(i) Geological log

The geological logs of drilled holes should be prepared in the following form.

Hole No.	Date
Location	Length (m)
Coordinates	Elevation of water level
Operator	Core inspector

Drilling and casing progress	Depth (m)	Graphic log	Geologic name	Rock grade	Core recovery (%) RQD	Water level	Description (Rock condition)	Permeability (Lugeon) test/ S.P.T.

(ii) Record of water level measurements in drill holes

The Contractor shall submit five (5) copies of report containing (i) and (ii) above upon the Completion of the Works.The report shall include photographs of drilling sites and of all core boxes filled with drilled cores, and records of the permeability test and S.T.P.

ATTACHMENT11-0-1 CHECK LIST OF JICA STUDY TEAM'S REACTION RE DOE'S COMMENT ON EIS FEB. 1988

DOE'S COMMENT	JICA STUDY TEAM'S REACTION
1.0 Effect on downstream water uses	
(a) Discharge of deoxygenated water from the dam will have detrimental effect on aquatic life.	Deoxygenated water, even if released from the dam, will be alleviated soon through aeration during flowing H_2S would be more detrimental on aquatic life, which should be obviated.
(b) Water discharged during power generation (70-80 cumecs) is not continuous throughout the day, and the nearest tributary which is Sg. Galas is some distance away. Sg. Lebir downstream of the proposed dam up to the confluence with Sg. Galas will not function like a normal river.	A re-regulating dam has been proposed to be provided at the site 3.3 km downstream from the dam to mitigate this effect. (refer to Section 11.12.3. of the Main Report)
(c) Increase in silt during the period of construction has not been predicted. Silt load increase in the river may have adverse impacts on fisheries and other aquatic life. Further studies should be done to find a solution to overcome these impacts.	A discussion has been made in Section 11.10. of the Main Report.
2.0 Relocation of settlers affected by dam impoundment	
(a) No definite plan for relocation of settlers have been mentioned in preliminary EIA. Hence, detail study should be carried out to outline the relocation and compensation plan/schedule.	This problem seems to be outwith of the scope of study by the JICA Study Team. A brief discussion has been made in Section 11.13.3. of the Main Report.
3.0 Forestry	
(a) Ample time should be allocated for Jabatan Hutan Negeri Kelantan to exploit the remaining forest resources based on the methods recommended (clear cutting and removal) in the preliminary EIA.	7 years will be allocated for this purpose.

DOE'S COMMENT	JICA STUDY TEAM'S REACTION
(b) Forest activities in watershed area after impoundment should be controlled/minimised to protect water quality in the lake. A map to mark the areas affected should be produced and made available to the parties concerned.	A discussion has been made in Section 12.6. of the Main Report.
(c) Further study should be carried out to formulate mitigating measures which could reduce eutrophication.	Refer to Section 12.6. of the Main Report.
4.0 Agriculture	
(a) Activities in the remaining 70% of existing agricultural land should be controlled to avoid surface runoff (chemicals/fertilisers/silt). Farmers should be educated by the relevant authorities on proper farming methods to minimise the above impacts.	Environment training programmes of personnel concerned have been proposed in Section 12.6. of the Main Report.
(b) Vegetation surrounding the lake should be preserved as a buffer strip. The width of the strip should take into consideration of the surrounding terrain and in any case should not be less than 20 meter. This buffer can help filter eroded materials from entering the lake.	Refer to Section 12.6. of the Main Report.
(c) Sediment traps should be provided at all tributaries leading to the lake.	Refer to Section 12.6. of the Main Report.
(d) Future land development outside the gazetted area (if any) should also incorporate land preservation measures.	This will be an institutional problem.

DOE'S COMMENT	JICA STUDY TEAM'S REACTION
(e) For land development under FELCRA compensation are due to FELCRA and the individual landowners.	Refer to Section 12.6. of the Main Report.
5.0 Flora	
(a) A detailed scientific survey should be carried out prior to impoundment to identify /rescue species which may be of medicinal/commercial potential.	Refer to Section 12.6. of the Main Report.
6.0 Fauna	
(a) Proposed location of new habitats should be identified prior to impoundment.	Refer to Section 12.6. of the Main Report.
(b) Translocation cost must be included in the overall dam cost.	Refer to Section 11.14. of the Main Report.
(c) Adequate time should be allowed for wild animals to escape as the lake water level is rising. If necessary, animals should be driven towards the 'safe' area before impoundment takes place.	In a wet cycle year, the impoundment will be completed (upto EL. 80m) in 5 weeks.
7.0 Conclusion	
(a) JICA study team has not made it clear whether the project should go ahead based on the impacts predicted, or whether detail studies should be carried out before any recommendation is made.	JICA Study Team recommends this project be implemented. Please refer to Section 2.2. of the Main Report for the concluding remark.

DOE'S COMMENT	JICA STUDY TEAM'S REACTION
(b) There is a mention of flood mitigation programme in the lower reaches but details on impacts brought about by the Lebir Dam Proejct has not been analysed. Economic analysis alone is not sufficient to show that flood mitigation prospects will make the overall project more viable. Resettlement, destruction to surrounding environment and loss of habitat to wildlife are some of the issues which should also be considered.	Several studies have been made in Section 11.12.2., and counter-measures have been worked out in the Main Report.

ATTACHMENT 11-0-2

DATA ON MEDICAL-ECOLOGY STUIED BY IMR

(at briefing in March 1988)

L.L.N. PROJECT – LEBIR DAM, KELANTAN

Summary – 17.8.87 – 27.8.87

Mosquito species	KESEDAR Lebir 1 (HBT – 4 nights)							KESEDAR Lebir 1 (BIC – 5 nights)							Remarks
	No. caught	No. dissected	Dilation				Infections	No. caught	No. dissected	Dilation				Infections	
			N	1	2	3				N	1	2	3		
Anopheles															
donaldi	3	3	2	1	–	–	–	2	2	1	1	–	–	–	
Mansonia															
dives	–	–	–	–	–	–	–	3	3	2	1	–	–	–	
Culex															
fuscocephalus	2	2	2	–	–	–	–	–	–	–	–	–	–	–	
gelidus	–	–	–	–	–	–	–	4	4	3	1	–	–	–	
quinquefasciatus	17	17	9	7	1	–	–	19	19	17	2	–	–	–	
sinensis	–	–	–	–	–	–	–	3	3	1	1	1	–	–	
tritaeniorhynchus	6	6	3	3	–	–	–	–	–	–	–	–	–	–	
Aedes															
albopictus	12	12	5	5	2	–	–	19	19	12	7	–	–	–	
lineatopennis	1	1	–	1	–	–	–	–	–	–	–	–	–	–	
niveus	1	1	1	–	–	–	–	10	10	4	6	–	–	–	
vexans	4	4	3	1	–	–	–	24	24	13	9	2	–	–	
Armigeres															
durhami	2	2	1	1	–	–	–	6	6	6	–	–	–	–	
Uranotenia sp.	1	1	–	1	–	–	–	–	–	–	–	–	–	–	
TOTAL:	49	49	26	20	3	–	–	90	90	59	28	3	–	–	

AAG/Tak.
10.9.1987

L.L.N. PROJECT - LEBIR DAM, KELANTAN

Summary - 17.8.87 - 27.8.87

Mosquito species	Kg. Jeram Panjang (HBT - 2 nights)							Kg. Jeram Panjang (BLC - 3 nights)							Remarks
	No. caught	No. dissected	Dilation N	Dilation 1	Dilation 2	Dilation 3	Infections	No. caught	No. dissected	Dilation N	Dilation 1	Dilation 2	Dilation 3	Infections	
Anopheles															
maculatus	2	2	-	1	1	-	-	11	[illegible]	[illegible]	[illegible]	-	-	-	
donaldi	2	2	-	2	-	-	-	9	9	7	2	-	-	-	
Mansonia															
bonneae	1	1	-	1	-	-	-	4	4	2	1	1	-	-	
Armigeres															
durhami	1	1	1	-	-	-	-	-	-	-	-	-	-	-	
subalbatus	1	1	-	-	1	-	-	1	1	1	-	-	-	-	
Culex															
annulus	-	-	-	-	-	-	-	3	3	1	1	1	-	-	
gelidus	1	1	-	1	-	-	-	5	5	2	3	-	-	-	
pseudovishnui	-	-	-	-	-	-	-	1	1	1	-	-	-	-	
quinquefasciatus	-	-	-	-	-	-	-	3	3	3	-	-	-	-	
tritaeniorhynchus	-	-	-	-	-	-	-	5	5	3	2	-	-	-	
Aedes															
albopictus	-	-	-	-	-	-	-	2	2	-	2	-	-	-	
niveus	-	-	-	-	-	-	-	1	-	-	-	-	-	-	
TOTAL:	8	8	1	5	2	-	-	45	4[illegible]	[illegible]	1	2	-	-	

AAC/Tak.
10.9.87

Aedes aegypti larval survey at Kampongs in the Dam Project A
at Sg. Lebir, Kuala Krai, Kelantan (17.8.87–27.8.87)

Locality	No. of houses		No. of houses with					Indices				
	Examined	With collections	Aedes aegypti	Aedes albopictus	Culex quinquefasciatus	Armigeres spp.	Toxorhynchites spp.	Aedes aegypti	Aedes albopictus	Culex quinquefasciatus	Armigeres spp.	Toxorhynchites spp.
KESEDAR Lebir 1	170	46	-	30	3	2	2	-	17.6	1.8	1.2	1.2
Kg. Jeram Panjang	22	16	-	9	1	1	-	-	40.9	4.5	4.5	-
TOTAL:	192	62	-	39	4	3	2	-	58.5	6.3	5.7	1.2

AAG/Tak.

Intestinal Helminth Infections in Sg.Lebir Area, Kelantan - 17hb - 27hb Aug. 1987

	Total samples	Infections		
		ALO	TTO	HWO
No	503	246	310	170
%	-	48.9	61.6	33.8

Intestinal Protosoan Infections in Sg.Lebir Area, Kelantan - 17hb - 27hb Aug. 1987

	Total samples	Infections	
		Amoebiasis	Giardiasis
No	160 *	26	15
%	-	16.3	9.4

* Not completed, Total samples ~ 500

LIST OF STREAMS SURVEYED FOR SNAIL INTERMEDIATE HOSTS OF SCHISTOSOMIASIS BY THE IMR AT SUNGAI LEBIR, KELANTAN FOR THE HYDROELECTRIC DAM PROJECT 17TH - 27TH AUGUST, 1987

Tributaries of Sg.Lebir, left upstream

1. Anak Sg. Dedah
2. Sg. Depak and tributary
3. Sg. Ma
4. Sg. Terong
5. Sg. Anak Miak
6. Sg. Lebir kecil
7. Anak Sg. Lebir Kecil
8. Sg. Kelinsar
9. Sg. Relak
10. Sg. Kecil
11. Sg. Antia

Tributaries of Sg.Lebir, right up stream

12. Sg. Cera
13-14 small streams, unnamed ~~anting~~, Sg.Lebir
15. Sg. Kelah
16. Sg. Lenggi-3 tributaries
17. Sg. Telon
18. Sg. Labut
19. Sg. Chalil - 3 tributaries
20. Sg. Lakit, tributary of Sg. Chalil
21. Sg. Anak Narong
22. Sg. Paloh } tributaries of Sg.Relai
*23 Unnamed stream, above Sg.Paloh } tributaries of Sg.Relai

24. Sg. Jemlak } tributaries of Sg. Aring
25. Sg. Pupot } tributaries of Sg. Aring

* Robertsiella sp. found in this stream.

Schistosome Infections in Sg.Lebir Area, Kelantan
17th - 27th Aug. 1987

	Stool for ova observation	Blood for ELISA	Blood for COPT
No of samples	503	273	40
No positive (%)	3 (0.6)	22 (8.1)	7
No border-line (%)	-	19 (7.0)	-

Villages in which there is Evidence of Schistosomasis Infections

Village	No of cases
Lebir (Malay)	9 (2 parasitologically confirmed)
Kg. Lenggi (Orang Asli)	13 (1 parasitologically confirmed)
Kg. Jeram Panjang (Malay)	1
Kg. Depak (Malay)	1
Kijang Bahagia (Malay)	1

Sungei Lebir Hydroelectric Scheme: Malaria and Filariasis Studies

A survey for malaria and filariasis was carried out among inhabitants of villages in the locality of the proposed Sungei Lebir Hydroelectric Dam Project in Kuala Krai, Kelantan, in August 1987. A total of 406 inhabitants (189 males and 217 females) from eight villages (Kampongs Sg. Lebir, Sg. Pandan, Miak, Betong, Jeram Panjang, Depak, Kijang Bahagia and Kpg. Orang Asli) were examined. The mean±S.D. age of the inhabitants was 20.53± 17.06 years. Only one (0.25%) person had malaria parasitaemia (*Plasmodium vivax* infection), with asexual and sexual counts of 2,960 and 40 per ul blood respectively. This subject was a 40 year old female from Kampong Jeram Panjang.

Serological studies using the enzyme-linked immunosorbent assay (ELISA) and indirect fluorescent antibody assay (IFA) with schizont antigens of *P. falciparum* (Gombak isolate 'A') were carried out on sera samples obtained from capillary blood. The IFA geometric mean titres (GMTs) were very low in all age-groups, the lowest (1.61±3.33) being in the youngest age-group, 0-4 years, and the highest (7.97±9.45) in those >= 40 years old. The mean GMT was 2.95±5.99 (Table 1). Only 26 out of 283 (9.19%) tested had a GMT > 1:40 (cut-off point for positive titre as determined from tests on 44 normal controls). The mean IFA GMT in Kampong Jeram Panjang (with the malaria subject) was 13.14±11.95 compared to 2.60±5.29 in the other seven villages. This difference is statistically significant (t = 7.86, df = 281, $P < 0.01$). ELISA optical density readings at 492 nm (OD492) were also very low in all age-groups, the lowest (0.21±0.10) being in the youngest age-group (0-4 years) and the highest (0.34±0.19) being in the age-group 35-39 years. The mean OD492 was 0.28±0.15. There were very few subjects with an OD492 reading >= 0.44 (mean ±3 SD OD492 readings of 44 normal controls), this being seen only in 37 out of 296 (12.5%) tested.

These serological findings are consistent with the low malaria endemicity in the area, as reflected in the low parasite rate (0.25%) and the low spleen rate in the age-group 2-9 years, this being 4.55% (2 out of 44). In view of the low transmission of the disease in the area, malaria will not be a problem if preventive measures like chemoprophylaxis of the labour force, residual spraying of houses, and personal protective measures like sleeping under mosquito nets are carried out. It will also be necessary to carry out periodic parasitological, seroepidemiological and entomological surveys at regular intervals to monitor the situation.

No filariasis infection was detected in the survey, and this disease is not expected to be a problem in the area.

Table 1

Results of the indirect fluorescent antibody assay (IFA) and enzyme-linked immunosorbent assay (ELISA) by age-groups, Lebir, Kuala Krai, Kelantan, 17-27 August 1987

Age-group (years)	IFA No. exam.	IFA No. Pos. (%)*	IFA GMT ±SD#	ELISA No. exam.	ELISA No. Pos. (%)+	ELISA Mean ±SD@
0-4	32	1(3.13)	1.61±3.33	31	0	0.21±0.10
5-9	49	0	1.35±2.50	54	1(1.85)	0.24±0.11
10-14	35	0	1.24±2.40	36	4(11.11)	0.24±0.14
15-19	9	0	2.28±5.14	10	2(20.0)	0.22±0.20
20-24	20	3(15.0)	4.16±6.53	20	1(5.0)	0.21±0.13
25-29	25	2(8.0)	4.04±5.39	26	8(30.77)	0.31±0.16
30-34	36	2(5.56)	2.98±5.97	40	5(12.50)	0.31±0.16
35-39	30	7(23.33)	7.72±9.32	31	7(22.58)	0.34±0.19
>= 40	47	11(23.40)	7.97±9.45	48	9(18.75)	0.32±0.15
Combined	283	26(9.19)	2.95±5.99	296	37(12.50)	0.28±0.15

* Titre > 1:40
# Geometric mean titre ± standard deviation
+ Optical density reading at 492 nm > 0.44
@ Meanc± standard deviation optical density reading at 492 nm

Attachment 13-1

Explanatory Demonstration of Project Cost Allocation

1. There are several methods which have been proposed in various countries for the allocation of a project cost among beneficiary sectors which are participating in a multi-purpose project, as mentioned below:

   - Benefits Method
   - Justifiable Expenditure Method
   - Alternative Expenditure Method
   - Alternative Justifiable Expenditure Method
   - Modified AJEM in consideration of Priority of Development
   - Modified AJEM in consideration of Priority of Usage
   - Separable Cost Remaining Benefit Method
   - Equal Charge Method
   - Individual Project Cost Method
   - Main Developer Burdening Method

   Each method has advantages and disadvantages involving assumptions, but none of them is considered to be perfect. It is rather more important to select one which may fit the situation of a country and make participants easily agree.

2. The following demonstration is a preliminary indication of a cost allocation of the Lebir dam project which has been made by applying Alternative Justifiable Expenditure Method.

   (1) Total Project Cost and Cost for Common Facilities

   Referring to Section 13.3.3 Estimated Cost by Purpose, the total project cost is divided into the following three categories:

		10^6M$
- Dam		238.9
- Power		262.2
- Environment		139.0
	Total	640.1

Whereas the category of Power is the specific cost for the power generation facilities, the categories Dam and Environment can be considered to be the cost for the common facilities of the power sector, the flood mitigation sector and the agriculture irrigation sector. The purpose of the cost allocation here is to allocate the cost for the common facilities among the participants, while the costs for the individual facilities should be born by each individual sector.

(2) Alternative Project Cost

The alternative project cost is understood to be a project cost for an alternative scheme which is assumingly worked out should each sector desire to develop a project to produce the same benefit individually.

As for the power sector, the alternative scheme is assumed to be the same one as present, although there is a possibility that a slightly lower dam than the present one can be worked out if a different design of the spillway is employed.

The alternative scheme for the flood sector was selected as a dam with the crest elevation of 80 m, while no alternative scheme was considered for the irrigation sector.

(3) Justifiable Expenditure

The justifiable expenditure in each sector is obtained by the following formula:

$$\text{J.E.} = \frac{\text{Annual Benefit - Annual Cost}}{\text{Capital Recovery Ratio (1 + Interest during construction)}}$$

The capital recovery ratio is computed by the following formula:

For Flood and Irrigation Sector:

$$C.R.R. = \frac{i(1+i)^n}{(1+i)^n - 1}$$

where, i = interest rate

n = project life (year)

For Power Sector:

$$C.R.R. = \frac{i(1+i)^n}{(1+i)^n - 1}\left[1 - \frac{B}{(1+i)^n}\right]$$

where, i = interest rate

n = project life (year)

B = residual value rate

The following inputs are used to compute C.R.R.:

Sector	i	n	B	C.R.R.
Power	0.08	50	0.1	0.0816
Flood	0.045	80	-	0.0464
Irrigation	0.045	50	-	0.0506

The justifiable expenditure of each sector is computed in the following table.

Sector	Annual Benefit 10^6M$	Annual Cost 10^6M$	J.E. 10^6M$
Power	63.8	1.5	658.2
Flood	16.1	0.7	331.9
Irrigation	15.0	0	296.4

Interests during construction are assumed as follow.

	Interest rate
Power	0.4 x i x T = 0.4 x 0.08 x 5 = 0.16
Flood	0
Irrigation	0

(4) Specific Cost for Individual Facilities

As mentioned above the specific cost for individual facilities of the power sector was estimated to be M$262.2 million, whereas that for the flood sector is estimated to be nil and that for the irrigation sector was excluded from the consideration because this had been already taken into account when the net benefit of the irrigation scheme was computed.

(5) Result of Cost Allocation

In accordance with the procedures outlined above and described in the attached table, the following result of the cost allocation of the Lebir dam project has been derived:

Sector	Allocated Cost	
		10^6M$
Power	414.9	(64.8 %)
Flood	105.4	(16.5 %)
Irrigation	119.8	(18.7 %)
Total	640.1	(100 %)

It should be noted that this result is merely a preliminary demonstration, for reference purpose, based on various assumptions used. Further precise study and investigation should be made for discussions on implementation basis.

Note: In preparation of this Attachment 13-1, the reference has been made to the article "Cost Allocation" written by Takamura Suzuki in the Hydro Power No.2 February 1953 published by the Association of Hydro Power Engineering of Japan.

TABLE OF COST ALLOCATION

Item	Unit	Power	Flood	Irrigation	Total
(a) Alternative Project Cost	10^6M$	640.1	260.4 (1)	-	-
(b) Justifiable Expenditure	10^6M$	658.2	331.9	296.4	1,286.5
(c) (a) or (b) whichever smaller	10^6M$	640.1	260.4	296.4	1,196.9
(d) Specific Cost for Individual Facilities (c) - (d)	10^6M$	262.2	0	-	-
(e) Possible Maximum Expenditure for Common Facilities	10^6M$	377.9	260.4	296.4	934.7
(f) Ratio of (e) to the total	%	40.4	27.9	31.7	100.0
(g) Allocation of Cost for Common Facilities	10^6M$	152.7	105.4	119.8	377.9
(h) Allocation of Project Cost (d) + (g)	10^6M$	414.9	105.4	119.8	640.1

(1) estimated cost for a dam with the crest height of EL.80 m

Attachment 14-1

Explanatory Note on the adapted Economic Evaluation Method

1. Basic Concept

The basic concept of the adopted method is based on the following requirements:

(1) The power demand in the entire power system increases continuously,

(2) A long term power development program covering at least 10 years period must be established. The program should be established by optimizing several alternative programs which should include various physically feasible power projects and cover various commissioning years in such a manner that the entire power system on the basis of well defined program would be operated in a most efficient and economical way. In other words, a system-wide approach should be adopted,

(3) The economic evaluation of particular projects should not be made on the basis of a comparison with another alternative project, but on a group basis, which should include various possible projects and various commissioning years.

2. Proposed Simplified Method

If the above procedure which involves detail studies for establishing the power development program of the country and economic evaluation of power projects in the context of the system-wide power requirements is applied, the required work becomes very complicated and enormous in volume. Such an approach is not found to be either suitable or appropriate for the purposes of a feasibility study of particular projects. In consideration of this, and keeping the foregoing basic concept in mind, a somewhat different simplified method is proposed and introduced for this Study, as briefly described below.

The basic assumptions of the simplified method are as shown below.

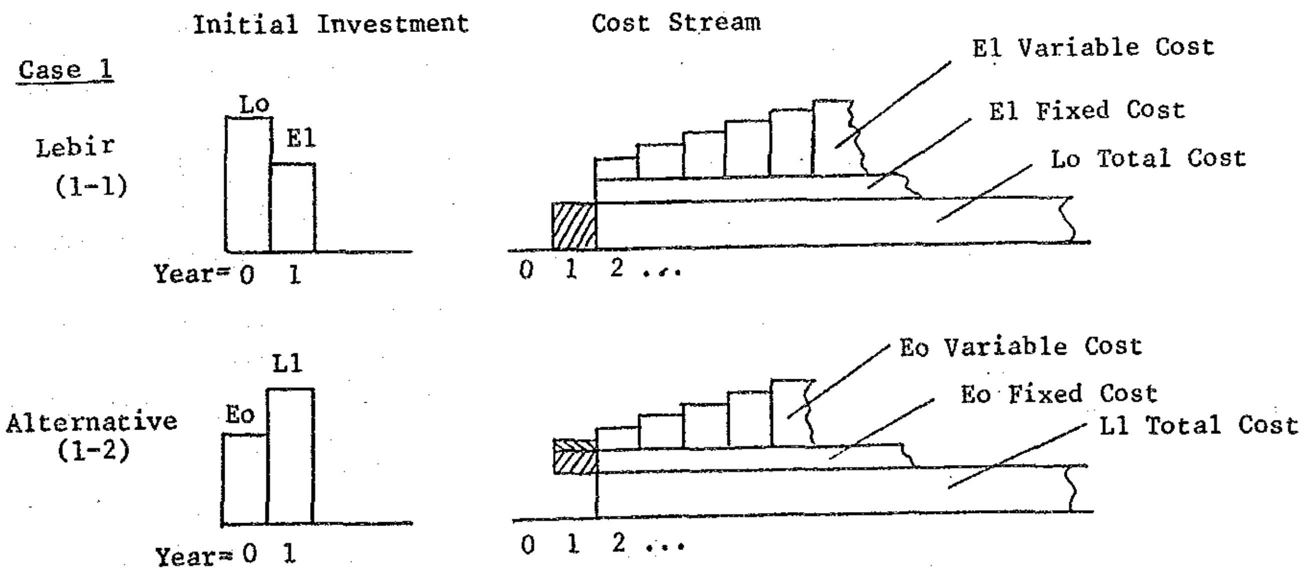
(1) It is assumed that the power demand in the NEB power system will increase after 1988/99 by over 300 MW every year,

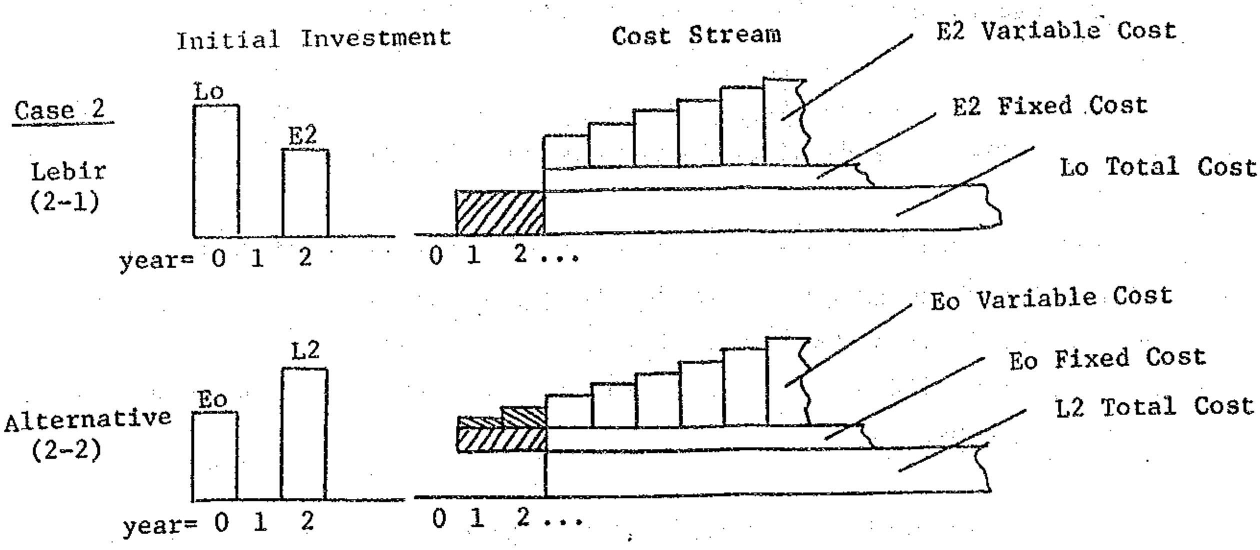
(2) The Lebir Project is considered to be one of the candidate power projects to be developed in the future as required to cope with this continuously increasing power demand. The conceived size of the Lebir Project is in the range of 150 - 300 MW,

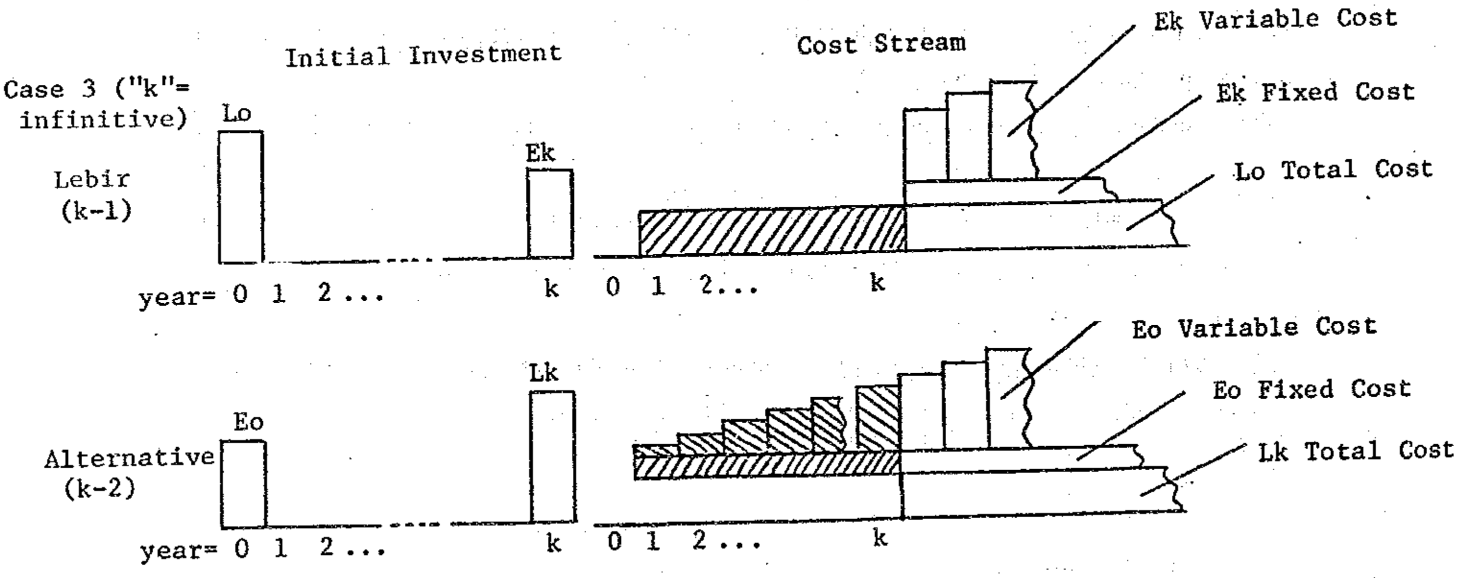
(3) As competitive thermal units against the Lebir Project, the most economical combined cycle and/or gas turbine plants are to be considered,

(4) The purpose of the feasibility study for the Lebir Project is not only to prove the feasibility of the implementation of the project, but also the time of the implementation, i.e., to determine the most appropriate economical year for the commissioning of the project as compared with other projects. The above means that the Lebir Project will continue to be considered a candidate until its implementation.

Illustrated below are some schematic patterns of cost comparison between the Lebir Project and its Alternatives.




Initial Investment
Cost Stream
Case 2
Lebir
(2-1)
Lo
E2
year= 0 1 2
0 1 2 ...
E2 Variable Cost
E2 Fixed Cost
Lo Total Cost
Alternative
(2-2)
Eo
L2
year= 0 1 2
0 1 2 ...
Eo Variable Cost
Eo Fixed Cost
L2 Total Cost


Initial Investment
Cost Stream
Case 3 ("k"=
infinitive)
Lebir
(k-1)
Lo
Ek
year= 0 1 2 ... k
0 1 2... k
Ek Variable Cost
Ek Fixed Cost
Lo Total Cost
Alternative
(k-2)
Eo
Lk
year= 0 1 2 ... k
0 1 2 ... k
Eo Variable Cost
Eo Fixed Cost
Lk Total Cost

In the above illustration, Lk (k = 0, 1, 2, ...) is the initial investment when the Lebir Project is developed in the k-th year, and Ek (k = 0, 1, 2, ...) is the same for the alternative projects. It can be assumed that both Lk and Ek are constant (Lk = constant and Ek = constant) in case the initial investment is considered on a constant price basis.

The variable costs of alternative projects are considered to be increasing annually due to escalation of fuel costs in real term.

3. Comparison between the Lebir and Alternative Projects

For economic comparison of the Lebir Project and the Alternative Projects, three cases have been developed and considered. These three cases, Case 1, 2 and 3 ("k" = infinitive), are shown in the above illustrations. The above investigated cases were based on the cost stream patterns depicted in the illustrations.

In Case 1, comparison is made between the annual costs of the two projects for the first year. These are the cross-hatched areas in the illustration. The annual costs for the following years are assumed identical, thus, cancelling each other. These are the white areas in the illustration.

In Case 2, the annual costs for the first 2 years are considered. Again, the costs for the following years are assumed to be identical. And, finally, in Case 3 ("k" = infinitive), the annual costs to the k-th year are analyzed and compared. The annual costs after the k-th year are assumed to be identical.

If Cases 1 and 2 are compared, it will be seen that in both cases the annual cost for the Lebir Project remains the same, however, the annual cost for the Alternative Project is increased in Case 2 due to the increased variable costs. This, thus, results in an economic advantage for the Lebir Project.

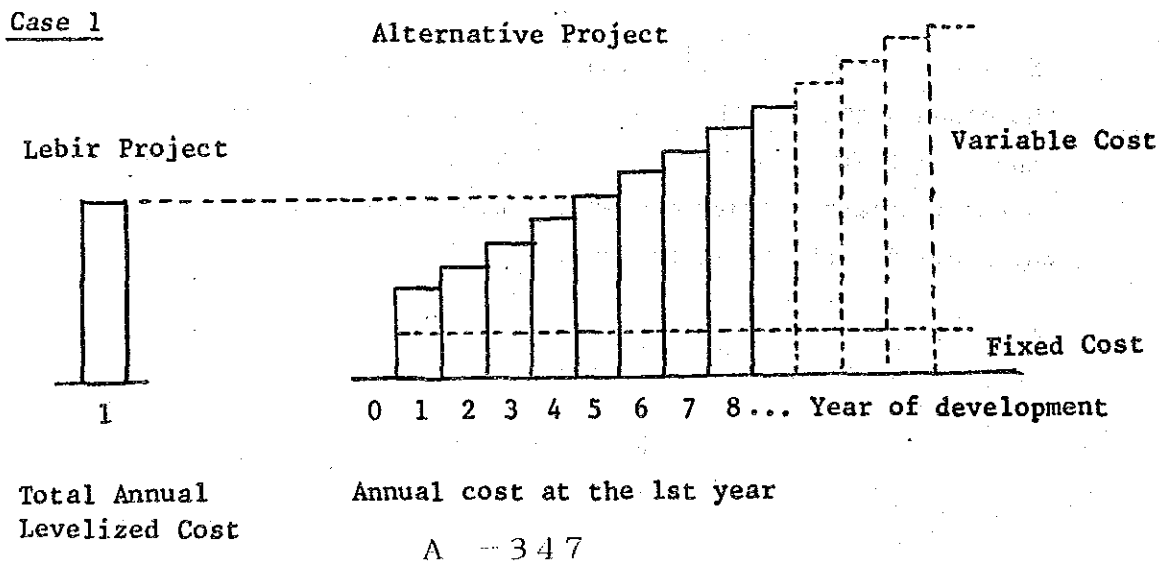
If Case 1 is then compared with Case 3, the annual cost of the alternative for each added year increases drastically as compared to the Lebir Project, so that the economic advantage of the Lebir Project is further significantly increased. As the comparison between the Lebir Project and the Alternative Project, which is most economical, should be made, further comparison in this Study has been made based on Case 1.

When the comparison made on the individual basis, i.e., the Lebir Project is compared with an alternative project without considering the effect of the large scale expending power system, such a comparison, in some special cases, could be quite realistic.

For the above comparison (individual basis), for Case 3, "k" should be assumed infinitive. However, the above approach would be unrealistic if applied to large scale and expanding power systems. The following discussion demonstrates the above point.

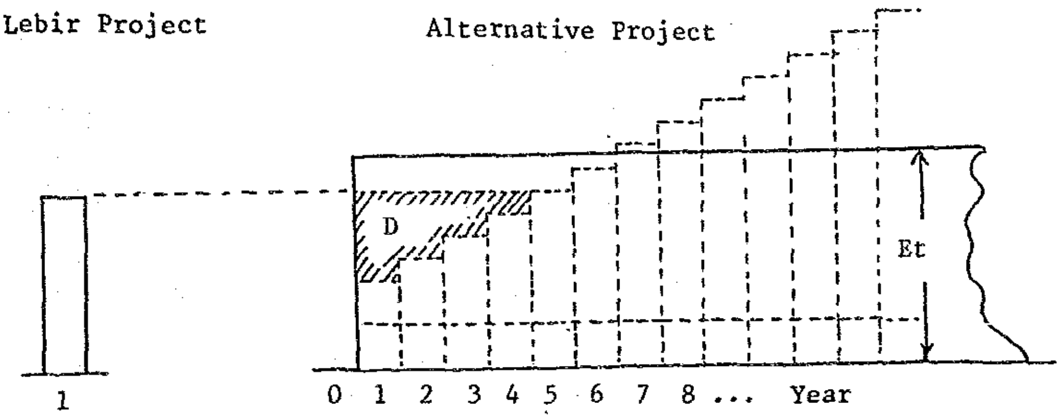
4. <u>Comparison of Cases 1 and 3 (k = infinitive)</u>

In Case 1, the cost comparison between the Lebir Project and the Alternative Project is made on the basis of the annual costs of the 1st year of operation. When the year of development of the Lebir Project is assumed to be variable (uncertain) and the annual costs of the 1st year of operation between the two projects are compared, a schematic diagram of cost comparison can be drawn as shown on the illustration below.



In the illustration above, the 1st year annual cost of the Lebir Project is assumed to be constant regardless of the year of development, whereas that of the Alternative Project is assumed to be increasing year after year. In this Case, even if the Lebir Project is not found to be feasible in the near future, there is still a possibility that it may turn out to be feasible at some time in the far future. This possibility is important and it should not be overlooked.

Case 3 (k = infinitive)



Total Annual Levelized Cost

Total Annual Levelized Cost (Et) through the whole life cycle

In Case 3 (k = infinitive), the total annual levelized cost of the Alternative Project is determined by considering the annual costs extending to the far future (project life time). In this Case, there is a possibility that, even if the Lebir Project is found to be feasible on the basis of the lower total annual levelized cost than that of the Alternative Project, some losses might still be incurred in the earlier years. As indicated in the illustration, the annual costs of the Lebir Project during these early years may be higher than those of the Alternatives. See the cross-hatched area in the illustration. Therefore, this method may likely produce misleading information leading to improper conclusions.

In a case, however, that the 1st year annual cost of the Alternative is higher than that of the Lebir Project at the development year, the conclusion that the Lebir Project could be feasible at that time could be derived by making either comparison, i.e., Case 1 or Case 3. The losses mentioned above in this case may not occur.

It is, therefore, considered that Case 1 is quite reasonable to use for this Study and at this time, and that the above is the main reason why this method has been adopted.

Attachment 14-2

Economic Evaluation of the Lebir Dam Project with Updated Parameters for Alternative Plants

1. Preface

During the discussions of the Draft Final Report on this Study at the meeting of February 1989, the most current information on Gas-turbine (GT) and Combined Cycle (CC) power plants as alternative plants for the Lebir Project was presented by NEB.

For the above reasons, an economic evaluation of this project was made using the new information and as required to determine whether there was any difference or deviation from the previous conclusions. Detail discussion of this evaluation is given below.

2. Updated Parameters for Economic Evaluation of Alternative Plants

The updated parameters for economic evaluation of alternative plants provided by NEB are presented in Table A.

3. Calculation Methods

Fixed cost (M$/kW) for alternative plants of GT and CC were calculated at the discount rates of 6, 8, 10, 12, 14, 18 and 20% which were considered as variable parameters. The above calculations were done for the case of including NOx countermeasure costs, and for the case of excluding them.

After the above, the variable costs (M$/MWh) were calculated accordingly.

The possibility of most economical combination of GT and CC plants as a substitution for the Lebir Project was studied at the discount rate of 10% in order to determine the most suitable alternative plant or combination of plants on the basis of the results of these calculations.

Table-A Updated Parameters for Economic Evaluation of Alternative Plants

Parameters	Alternative Plants		Remarks
	Gas-turbine	Combined Cycle	
Outage (%)	20	12	
Derating (%)	12	8	
Station use* (%)	1*	4*	
Investment (M$/kW)	1081 + 57*	1573 + 57*	+ NOx countermeasure*
Life Cycle (years)	15	20	
Disbursement Schedule (%)	25, 75	10, 15, 35, 40	
Fixed O/M (M$/kW-yr.)	0.96	13.80	
Fuel Price (Mx10^{-6}$/Kcal)			
(Yr 1990)	15	15	3.78 M$/MBTU
(Yr 1999)	17.4	17.4	4.385 M$/MBTU
Heat Rate (Kcal/KWh)	3100	2250	
Variable O/M (M$/MWh)	3.0	2.0	

Notes:
- NOx countermeasure cost for Combined Cycle plants is based on 3.5% of total investment. The above also applies to Gas-turbine plants.
- Fuel price for the year 1999 is determined on the basis of the assumption of 1% of escalation in real terms per annum between 1990 and 1995, and 2.5% per annum, after 1995.
- Figures with an asterisk are supplied by JICA Team.

Basic economic features of the Lebir Project are as follows:-

- Construction Cost	640.1×10^6 M$
- Output	
Generating-end	240.5 MW
Sending-end	238.6 MW
- Generated energy	
Generating-end	373.3 GWh
Sending-end	372.2 GWh
- Flood control benefit	27.3×10^6 M$/year
- Agricultural incremental benefit	According to economic price

4. Key Calculation Parameters

(1) Fixed Cost (M$/kW-year)

The Fixed Cost calculated for the rate of the sending-end output (MW) is a sum of the Capital Recovery Cost and the Fixed O/M Cost. The calculation results are shown in Table-B, below.

Table-B Fixed Cost (M$/kW-year) of Alternative Plants

Discount Rate (%)	Gas-Turbine Plant: Capital Recovery Cost		Gas-Turbine Plant: Fixed O/M Cost	Gas-Turbine Plant: Total	Combined Cycle Plant: Capital Recovery Cost		Combined Cycle Plant: Fixed O/M Cost	Combined Cycle Plant: Total
6	162.09	(170.63)	1.38	(172.01)	186.80	(193.57)	17.76	(211.33)
8	184.83	(194.58)	"	(195.96)	222.41	(230.47)	"	(248.23)
10	209.02	(220.04)	"	(221.42)	261.40	(270.88)	"	(288.64)
12	234.56	(246.93)	"	(248.31)	303.65	(314.65)	"	(332.41)
14	261.36	(275.14)	"	(276.52)	349.00	(361.65)	"	(379.41)
16	289.31	(304.57)	"	(305.95)	397.32	(411.72)	"	(429.48)
18	318.33	(335.12)	"	(336.50)	448.49	(464.74)	"	(482.50)
20	348.32	(366.69)	"	(368.07)	502.40	(520.61)	"	(538.37)

Notes:
- The above figures in brackets show the cost including NOx countermeasure cost
- Total is equal to: Capital Recovery Cost + Fixed O/M cost
- GT Capital Recovery Cost is equal to: Investment (M$/KW) $\times \left[(0.25 \times (1 + i) + 0.75) \times \frac{i(1+i)^{15}}{(1+i)^{15}-1}\right] \div k$
- CC Capital Recovery Cost is equal to: Investment (M$/KW) $\times \left[(0.10 \times (1 + i)^{3} + 0.15 \times (1 + i)^{2} + 0.35 \times (1 + i)^{1} + 0.40) \times \frac{i(1+i)^{20}}{(1+i)^{20}-1}\right] \div k$
- Fixed O/M Cost is equal to: Fixed O/M (M$/KW-year) $\div$ k
- k = (1 - Outage)(1 - Derating)(1 - Station Use)

(2) Variable Cost (M$/MWh)

The Variable Cost calculated for the rate of the sending-end generated energy (MWh) is a sum of the Fuel Cost and the Variable O/M Cost.

The results are as shown below:

Plant	Fuel Cost	Variable O/M Cost	Total
Gas-turbine	54.48	3.00	57.48
Combined Cycle	40.78	2.00	42.78

Note:

Total = [Fuel Price (M$ x 10^{-6}/Kcal) x Heat Rate (Kcal/KWh) x 10^{-3}] ÷ (1 - Station Use) + Variable O/M (M$/MWh)

(3) Total Cost (M$/kW-year)

The Total Cost which is the sum of the Fixed Cost and the Variable Cost is given by the following equations as a function of f (Plant Factor) using a discount rate of 10%.

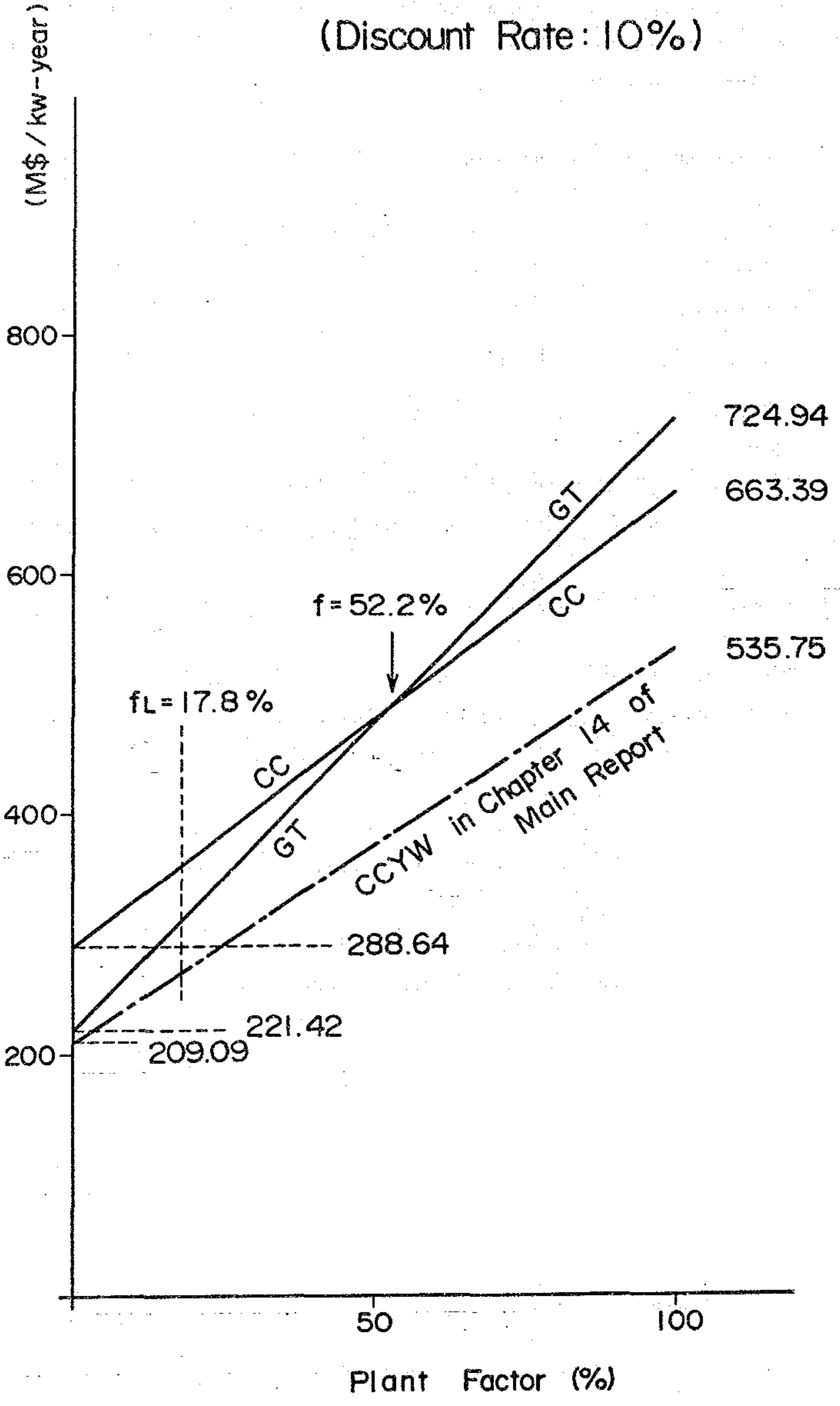
GT Total Cost = 221.42 + 57.48 x 8.76f (M$/kW-year)
CC Total Cost = 288.64 + 42.78 x 8.76f (M$/kW-year)

The Plant Factor at which the total GT and CC costs are equal (break-even plant factor) is determined as follows:

$$f = \frac{(288.64 - 221.42)}{(57.48 - 42.78) \times 8.76} = 0.522$$

The results of the calculations are shown in Fig. I.

Fig. I Total Cost (Fixed Cost + Variable Cost)
(Discount Rate: 10%)



(4) Study of Alternative Plants

Total cost of GT and CC alternative plants, alone or in combination with each other, were studied in order to determine the feasibility of substituting the Lebir Project with one of these plants.

The following symbols and input data were used in these studies:

- Lebir Project

Sending-end output	P_L = 238.6 MW
Sending-end generated energy	G_L = 372.2 GWh

- GT

Fixed Cost	F_G = 221.42 M$/kW-year
Variable Cost	V_G = 57.48 M$/MWh

- CC

Fixed Cost	F_C = 288.64 M$/kW-year
Variable Cost	V_C = 42.78 M$/MWh

- Others

Composition ratio of GT	X
Plant Factor of GT	f_G
Yearly hours x 10^{-3}	T = 8.76
Total Cost (10^3M$)	TC(X, f_G)

The values of F_G and F_C shown above were obtained at the discount rate of 10%.

The total cost TC (X, f_G) is determined as follows:

$$
\begin{aligned}
TC(X, f_G) &= P_L \cdot X \times F_G + P_L \cdot (1 - X) \times F_C \\
&\quad + P_L \cdot X \cdot T \cdot f_G \times V_G + (G_L - P_L \cdot X \cdot T \cdot f_G) \times V_C \\
&= X \cdot (P_L \cdot F_G - P_L \cdot F_C) + P_L \cdot F_C \\
&\quad + X \cdot f_G(P_L \cdot T \cdot V_G - P_L \cdot T \cdot V_C) + G_L \cdot V_C \\
&= P_L \cdot F_C + G_L \cdot V_C + P_L(F_G - F_C) \cdot X \\
&\quad + P_L \cdot T(V_G - V_C) \cdot X \cdot f_G
\end{aligned}
$$

The Plant Factor (f_L) for the Lebir Project is given by the following formula:

$$f_L = \frac{G_L}{P_L \cdot T}$$

Also, f_G is a function of X, and $f_G(1) = f_L$, if expressed as $f_G(X)$.

If the operation curve of the Lebir Project is approximated by a triangle, $f_G(X)$ can be expressed by the following formula:

$$f_G(X) = f_L \cdot X = \frac{G_L}{P_L \cdot T} \cdot X$$

The following equation is obtained when the above formula is introduced into the expression for $TC(X, f_G)$ given above:

$$TC(X, f_G) = P_L \cdot F_C + G_L \cdot V_C + P_L(F_G - F_C) \cdot X$$

$$+ P_L \cdot T(V_G - V_C) \cdot X \cdot \frac{G_L}{P_L \cdot T} X$$

$$= P_L \cdot F_C + G_L \cdot V_C + P_L(F_G - F_C) \cdot X + (V_G - V_C) \cdot G_L \cdot X^2$$

$$\equiv TC(X)$$

The condition of X at which TC(X) will be minimum is derived as follows:

$$\frac{dTC(X)}{dX} = P_L(F_G - F_C) + 2(V_G - V_C) \cdot G_L \cdot X = 0$$

$$X = \frac{P_L(F_C - F_G)}{2(V_G - V_C)G_L}$$

For a 10% discount rate, the following value for X is obtained using the input data given above.

$$X = \frac{238.6(288.64 - 221.42)}{2(57.48 - 42.78) \times 372.2} = 1.47$$

The range of practical existence of X is shown to be as follows:

$$0 \leq X \leq 1.0$$

This means that the above obtained value for X of 1.47 is not within the practical range of existence.

Thus, the condition of X at which TC(X) is minimum within the range of practical existence of X was studied further, as described below.

TC(X) is a quadratic equation as a function of "X", and it is of a U shape. Its value is minimum for X = 1.47. Then, the condition at which TC(X), within the range of practical existence of X, becomes minimum, is for X=1.0.

On the basis of the above, the following equation for TC(X) is obtained by applying the above condition:

$$\begin{aligned} TC(X) &= P_L \cdot F_C + G_L \cdot V_C + P_L(F_G - F_C) + (V_G - V_C) \cdot G_L \\ &= P_L \cdot F_G + G_L \cdot V_G \end{aligned}$$

In case of a discount rate of 10%, the above formula shows, on the basis of the latest information, that a GT plant is the most economical alternative plant to be considered as a substitution of the Lebir Project.

The results of the calculations are shown below.

X	0.0	0.2	0.4	0.6	0.8	1.0
TC(X)	84.79	81.80	79.25	77.14	75.46	74.22

(Unit: 10^6 M$)

According to these results, TC(X) is getting smaller with the increase of X, which is composition ratio of GT, and it takes the minimum value at X = 1.0.

Based on the above studies and calculations, it is found that there is no suitable combination of GT and CC plants which could be considered as an economical substitution for the Lebir Project. The above studies clearly show that a GT plant is the only alternative which can be considered as most economical.

The necessary conditions for the combination of GT and CC plants to become most economical are reviewed further below.

The condition at which TC(X) is minimum is given with the formula:

$$X = \frac{P_L(F_C - F_G)}{2(V_G - V_C)G_L} < 1$$

The break-even plant factor, or the plant factor at which the total GT and CC costs are equal is defined as follows:

$$f = \frac{F_C - F_G}{(V_G - V_C)T}$$

The plant factor for the Lebir Project is given with the following expression:

$$f_L = \frac{GL}{P_L \cdot T}$$

If f and f_L are introduced into the formula for X, the following is obtained:

$$X = \frac{f}{2f_L} < 1$$

$$f_L > \frac{f}{2}$$

The above shows that for the combination alternative of GT and CC to become most economical, the plant factor of the Lebir Project f_L must be larger than the break-even plant factor f.

(5) Total Cost of a GT plant as a substitution for the Lebir Project

The total costs of a GT plant considered as a substitution for the Lebir Project for various discount rates are shown below.

Discount Rate (%)	$P_L \cdot F_G$		$G_L \cdot V_G$	Total	
6	39.00	(41.04)	21.39	60.39	(62.43)
8	44.43	(46.76)	"	65.82	(68.15)
10	50.20	(52.83)	"	71.59	(74.22)
12	56.30	(59.25)	"	77.69	(80.64)
14	62.69	(65.98)	"	84.08	(87.37)
16	69.36	(73.00)	"	90.75	(94.39)
18	76.28	(80.29)	"	97.67	(101.68)
20	83.44	(87.82)	"	104.83	(109.21)

(Unit: 10^6 M$)

The figures in brackets show the cost including NOx countermeasure cost.

(6) Total Cost of the Lebir Project

The total cost of the Lebir Project as calculated and reported in Chapter 14, Volume 1 of the Final Report, is summarized below.

Discount Rate (%)	Fixed Cost	Less Benefit from Flood Control	Less Benefit from Flood Control/Irrigation
6	51.319	24.019	1.288
8	67.675	40.375	21.655
10	86.193	58.893	43.899
12	106.775	79.475	67.949
14	129.426	102.126	93.824
16	154.224	126.924	122.117
18	181.294	153.997	151.555
20	210.806	183.506	183.781

(Unit: 10^6M$)

Notes:
- Flood control benefit of 27.3 x 10^6M$.
- Agricultural incremental benefit is calculated at Economic Price.

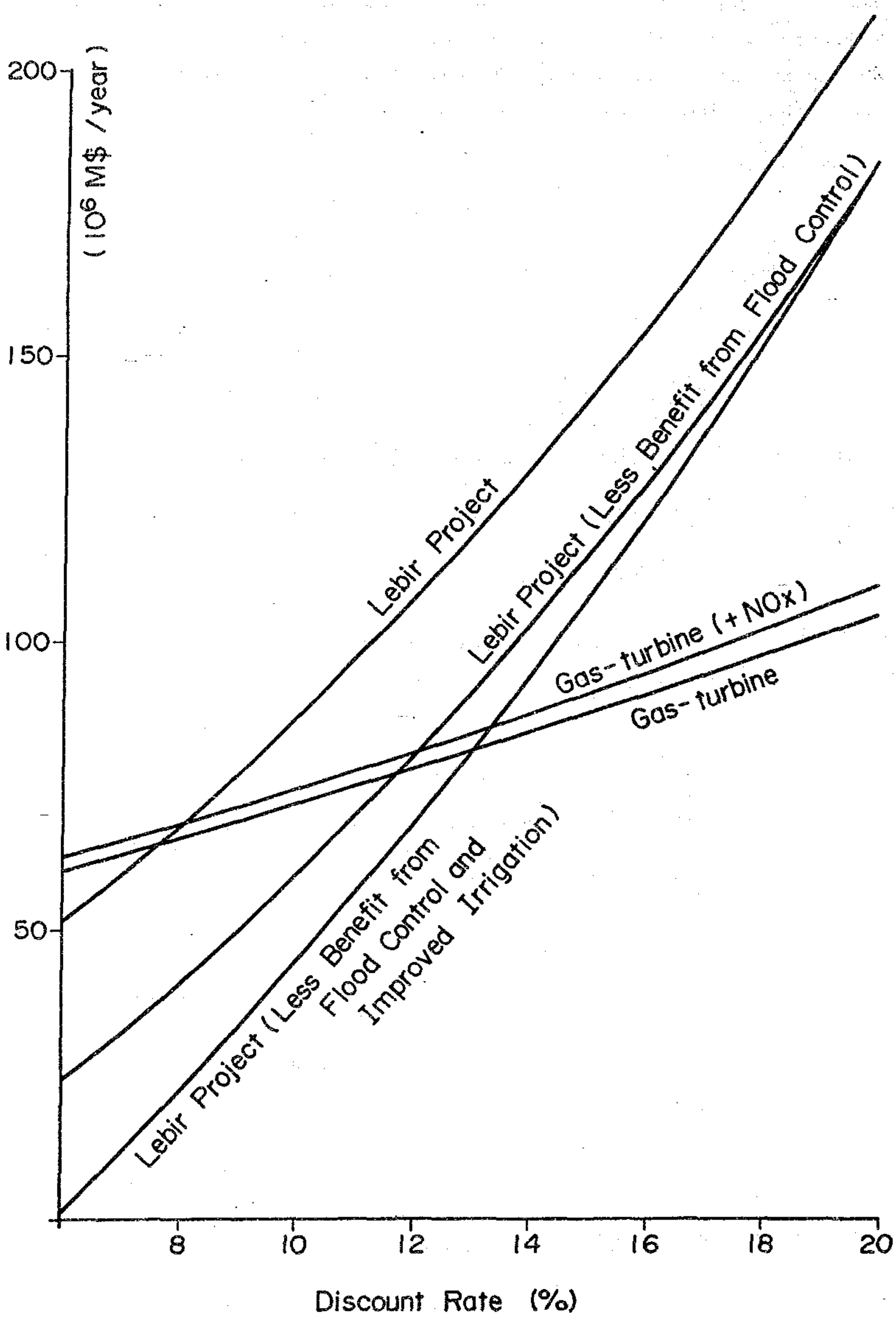
5. EIRR

The results of the studies described in this Section are summarized in Fig. II. From Fig. II, the following values of EIRR are derived:

Item	Gas-turbine without NOx Countermeasure Cost	Gas-turbine with NOx Countermeasure Cost
EIRR for power benefits only	7.7 %	8.1 %
EIRR for power plus flood control benefits	11.8 %	12.2 %
EIRR for power, flood control and agricultural benefits	13.0 %	13.4 %

It is clear from the above that the EIRR is about 8% for power benefits only, about 12% for power plus flood control benefits, and about 13% for power, flood control and agricultural benefits. Furthermore, if NOx countermeasure costs for gas-turbine as alternative plant are considered, the EIRR increases by about 0.4% above the values obtained when no such consideration is made.

Fig. II Annual Levelized Cost



6. Conclusion

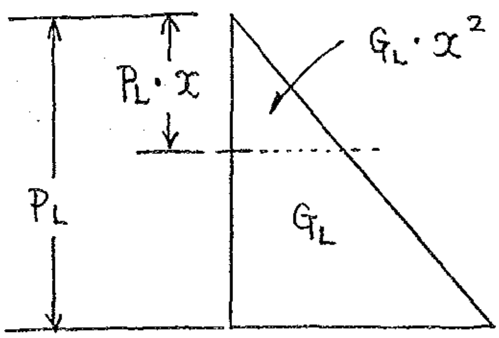
The EIRR is about 8% when the Lebir Project is substituted with a Gas-turbine plant evaluated to be the most economical alternative plant.

The EIRR will be about 12%, an increase of 4%, when the flood control benefits are considered additionally. Furthermore, the EIRR will become about 13%, if the agricultural incremental benefits are added resulting in a 1% further increase.

The previous conclusions with regard to the EIRR, as given in the Draft Final Report and consisting of below 6% for power only, 10.7% for power plus flood, and 12.4% for power, flood and irrigation, should be slightly modified as affected by this updated data, but the basic conclusions remain unchanged.

A supplemental explanation and further details on the plant factor $f_G(X)$, for the GT plant considered as a substitution for the Lebir Project, are given below.

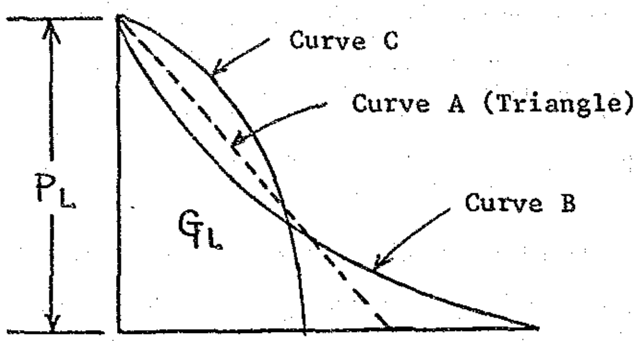
The following equation is derived when the operation curve of the Lebir Project is approximated by a triangle.



$$f_G(X) = \frac{G_L \cdot X^2}{P_L \cdot X \cdot T} = \frac{G_L}{P_L \cdot T} \cdot X = f_L \cdot X$$

However, the operation curve of the Lebir Project can not always be approximated by a triangle.

For instance, the following operation curves can also be assumed.



The operation curve of the Lebir Project will depend on both, the shape of the duration curve for the gross power system demand, and the composition situation of the gross power supply in the total power system of NEB.

The equation for $f_G(X)$ can be expressed as follows:

$$f_G(X) = f_L \cdot X^2 = \frac{G_L}{P_L \cdot T} X^2$$

If the above expression is introduced into the equation for TC(X, f_G), given is Section 4(4) above, the following is derived:

$$TC(X) = P_L \cdot F_C + G_L \cdot V_C + P_L(F_G - F_C) \cdot X + (V_G - V_C)G_L \cdot X^3$$

$$\frac{dTC(X)}{dX} = P_L(F_G - F_C) + 3(V_G - V_C)G_L X^2$$

Thus,

$$X = \sqrt{\frac{P_L(F_C - F_G)}{3(V_G - V_C)G_L}} \fallingdotseq 0.99$$

Even in case when $f_G(X) = f_L \cdot X^2$, it is clear from the above that the most economical alternative plant to be considered as a substitution for the Lebir Project is a GT plant.

If $f_G(X)$ is assumed to be equal to $f_L \cdot X$ or $f_L \cdot X^2$, the solutions of $f_G(X)$ for X = 0.7, as a composition ratio of GT, are shown below.

$f_G(X)$	$f_L \cdot X$	$f_L \cdot X^2$
X = 0.7	12.46 %	8.72 %

In the economic evaluation of other projects owned by NEB, there was a case in which $f_G(X)$ = 10% for X = 0.7.

It is not unusual that f(X) is normally being forecasted to be much smaller in case of insufficiency of peak supply, and much larger in case of superfluous peak supply.

Based on the above, it is concluded that the most suitable alternative plant to be considered as a possible substitution for the Lebir Project is a GT plant under the condition of $f_G(X) = f_L \cdot X^n$ $(n \leq 2)$. For these studies, the value of n was assumed to be 1, that is, $f_G(X) = f_L \cdot X$.

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