5	18.67	91.27
" 10th	Hydro power	283.9	2.53	37.39
	Total	1,136.4	21.22	77.81

Table 5.6 Maximum and Minimum Demand

	Max. Demand	Mini. Demand
1990	4,436 MW	1,983 MW
1995	6,496 MW	2,903 MW
2000	9,759 MW	4,363 MW

Fig. 5.2 System Load Curve

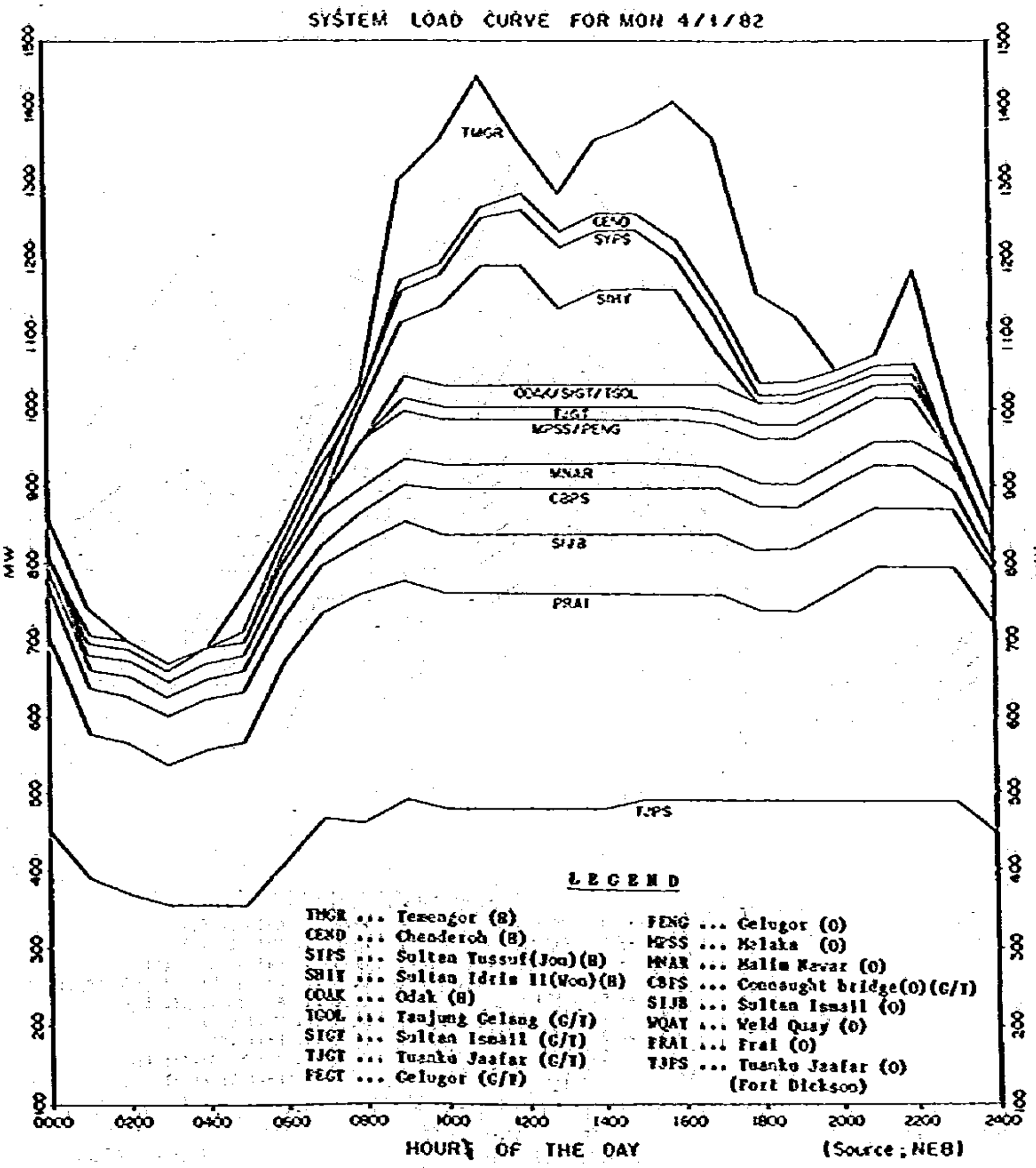


Fig. 5.3 System Load Curve

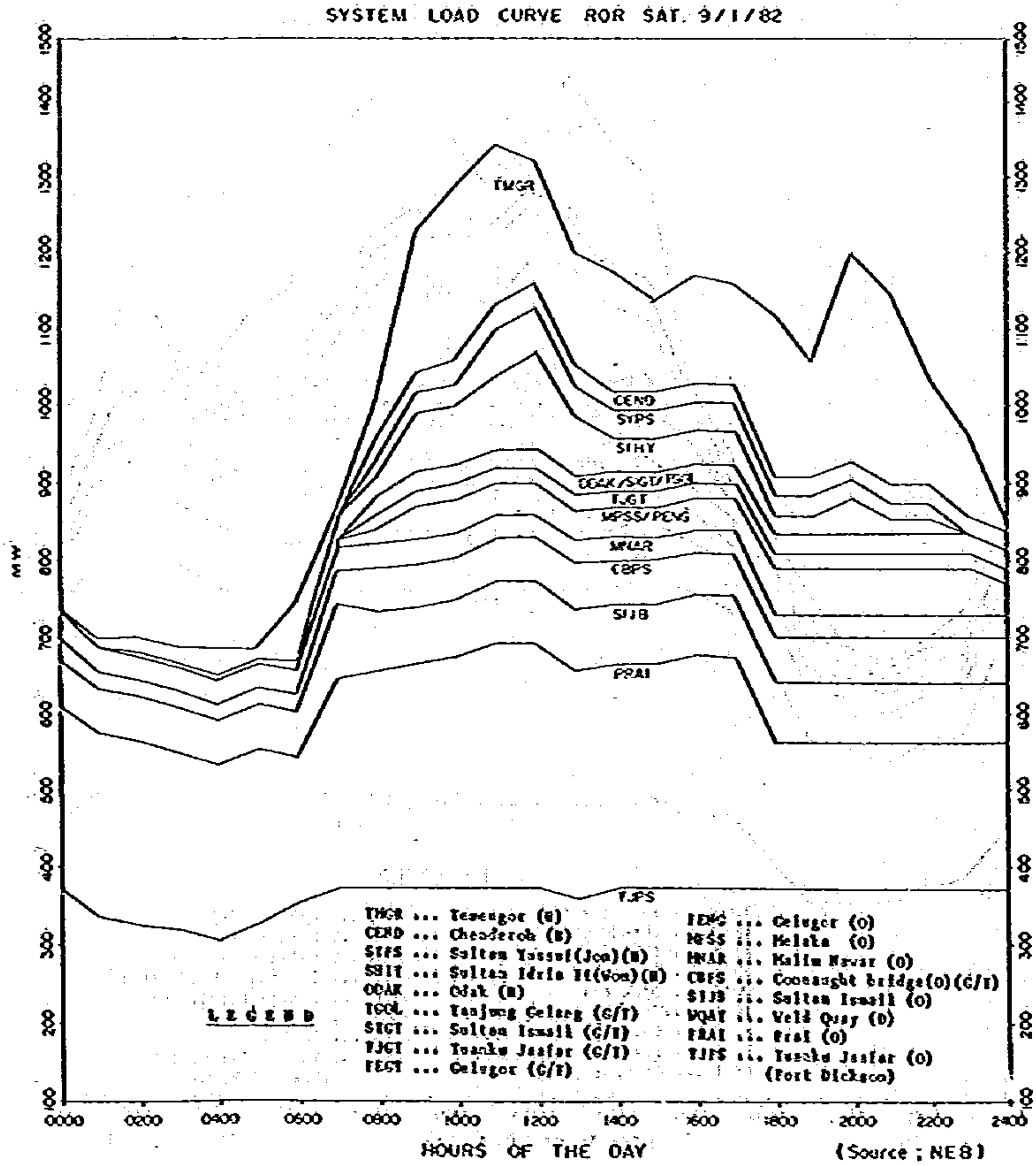


Fig. 5.4 System Load Curve

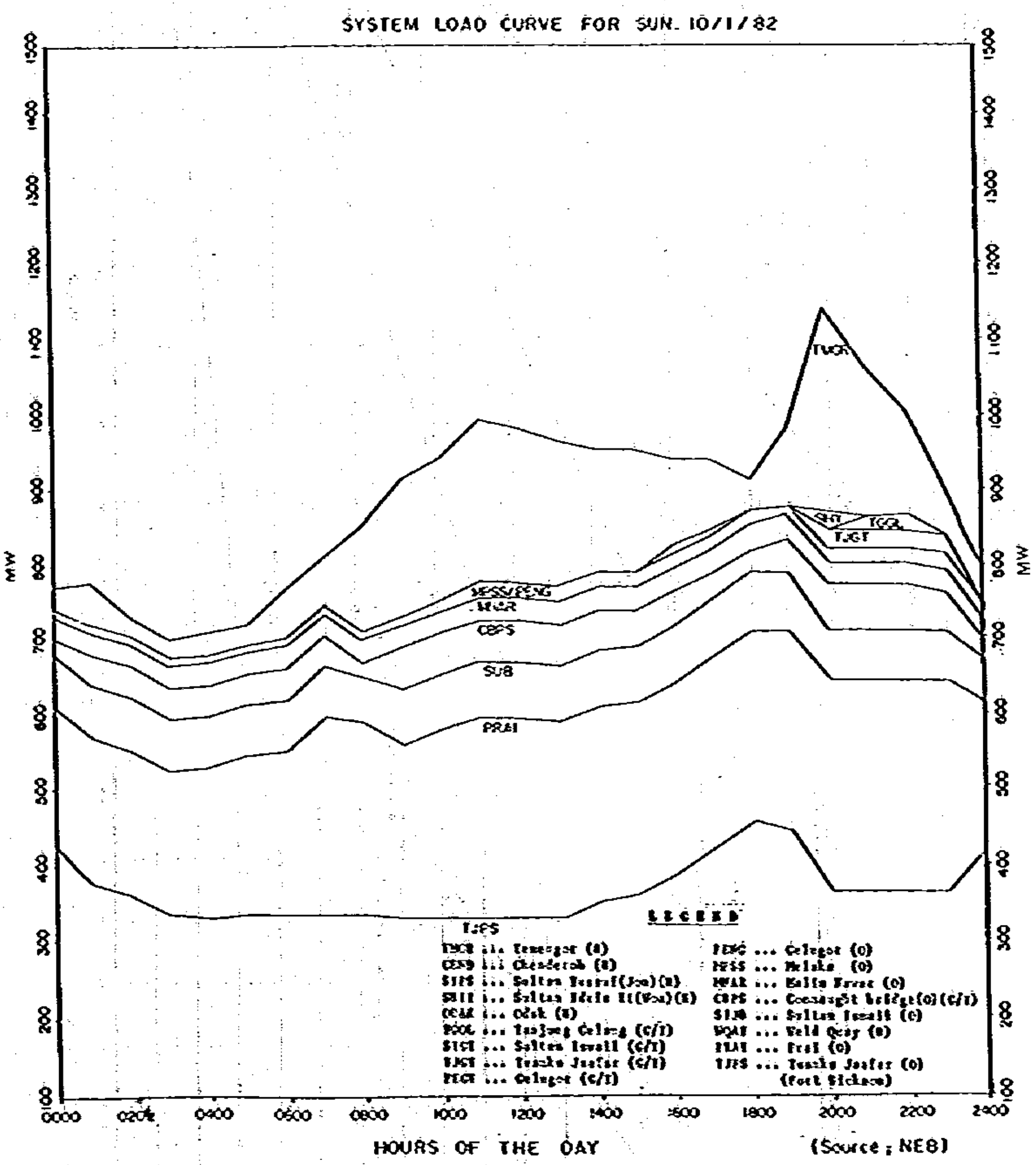


Fig. 5.5 Weekday Load Duration Curve

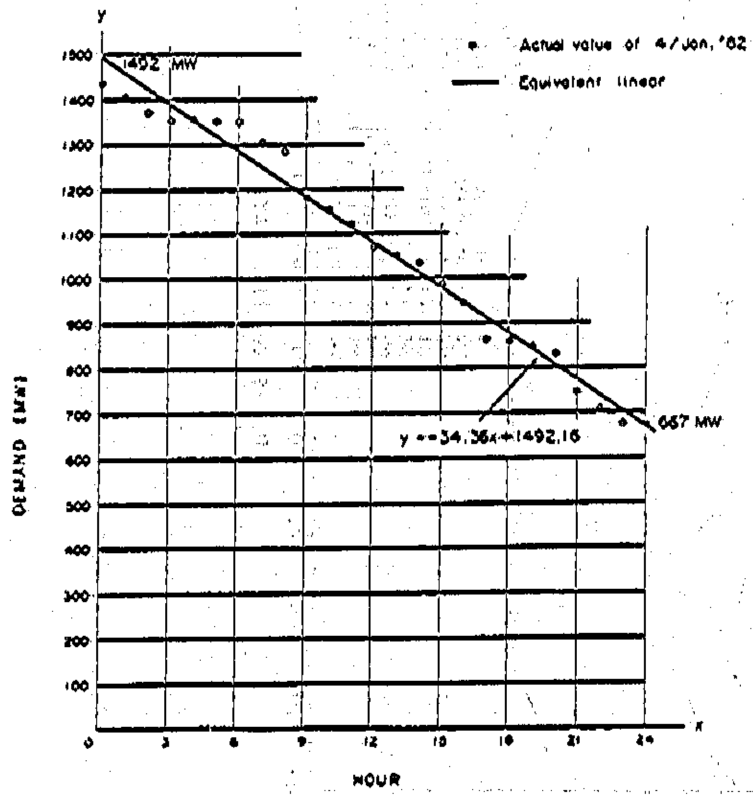


Fig. 5.6 Forecasted Weekday Load Duration Curve

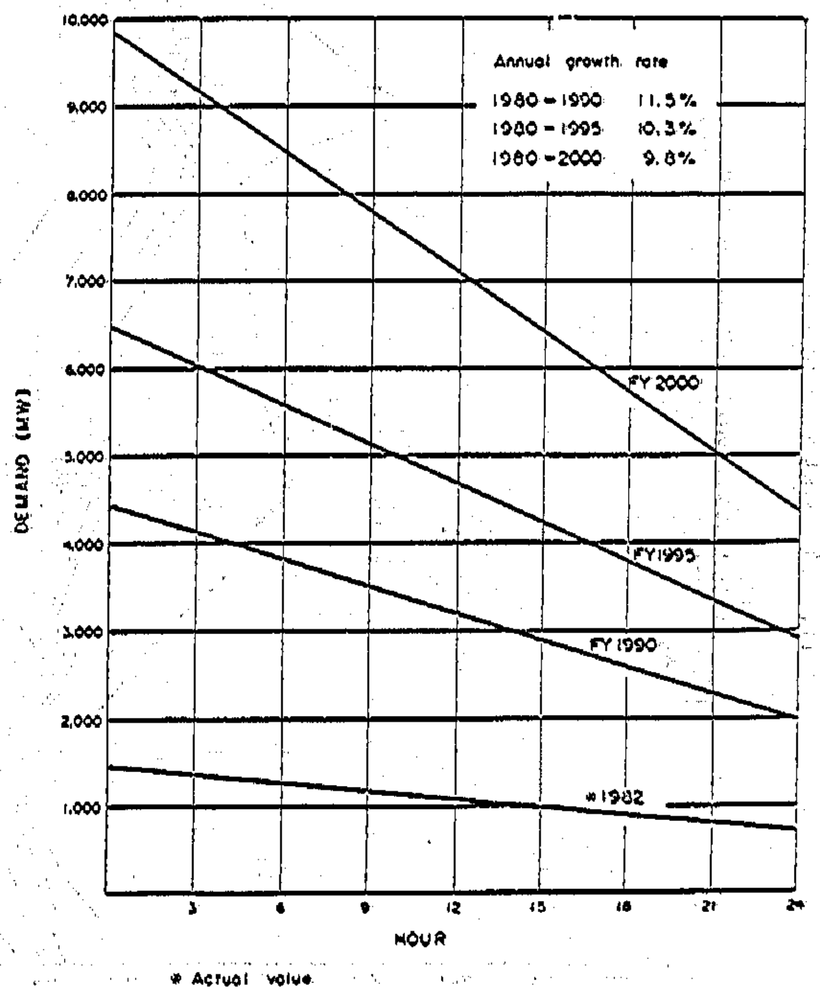
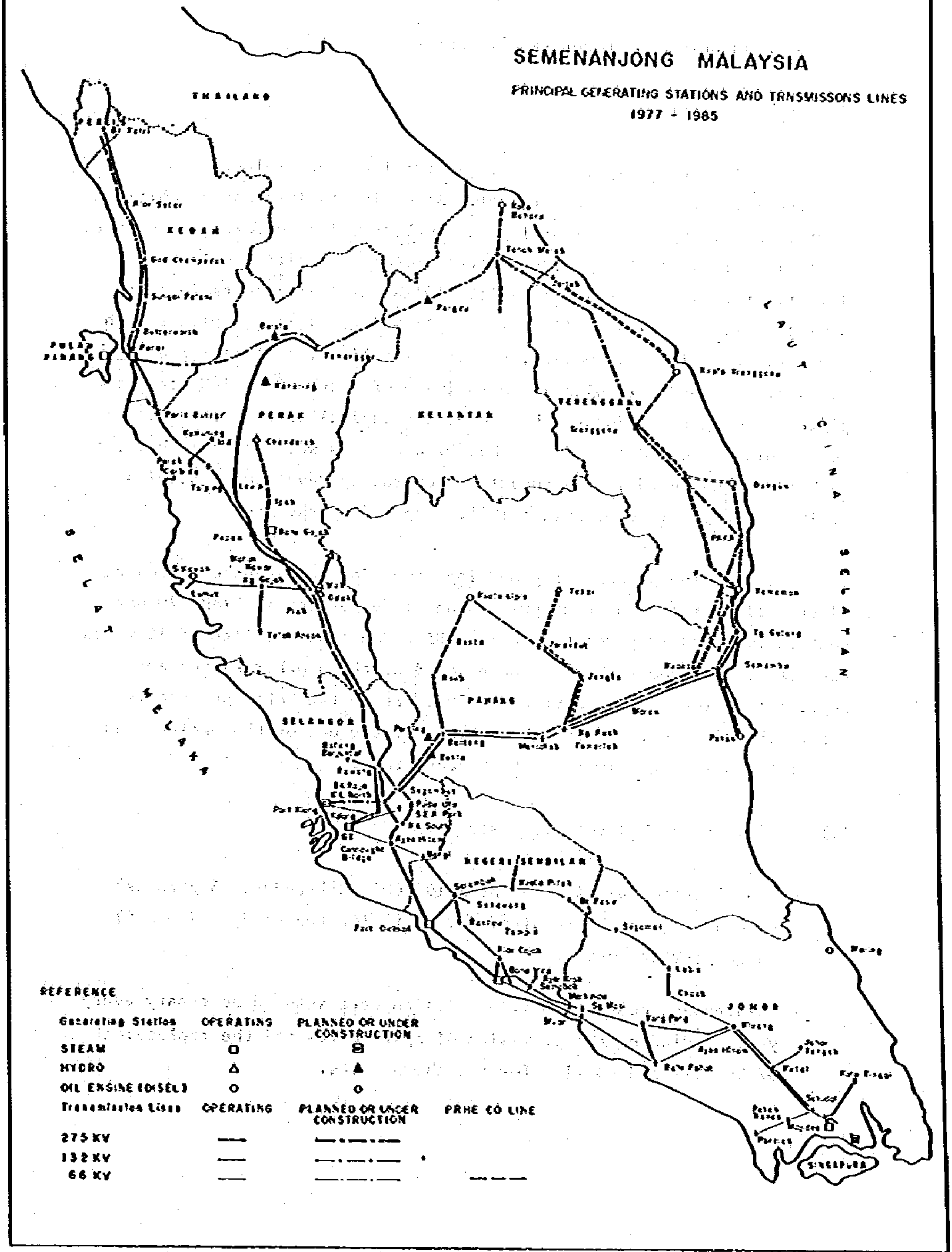


Fig. 5.7 Main Transmission System



5.2.4 Assumptions of Power Benefit Analysis

(1) Capital Cost

As previously explained, gas turbines were selected as an alternative for the present project. According to information obtained from Japanese suppliers exporting gas turbine units to foreign countries including Malaysia, the present international competitive unit cost (c.i.f. price in Malaysia) is US$160-170/kW, excluding costs for site development, transmission lines and engineering. This - together with the costs for site development, transmission lines, engineering and contingency added - results in an estimate of about US$300/kW for a complete set of gas turbines. Therefore, the capital cost in terms of local currency was determined as M$660/kW. It is worth noting that the same figure was used in the Report of Generation Development Studies FY 1986 through FY 1990, August 1981, supplied by the NEB.

For the purpose of preparing cash flow tables, the following distribution of capital costs was assumed: 20 percent in 1989, 70 percent in 1990 and 10 percent in 1991. Since an economic life of 15 years was assumed for gas turbines, there would be three other subsequent capital investment flows during the 50 years of the Tekai project is life. The salvage value of gas trubines at the end of the project was calculated assuming a 10 percent discount rate.

(2) Operation and Maintenance Costs

- Annual personnel expenses of M$192,000 (M$12,000 x 16 persons) were assumed to be required for operating two 22 MW and one 67 MW gas turbine units.

- Maintenance costs of M$6.152 million were assumed necessary every year, including the provision of spare parts and the replacement of buckets and nozzles for the above units.

(3) Fuel Costs

The NEB purchases its fuel oil at a domestic market. For the calculation of economic return, however, the world market price of M$617/ton (US$30/bbl) was used, based on the Singapore f.o.b. price of medium fuel oil in early 1982.

An amount of 313.62 ton/G.W.H of fuel consumption was obtained by assuming the daily load curve shown in Fig. 5.8 and using technical data supplied by a plant manufacturer (see Table 5.7) were used. A decrease of 10 percent in thermal efficiency due to temperatures in Malaysia and a heat value of 11,000 kcal/kg were assumed in this calculation.

(4) Adjustment Factors

Adjustment factors of 1,119 for kW value and 0.982 for kW.H value (see Table 5.8) were applied for the above costs in preparing cash flow tables.

Table 5.7 Annual Fuel Consumption

Item / Unit	Name-Plate Rating (Kw)	Heat Rate LHV (Kcal/Kw·h)	Daily Runnig Hour	Annual Generating Energy (10^6Kw·h)	Annual Fuel Consumption for Energy Generation (ton)	Annual Running Days *1	Annual Fuel Consumption for Starting Up *2 (ton)	Total Annual Fuel Consumption (ton)
1	75,000	2,670	6.20	123.91	35,755	365	240	35,955
2	75,000	2.670	3.86	66.25	20,206	365	240	20,446
3	24,700	3,080	24.0	55.12	17,740	365	91	20,484
Total				245.28	76,354		571	76,925

*1 Actual annual running days are decreased by 10% due to overhauls.

*2 329 times of annual starting ups are supposed, considering 10% of overhaul rate.

Table 5.8 Adjustment Factors

	Hydro	Gas Turbine
Transmission Loss Rate	4.0%	1.5%
Accident Frequency	0.5%	5.0%
Station Use	0.3%	1.0%
Overhaul Rate	2.0%	10.0%

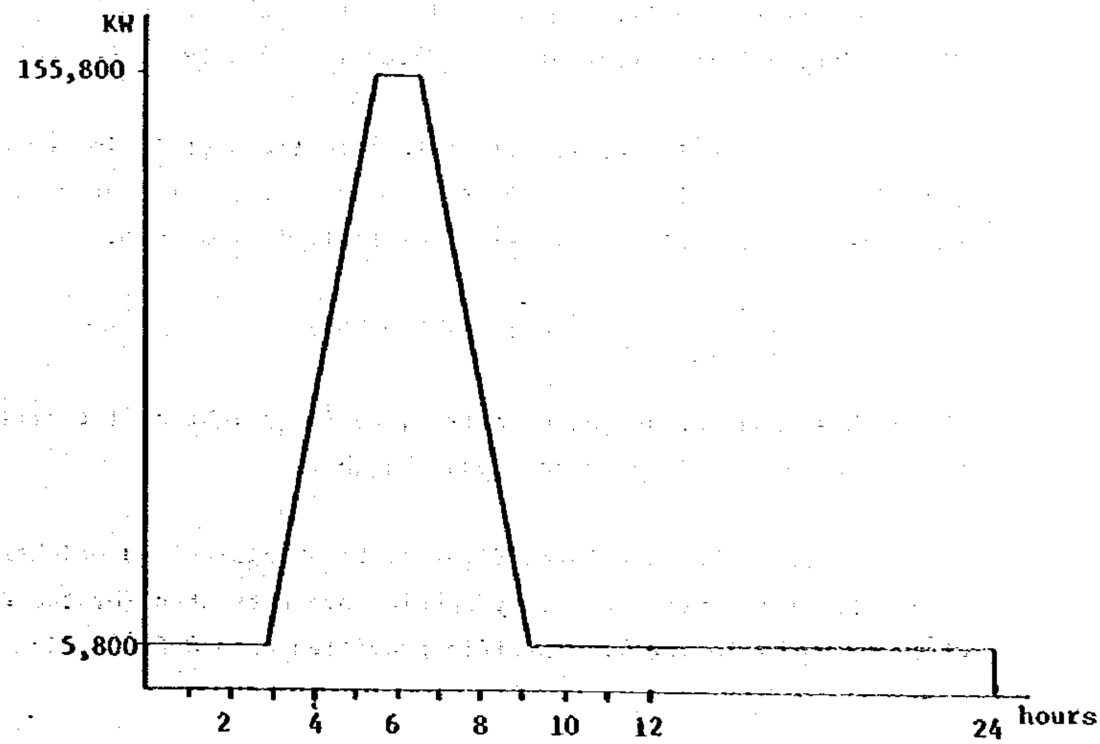
(For KW Value)

$$\frac{(1-0.04)}{(1-0.015)} \times \frac{(1-0.005)}{(1-0.05)} \times \frac{(1-0.003)}{(1-0.01)} \times \frac{(1-0.02)}{(1-0.1)} = 1.119$$

(For KW·H Value)

$$\frac{(1-0.04)}{(1-0.015)} \times \frac{(1-0.003)}{(1-0.01)} = 0.982$$

Fig. 5.8 Model Daily Power Generation Curve



5.3 Forestry

5.3.1 Forest Resources in the Reservoir Area

It is anticipated that the proposed Upper Tekai Dam will begin to store water in November 1989 and that by the middle of 1991 both the Upper and Lower Tekai Dams will reach operating levels. The reservoirs of the two dams will flood an area of about 8,210 ha including approximately 7,960 ha of primary forest area (see Table 5.9). These areas include a number of small islands in the proposed reservoirs.

Logging is practiced at present in Malaysia, for marketable species of trees with a Diameter at Reference Point (usually at breast height) of 18 inches (45.7 cm) and over. Thus, for the present purpose of economic evaluation, the forest resources in the reservoir area are based, in order to obtain the total net volume of marketable trees of 18 inches and over, on the following two data sources:

(1) Data gathered at PLOT-1 (0.25 ha) and PLOT-2 (0.15 ha) of the field biotic environment survey carried out by the present study team (for details, see Appendix 2, Fig. 2); and

(2) A National Inventory of West Malaysia, 1970-1972

For the 14 species of marketable trees of 18 inches and over recorded in the PLOT-1 and PLOT-2, a bole volume (or a gross volume) of each tree was calculated by using the following formula:

$$V = \frac{d^2 \cdot hb}{12h^2} (3h^2 - 3h \cdot hb + hb^2)$$

where, h stands for height of a tree, hb for height of the first large branch and d for diameter at breast height.

From the calculated figures, bole volumes and weights of marketable trees per hectare by species are estimated for the PLOT-1 and PLOT-2 (see Table 5.10). Specific gravities of 0.8 for medium hard wood and 0.6 for light hard wood are assumed in this estimation. In Table 5.10, the log prices at the Jerantut log-yard in 1981 obtained from the Forestry Department are also shown. Then, by applying the estimated loss rates of 15 percent during harvesting and transport and 30 to 35 percent of defective trees for sales net volumes and weights are estimated at 106.55 m^3/ha and 71.71 ton/ha for the PLOT-1 and 54.11 m^3/ha and 36.25 ton/ha for the PLOT-2. As PLOT-1 and PLOT-2 can be regarded as representing 4,580 ha and 3,380 ha of the total flooded forest area of 7,960 ha (see Table 5.9), the total net volume and weight of forest resources are estimated at about 0.67 million m^3 and 0.45 million tons, based on the field survey data.

The second data source (A National Forest Inventory of West Malaysia) shows the national weighted average figures of gross volume of forest resources by forest type (see Table 5.11). Since the net volume of marketable species expressed as a percentage of gross volume was estimated at 47 (see Table 5.12), the estimated net volumes and weights per hectare for the forest types S and G, which are mapped in the reservoir area, are 87.28 m^3/ha and 57.48 ton/ha for the forest type S and 78.26 m^3/ha and 52.43 ton/ha for the forest type G, respectively. Thus, by multiplying the estimated forest areas of 1,100 ha for the type S and 6,860 ha for the type G, we arrived at a total net volume of about 0.63 million m^3 and a total net weight of about 0.42 million tons.

The small differences between the two estimations seem to be due mainly to (1) the smallness of both PLOT-1 (representing areas of low undulation) and PLOT-2 (representing relatively steep slopes along the river channel); (2) the fact that the national inventory data cover a wide area with different characteristics by random samplings in which 10 to 30 percent of standard error is reportedly involved; and (3) possible inaccuracy of the small-scale inventory map indicating the border line of forest types. Thus, in the following valuation of forestry losses, the average figures of the two estimates of 0.65 million m^3 and 0.435 million tons are used.

Table 5.9 Forest Areas of Upper and Lower Tekai Reservoirs

	Total Area (ha)	Forest Area (ha)	Areas Represented by PLOT-1 and PLOT-3 (ha)	Areas by Forest Type (ha)
Upper Tekai Reservoir	7,600	7,400	4,580 (PLOT-1) 2,820 (PLOT-2)	1,100 (Forest Type: S) 6,300 (Forest Type: G)
Lower Tekai Reservoir	610	560	560 (PLOT-2)	560 (Forest Type: G)
Total	8,210	7,960	7,960	7,960

Table 5.10 Bole Volumes, Weights and Prices of Marketable Trees

		Bole Volume (M^3/ha)	Bole Weight (ton/ha)	Percentage of Weight	Prices (1981) (M$/ton)	
PLOT-1	Keruing	48.29	38.63	29.7	254	
	Kempas	22.54	18.03	13.9	209	
	Other MHW	-	-	-	-	
	L.R. Meranti	9.55	5.78	4.4	280	
	Mersawa	78.01	46.81	36.0	260	
	Nyatoh	7.47	4.48	3.5	174	
	Other LHW	26.99	16.19	12.5	137	
	Total	192.85	129.88	100.0	M$ 234/ton	(Weighted Average)
PLOT-2	Other MHW	31.28	25.02	41.1	140	
	L.R. Meranti	36.19	21.72	35.7	280	
	Other LHW	23.48	14.09	23.2	137	
	Total	90.95	60.83	100.0	M$ 189/ton	(Weighted Average)

Table 5.11 Gross Volume of Primary Forest by Forest Type (National Weighted Average)

Forest Type	Diameter at Reference 12+(30.5cm)	Point in Inches 18+(45.7cm)
S	247.3 m^3/ha	185.7 m^3/ha
G	221.2	166.5
M	183.7	129.6

Source: A National Forest Inventory of West Malaysia, 1970 - 1972

Table 5-12 Net Volume of Marketable Species Expressed as a Percentage of Gross Volume

Type of Forest	Diameter at Reference 18+(45.7cm)	Point in Inches 24+(61.0cm)
Primary Hill	47	51
Recently Harvested Hill	40	42
Hill Forest Harvested before 1966	43	46

Source: A National Forest Inventory of West Malaysia, 1970 - 1972

5.3.2 Valuation of Forestry Losses

The valuation of expected forestry losses requires estimates of yearly net benefits accrual to logging activities in the storage area with and without the present Tekai dams. Since it was clarified at the discussion with Pahang State officials that there would be adequate time for forest harvesting before reservoir impoundment, the following two cases were assumed for the with condition.

Case 1 : 50 percent of forest resources in the storage area logged
Case 2 : 70 percent of forest resources in the storage area logged

For these two cases, it was further assumed that log harvesting would be carried out for four years - from 1986 to 1990. For the without condition, it was assumed that 50 percent of forest resources in the storage area would be logged within six years and relogged on a 45-year cycle.

The price of logs harvested in the area was estimated at M$144/$m^3$ by using the data obtained from the Forestry Department. These data are shown in Table 5.10. Logging costs, including felling, skidding, yarding and hauling cost, were assumed to be M$106/$m^3$, based on the data supplied by Jengka Co. to NEB. Because hauling roads are necessary for both with and without conditions, road construction cost was ignored for the present purpose. These assumptions finally lead to a net benefit of M$38/$m^3$ for one unit of the logging product in the area.

Table 5.13 shows the yearly logging benefits for years up to 2111 for the without and the two with cases of the Project. Two alternative scenarios assuming 1.5 percent and 3 percent of relative escalation in log price per annum are also presented in the Table. Summarized in Table 5.14 are estimated of net present values of forestry losses for these cases and scenarios by applying a 10 percent discount rate.

Table 5.13 Projected Cash Flows for Forest Production (M$ x 10^6)

Year	Without Dams			With Dams: Case 1						With Dams: Case 2					
	Constant Log Price	Price Escalation 1.5%	Price Escalation 3.0%	Constant Price		Escalation 1.5%		Escalation 3.0%		Constant Price		Escalation 1.5%		Escalation 3.0%	
					Increment		Increment		Increment		Increment		Increment		Increment
	(A)	(B)	(C)	(D)	(D)-(A)	(E)	(E)-(B)	(F)	(F)-(C)	(G)	(G)-(A)	(H)	(H)-(B)	(I)	(I)-(C)
1986	3.71	3.87	4.05	3.09	-0.62	3.23	-0.64	3.37	-0.68	4.32	0.61	4.52	0.65	4.72	0.67
1987	3.71	3.93	4.17	3.09	-0.62	3.28	-0.65	3.48	-0.69	4.32	0.61	4.59	0.66	4.87	0.70
1988	3.71	3.99	4.30	3.09	-0.62	3.33	-0.66	3.58	-0.72	4.32	0.61	4.66	0.67	5.01	0.71
1989	3.71	4.05	4.42	3.09	-0.62	3.38	-0.67	3.69	-0.73	4.32	0.61	4.73	0.08	5.16	0.74
1990	3.71	4.11	4.56	-	-3.71	-	-4.11	-	-4.56	-	3.71	-	-4.11	-	-4.56
1991	3.71	4.17	4.69	-	-3.71	-	-4.17	-	-4.69	-	3.71	-	-4.17	-	-4.69
2016-21	22.23	37.72	63.56	-	-22.23	-	-37.72	-	-63.56	-	-22.23	-	-37.72	-	-63.56
2049-51	22.23	58.97	754.23	-	-22.23	-	-58.97	-	-154.28	-	-22.23	-	-58.97	-	-154.28
2076-81	22.23	92.17	374.47	-	-22.23	-	-92.17	-	-374.47	-	-22.23	-	-92.17		-374.47
2106-11	22.23	144.06	908.04	-	-22.23	-	-144.06	-	-908.04	-	-22.23	-	-144.06		-908.04

Notes: The figures shown in 'Increment' columns are forestry losses attributable to the Project.
Cash flow figures after 2112 are omitted.

Table 5.14 NPV of Forestry Losses (M$ x 10^6)

	Log Price		
	Constant Price	1.5% of Escalation per annum	3% of Escalation per annum
Case 1: 50% logged	8.06	9.59	11.83
Case 2: 70% logged	3.76	4.99 (most likely)	6.93

Note: A 10% discount rate is applied for 300 years of cash flow streams.

5.4 Flood Mitigation

5.4.1 Flood Damages in the Past

Major flood damages coincide with the north-east monsoon seasons. Fig. 5.9 shows storm rainfall distribution in the monsoon season. Judging from the isohyet pattern, high intensity rainfall occurs along the Tekai and the Tembeling. As a result, a such a rather narrow river as the Tekai rises very rapidly in the monsoon season. Although there is no substantial flood record on the Tekai, most of the tributaries of the Pahang are subject to the overflowing of their banks every wet season. The Pahang River system has an extremely high intensity of rainfall once or twice during the monsoon season inundating the area beyond its banks for a week or more.

Three serious floods in the past were recorded in 1926, 1971 and 1972. The 1926 flood was the biggest for the twentieth century in terms of rainfall intensity. Nevertheless, their flood damages were not very serious because the Basin was not adequately developed at that time. In contrast, many development schemes, both urban and rural, were carried out during the 1960s and 70s in the lower areas along the Pahang. As a result, the 1971 flood in January caused serious damages with 24 deaths and 153 thousand refugees. It was considered to be the biggest damage in this century despite the fact that the rainfall intensity was less than that of the 1926 flood. In the case of the 1972 flood, the rainfall was largely restricted to the eastern half of the Pahang.

Table 5.15 shows 1970/71 flood damages to crops, livestock, and fisheries. Data analyzed were provided from the Pahang State Government. In order to clarify 1970/71 flood damages along the Pahang, seven districts were grouped into the following two: (1) districts through which the Tekai, and its downstreams in the Tembeling and the Pahang flow such as Jerantut, Temerloh and Pekan: (2) the remaining four districts of Lipis, Kerau, Bentong, and Kuantan.

It is clear that, in regard to the various categories, most of the 1970/71 flood damages are concentrated in the former three districts except for those depending on a coconut and fresh water diet. Flood damages to rubber, buffaloes, and cattle are exclusively concentrated in the former. The number of casualities and damages to padi, tapioca and goats and sheep are also concentrated in the former districts which account for more than 90 percent of the total. The number of damaged houses, fruits, chickens and pigs are also concentrated in the former districts. This analysis shows that the 1970/71 flood damages in Pahang State are highly concentrated in the districts along the Pahang in the downstream of the Tekai. This implies that flood mitigation measures for the Pahang river system, including the proposed Tekai dams, could save enormous amounts of economic resources in these areas from flood resulting from intense rainfall in the catchment area of the Pahang.

Table 5.16 shows relationships between three district water warning levels and actual water levels recorded during major floods. Normal water levels range from 194.5 feet or 59.3 m at Kuala Tahan to 19.0 feet or 5.8 m at Kg. Paloh Hinai. The first warning level was set up at 15.5 feet or 4.7 m above normal water level at Kuala Tahan and at 12 feet or 3.7 m at Kg. Paloh Hinai. The third warning level is set up at 25.5 feet or 7.8 m above normal water level at Kuala Tahan and at 18.0 feet or 5.5 m at Kg. Paloh Hinai.

The difference between the normal water level and the third water warning level is larger in the downstream. The upperstream seems to be more tolerable to water fluctuations than the upstream. Nevertheless, as shown in Table 5.17, the frequency of floods over the third warning level is higher at locations along the upperstream than at those along the downstream. For example, the number of floods going over the third warning level at Kuala Tahan is nine out of fourteen or 64.3 percent. At Kg. Paloh Hinai, the number is five out of thirteen floods or 38.5 percent. Conversely, the frequency of floods below the first warning level is less at locations along the upperstream than at those along the downstream. Four out of fourteen floods or 28.6 percent at Kuala Tahan are below the first warning level. At Kg. Paloh Hinai five out of thirteen floods or 38.5 percent are below the first warning level.

The data show that the actual water levels in the upperstream often rise beyond the third warning level. Those in the downstream do not rise very often beyond the third warning level. The number of water levels below the first warning level is the same as that beyond the third warning level.

5.4.2 Flood Mitigation Effects of Tekai Dams

The preceding analysis shows that the water level in the downstream of the Pahang has smaller fluctuations than in the upperstream. Careful attention is needed, however, to this point because smaller fluctuations do not mean less flood damage. As shown in Table 5.15, most flood damages in Pahang State were concentrated along the downstream of the Pahang.

Table 5.18 shows the calculated water flow with and without the Tekai dams at the lower dam site. The calculations were made by adopting the recorded hydrograph of December 1972 and by using adjustment factors of 0.8, 1.0, 1.2, 1.4, 1.6, 1.8 and 2.0 (see Volume III for detail). Because of the small storage capacity of the Lower reservoir, it was assumed that the storm water would be stored in the Upper reservoir only. The relationship between the calculated water with and without the Tekai dams is plotted on the solid line in Fig. 5.10, while the dotted line indicates flood surcharge volume of the Upper reservoir.

By using the relationship shown in Fig. 5.10, flood mitigation effects were calculated by assuming five cases of flood water flows at Kg. Merting and at Kg. Temerloh where hydrological data were available (see Tables 5.19 and 5.20). In this calculation, the water flows attributable to the Tekai were assumed to be proportionate to the catchment areas at the Lower Tekai dam site and at Kg. Merting and Kg. Temerloh. Changes in water levels were calculated by using available Height-Quantity curves (see Figs. 5.11 and 5.12).

As seen from the Tables 5.19 and 5.20, a substantial volume of flood water will be cut at Kg. Merting and Kg. Temerloh. Nevertheless, the economic effects due to the cutting of water levels will be too small to calculate at the moment due to the comparatively small size of the Project's catchment area. It must be mentioned, however, that when the storm rainfall is concentrated in the northern part of the Pahang Basin as illustrated in Figs. 5.11 and 5.12 for the 1971 flood, the flood mitigation effects of the Project on water levels will be much greater than the calculated figures. Also, it must be emphasized that the positively tangible effects of the present Project will become more prominent with the implementation of comprehensive flood control measures as recommended in the following.

5.4.3 Comprehensive Flood Control Measures for the Pahang Basin

In general, flood control measures include river channel improvements and construction of new flood-channels to increase flood discharge capacity; and the construction of retarding basins, regulating reservoirs and dams to regulate flood discharge itself. A decision as to which of these measures or which combination of these measures is to be chosen depends largely on characteristics of the pattern of floods and the present as well as future land uses of the river basin area concerned.

The flood patterns of the Pahang are characterized by a relatively flat hydrograph with long lasting rainfalls. Extensive swamps and barrens in the middle to lower reaches of the river suggest that land use constraints are few. In addition, power development potentials are found in the upper reaches. Considering these characteristics of the Pahang Basin area, the following flood control measures are recommended (see Fig. 5.13).

(1) From Temerloh to the River-Mouth

Little physical constraints suggest that channel improvements together with flood-channels and/or retarding basins may be advantageous.

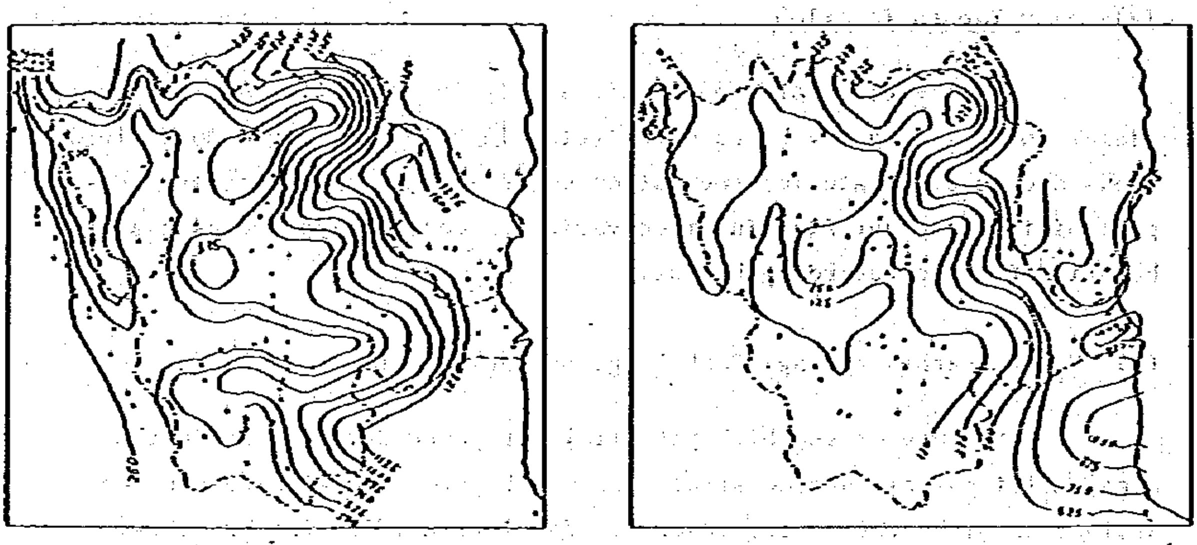
(2) From Yap to Temerloh

As the wilds are found extensively in the left bank, flood-plains in that area may be used for retardings in order to reduce flood flows and to alleviate implementation costs in the lower reaches. Opportunities to plant floating rice varieties can be expected as a side benefit of these retarding basins.

(3) Upper Reaches eg. Sg. Tembeling, Sg. Jelai, etc.

Because of the high potential for power development in the area, multi-purpose dam constructions may be promoted with careful co-ordination with other water resources development. In the branches, however, channel improvements may also be required.

Fig. 5.9 Storm Rainfall Distribution



20 December - 5January 1971

11 December - 23 December 1972

Note:All Isohyets are in Millimeters

(Source; 3.2.6, Vol.3, Pahang River Basin Study)

Table 5.15 1970/71 Flood Damages to Crops, Livestock, and Fresh Water Fishes

District	No. of Casual-ties	No. of Houses Damaged	Crop Damage (Arro)					Livestock					Loss of Fresh Water Diet ($)
			Padi	Rubber	Coconut	Fruits	Tapioca	Buffaloes	Cattle	Goats/Sheep	Chickens	Pigs	
1) Jerantut	132	33	-	-	-	-	-	-	-	-	-	-	550
2) Temerloh	1,054	39	246.5	26.5	-	33	70.5	4	-	52	52	-	1,350
3) Pekan	1,822	115	307	8,060	110	1,771	370	-	11	5	1584	12	2,210
4) Lipis	62	1	3.5	-	-	-	-	-	-	-	-	-	11,290
5) Raub*	*	*	*	*	*	*	*	*	*	*	*	*	1,050
6) Bentong	4	1	28	-	-	-	-	-	-	4	10	-	4,798
7) Kuantan	178	26	3	-	300	798	25.5	-	-	-	573	3	3,000
TOTAL	3,252	215	588	8,086.5	410	2,602	466	4	11	61	2,219	15	24,248
{[(1)+2)+3)]÷ TOTAL}x100	(92.5%)	(87.0%)	(94.1%)	(100%)	(26.8%)	(69.3%)	(94.5%)	(100%)	(100%)	(93.4%)	(73.7%)	(80%)	(16.9%)

* No data available.

Table 5.16 Flood and Water Warning Level along the Pahang River

(Unit: Foot)

	Kuala Tahan	Kuala Tembeling	Jerantut Ferry	Temprloh Bridge	Kg. Tg. Belimbing	Kg. Paloh Hinai
Normal Level	+194.5	+140.0	+130.0	+83.0	+38.0	+19.0
First Warning Level	+15.5	+17.0	+15.0	+13.0	+8.0	+12.0
Second Warning Level*	+20.5 (+5)	+25.0 (+8)	+23.0 (+8)	+20.0 (+7)	+11.0 (+3)	+15.0 (+3)
Third Warning Level	+25.5 (+5)	+32.0 (+7)	+30.0 (+7)	+26.0 (+6)	+14.0 (+3)	+18.0 (+3)
Dec.1926 Flood level	+76.3(III)	+81.1(III)	+58.8(III)	+54.9(III)	+45.0(III)	+33.4(III)
Dec.1931 Flood level	+46.4(III)	+59.5(III)	+46.5(III)	+39.4(III)	-	-
March 1967 Flood level	+34.4(III)	+41.6(III)	+34.5(III)	+26.5(III)	+14.8(III)	+18.5(III)
Jan. 1971 Flood level	+50.5(III)	+58.8(III)	+50.4(III)	+42.7(III)	+29.1(III)	+26.9(III)
Dec. 1971 Flood level	+41.3(III)	+49.5(III)	+42.7(III)	+32.8(III)	+21.1(III)	+22.0(III)
Dec. 1972 Flood level	+36.8(III)	+40.9(III)	+32.8(III)	+26.7(III)	+14.3(III)	+18.8(III)
Dec. 1973 Flood level	+38.8(III)	+42.6(III)	+34.8(III)	+26.5(III)	+13.2 (II)	+16.9 (II)
Dec. 1974 Flood level	+8.7	+13.7	+10.0	+6.5	+1.0	+8.3
Dec. 1975 Flood level	+35.0(III)	+37.0(III)	+29.9 (II)	+23.7 (II)	+12.0 (II)	+16.2 (II)
Dec. 1976 Flood level	+9.9	+18.2 (I)	+12.7	+12.2	+4.8	+10.3
Nov. 1977 Flood level	+5.2	+16.4	+12.0	+9.3	+2.8	+7.8
Nov. & Dec. 1978 Flood level	+25.2 (II)	+17.6 (I)	+20.3 (I)	+16.7 (I)	+5.5	+10.4
Nov. 1979 Flood level	+34.9(III)	+38.9(III)	+33.6(III)	+25.0 (II)	+13.6 (II)	+17.6 (II)
Dec. 1980 Flood level	+11.8	+19.6 (I)	+15.8 (I)	+8.1	+5.8	+9.0

*Danger begins when flood exceeds third warning level.

III > third warning level
II > second warning level
I > first warning level

Table 5.17 <u>Frequency of Flood Exceeding Respective/Warning Levels</u>

	Kuala Tahan	Kuala Tembeling	Jerantut Ferry	Temerloh Bridge	Kg. Tg. Belimbing	Kg. Paloh Hinai
Below First Warning Level	4/14 (28.6%)	2/14 (14.3%)	3/14 (21.4%)	4/14 (28.6%)	5/13 (38.5%)	5/13 (38.5%)
Above First Warning Level	0/14 (0%)	3/14 (21.4%)	2/14 (14.3%)	1/14 (7.1%)	0/13 (0%)	0/13 (0%)
Above Second Warning Level	1/14 (7.1%)	0/14 (0%)	1/14 (7.1%)	2/14 (14.3%)	3/13 (23.1%)	3/13 (23.1%)
Above Third Warning Level	9/14 (64.3%)	9/14 (64.3%)	8/14 (57.1%)	7/14 (50.0%)	5/13 (38.5%)	5/13 (38.5%)

Table 5.18 Flood Water Flow Calculation

Adjustment Factor	Flood water flow at Lower Dam site without Tekai Dams (m^3/sec)	Surcharge water level in Upper Dam (m)	Flood surcharge volume ($10^6 m^3$)	Discharge from Upper Dam (m^3/sec)	Discharge from Lower Dam (m^3/sec)
0.8	780	158.429	131.5	130	150
1.0	1,220	159.137	169.6	240	270
1.2	1,780	159.707	209.5	360	410
1.4	2,440	160.240	249.2	470	550
1.6	3,120	160.739	289.1	580	700
1.8	3,750	161.212	329.1	700	820
2.0	4,470	161.655	368.9	810	960

Table 5.19 Flood Mitigation at Kg. Merting

Water flow without Tokai dams (m^3/sec)	Water level (m)	Water flow of the Tokai (m^3/sec)	Flood surcharge volume (10^6m^3)	Water discharge from lower Tokai (m^3/sec)	Volume to be out (m^3/sec)	Water flow with Tokai dams (m^3/sec)	Difference in water level (m)
2000	57.59	550	1.18	100	450	1550	56.59 1.00
4000	51.15	1090	1.58	240	850	3150	59.77 1.38
6000	63.96	1640	1.99	380	1260	4740	62.25 1.71
8000	66.38	2190	2.32	500	1690	6310	64.36 2.02
10,000	68.53	2930	2.70	630	2100	7900	66.26 2.27

Table 5.20 Flood Mitigation at Kg. Temerloh

Water flow without Tokai dams (m^3/sec)	Water level (m)	Water flow of the Tokai (m^3/sec)	Flood surcharge volume (10^6m^3)	Water discharge from lower Tokai (m^3/sec)	Volume to be out (m^3/sec)	Water flow with Tokai dams (m^3/sec)	Difference in water level (m)
6,000	34.44	440	108	70	370	5630	34.08 0.36
8,000	36.21	580	123	120	460	7540	35.82 0.39
10,000	37.76	730	132	150	580	9920	37.32 0.44
20,000	43.72	1450	184	330	1120	18880	43.15 0.57
30,000	48.21	2180	232	500	1680	27820	47.31 0.90

Fig. 5.10 Flood Water Flow With and Without Tekai Dams

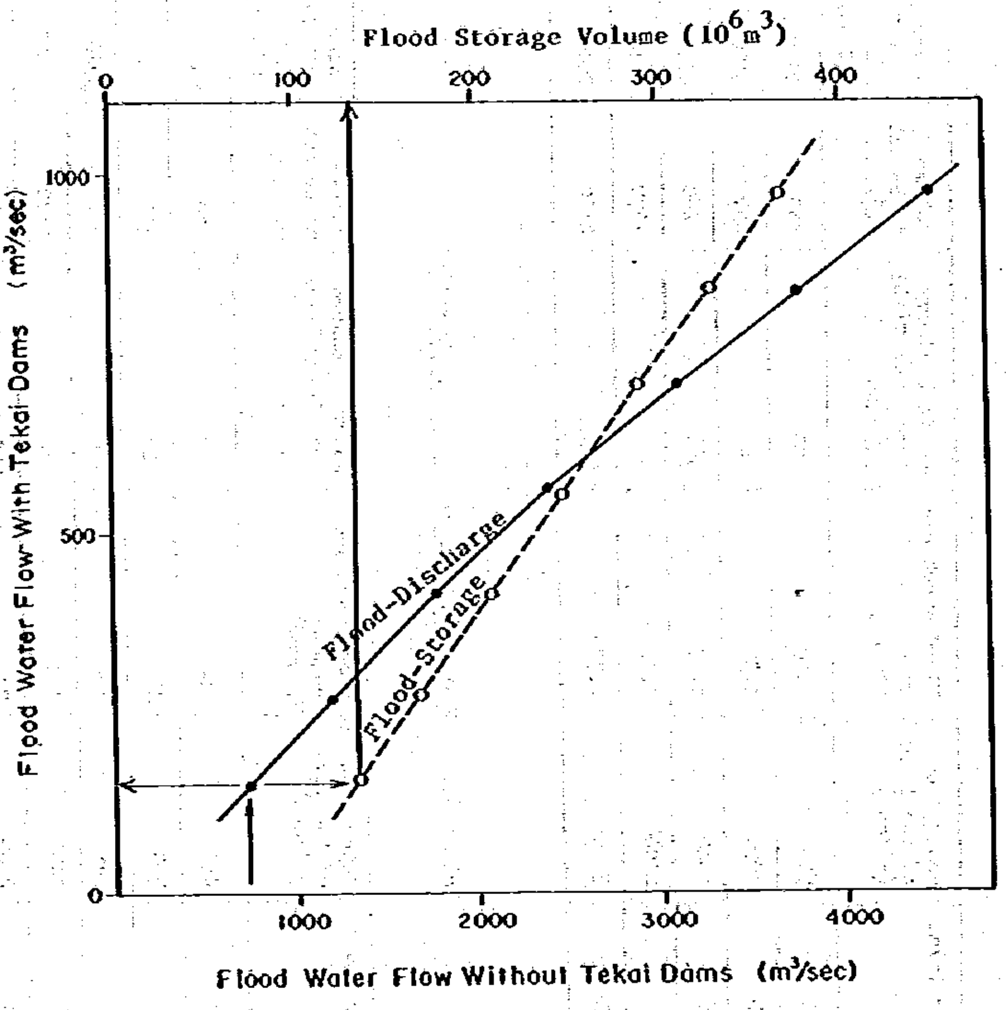


Fig. 5.11 H-Q Curve at Kg. Merting

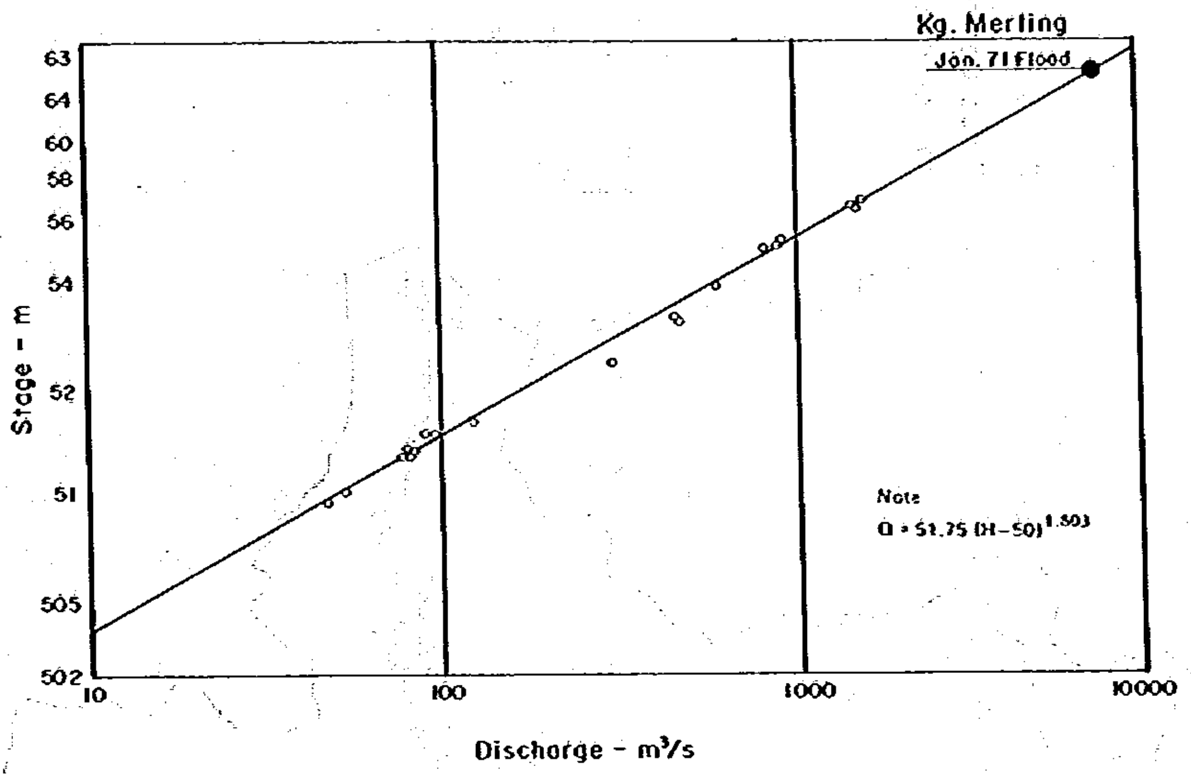
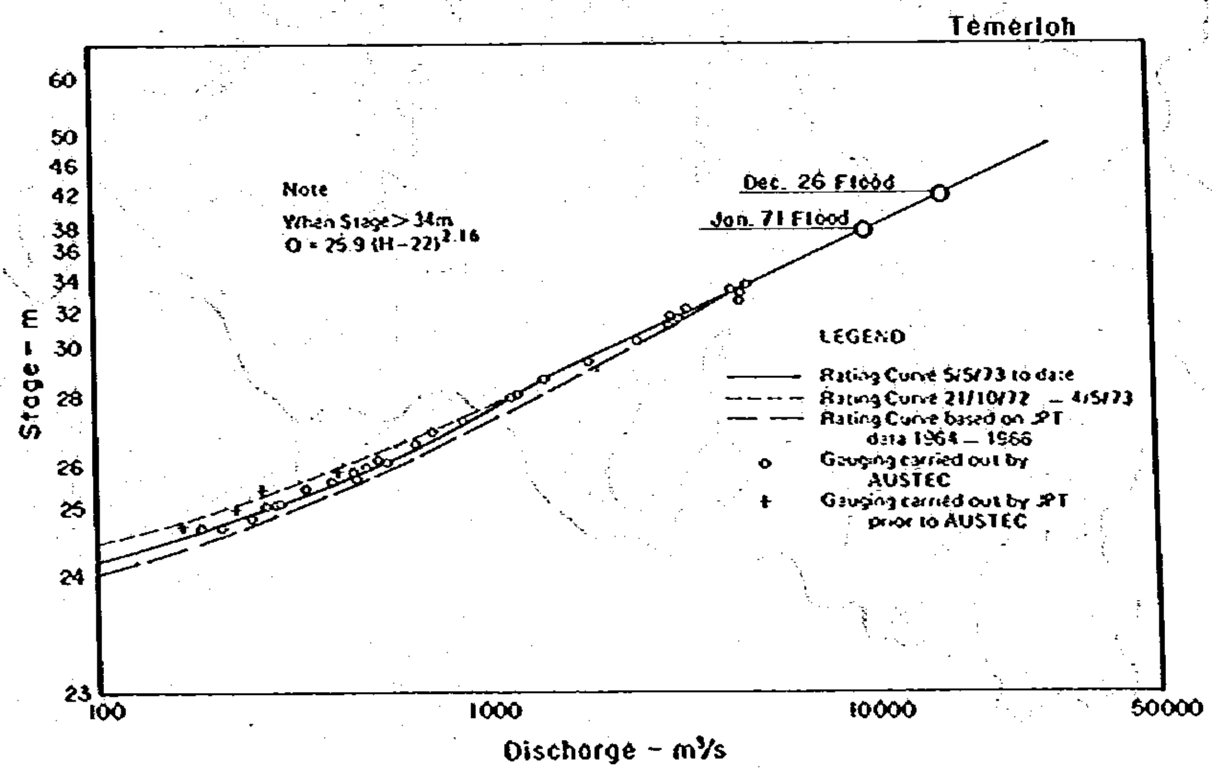


Fig. 5.12 H-Q Curve at Kg. Temerloh



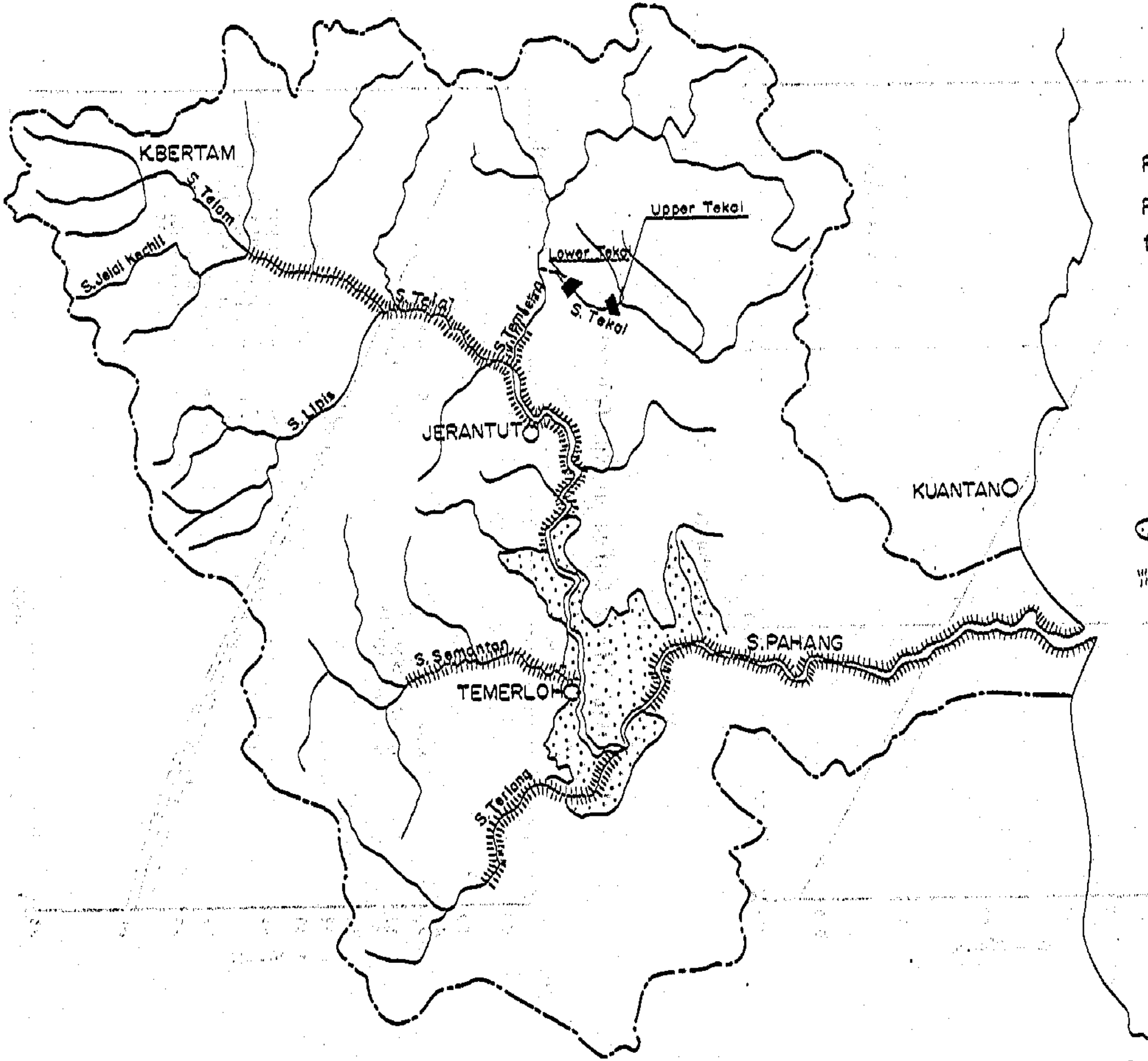


Fig. 5.13
Flood Control Measures for the Pahang Basin

5.5 Agriculture and Irrigation

Careful investigations were carried out on the existing and potential agricultural activities in the State of Pahang, concentrating particularly on the possible impact of the Project on the rice culture in the region. The study included both the positive and negative effects foreseen by the operation of the Project on the production of rice and other major crops, as well as the water transportation activities in the State. However, in considering the relatively minor impact of the Project on the agricultural activities in the region, only a brief summary of the investigation results will be presented in this section of the report.

The State of Pahang is comprised mainly of seven districts: Jerantut, Temerloh, Pekan, Lipis, Raub, Bentong and Kuantan. The ratios of rice area to the total land area of all these districts have been low, ranging from 2 to 13 percent in 1974, and tended to decline (see Table 5.21). The remaining land area consists mostly of forest and swamp, and to a certain extent by perenial crops. The two extensive areas of forest -- Taman Negara in the northern Pahang and the Klau Game Reserve in the southwest -- occupy a total land area of 3,130 square kilometers. Swamps are found extensively in the coastal plain and in the Tasek Bera region in the southwest. Along the coast are fishing villages, and also single-cropping padi is found. The banks and levees of the Pahang River, and the interior valleys are dominated by a mixed-cropping system in which farmers cultivate at the same time coconuts, fruit trees, bananas, cassava, vegetables and a few rubber trees; paid-fields are found only in the inundated valley floors. The inland region of Pahang State, especially in its western and southwestern parts, is planted mainly in rubber, and to a lesser extent in oil palm.

The rice production in Pahang State is presently carried out under the following three types of water supply: irrigation system, pump system, and rain-fed system. The average ratios of land area under these three systems in the region's total rice area are 25.5 percent, 36.9 percent, and 37.6 percent respectively. While the rice fields of those districts with small rice areas -- such as Lipis, Bentong and Raub -- are almost totally irrigated, the rice cultivation in the Temerloh District which occupies more than 60 percent of the total rice area of Pahang State is almost entirely under the rain-fed system (see Table 5.22). The results of a previous study "Pahang Tua Irrigation System" showed that the average yield of rice cultivated in irrigated land was about 80 percent larger compared to the yield of rice under the rain-fed system in the region. Thus, investments in irrigation proved to have high returns, and possible effects of the Project on the water availability for irrigation in the future must be the major factor for consideration.

The Pahang River forms the so-called Pahang River Basin which includes the whole area of Pahang State except large parts of Kuantan District and of the Pekan District. The Pahang River Basin is one of the flood-prone areas in Peninsular Malaysia. The flooding in this basin is caused by the occurrence of tropical depressions during the North-East Monsoon period which lasts from November to January. These depressions result in long-lasting heavy rainfall which makes the Pahang River overspill its banks in the middle and lower reaches and results in disastrous flooding in the lower areas of the basin (see details in the previous section).

The present Dam Project which is proposed to utilize the water flow in the Tekai River will principally affect the water flow of the lower stream of the Pahang River in the following manner: (1) The proposed Dam will store water in its reservoir and thus reduce the water flow in the lower stream of the Pahang River during rainy seasons; (2) the proposed Dam will release water and thus increase the water flow in the lower stream of the Pahang River during dry seasons (see Table 5.23 for the expected changes in water flow at Temerloh). Therefore, the possible positive and/or negative impacts of the proposed projects can be identified by investigating possible effects of these changes in water availability to agricultural production. Following are the major findings of the present study.

(a) The project has no negative effects on agricultural production, as the water flow of the Pahang River in rainy seasons is far more than enough to supply water for irrigation in the foreseeable future (see Table 5.24).

(b) Instead, the proposed project may contribute to increasing rice production, as the Project will increase the water availability in dry seasons during which future irrigation projects may be short of water. It is estimated that the proposed Dam will work in increasing about 30 percent of the minimum water flow at Temerloh, the district with the largest rice area and the lowest irrigation ratio.

(c) The project will, to some extent, reduce the maximum water flow in the lower stream of the Pahang River and, thus, will function in mitigating crop damages brought about by flood.

(d) As the Project will increase the water flow in the lower stream of the Pahang River in dry seasons, it will contribute to improving water transportation which is presently an important transportation network in the area.

Table 5.21 Rice Area by Districts in Pahang State

(Unit: acres. %)

District	1974			1966		
	Rice Area	Total Agricultural Land	% of Rice Area	Rice Area	Total Agricultural Land	% of Rice Area
Jerantut	7,392	152,671	4.8	4,810	53,,305	9.0
Temerloh	23,907	374,174	6.4	21,441	197,527	10.9
Pekan	13,994	104,085	13.4	6,749	48,176	14.0
Lipis	6,820	117,927	5.8	5,352	67,415	7.9
Raub	4,896	117,927	4.2	3,855	84,558	4.6
Bentong	2,277	123,055	1.9	1,113	92,377	1.2
Kuantan	1,653	84,486	2.0	735	43,953	1.7
Total	61,469	1,138,483	5.4	44,222	598,098	7.4

Source: Ministry of Agriculture, The Present Land Use of Penisular Malaysia Vol.1

Table 5.22 Area by the Type of System in Pahang State

(Unit : acre, %)

District	Irrigation System (A)	Pump System (B)	Rain-fed System (C)	Total (A)+(B)+(C)=(D)	$\frac{(A)}{(D)}$x100	$\frac{(B)}{(D)}$x100	$\frac{(C)}{(D)}$x100
Jerantut	759	1,100	1,120	2,979	25.5	36.9	37.6
Temerloh	553	2,025	22,602	25,180	2.2	8.0	89.8
Pekan	1,005	5,141	6,579	12,725	7.9	40.4	51.7
Lipis	2,095	0	0	2,095	100.0	0.0	0.0
Raub	2,850	819	110	3,779	75.4	3.1	2.9
Bentong	1,535	0	66	1,601	95.9	0.0	4.1
Kuantan	631	402	1,219	2,252	28.0	17.9	54.1

Table 5.23 Changes in Water Flow at Temerloh

Year	Average Water flow without Tekai dams (m^3/sec)	Minimum water flow (m^3/sec)	Tekai's portion in the minimum water flow (m^3/sec)	Minimum water flow without the flow from the Tekai (m^3/sec)	Minimum water flow with the operation of Tekai dams (m^3/sec)	Increase in water flow (m^3/sec)
1975	545.41	124.13	9.02	115.11	155.11	30.98
1976	343.84	91.22	6.63	84.59	124.59	33.37
1977	330.75	116.37	8.45	107.92	147.72	31.55
1978	382.66	152.23	11.06	141.17	181.17	28.94
1979	470.77	64.89	4.71	60.18	100.18	35.29
1980	409.06	92.55	6.72	85.83	125.83	33.28

Table 5.24 River Utilization Ratio in Pahang Basin, in 1990 and 2000

(Unit: $10^6 m^3$/year)

	1990	2000	1990	2000
Surface Run-off (A)	26,660	26,660	100.0	100.0
Demand Domestic & Industrial	54	102	52.9	100.0
Irrigation	585	818	71.5	100.0
Total (B)	639	920	69.5	100.0
Ratio $(\frac{(A)}{(B)} \times 100)$	2%	3%		
[National Total] Surface Run-off (C)	150,100	150,100	100.0	100.0
Demand Domestic & Industrial	2,210	4,157	53.2	100.0
Irrigation	8,380	9,098	92.1	100.0
Total (D)	10,590	13,255	79.9	100.0
Ratio $(\frac{(D)}{(C)} \times 100)$	7%	9%		

Source: National Water Resource Study

5.6 Tourism

The number of foreign tourists visiting Peninsular Malaysia doubled in the last decade, from 869,599 in 1973 to 2,093,121 in 1982 (see Fig. 5.14). Foreign exchange earnings by the tourist industry also increased rapidly from M$132 million in 1970 to M$545 million in 1980. The amount of the earnings was ranked seventh in 1979 after rubber, crude petroleum, tin, sawn logs, palm oil and sawn timber.

Fig. 5.15 shows the increases of tourist arrivals by modes of travel. The largest share was assigned to arrivals by road from 1973 to 1978. After 1979, however, those by air have occupied the largest shares. The rapid increase of foreign tourists by air coincides with promotion efforts undertaken by the Tourist Development Corporation (TDC) and Malaysian Airline System (MAS).

According to the Fourth Malaysia Plan (1981-1985), programmes to promote the development of the tourist industry will be further expanded. TDC will reinforce promotion activities through tourism sales missions to explore new tourist markets. Foreign exchange earnings from tourism are expected to amount to M$877 million at the end of 1985. Thus, tourism will remain one of the major foreign exchange earners which generate a considerable number of employment opportunities.

There are two possible routes for tourists to get to the site of Tekai Power Station, one waterway and one overland route from the town of Jerantut, which is connected with major big cities by road and railway networks. Taman Negara, adjacent to the Project area, however, is accessible only by boat from Kuala Tembeling near Jerantut.

For the future of the area, two proposals of transport facilities by the government must be mentioned. First, a new railway in envisaged to be constructed along the eastern coast of the Peninsula where the tourist industry will be developed. And second, a highway construction is proposed to the north of Taman Negara. Once these facilities are constructed, a circular transport network will be established around the Project area. Not only Tekai Dams but also Taman Negara will be enclosed within this circular network. Eventually, the access to both Tekai Dams and Taman Negara will become much more convenient compared with the present situation. Thus, Tekai Dams and Taman Negara can be considered as a set of the tropical tourist industry.

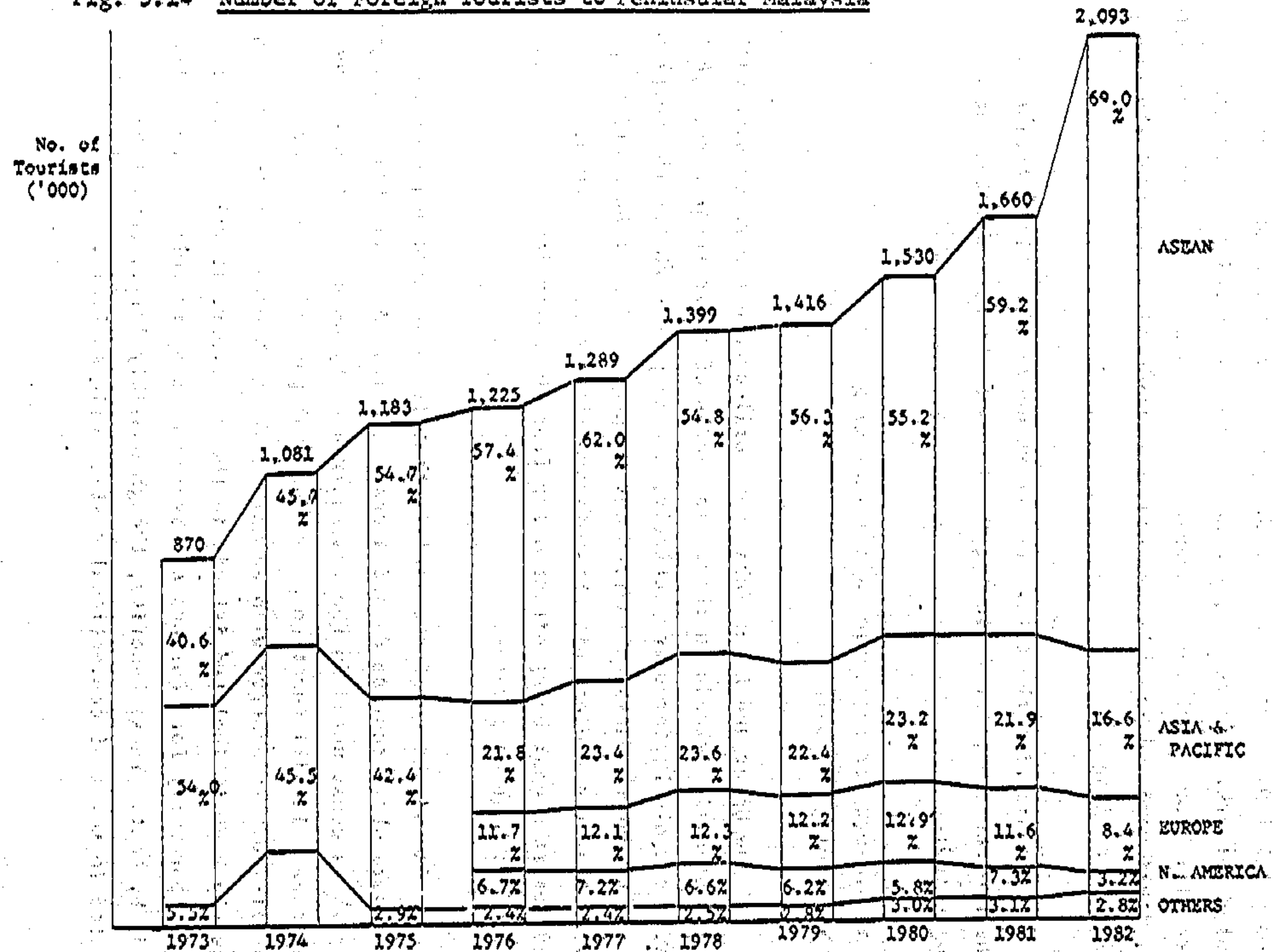
Considering the future transport network and characteristics of the Project area, the following two types of tourism development can be suggested:

a) resort for recreation and sightseeing
b) zoological park

The Upper and Lower Tekai Dams will create two reservoirs with a number of small islands in them. The areas of these reservoirs, 7,600 hectares and 610 hectares respectively, are large enough for the development of the above mentioned tourism development. It must be mentioned, however, that the Project site has disadvantages compared with other inland resort areas; being situated far from the major large cities and subjected to high temperature.

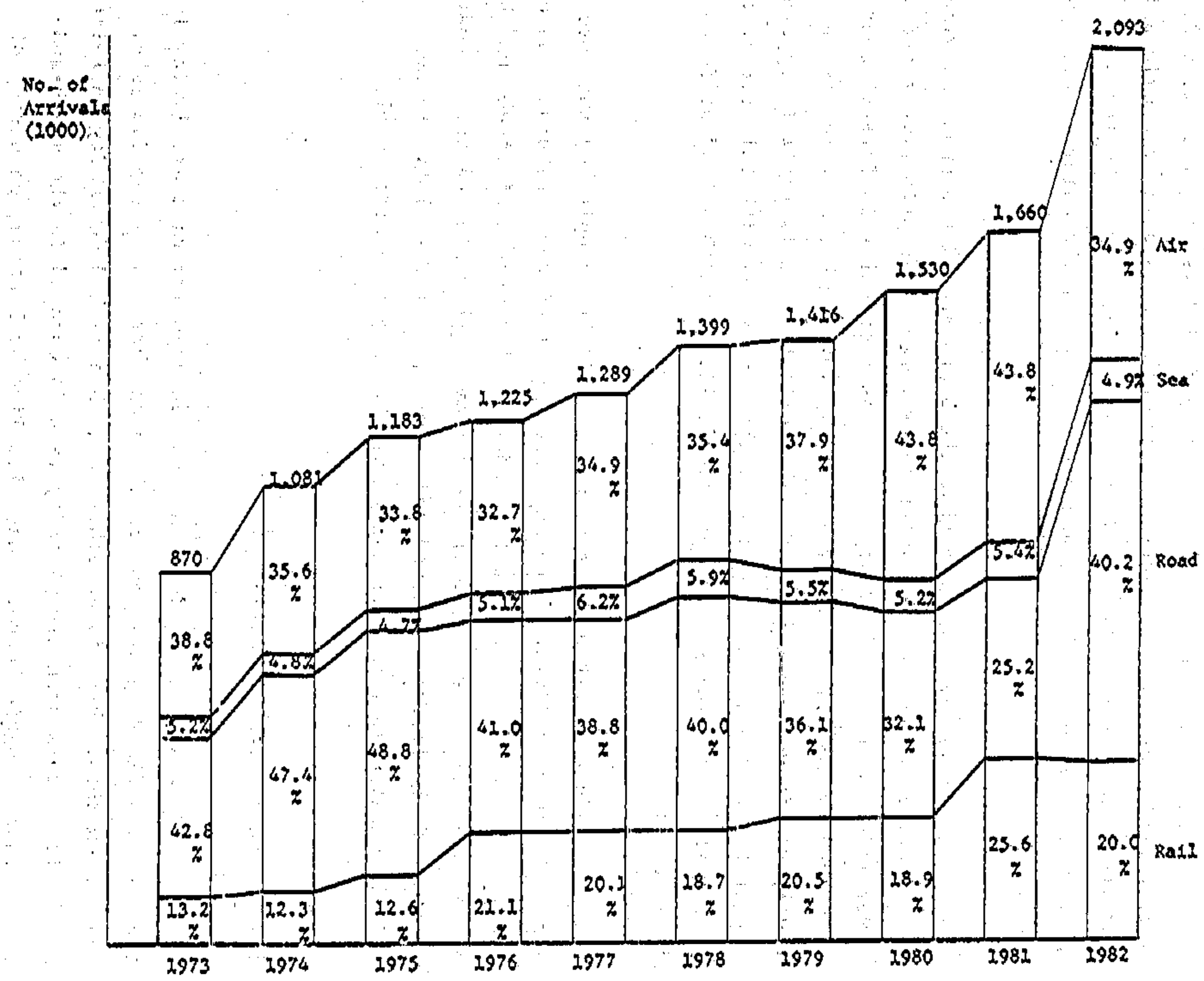
One advantage of the site is that it is located adjacent to Taman Negara where tourism demand already exists. Assuming that zoological park is constructed in the reservoir area by using small island as animal cages, it will function as an integral part of Taman Negara, as it is difficult to observe wild animals in Taman Negara. If the animals are safely kept in isolated islands in the reservoir, it will create a unique opportunity for tourists to observe them by travelling around the islands by boat. These benefits, though possibly large, cannot be evaluated in terms of conventional cost-benefit analysis.

Fig. 5.14 Number of Foreign Tourists to Peninsular Malaysia



Note: Presented Data analized is for Penninsular Malaysia (not including Singaporean visitors coming by road via Johore Bahru Causeway). Included in ASEAN are Indonesia, Philippines, Singapore, and Thailand. Included in ASIA & PACIFIC are Hong Kong, India, Japan, Taiwan, China, Australia and New Zealand. Included in EUROPE are United Kingdom, Ireland, Western and Eastern Europe. Included in NORTH AMERICA are United States of America and Canada.

Fig. 5.15 Number of Foreign Tourists to Peninsular Malaysia by Model of Travel



5.7 Other Aspects

5.7.1 Environmental Implications

The area surrounding the proposed site is, in general, endowed with a wealth of natural resources rather than a base for economic and industrial activities. The environmental implications here focus on factors concerning the biota, and preservation of the natural environment.

The survey indicates that the biota around the proposed site is characterized by lowland dipterocarps forest in a primitive state and diversified fauna. Lowland dipterocarp is tropical rain forests characterized by high productivity and widely varying biota, which is relatively sensitive to development. The current trend is for this type of forest to decrease. Also notable is that, parallel with this trend, the population of several species of animals living in this kind of forest is decreasing.

Since a portion of this forest will be occupied by this project, the animals living there may lose a part of their natural environment. However, it is difficult to estimate the degree of effect on the biota solely from the result of the survey on this limited area. Positioning of the forest concerned and a survey on the ecology of those animals whose number is decreasing must be made on a wider scale.

5.7.2 Innundation of Settlement

Several households of a mountain minority race are living in the proposed flooding area and in the area surrounding the dam lake. Apart from this, there is no other long-established community on related facilities. This mountain minority race is engaged in the slash-and-burn method of agriculture. They also live by hunting, gathering of fruit, etc. The exact population, however, could not be ascertained.

The projected effect of dam construction on these inhabitants includes sumbersion of a part of their living place and fruit-gathering area beneath the dam lake. In addition to this direct effect, there is the indirect effect of the temporary influx of a large number of laborers at the construction stage. This will have a considerable influence on the living environment of the minority race living in the area.

The decision has been made to carry out a survey on the actual condition of these people before implementation of this project. In addition, an anthropological study should be made on how they will be able to adapt themselves to the new environment and to establish flexible and effective countermeasures to minimize the effect of the development project this community.

5.7.3 Mineral Resources

There is no previous record of any mineral findings or investigations within the Tekai area. Recently, however, the Malaysia Geological Survey Department has done research in this area. Evaluation of mineral resources within the dam filling area was made on the basis of the result of research by the Department. The table below summarizes the result of our research on various minerals.

As is evident from the table, no apparent prospective mineral resources exist in the dam filling area. However, the potential of uranium and mineral phosphate reserves existing should not be completely ruled out for rocks in the Tembeling group. (See the remarks in the attached Table 5.25) The dam filling area is principally made up of Tembeling group rocks, but the filling area occupies a very small percentage of the entire area including the Tembeling group. As a result, the probability of these mineral resources existing within the filling area is exrremely small.

Table 5.25 Mineral Resources Survey Data within the Tekai Area

Investigation Method	Minerals	Concentration or Outcrop State	Evaluation	Remarks
Geochemical Survey of Stream Silt	Copper	0 ∿ 25 ppm	Not prospective	No geological indication of mineralization
	Zinc	0 ∿ 180 ppm	ditto	One exceptional case showed a concentration of 460 ppm. However, there was no geological indication of mineralization
	Lead	0 ∿ 35 ppm	ditto	Mostly less than 10 ppm, except for a very limited area where concentration was 60 ppm or more
	Arsenic	0 ∿ 20 ppm	ditto	
	Molybdenum	Less than 2 ppm	ditto	
	Tin	13 ppm	ditto	19 ppm at several points
	Tangsten	Less than 4 ppm	ditto	
Panning	Heavy metals (excluding ferric oxide)	0 or extremely few	Ditto	No indication except for gold in the Sg. Kulin area
	Ferric oxide	Slightly	ditto	
Aerial Prospecting	Barite	65 cm wide metalliferous vein (Sg. Retang) 10 cm diameter brecciated block (anak Sg. Keram)	Small reserves	

(continued)

(Continued)

Investigation Method	Minerals	Concentration or Outcrop State	Evaluation	Remarks
No Detailed Survey	Uranium ore	——	Not identified up to now	Rocks in the Tembeling group are similar to uranium producing beds in Thailand and America. Therefore, the potential of uranium resources existing should not be ruled out
	Mineral phosphate	——	Not identified up to now	Termus shale is similar to the mineral phosphate producing bed in Thailand, but the presence of this has not been identified.

5.8 Economic Evaluation

The principal costs and benefits of the proposed Project are those associated with the electrical power supply. In the preceding sections, however, other associated aspects -- including forestry, flood mitigation, irrigation and agriculture, tourism and some others -- are also dealt with. Among these aspects, forestry losses, innundation of settlements and the environmental impact on flora and fauna can be considered as types of indirect effects of the Project to the region's economy and society. In economic analysis, however, only forestry losses in terms of opportunity cost of land were estimated (H$3.76 million to H$11.83 million depending on assumptions -- see Table 5.1), since other indirect effects are not obvious and not measurable.

With regard to flood mitigation, agriculture and irrigation, and tourism, due to the limited effects of the Project at present and uncertainties involved in the future, only qualitative assessments were made. It must be emphasized, however, that the Project will positively function in the future development of the region and no adverse effects will be brought about in the downstream areas. These associated effects are summarized in Table 5.26.

The power benefits, in the absence of an established and properly measured methodology, were conventionally evaluated by comparison with alternative gas turbine units, which have the load-follow operation for the peak demand to be met by the Project. Assumptions for the power benefits, or the costs attributable to the alternative gas turbines, are presented in Section 5.2. The economic analysis for power benefits was carried out based on these assumptions. With regard to the fuel cost, however, the analysis included with and without cases of relative fuel price escalation together with cases using natural gas with 70 percent of the fuel oil price or the oil equivalent price. Thus, the analysis was extended to cover the following six cases of different fuel cost streams.

Table 5.26 Summary of Effects on Other Associated Aspects

Item	Effects	Remarks
Forestry	Cost of about M$5 million	Subject to harvesting schedule and future log prices
Flood Mitigation	Expected to be small but positive	
Irrigation and Agriculture	Expected to be small but positive	
Tourism	Expected to be developed as a center of tourism combined with Taman Negara (National Park)	Further studies required
Environmental Implications	Not quantatively measured	
Innundation of Settlement	Small	
Mineral Resources	Small	

Case 1 : Fuel oil at constant price

Case 2 : Fuel oil with relative price escalation of 1.5 percent per annum

Case 3 : Fuel oil with relative price escalation of 3 percent per annum

Case 4 : Natural gas at constant OEP

Case 5 : Natural gas with relative price escalation of 1.5 percent per annum

Case 6 : Natural gas with relative price escalation of 3 percent per annum

The following tables of A-1 to A-12 show that differential cash flows for each of these cases throughout the assumed Project's economic life of 50 years and the present values of these cash flows discounted at rates of 8, 10, 12, 14, 16 and 18 percent, respectively. 1983 was taken as the base year for the calculation of fuel costs and 1984 for the present values.

The calculated net present values and IRRs of the Project for the above assumed six cases are summarized in Table 5.27 and Figure 5.16. It must be mentioned, however, that these estimates do not include the cost of land loss or the forestry losses incurred by the Project. If this cost, say H$5 million, is included, the estimated IRRs will decrease by about 0.4 percent.

Table 5.27 Series Development for Upper and Lower Tekai

(NPVs and IRRs)

	IRR	NPV ($H\$x10^6$) for Discount Rate			
	%	10%	12%	14%	16%
Case 1	14.78	104.8	46.8	10.2	-13.3
Case 2	17.13	181.8	98.7	46.8	13.4
Case 3	19.60	292.0	170.2	95.7	48.3
Case 4	11.62	33.2	6.6	-30.6	-45.3
Case 5	13.67	87.1	29.8	-5.0	-26.6
Case 6	15.86	164.2	79.8	29.2	-2.2

Fig. 5.16 Net Present Value VS. Discount Rate

(Series Development)

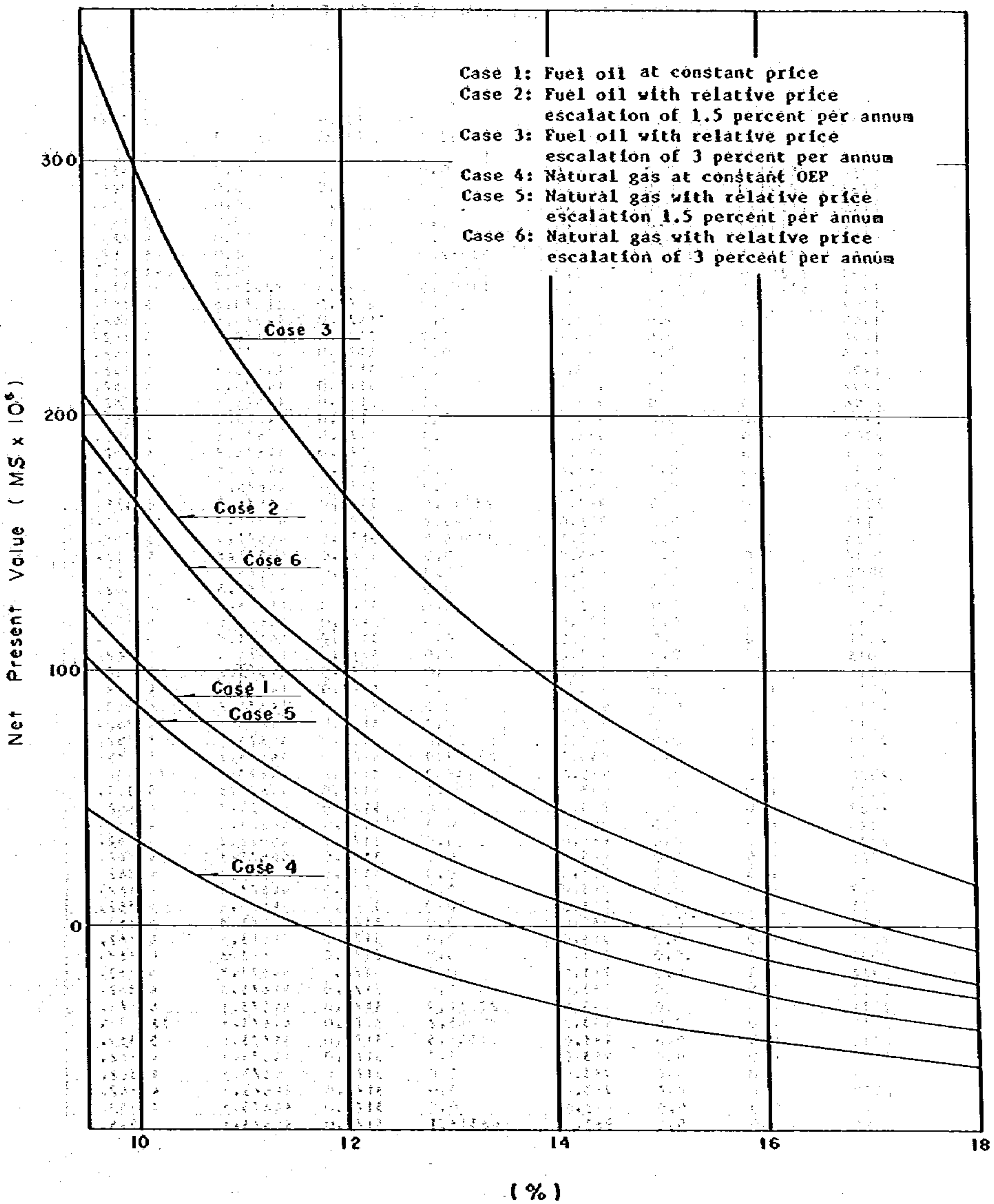


Table. A.1.

DIFFERENTIAL CASH FLOW SHEET (THOUSAND M$)
---CASE 1 : FUEL OIL (CONSTANT PRICE)---

YEAR	TEKAI (CONST.)	(TRANS.)	(O-M)	GAS TURBINE (CONST.)	(O-M)	(FUEL)	BENEFIT
1984	5556.0	0.0	0.0	0.0	0.0	0.0	-5556.0
1985	8021.0	0.0	0.0	0.0	0.0	0.0	-8021.0
1986	16623.0	0.0	0.0	0.0	0.0	0.0	-16623.0
1987	26134.0	0.0	0.0	0.0	0.0	0.0	-26134.0
1988	40517.0	5209.6	0.0	0.0	0.0	0.0	-45726.6
1989	73754.0	9116.8	0.0	23012.9	0.0	0.0	-59457.7
1990	89264.0	9116.8	0.0	80545.2	0.0	0.0	-17535.5
1991	87443.0	2604.8	405.0	11506.5	96.0	22336.7	-56513.4
1992	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
1993	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
1994	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
1995	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
1996	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
1997	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
1998	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
1999	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2000	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2001	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2002	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2003	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2004	0.0	0.0	983.0	23012.9	3172.0	44673.3	69375.7
2005	0.0	0.0	983.0	80545.2	3172.0	44673.3	127405.0
2006	0.0	0.0	983.0	11506.5	3172.0	44673.3	59369.3
2007	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2008	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2009	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2010	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2011	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2012	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2013	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2014	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2015	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2016	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2017	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2018	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2019	0.0	0.0	983.0	23012.9	3172.0	44673.3	69375.7
2020	0.0	0.0	983.0	80545.2	3172.0	44673.3	127402.0
2021	0.0	0.0	983.0	11506.5	3172.0	44673.3	58369.3
2022	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2023	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2024	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2025	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2026	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2027	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2028	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2029	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2030	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2031	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2032	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2033	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2034	0.0	0.0	983.0	23012.9	3172.0	44673.3	69375.7
2035	0.0	0.0	983.0	80545.2	3172.0	44673.3	127405.0
2036	0.0	0.0	983.0	11506.5	3172.0	44673.3	59369.3
2037	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2038	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2039	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2040	0.0	0.0	983.0	0.0	3172.0	44673.3	46362.3
2041	0.0	0.0	983.0	-46316.1	3172.0	44673.3	545.7

Table. A.2.

NET PRESENT VALUES (THOUSAND M$)

---- CASE 1 : FUEL OIL (CONSTANT PRICE) ----

YEAR	PRESENT VALUES FOR DISCOUNT RATE 8%	10%	12%	14%	16%	18%
1984	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0
1985	-7426.9	-7291.8	-7161.6	-7036.0	-6914.7	-6797.5
1986	-14294.6	-13779.3	-13291.6	-12829.3	-12390.8	-11974.3
1987	-20785.7	-19672.4	-18637.3	-17673.5	-16775.0	-15936.4
1988	-33610.4	-31231.9	-29060.1	-27073.5	-25254.4	-23585.3
1989	-40738.3	-37167.1	-33965.0	-31088.4	-28499.2	-26164.5
1990	-11239.5	-10067.7	-9036.1	-8125.7	-7320.5	-6606.9
1991	-32975.1	-29000.3	-25563.8	-22584.2	-19996.1	-17741.0
1992	25318.5	21361.9	18927.1	16423.2	14294.4	12457.3
1993	23443.1	19374.4	16399.2	14410.7	12322.7	10565.5
1994	21706.6	18067.7	15088.6	12641.0	10623.0	8953.8
1995	20398.7	16425.1	13472.0	11088.6	9157.8	7588.9
1996	18609.9	14932.0	12028.5	9726.8	7894.7	6431.5
1997	17231.4	13574.5	10739.8	8532.3	6805.7	5449.6
1998	15955.0	12340.5	9589.1	7484.5	5867.0	4619.3
1999	14773.1	11218.6	8561.7	6565.3	5057.8	3913.3
2000	13678.8	10198.7	7644.4	5759.1	4360.2	3316.3
2001	12665.6	9271.6	6825.3	5051.8	3758.8	2810.3
2002	11727.4	8428.7	6094.0	4431.4	3240.3	2382.1
2003	10858.7	7662.5	5441.1	3887.2	2793.4	2018.7
2004	14991.7	10386.6	7243.8	5084.3	3590.6	2550.9
2005	25310.4	17216.8	11792.9	8132.0	5643.9	3941.6
2006	10736.5	7170.4	4823.8	3268.0	2229.0	1530.3
2007	7981.5	5233.6	3457.9	2301.5	1542.8	1041.2
2008	7390.2	4757.8	3087.4	2018.9	1330.0	882.4
2009	6842.8	4325.3	2756.6	1771.0	1146.5	747.8
2010	6335.9	3932.1	2461.3	1553.5	988.4	633.7
2011	5866.6	3574.6	2197.6	1362.7	852.0	537.1
2012	5432.1	3249.6	1962.1	1195.3	734.5	455.1
2013	5029.7	2954.2	1751.9	1048.6	633.2	385.7
2014	4657.1	2685.6	1564.2	919.8	545.9	326.9
2015	4312.1	2441.5	1396.6	806.8	470.6	277.2
2016	3992.7	2219.5	1247.0	707.7	405.7	234.8
2017	3697.0	2017.8	1113.4	620.8	349.7	198.9
2018	3423.1	1834.3	994.1	544.6	301.5	168.6
2019	4726.0	2486.5	1323.4	712.3	387.5	213.0
2020	7978.9	4121.6	2154.5	1139.3	609.1	327.2
2021	3384.6	1716.6	851.3	457.3	240.6	127.8
2022	2516.1	1252.9	631.8	322.6	166.5	87.0
2023	2329.7	1139.0	564.1	282.8	143.5	73.7
2024	2157.1	1035.4	503.6	248.1	123.7	62.5
2025	1997.4	941.3	449.7	217.6	106.7	52.9
2026	1849.4	855.7	401.5	190.9	92.0	44.9
2027	1712.4	777.9	358.5	167.5	79.3	38.0
2028	1585.6	707.2	320.1	146.9	68.3	32.2
2029	1468.1	642.9	285.8	128.9	58.9	27.3
2030	1359.4	584.5	255.2	113.0	50.8	23.1
2031	1258.7	531.3	227.8	99.2	43.8	19.6
2032	1165.4	483.0	203.4	87.0	37.7	16.6
2033	1079.1	439.1	181.6	76.3	32.5	14.1
2034	1639.8	595.2	241.3	99.8	41.8	17.3
2035	2515.3	926.7	393.6	159.6	65.7	27.5
2036	1067.0	410.9	161.0	64.1	26.0	10.7
2037	793.2	299.9	115.4	45.2	18.0	7.3
2038	734.4	272.7	103.1	39.6	15.5	6.2
2039	680.0	247.9	92.0	34.8	13.4	5.2
2040	629.7	225.3	82.2	30.5	11.5	4.4
2041	6.8	2.4	0.9	0.3	0.1	0.0
TOTAL	199923.3	104844.9	46821.5	13233.6	-13333.5	-23673.8

Table, A.3.

DIFFERENTIAL CASH FLOW SHEET (THOUSAND M$)
---CASE 2 : FUEL OIL (PRICE ESCALATION 1.5% PER ANNUM)---

YEAR	TEKAI (CONST.)	(TRANS.)	(O-M)	GAS TURBINE (CONST.)	(O-M)	(FUEL)	BENEFIT
1984	5556.0	0.0	0.0	0.0	0.0	0.0	-5556.0
1985	8021.0	0.0	0.0	0.0	0.0	0.0	-8021.0
1986	16673.0	0.0	0.0	0.0	0.0	0.0	-16673.0
1987	26134.0	0.0	0.0	0.0	0.0	0.0	-26134.0
1988	40517.0	5209.6	0.0	0.0	0.0	0.0	-45726.6
1989	73754.0	9116.8	0.0	23012.9	0.0	0.0	-59357.6
1990	89264.0	9116.8	0.0	80545.2	0.0	0.0	-178351.6
1991	87463.0	2604.8	405.0	11506.5	961.0	25162.3	-53538.9
1992	0.0	0.0	923.0	0.0	3172.0	51079.5	53263.5
1993	0.0	0.0	983.0	0.0	3172.0	51845.6	54334.6
1994	0.0	0.0	983.0	0.0	3172.0	52623.3	54212.3
1995	0.0	0.0	983.0	0.0	3172.0	53412.6	55601.6
1996	0.0	0.0	983.0	0.0	3172.0	54213.3	56402.3
1997	0.0	0.0	983.0	0.0	3172.0	55027.0	57216.0
1998	0.0	0.0	983.0	0.0	3172.0	55852.6	58041.6
1999	0.0	0.0	983.0	0.0	3172.0	56690.2	58879.2
2000	0.0	0.0	983.0	0.0	3172.0	57540.5	59729.5
2001	0.0	0.0	983.0	0.0	3172.0	58403.6	60592.6
2002	0.0	0.0	983.0	0.0	3172.0	59279.6	61468.6
2003	0.0	0.0	983.0	0.0	3172.0	60168.3	62357.3
2004	0.0	0.0	983.0	23012.9	3172.0	61071.3	86273.2
2005	0.0	0.0	983.0	80545.2	3172.0	61987.4	144721.6
2006	0.0	0.0	983.0	11506.5	3172.0	62917.2	76612.7
2007	0.0	0.0	983.0	0.0	3172.0	63860.9	66049.9
2008	0.0	0.0	983.0	0.0	3172.0	64818.8	67007.8
2009	0.0	0.0	983.0	0.0	3172.0	65791.1	67980.1
2010	0.0	0.0	983.0	0.0	3172.0	66777.9	68966.9
2011	0.0	0.0	983.0	0.0	3172.0	67779.6	69968.6
2012	0.0	0.0	983.0	0.0	3172.0	68796.3	70985.3
2013	0.0	0.0	983.0	0.0	3172.0	69828.2	72017.2
2014	0.0	0.0	983.0	0.0	3172.0	70875.6	73064.6
2015	0.0	0.0	983.0	0.0	3172.0	71938.7	74127.7
2016	0.0	0.0	983.0	0.0	3172.0	73017.8	75206.8
2017	0.0	0.0	983.0	0.0	3172.0	74113.0	76302.0
2018	0.0	0.0	983.0	0.0	3172.0	75224.7	77413.7
2019	0.0	0.0	983.0	23012.9	3172.0	76353.0	101554.9
2020	0.0	0.0	983.0	80545.2	3172.0	77498.3	160232.5
2021	0.0	0.0	983.0	11506.5	3172.0	78660.8	92356.3
2022	0.0	0.0	983.0	0.0	3172.0	79840.7	82029.7
2023	0.0	0.0	983.0	0.0	3172.0	81038.3	83227.3
2024	0.0	0.0	983.0	0.0	3172.0	82253.8	84442.8
2025	0.0	0.0	983.0	0.0	3172.0	83487.6	85676.6
2026	0.0	0.0	983.0	0.0	3172.0	84739.9	86928.9
2027	0.0	0.0	983.0	0.0	3172.0	86011.0	88200.0
2028	0.0	0.0	983.0	0.0	3172.0	87301.1	89490.1
2029	0.0	0.0	983.0	0.0	3172.0	88610.6	90799.6
2030	0.0	0.0	983.0	0.0	3172.0	89939.3	92128.3
2031	0.0	0.0	983.0	0.0	3172.0	91288.3	93477.3
2032	0.0	0.0	983.0	0.0	3172.0	92657.1	94846.1
2033	0.0	0.0	983.0	0.0	3172.0	94048.0	96237.0
2034	0.0	0.0	983.0	23012.9	3172.0	95453.7	120655.6
2035	0.0	0.0	983.0	80545.2	3172.0	96890.5	179624.7
2036	0.0	0.0	983.0	11506.5	3172.0	98343.9	112039.4
2037	0.0	0.0	983.0	0.0	3172.0	99819.0	102008.0
2038	0.0	0.0	983.0	0.0	3172.0	101316.3	103505.3
2039	0.0	0.0	983.0	0.0	3172.0	102836.0	105025.0
2040	0.0	0.0	983.0	0.0	3172.0	104373.5	156567.5
2041	0.0	0.0	983.0	-46316.1	3172.0	105944.1	61817.0

Table. A.4.

NET PRESENT VALUES (THOUSAND M$)

---CASE 2 : FUEL OIL (PRICE ESCALATION 1.5% PER ANNUM)---

PRESENT VALUES FOR DISCOUNT RATE

YEAR	8%	10%	12%	14%	16%	18%
1984	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0
1985	-7426.9	-7291.3	-7161.6	-7036.0	-6914.7	-6797.5
1986	-14294.4	-13779.3	-13291.6	-12829.3	-12390.3	-11974.3
1987	-20785.7	-19672.4	-18637.3	-17673.5	-16775.0	-15936.4
1988	-33610.4	-31231.9	-29060.1	-27073.3	-25254.4	-23585.3
1989	-40733.3	-37367.1	-33965.0	-31033.4	-28499.2	-26164.5
1990	-11239.5	-10067.7	-9036.1	-8125.7	-7320.5	-6536.7
1991	-31326.5	-27550.5	-24235.8	-21455.3	-18996.4	-16854.0
1992	28779.3	24850.2	21514.3	18673.8	16248.3	14171.5
1993	27030.8	22916.0	19495.4	16616.1	14202.6	12192.5
1994	25383.7	21132.5	17648.1	14735.3	12425.1	10472.7
1995	23846.6	19488.1	15984.2	13156.3	10865.5	9003.9
1996	22398.4	17971.7	14477.2	11706.9	9501.8	7737.6
1997	21038.2	16573.5	13112.5	10417.3	8309.3	6653.5
1998	19760.9	15284.1	11876.4	9269.8	7266.5	5719.9
1999	18561.2	14095.2	10757.0	8248.3	6354.7	4917.4
2000	17434.5	12998.9	9743.2	7340.3	5557.3	4227.4
2001	16376.3	11987.9	8825.0	6531.9	4860.0	3634.4
2002	15382.5	11055.7	7993.4	5812.6	4250.2	3124.5
2003	14449.1	10196.0	7240.2	5172.5	3717.0	2635.2
2004	18509.8	12824.0	8943.7	6277.4	4433.2	3149.5
2005	28749.3	19556.4	13395.4	9237.0	6410.9	4477.3
2006	14092.2	9411.6	6331.5	4289.4	2925.7	2009.5
2007	11249.3	7376.4	4873.7	3243.9	2174.4	1467.5
2008	10567.1	6803.0	4414.6	2886.3	1901.7	1261.7
2009	9926.3	6274.3	3998.8	2569.0	1663.2	1094.5
2010	9324.5	5786.7	3622.2	2286.2	1454.6	932.6
2011	8759.2	5337.1	3281.1	2034.6	1272.2	801.3
2012	8228.2	4922.4	2972.1	1810.6	1112.6	689.5
2013	7729.4	4539.9	2692.2	1611.4	973.1	592.7
2014	7261.0	4187.2	2438.3	1434.0	851.1	509.5
2015	6821.0	3862.0	2209.1	1276.2	744.4	433.2
2016	6407.6	3562.0	2001.2	1135.3	651.0	376.7
2017	6019.4	3285.3	1812.8	1010.8	569.4	323.7
2018	5654.7	3030.2	1642.1	899.6	498.0	278.5
2019	6868.6	3613.8	1923.4	1035.2	563.2	309.6
2020	10034.5	5183.4	2709.6	1432.8	766.1	414.0
2021	5355.4	2716.1	1394.4	724.4	330.6	202.2
2022	4404.2	2193.1	1105.3	564.4	291.5	152.2
2023	4137.5	2022.8	1001.8	502.3	254.9	130.9
2024	3387.0	1265.8	907.5	447.1	223.0	112.5
2025	3651.7	1720.9	822.1	397.9	195.0	96.3
2026	3430.6	1587.4	744.7	354.1	170.6	83.2
2027	3222.9	1464.1	674.7	315.2	149.2	71.5
2028	3027.8	1350.5	611.2	280.5	130.5	61.5
2029	2844.6	1245.7	553.7	249.7	114.2	52.9
2030	2672.4	1149.0	501.6	222.2	99.8	45.5
2031	2510.7	1059.9	454.4	197.8	87.3	39.1
2032	2358.3	977.6	411.7	176.0	76.4	33.6
2033	2216.1	901.8	373.0	156.7	66.8	28.9
2034	2572.6	1027.9	417.5	172.3	72.2	30.7
2035	3546.1	1391.0	554.9	225.0	92.7	33.8
2036	2048.0	788.8	309.1	123.1	49.3	20.5
2037	1726.5	652.9	251.2	98.3	39.1	15.3
2038	1622.1	602.2	227.6	87.5	34.2	13.6
2039	1524.0	555.5	206.2	77.9	29.9	11.7
2040	1431.8	512.4	186.3	69.3	26.2	10.1
2041	769.1	270.2	96.8	35.3	13.1	4.9
TOTAL	320630.6	181843.6	98732.2	46840.9	13419.0	-3565.9

Table.A.5.

DIFFERENTIAL CASH FLOW SHEET (THOUSAND M$)
---CASE 3 : FUEL OIL (PRICE ESCALETION 3.0% PER ANNUM)---

YEAR	TEKAI (CONST.)	TEKAI (TRANS.)	TEKAI (O-M)	GAS TURBINE (CONST.)	GAS TURBINE (O-M)	GAS TURBINE (FUEL)	BENEFIT
1984	5556.0	0.0	0.0	0.0	0.0	0.0	-5556.0
1985	8021.0	0.0	0.0	0.0	0.0	0.0	-8021.0
1986	16673.0	0.0	0.0	0.0	0.0	0.0	-16673.0
1987	26184.0	0.0	0.0	0.0	0.0	0.0	-26184.0
1988	40517.0	5209.6	0.0	0.0	0.0	0.0	-45726.6
1989	73754.0	9116.8	0.0	23012.9	0.0	0.0	-59857.9
1990	89264.0	9116.8	0.0	80545.2	0.0	0.0	-17835.6
1991	87443.0	2604.8	405.0	11506.5	96.0	28295.7	-50554.5
1992	0.0	0.0	983.0	0.0	3172.0	58289.1	60478.1
1993	0.0	0.0	983.0	0.0	3172.0	60037.7	62226.7
1994	0.0	0.0	983.0	0.0	3172.0	61838.9	64027.9
1995	0.0	0.0	983.0	0.0	3172.0	63674.0	65863.0
1996	0.0	0.0	983.0	0.0	3172.0	65604.3	67793.3
1997	0.0	0.0	983.0	0.0	3172.0	67573.0	69762.0
1998	0.0	0.0	983.0	0.0	3172.0	69690.1	71879.1
1999	0.0	0.0	983.0	0.0	3172.0	71643.1	73832.1
2000	0.0	0.0	983.0	0.0	3172.0	74138.7	76327.7
2001	0.0	0.0	983.0	0.0	3172.0	76053.9	78242.9
2002	0.0	0.0	983.0	0.0	3172.0	78335.5	80524.5
2003	0.0	0.0	983.0	0.0	3172.0	80635.5	82824.5
2004	0.0	0.0	983.0	23012.9	3172.0	83106.1	108308.0
2005	0.0	0.0	983.0	80545.2	3172.0	85599.3	168333.4
2006	0.0	0.0	983.0	11506.5	3172.0	88167.2	101862.7
2007	0.0	0.0	983.0	0.0	3172.0	90812.2	93001.2
2008	0.0	0.0	983.0	0.0	3172.0	93536.6	95725.6
2009	0.0	0.0	983.0	0.0	3172.0	96342.6	98531.6
2010	0.0	0.0	983.0	0.0	3172.0	99232.9	101421.9
2011	0.0	0.0	983.0	0.0	3172.0	102209.9	104398.9
2012	0.0	0.0	983.0	0.0	3172.0	105276.1	107465.1
2013	0.0	0.0	983.0	0.0	3172.0	108434.4	110623.4
2014	0.0	0.0	983.0	0.0	3172.0	111687.4	113876.4
2015	0.0	0.0	983.0	0.0	3172.0	115038.0	117227.0
2016	0.0	0.0	983.0	0.0	3172.0	118489.1	120678.1
2017	0.0	0.0	983.0	0.0	3172.0	122043.3	124232.3
2018	0.0	0.0	983.0	0.0	3172.0	125205.0	127394.0
2019	0.0	0.0	983.0	23012.9	3172.0	129476.2	154678.1
2020	0.0	0.0	983.0	80545.2	3172.0	133360.4	216094.6
2021	0.0	0.0	983.0	11506.5	3172.0	137361.2	151056.7
2022	0.0	0.0	983.0	0.0	3172.0	141482.0	143671.0
2023	0.0	0.0	983.0	0.0	3172.0	145726.5	147915.5
2024	0.0	0.0	983.0	0.0	3172.0	150093.5	152282.5
2025	0.0	0.0	983.0	0.0	3172.0	154601.2	156790.2
2026	0.0	0.0	983.0	0.0	3172.0	159239.2	161428.2
2027	0.0	0.0	983.0	0.0	3172.0	164016.3	166205.3
2028	0.0	0.0	983.0	0.0	3172.0	168936.3	171125.3
2029	0.0	0.0	983.0	0.0	3172.0	174004.3	176193.3
2030	0.0	0.0	983.0	0.0	3172.0	179224.9	181413.9
2031	0.0	0.0	983.0	0.0	3172.0	184601.6	186790.6
2032	0.0	0.0	983.0	0.0	3172.0	190137.7	192326.7
2033	0.0	0.0	983.0	0.0	3172.0	195843.3	198032.3
2034	0.0	0.0	983.0	23012.9	3172.0	201719.1	226923.9
2035	0.0	0.0	983.0	80545.2	3172.0	207770.6	290504.3
2036	0.0	0.0	983.0	11506.5	3172.0	214003.7	227699.2
2037	0.0	0.0	983.0	0.0	3172.0	220423.3	222612.3
2038	0.0	0.0	983.0	0.0	3172.0	227036.4	229225.4
2039	0.0	0.0	983.0	0.0	3172.0	233847.4	236036.4
2040	0.0	0.0	983.0	0.0	3172.0	240862.9	243051.9
2041	0.0	0.0	983.0	-46316.1	3172.0	248088.7	203961.6

Table.A.6.

NET PRESENT VALUES (THOUSAND M$)

---CASE 3 : FUEL OIL (PRICE ESCALETION 3.0% PER ANNUM)---

YEAR	8%	10%	12%	14%	16%	18%
	PRESENT VALUES FOR DISCOUNT RATE					
1984	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0
1985	-7426.9	-7291.3	-7161.6	-7036.0	-6914.7	-6797.5
1986	-14294.4	-13779.3	-13291.6	-12829.3	-12390.8	-11974.3
1987	-20785.7	-19672.4	-18637.3	-17673.5	-16775.0	-15936.4
1988	-33610.4	-31231.9	-29060.1	-27073.6	-25254.4	-23585.5
1989	-40733.3	-37167.1	-33965.0	-31033.4	-28499.2	-26164.5
1990	-11239.5	-10067.7	-9036.1	-8125.7	-7320.5	-6606.9
1991	-29493.2	-25942.5	-22868.4	-20203.5	-17337.8	-15373.4
1992	32674.4	28213.5	24426.1	21201.2	18447.4	16337.5
1993	31128.9	26390.2	22439.6	19135.2	16362.7	14027.4
1994	29657.3	24685.5	20615.3	17271.1	14514.1	12233.5
1995	28256.1	23091.6	18939.8	15589.1	12374.7	10667.7
1996	26921.9	21601.2	17401.0	14071.3	11420.8	9302.7
1997	25651.4	20207.6	15987.7	12701.5	10131.3	8112.5
1998	24441.4	18904.3	14689.5	11465.5	8937.7	7074.3
1999	23289.2	17635.6	13497.1	10349.9	7973.4	6169.9
2000	22191.8	16545.9	12401.8	9343.2	7073.7	5381.0
2001	21146.2	15580.0	11325.7	8434.6	6275.7	4693.0
2002	20151.2	14483.1	10471.4	7614.5	5567.8	4093.1
2003	19203.1	13550.7	9622.3	6874.3	4939.9	3570.0
2004	23237.3	16099.3	11228.0	7880.7	5565.5	3953.9
2005	33440.5	22747.0	15580.9	10744.1	7456.8	5207.8
2006	18736.7	12513.4	8418.2	5703.1	3889.9	2673.6
2007	15839.6	10386.2	6862.4	4567.5	3063.7	2066.4
2008	15095.9	9718.6	6306.6	4123.9	2716.7	1802.4
2009	14387.4	9094.1	5796.0	3723.5	2410.6	1572.3
2010	13712.4	8509.9	5326.8	3362.1	2139.1	1371.5
2011	13069.4	7963.3	4895.7	3035.8	1898.2	1196.4
2012	12456.7	7452.0	4499.5	2741.2	1684.4	1043.7
2013	11873.0	6973.7	4135.5	2475.2	1494.7	910.5
2014	11316.5	6526.1	3801.0	2235.1	1326.5	794.3
2015	10786.8	6107.4	3493.6	2018.3	1177.2	692.9
2016	10281.8	5715.6	3211.1	1822.5	1044.7	604.5
2017	9800.6	5349.1	2951.5	1645.8	927.1	527.4
2018	9342.1	5006.1	2712.9	1486.2	822.8	460.1
2019	10461.6	5504.1	2929.5	1576.7	857.8	471.6
2020	13532.9	6990.5	3654.2	1932.3	1033.1	553.3
2021	8759.2	4442.3	2280.7	1184.8	622.6	331.3
2022	7713.8	3841.0	1936.8	988.5	510.5	266.6
2023	7353.4	3595.0	1780.4	892.7	453.1	232.5
2024	7009.9	3364.3	1636.6	806.3	402.1	202.9
2025	6682.6	3149.3	1504.5	728.2	356.9	177.1
2026	6370.6	2947.7	1383.0	657.6	316.8	154.5
2027	6073.3	2759.1	1271.4	593.9	281.2	134.3
2028	5789.9	2582.5	1168.8	536.4	249.6	117.6
2029	5519.8	2417.3	1074.4	484.5	221.5	102.6
2030	5262.3	2262.6	987.7	437.6	196.6	89.6
2031	5017.0	2117.9	908.1	395.2	174.5	78.1
2032	4783.1	1982.4	834.8	357.0	154.9	68.2
2033	4560.1	1855.7	767.5	322.4	137.5	59.5
2034	4536.3	1933.0	785.2	324.1	135.8	57.2
2035	5735.1	2249.7	897.5	363.9	149.9	62.7
2036	4162.2	1603.0	628.1	250.2	101.3	41.6
2037	3767.8	1424.8	548.3	214.6	85.4	34.5
2038	3592.4	1333.7	504.1	193.8	75.8	30.1
2039	3425.1	1248.5	463.4	175.1	67.3	26.3
2040	3265.7	1168.7	426.1	158.1	59.7	22.9
2041	2537.4	891.6	319.2	116.4	43.2	16.3
TOTAL	501153.2	291956.3	170220.5	95720.3	43273.4	17137.5

Table. A.7.

DIFFERENTIAL CASH FLOW SHEET (THOUSAND M$)
---CASE 4 : NATURAL GAS (CONSTANT PRICE)---

YEAR	TEKAI (CONST.)	TEKAI (TRANS.)	TEKAI (O-M)	GAS TURBINE (CONST.)	GAS TURBINE (O-M)	GAS TURBINE (FUEL)	BENEFIT
1984	5556.0	0.0	0.0	0.0	0.0	0.0	-5556.0
1985	8021.0	0.0	0.0	0.0	0.0	0.0	-8021.0
1986	16673.0	0.0	0.0	0.0	0.0	0.0	-16673.0
1987	26134.0	0.0	0.0	0.0	0.0	0.0	-26134.0
1988	40517.0	5209.6	0.0	0.0	0.0	0.0	-45726.6
1989	73754.0	9116.8	0.0	23012.9	0.0	0.0	-59557.7
1990	89264.0	9116.8	0.0	80545.2	0.0	0.0	-173354.6
1991	87443.0	2604.8	405.0	11506.5	961.0	15635.3	-63214.5
1992	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
1993	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
1994	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
1995	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
1996	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
1997	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
1998	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
1999	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2000	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2001	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2002	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2003	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2004	0.0	0.0	983.0	23012.9	3172.0	31271.7	56473.5
2005	0.0	0.0	983.0	80545.2	3172.0	31271.7	114005.8
2006	0.0	0.0	983.0	11506.5	3172.0	31271.7	44967.1
2007	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2008	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2009	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2010	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2011	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2012	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2013	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2014	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2015	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2016	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2017	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2018	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2019	0.0	0.0	983.0	23012.9	3172.0	31271.7	56473.5
2020	0.0	0.0	983.0	80545.2	3172.0	31271.7	114005.8
2021	0.0	0.0	983.0	11506.5	3172.0	31271.7	44967.1
2022	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2023	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2024	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2025	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2026	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2027	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2028	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2029	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2030	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2031	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2032	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2033	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2034	0.0	0.0	983.0	23012.9	3172.0	31271.7	56473.5
2035	0.0	0.0	983.0	80545.2	3172.0	31271.7	114005.8
2036	0.0	0.0	983.0	11506.5	3172.0	31271.7	44967.1
2037	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2038	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2039	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2040	0.0	0.0	983.0	0.0	3172.0	31271.7	33460.6
2041	0.0	0.0	983.0	-46316.1	3172.0	31271.7	-12855.4

Table. A.8.

NET PRESENT VALUES (THOUSAND M$)
---CASE 4 : NATURAL GAS (CONSTANT PRICE)---

YEAR	8%	10%	12%	14%	16%	18%
			PRESENT VALUES FOR DISCOUNT RATE			
1984	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0
1985	-7426.9	-7291.8	-7161.6	-7036.0	-6914.7	-6797.5
1986	-14294.4	-13779.3	-13291.6	-12829.3	-12390.8	-11974.3
1987	-20785.7	-19672.4	-18637.3	-17673.5	-16775.0	-15936.4
1988	-33610.4	-31231.9	-29060.1	-27073.3	-25254.4	-23585.3
1989	-40733.3	-37167.1	-33965.0	-31083.4	-28499.2	-26164.5
1990	-11239.5	-10067.7	-9036.1	-8125.7	-7320.5	-6606.9
1991	-36385.1	-32439.1	-23595.1	-25262.9	-22367.2	-19844.6
1992	18077.8	15609.7	13514.2	11730.0	10206.4	8901.4
1993	16738.7	14190.6	12066.3	10289.4	8798.6	7543.9
1994	15498.8	12900.5	10723.4	9025.3	7535.0	6393.2
1995	14350.7	11727.8	9619.2	7917.4	6538.8	5417.7
1996	13287.7	10661.6	8538.5	6945.1	5636.9	4591.5
1997	12303.4	9692.4	7668.3	6092.2	4859.4	3891.1
1998	11392.1	8811.2	6846.7	5344.0	4189.1	3297.5
1999	10543.2	8010.2	6113.1	4637.7	3611.3	2794.5
2000	9766.9	7232.0	5453.2	4112.0	3113.2	2369.2
2001	9043.4	6620.0	4873.4	3607.1	2683.8	2007.0
2002	8373.5	6018.2	4351.2	3164.1	2313.6	1700.3
2003	7753.2	5471.1	3885.0	2775.5	1994.5	1441.4
2004	12116.3	8394.4	5854.4	4109.1	2901.9	2061.6
2005	22648.0	15405.7	10552.4	7276.6	5050.2	3527.0
2006	8271.3	5524.0	3716.2	2517.6	1717.2	1178.9
2007	5698.9	3736.8	2469.0	1643.3	1101.5	743.4
2008	5276.7	3397.1	2204.5	1441.5	949.6	630.0
2009	4885.9	3086.3	1968.3	1264.5	818.6	533.9
2010	4523.9	2807.5	1757.4	1109.2	705.7	452.5
2011	4188.8	2552.3	1569.1	973.0	608.4	383.5
2012	3878.6	2320.3	1401.0	853.5	524.5	325.0
2013	3591.3	2109.3	1250.9	748.7	452.1	275.4
2014	3325.2	1917.6	1116.9	656.7	389.8	233.4
2015	3078.9	1743.3	997.2	576.1	336.0	197.8
2016	2850.9	1584.8	890.3	505.3	289.7	167.6
2017	2639.7	1440.7	795.0	443.3	249.7	142.0
2018	2444.1	1309.7	709.8	388.8	215.3	120.4
2019	3819.6	2009.6	1069.6	575.7	313.2	172.2
2020	7139.6	3688.0	1927.9	1019.4	545.1	294.6
2021	2607.5	1322.4	678.9	352.7	185.3	98.5
2022	1796.5	894.6	451.1	230.2	118.9	62.1
2023	1663.4	813.2	402.7	202.0	102.5	52.6
2024	1540.2	739.3	359.6	177.2	88.4	44.6
2025	1426.1	672.1	321.1	155.4	76.2	37.9
2026	1320.5	611.0	286.7	136.3	65.7	32.0
2027	1222.7	555.5	256.0	119.6	56.6	27.1
2028	1132.1	505.0	228.5	104.9	48.8	23.0
2029	1048.3	459.1	204.0	92.0	42.1	19.5
2030	970.6	417.3	182.2	80.7	36.3	16.5
2031	898.7	379.4	162.7	70.3	31.3	14.0
2032	832.1	344.9	145.2	62.1	26.9	11.9
2033	770.5	313.5	129.7	54.5	23.2	10.1
2034	1204.1	481.1	195.4	80.7	33.8	14.4
2035	2250.7	892.9	352.2	142.4	58.8	24.5
2036	822.0	316.6	124.0	49.4	20.0	8.2
2037	566.3	214.2	82.4	32.3	12.8	5.2
2038	524.4	194.7	73.6	28.3	11.1	4.4
2039	485.5	177.0	65.7	24.3	9.5	3.7
2040	449.6	160.9	58.7	21.3	8.2	3.2
2041	-159.9	-56.2	-20.1	-7.3	-2.7	-1.0
TOTAL	100347.3	33217.7	-6555.4	-30642.2	-45325.3	-54165.4

Table.A.9.

DIFFERENTIAL CASH FLOW SHEET (THOUSAND M$)
---CASE 5 : NATURAL GAS (PRICE ESCALETION 1.5% PER ANNUM)---

YEAR	TEKAI (CONST.)	TEKAI (TRANS.)	TEKAI (O-M)	GAS TURBINE (CONST.)	GAS TURBINE (O-M)	GAS TURBINE (FUEL)	BENEFIT
1984	5556.0	0.0	0.0	0.0	0.0	0.0	-5556.0
1985	8021.0	0.0	0.0	0.0	0.0	0.0	-8021.0
1986	16673.0	0.0	0.0	0.0	0.0	0.0	-16673.0
1987	26184.0	0.0	0.0	0.0	0.0	0.0	-26184.0
1988	40517.0	5209.6	0.0	0.0	0.0	0.0	-45726.6
1989	73754.0	9116.8	0.0	23012.9	0.0	0.0	-59857.9
1990	89264.0	9116.8	0.0	80545.2	0.0	0.0	-17835.6
1991	87443.0	2604.3	405.0	11506.5	96.0	17613.6	-61236.2
1992	0.0	0.0	983.0	0.0	3172.0	35755.6	37944.6
1993	0.0	0.0	983.0	0.0	3172.0	36291.9	38480.9
1994	0.0	0.0	983.0	0.0	3172.0	36836.3	39025.3
1995	0.0	0.0	983.0	0.0	3172.0	37388.3	39577.3
1996	0.0	0.0	983.0	0.0	3172.0	37949.7	40138.7
1997	0.0	0.0	983.0	0.0	3172.0	38513.9	40702.9
1998	0.0	0.0	983.0	0.0	3172.0	39046.7	41235.7
1999	0.0	0.0	983.0	0.0	3172.0	39683.1	41872.1
2000	0.0	0.0	983.0	0.0	3172.0	40278.4	42467.4
2001	0.0	0.0	983.0	0.0	3172.0	40882.5	43071.5
2002	0.0	0.0	983.0	0.0	3172.0	41495.7	43684.7
2003	0.0	0.0	983.0	0.0	3172.0	42118.2	44307.2
2004	0.0	0.0	983.0	23012.9	3172.0	42749.9	67951.8
2005	0.0	0.0	983.0	80545.2	3172.0	43391.2	126125.3
2006	0.0	0.0	983.0	11506.5	3172.0	44042.0	57737.5
2007	0.0	0.0	983.0	0.0	3172.0	44702.6	46891.6
2008	0.0	0.0	983.0	0.0	3172.0	45373.2	47562.2
2009	0.0	0.0	983.0	0.0	3172.0	46053.8	48242.8
2010	0.0	0.0	983.0	0.0	3172.0	46744.5	48933.5
2011	0.0	0.0	983.0	0.0	3172.0	47445.7	49634.7
2012	0.0	0.0	983.0	0.0	3172.0	48157.4	50346.4
2013	0.0	0.0	983.0	0.0	3172.0	48879.7	51068.7
2014	0.0	0.0	983.0	0.0	3172.0	49612.9	51801.9
2015	0.0	0.0	983.0	0.0	3172.0	50357.1	52546.1
2016	0.0	0.0	983.0	0.0	3172.0	51112.5	53301.5
2017	0.0	0.0	983.0	0.0	3172.0	51879.1	54068.1
2018	0.0	0.0	983.0	0.0	3172.0	52657.3	54846.3
2019	0.0	0.0	983.0	23012.9	3172.0	53447.1	78649.0
2020	0.0	0.0	983.0	80545.2	3172.0	54248.8	136983.0
2021	0.0	0.0	983.0	11506.5	3172.0	55062.5	68758.0
2022	0.0	0.0	983.0	0.0	3172.0	55888.5	58077.5
2023	0.0	0.0	983.0	0.0	3172.0	56726.9	58915.9
2024	0.0	0.0	983.0	0.0	3172.0	57577.7	59766.7
2025	0.0	0.0	983.0	0.0	3172.0	58441.3	60630.3
2026	0.0	0.0	983.0	0.0	3172.0	59317.9	61506.9
2027	0.0	0.0	983.0	0.0	3172.0	60207.1	62396.1
2028	0.0	0.0	983.0	0.0	3172.0	61110.3	63299.3
2029	0.0	0.0	983.0	0.0	3172.0	62027.4	64216.4
2030	0.0	0.0	983.0	0.0	3172.0	62957.8	65146.8
2031	0.0	0.0	983.0	0.0	3172.0	63902.2	66091.2
2032	0.0	0.0	983.0	0.0	3172.0	64860.7	67049.7
2033	0.0	0.0	983.0	0.0	3172.0	65833.6	68022.6
2034	0.0	0.0	983.0	23012.9	3172.0	66821.1	92023.0
2035	0.0	0.0	983.0	80545.2	3172.0	67823.4	150557.6
2036	0.0	0.0	983.0	11506.5	3172.0	68840.7	82536.2
2037	0.0	0.0	983.0	0.0	3172.0	69873.3	72062.3
2038	0.0	0.0	983.0	0.0	3172.0	70921.4	73110.4
2039	0.0	0.0	983.0	0.0	3172.0	71985.2	74174.2
2040	0.0	0.0	983.0	0.0	3172.0	73064.9	75253.9
2041	0.0	0.0	983.0	-46316.1	3172.0	74160.6	30033.5

Table. A.10.

NET PRESENT VALUES (THOUSAND M$)
---CASE 5 : NATURAL GAS (PRICE ESCALETION 1.5% PER ANNUM)---

YEAR	PRESENT VALUES FOR DISCOUNT RATE 8%	10%	12%	14%	16%	18%
1984	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0
1985	-7426.9	-7291.8	-7161.6	-7036.0	-6914.7	-5797.5
1986	-14294.4	-13779.3	-13291.6	-12829.3	-12390.6	-11974.3
1987	-20785.7	-19672.4	-18637.3	-17673.5	-16775.0	-15936.4
1988	-33610.4	-31231.9	-29060.1	-27073.6	-25254.4	-23585.3
1989	-40738.5	-37167.1	-33965.0	-31048.4	-28499.2	-26164.5
1990	-11239.5	-10067.7	-9036.1	-8125.7	-7320.5	-6606.9
1991	-35731.1	-31424.1	-27700.4	-24472.5	-21667.4	-19223.3
1992	20500.3	17201.5	15325.2	13301.3	11574.1	10094.7
1993	19250.1	16319.7	13376.6	11833.2	10118.7	8675.9
1994	18076.3	15046.0	12565.1	10526.3	8846.4	7456.4
1995	16974.3	13871.8	11377.7	9364.3	7734.2	6403.4
1996	15939.6	12789.4	10302.6	8331.2	6761.9	5507.9
1997	14968.2	11791.6	9329.2	7411.7	5911.9	4733.3
1998	14056.2	10871.8	8447.9	6593.7	5163.8	4062.7
1999	13199.9	10023.9	7649.9	5866.2	4519.1	3497.0
2000	12395.8	9242.2	6927.4	5218.9	3951.2	3005.7
2001	11640.9	8521.5	6273.1	4643.1	3454.7	2583.4
2002	10932.1	7857.1	5680.8	4130.9	3020.6	2220.5
2003	10266.5	7244.6	5144.4	3675.2	2641.0	1993.6
2004	14579.0	10100.6	7044.4	4944.3	5491.7	2490.6
2005	25055.6	17063.4	11674.1	8050.1	5537.1	3992.0
2006	10620.3	7092.8	4771.6	3232.6	2204.9	1513.8
2007	7986.4	5236.8	3460.0	2303.0	1543.7	1041.9
2008	7500.5	4828.8	3133.5	2049.0	1349.8	895.6
2009	7044.3	4452.6	2837.8	1823.1	1180.3	767.8
2010	6615.9	4105.8	2570.0	1622.1	1032.1	661.7
2011	6213.6	3786.0	2327.6	1443.3	902.4	563.3
2012	5835.9	3491.2	2108.0	1284.2	789.1	489.0
2013	5481.1	3219.4	1909.1	1142.7	690.0	420.3
2014	5147.9	2968.7	1729.0	1016.7	603.4	361.3
2015	4835.1	2737.6	1566.0	904.7	527.6	310.6
2016	4541.3	2524.5	1418.3	805.0	461.4	267.0
2017	4265.4	2328.0	1284.5	716.3	403.5	229.5
2018	4006.3	2146.8	1163.4	637.4	352.8	197.3
2019	5319.4	2798.7	1489.6	801.7	436.2	239.3
2020	8578.5	4431.3	2316.4	1224.9	654.9	353.9
2021	3987.0	2022.1	1038.1	539.3	283.4	150.6
2022	3118.2	1552.7	782.9	399.6	206.4	107.8
2023	2928.9	1431.9	709.1	355.6	180.5	92.6
2024	2751.1	1320.5	642.3	316.4	157.8	79.6
2025	2584.1	1217.8	581.8	281.6	138.0	68.5
2026	2427.3	1123.1	526.9	250.6	120.7	58.9
2027	2280.0	1035.8	477.3	223.0	105.6	50.6
2028	2141.7	955.3	432.3	198.4	92.3	43.5
2029	2011.8	881.0	391.6	176.6	80.7	37.4
2030	1889.7	812.5	354.7	157.1	70.6	32.2
2031	1775.1	749.4	321.3	139.8	61.7	27.6
2032	1667.5	691.1	291.0	124.4	54.0	23.8
2033	1566.4	637.4	263.6	110.7	47.2	20.4
2034	1962.0	783.9	318.4	131.4	55.1	23.4
2035	2972.3	1165.9	465.1	189.6	77.7	32.5
2036	1508.7	581.1	227.7	90.7	36.7	15.1
2037	1219.7	461.2	177.5	69.5	27.6	11.2
2038	1145.8	425.4	160.8	61.8	24.2	9.6
2039	1076.3	392.3	145.6	55.0	21.1	8.3
2040	1011.1	361.9	131.9	49.0	18.5	7.1
2041	373.6	131.3	47.0	17.1	6.4	2.4
TOTAL	184842.4	87117.0	29782.2	-5020.3	-26598.3	-41073.0

Table.A.11. DIFFERENTIAL CASH FLOW SHEET (THOUSAND M$)

---CASE 6 : NATURAL GAS (PRICE ESCALETION 3.0% PER ANNUM)---

YEAR	TEKAI (CONST.)	TEKAI (TRANS.)	TEKAI (O-M)	GAS TURBINE (CONST.)	GAS TURBINE (O-M)	GAS TURBINE (FUEL)	BENEFIT
1984	5556.0	0.0	0.0	0.0	0.0	0.0	-5556.0
1985	8021.0	0.0	0.0	0.0	0.0	0.0	-8021.0
1986	16673.0	0.0	0.0	0.0	0.0	0.0	-16673.0
1987	26184.0	0.0	0.0	0.0	0.0	0.0	-26184.0
1988	40517.0	5209.6	0.0	0.0	0.0	0.0	-45726.6
1989	73754.0	9116.8	0.0	23012.9	0.0	0.0	-59857.9
1990	89264.0	9116.8	0.0	80545.2	0.0	0.0	-17835.6
1991	87443.0	2604.8	405.0	11506.5	96.0	19507.0	-59343.4
1992	0.0	0.0	983.0	0.0	3172.0	40502.3	42691.3
1993	0.0	0.0	983.0	0.0	3172.0	42026.4	44215.4
1994	0.0	0.0	983.0	0.0	3172.0	43287.2	45476.2
1995	0.0	0.0	983.0	0.0	3172.0	44585.2	46774.2
1996	0.0	0.0	983.0	0.0	3172.0	45923.4	48112.4
1997	0.0	0.0	983.0	0.0	3172.0	47301.1	49490.1
1998	0.0	0.0	983.0	0.0	3172.0	48720.1	50909.1
1999	0.0	0.0	983.0	0.0	3172.0	50181.7	52370.7
2000	0.0	0.0	983.0	0.0	3172.0	51687.1	53876.1
2001	0.0	0.0	983.0	0.0	3172.0	53237.7	55426.7
2002	0.0	0.0	983.0	0.0	3172.0	54834.8	57023.8
2003	0.0	0.0	983.0	0.0	3172.0	56477.9	58666.9
2004	0.0	0.0	983.0	23012.9	3172.0	58174.3	83376.1
2005	0.0	0.0	983.0	80545.2	3172.0	59919.5	142653.7
2006	0.0	0.0	983.0	11506.5	3172.0	61717.0	75412.5
2007	0.0	0.0	983.0	0.0	3172.0	63568.5	65757.5
2008	0.0	0.0	983.0	0.0	3172.0	65475.6	67664.6
2009	0.0	0.0	983.0	0.0	3172.0	67439.3	69628.3
2010	0.0	0.0	983.0	0.0	3172.0	69463.0	71652.0
2011	0.0	0.0	983.0	0.0	3172.0	71546.9	73735.9
2012	0.0	0.0	983.0	0.0	3172.0	73693.3	75882.3
2013	0.0	0.0	983.0	0.0	3172.0	75904.1	78093.1
2014	0.0	0.0	983.0	0.0	3172.0	78181.2	80370.2
2015	0.0	0.0	983.0	0.0	3172.0	80526.6	82715.6
2016	0.0	0.0	983.0	0.0	3172.0	82942.6	85131.6
2017	0.0	0.0	983.0	0.0	3172.0	85430.6	87619.6
2018	0.0	0.0	983.0	0.0	3172.0	87993.5	90182.5
2019	0.0	0.0	983.0	23012.9	3172.0	90633.3	115835.2
2020	0.0	0.0	983.0	80545.2	3172.0	93352.3	176086.5
2021	0.0	0.0	983.0	11506.5	3172.0	96152.8	109848.3
2022	0.0	0.0	983.0	0.0	3172.0	99037.4	101226.4
2023	0.0	0.0	983.0	0.0	3172.0	102008.5	104197.5
2024	0.0	0.0	983.0	0.0	3172.0	105068.8	107257.8
2025	0.0	0.0	983.0	0.0	3172.0	108220.8	110409.8
2026	0.0	0.0	983.0	0.0	3172.0	111467.4	113656.4
2027	0.0	0.0	983.0	0.0	3172.0	114811.4	117000.4
2028	0.0	0.0	983.0	0.0	3172.0	118255.7	120444.7
2029	0.0	0.0	983.0	0.0	3172.0	121803.4	123992.4
2030	0.0	0.0	983.0	0.0	3172.0	125457.4	127646.4
2031	0.0	0.0	983.0	0.0	3172.0	129221.1	131410.1
2032	0.0	0.0	983.0	0.0	3172.0	133097.7	135286.7
2033	0.0	0.0	983.0	0.0	3172.0	137090.6	139279.6
2034	0.0	0.0	983.0	23012.9	3172.0	141203.3	166405.2
2035	0.0	0.0	983.0	80545.2	3172.0	145439.4	228173.6
2036	0.0	0.0	983.0	11506.5	3172.0	149802.6	163498.1
2037	0.0	0.0	983.0	0.0	3172.0	154295.6	155435.6
2038	0.0	0.0	983.0	0.0	3172.0	158925.4	161114.4
2039	0.0	0.0	983.0	0.0	3172.0	163693.2	165882.2
2040	0.0	0.0	983.0	0.0	3172.0	168604.0	170793.0
2041	0.0	0.0	983.0	-46316.1	3172.0	173662.0	129534.9

Table, A.12.

NET PRESENT VALUES (THOUSAND H$)

---CASE 6 : NATURAL GAS (PRICE ESCALETION 3.0% PER ANNUM)---

YEAR	PRESENT VALUES FOR DISCOUNT RATE 8%	10%	12%	14%	16%	18%
1984	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0	-5556.0
1985	-7426.9	-7291.3	-7161.6	-7036.0	-6914.7	-6797.5
1986	-14294.4	-13779.3	-13291.6	-12829.3	-12390.8	-11974.3
1987	-20785.7	-19672.4	-18637.3	-17673.5	-16775.0	-15936.4
1988	-33610.4	-31231.9	-29060.1	-27073.8	-25254.4	-23585.3
1989	-40733.3	-37167.1	-33965.0	-31038.4	-28499.2	-26164.5
1990	-11239.5	-10067.7	-9036.1	-8125.7	-7320.5	-6605.9
1991	-34451.3	-30298.6	-26708.2	-23596.0	-20891.3	-18535.2
1992	23226.9	20055.8	17363.5	15071.0	13113.5	11437.4
1993	22118.7	18751.7	15944.5	13596.6	11626.6	9968.7
1994	21064.3	17533.1	14642.1	12266.7	10305.7	8638.7
1995	20060.9	16394.3	13446.7	11067.3	9140.6	7573.7
1996	19106.1	15330.1	12349.3	9986.2	8105.2	6602.0
1997	18197.4	14335.5	11341.9	9010.6	7137.3	5755.1
1998	17332.6	13406.0	10412.0	8130.7	6373.6	5017.0
1999	16509.4	12537.1	9567.9	7337.0	5652.2	4373.3
2000	15725.9	11725.0	8788.4	6620.9	5012.7	3813.2
2001	14980.1	10965.9	8072.6	5975.0	4445.6	3324.5
2002	14270.2	10256.3	7415.4	5392.3	3942.9	2898.6
2003	13594.3	9592.8	6811.9	4866.5	3497.1	2527.3
2004	17888.2	12393.4	8643.6	6066.6	4284.3	3043.7
2005	28339.0	19276.9	13204.0	9105.1	6319.3	4413.3
2006	13871.4	9264.1	6232.3	4222.2	2829.8	1927.2
2007	11199.5	7343.7	4852.1	3229.5	2164.8	1461.0
2008	10670.7	6869.7	4457.9	2915.1	1920.3	1274.1
2009	10167.1	6426.5	4095.8	2631.3	1703.5	1111.1
2010	9637.5	6012.0	3763.2	2375.2	1511.2	963.9
2011	9230.8	5624.4	3457.8	2144.1	1340.7	845.0
2012	8795.8	5261.9	3177.1	1935.6	1139.4	737.3
2013	8381.6	4923.0	2919.4	1747.3	1055.2	642.7
2014	7987.0	4605.9	2682.6	1577.4	936.2	560.6
2015	7611.2	4309.4	2465.1	1424.1	830.6	488.9
2016	7253.2	4032.0	2265.2	1285.7	736.9	426.5
2017	6912.2	3772.6	2081.7	1160.3	653.9	372.0
2018	6587.4	3530.0	1913.0	1048.0	530.2	324.4
2019	7834.5	4121.9	2193.9	1180.8	642.4	353.2
2020	11027.4	5696.3	2977.7	1574.5	841.9	455.0
2021	6369.7	3230.5	1658.5	861.6	452.7	240.5
2022	5434.9	2706.3	1364.6	696.5	359.7	187.3
2023	5180.0	2532.5	1254.2	628.9	319.2	163.9
2024	4937.2	2369.9	1152.7	567.9	283.2	142.9
2025	4705.8	2217.7	1059.4	512.8	251.3	124.7
2026	4485.4	2075.4	973.7	463.0	223.0	109.3
2027	4275.3	1942.2	895.0	418.1	197.9	94.9
2028	4075.2	1817.7	822.6	377.6	175.6	82.9
2029	3884.4	1701.1	756.1	340.9	155.9	72.2
2030	3702.7	1592.0	695.0	307.9	138.3	63.0
2031	3529.5	1490.0	639.8	278.0	122.8	55.0
2032	3364.5	1394.5	587.2	251.1	109.0	53.0
2033	3207.2	1305.1	539.8	226.8	96.7	41.8
2034	3548.0	1417.5	575.8	237.6	99.6	42.4
2035	4504.6	1767.0	704.9	285.5	117.7	49.2
2036	2988.7	1151.1	451.0	179.7	72.7	29.9
2037	2648.6	1001.5	385.4	150.8	60.0	24.3
2038	2525.0	937.4	354.3	136.2	53.3	21.2
2039	2407.1	877.4	325.7	123.0	47.3	18.5
2040	2294.8	821.3	299.4	111.1	42.0	16.1
2041	1611.5	566.2	202.8	73.9	27.4	10.4
TOTAL	311208.1	164196.1	79824.0	29195.3	-2200.1	-22033.4

6. SUMMARY AND CONCLUSION

6. Summary and Conclusion

The purpose of this investigation is to study the feasibility of the Tekai River Basin Water-power Development Project for the Pahang Drainage System running through the Pahang. The study was performed to ascertain the most economical development method, development scale, structural design and work schedule for the two proposed sites (Upper and Lower Tekai). These sites, located on the downstream basin of the Takai River, were selected to ensure the highest possible effective utilization of hydraulic resources.

Study of the development method and scale was made on two cases: a single development plan (independent Upper and Lower Tekai) and a series development plan (integrating Upper and Lower Tekai). In this study, water power, that is, the ability to respond quickly to load fluctuation and the superior availability of power supply to meet peak load demand, were taken into consideration.

The optimum scale of single development was determined from the benefit/cost (B/C) ratio and extra benefit (B-C), while calculating annual power generation on the basis of comparison of dam height, equipment output and available water depth.

The optimum scale of series development was determined from B/C and B-C, while calculating annual power generation on the basis of comparison of equipment output (the optimum scale of the independent development plan for the Upper Tekai fixed and the H.W.L. of the Lower Tekai set to tailrace water level of the Upper Tekai). In calculating the benefit, the gas turbine was considered as a substitute thermal power source.

For the design of sturctures, a study was made of the arrangement and technical data to ensure the highest level of economical feasibility within a precision range applicable at the feasibility study stage. Results of various investigations of topography, geology, weather, river conditions, etc. were used as bases for conclusions.

As for the development method, it is concluded that the series development (integrating the Upper and Lower dam) is feasible, as a result of the examination of the aforementioned facts. It is recommended that the Detail Design of this project be started immediately, including the construction of the access road and the logging of the area to be innundated by the Upper dam.

The following are the most optimum development scale and the principal dimensions of Tekai Project.

(1) The most appropriate form and scale for the proposed Upper Tekai dam is the center core rockfill type with a height of 101 m (crest level EL. 166.2 m). For the Lower Tekai, a concrete gravity dam with a height of 38 m (crest level EL. 81 m) would be recommended.

(2) The installed capacity of the Upper Tekai dam is 150 MW, while the Lower Tekai works' capacity is 5.8 MW. Consequently, the total of the two dams is 155.8 MW.

(3) The average annual energy generation is 194.8 GWH at Upper Tekai and 40.3 GWH at Lower Tekai, totaling 235.1 GWH for the two dams.

(4) The estimated construction cost is 289×10^6 M$ for Upper Tekai and 62×10^6 M$ for Lower Tekai, totaling therefore 351×10^6 M$.

(5) The benefit/cost ratio (B/C) of the series development of Upper and Lower Tekai is 1.53, the extra benefit (B-C) is 23.10×10^6 M$ and the internal rate of return (I.R.R.) is 14.78% (Assuming that fuel oil remains at a constant price, including construction cost of power transmission line).

(6) The approximate stage of execution of works is expected to be as follows, when the start of operation of Upper and Lower Tekai is planned in July 1991.

(1) Tekai Development Scheme

	Upper Dam	Lower Dam	Series
. Installed Capacity	150,000 kW	5,800 kW	155,800 kW
. Dam Body Volume	3.125×10^6 m^3	5.69×10^4 m^3	
. Dam Height	101 m	38 m	
. Maximum Operating Level	157 m	75 m	
. Minimum Operating Level	147 m	70.5 m	
. Effective Depth	10 m	4.5 m	
. Effective Storage Capacity	680×10^6 m^3	21.5×10^6 m^3	
. Normal Water Level	153.7 m	73.5 m	
. Tailrace Water Level	75 m	55.6 m	
. Maximum Turbine Discharge	235 m^3/s	40 m^3/s	
. Construction Cost	289×10^6 M$	62×10^6 M$	351×10^6 M$
. Annual Cost	35.83×10^6 M$	7.98×10^6 M$	43.81×10^6 M$
. Annual Energy Generation	194.8×10^6 kWh	40.3×10^6 kWh	235.1×10^6 kWh
. Annual Benefit	58.42×10^6 M$	8.49×10^6 M$	66.91×10^6 M$
. B-C	22.59×10^6 M$	0.51×10^6 M$	23.10×10^6 M$
. B/C	1.63	1.06	1.53

(2) Estimated Construction Cost

For Optimum Development Scheme

	Upper Tekai	Lower Tekai
. Preparatory Works	32.26×10^6 M$	3.93×10^6 M$
Access Road	16.51×10^6 "	0.10×10^6 "
Temporary Facilities	15.74×10^6 "	3.83×10^6 "
. Civil Works	156.19×10^6 "	34.77×10^6 "
Diversion and Care of River	20.57×10^6 "	5.08×10^6 "
Dam	59.97×10^6 "	$16.00\ 10^6$ "
Spillway	21.20×10^6 "	4.95×10^6 "
Intake Structure	3.51×10^6 "	0.92×10^6 "
Penstock	25.65×10^6 "	0.81×10^6 "
Powerhouse	20.45×10^6 "	6.44×10^6 "
Switchyard	1.33×10^6 "	---
Mechanical Equipment	3.50×10^6 "	0.58×10^6 "
. Generating Equipment	53.00×10^6 "	13.00×10^6 "
. Engineering Service	19.31×10^6 "	4.14×10^6 "
. Government Administration	7.25×10^6 "	1.55×10^6 "
. Contingency	21.44×10^6 "	4.59×10^6 "
. Grand Total	289.45×10^6 M$	61.98×10^6 M$

(3) Economic Analysis

Series Development for Upper and Lower Tekai

	IRR	NPV (Mx10^6$) for Discount Rate			
	%	10%	12%	14%	16%
Case 1	14.78	104.8	46.8	10.2	-13.3
Case 2	17.13	181.8	98.7	46.8	13.4
Case 3	19.60	292.0	170.2	95.7	48.3
Case 4	11.62	33.2	6.6	-30.6	-45.3
Case 5	13.67	87.1	29.8	-5.0	-26.6
Case 6	15.86	164.2	79.8	29.2	-2.2

Case 1 : Fuel oil at constant price

Case 2 : Fuel oil with relative price escalation of 1.5 percent per annum

Case 3 : Fuel oil with relative price escalation of 3 percent per annum

Case 4 : Natural gas at constant OEP

Case 5 : Natural gas with relative price escalation of 1.5 percent per annum

Case 6 : Natural gas with relative price escalation of 3 percent per annum

(4) Construction Schedule

Upper Tekai

a) Completion of access road and temporary road (road from the aggregate plant to spoil site) - February 1986
b) Start of excavation of diversion tunnel - June 1986
c) Start of excavation of diversion and dam - October 1987
d) Dam embankment start - July 1988
e) Grouting of dam body - October 1989 (complete)
f) Spillway - July 1987
g) Penstock - May 1987
h) Power plant - March 1988
i) Start of reservoir filling - November 1989
j) Start of operations - July 1991

Lower Tekai

a) Start of temporary faciliites erection - January 1989
b) First coffering - April 1989
c) Dam excavation - August 1989
d) Start of concrete pouring on the right bank - January 1990
e) Secondary coffering - June 1990
f) Start of concrete placement on the left bank - October 1990
g) Excavation of spillway and water intake - August 1989
h) Penstock - November 1989
i) Power plant - August 1989
j) Start of operations - July 1991