CHAPTER J. ESTIMATED CONSTRUCTION COST

J-1 Estimated Construction Cost

J-1-1 General

The construction costs of the Sambor Dam, including the power generating, power transmitting and transforming facilities as shown in Table J-1, are estimated to be $318.1 million.

Table J-1 Summary of Estimated Construction Cost

(Unit: Million Dollars)

		Project Cost		
		Total	Foreign Currency	Domestic Currency
(1)	Reservoir and Dam	104.3	69.1	35.2
(2)	Power Plant	165.4	126.0	39.4
(3)	Transmission Line and Substation	48.4	41.5	6.9
(4)	Total	318.1	236.6	81.5

Note: General Property and Engineering Fee are included in Item (1) to (3).

This construction cost is based on prices as of January 1967 with consideration given to natural conditions and regional social environment which influence the works, the magnitude of the construction works and the technical levels conceivable at present.

The estimate includes the costs of civil structures such as the dam, power station and spillway, and electrical equipment, transmission lines and substations as well as telecommunication facilities required for operation and maintenance of these facilities, transportation facilities required for smooth performance of construction works, construction camp, contingencies to cover unforeseen conditions and engineering fees. However, the following are not included:

(1) Personnel expenses of the owner organization of the project.

(2) Personnel expenses disbursed for the Government of Cambodia employees in connection with this project.

(3) Custom duties, business taxes, sales taxes, etc.

(4) Other costs connected with the project to be borne by the Government of Cambodia or local autonomous bodies.

(5) Interest during construction. (as for interest, see K-4)

J-1-2 Domestic Currency and Foreign Currency

Wages of indigenous labor, local living expenses of construction supervisors and technical instructors, lumber, oil and lubricants and other materials procurable in Cambodia are listed under domestic currency in the breakdown of construction costs. All other items will be paid for in foreign currency. As a result, the foreign currency requirement is estimated at $236.6 million, which is approximately 75% of the total construction costs and the domestic currency requirement at $81.5 million, which is approximately 25% of the total construction cost.

J-1-3 Breakdown of Construction Cost

The breakdown by items of construction costs is shown in Table J-2

Land and right-of-way costs include relocation of houses and public buildings in reservoir area based on information provided by the Governor of Kratie Province.

The costs of civil and architectural works are based on the assumption that the works will be performed by contractors, and in estimating the cost of each item of work, the costs were used taking into accounts conditions experienced on similar work in Japan and regional peculiarities to the project area. However, import duties are not included in the costs of construction equipments and plants to be used on the project. All materials to be used in the project, other than those procurable in Cambodia, are assumed to be imported from Japan.

Mechanical and electrical equipment were assumed to be manufactured in Japan and the costs of installation costs are also included in this item of cost.

Engineering fees of approximately 4.5% of total construction costs is included for preparation of detail designs, specifications and for supervision of construction works

Contingencies of approximately 15% for civil and architectural works and approximately 5% for other items are included.

Table J-2 Breakdown of Estimated Construction Cost (1)

(Unit: $)

(1)	Reservoir and Dams	
(1-1)	Land and Right-of-way	3,240,000
(1-2)	Relocation of Existing Property	2,140,000
(1-3)	Earth-fill Dam on Left Bank	12,400,000
(1-4)	Rock-fill Dam in River Bed	14,000,000
(1-5)	Earth-fill Dam on Right Bank	10,900,000
(1-6)	Spillway	53,000,000
(1-7)	Spillway channel	4,020,000
	Subtotal	99,700,000
(2)	Power Plant	
(2-1)	Civil Works	94,800,000
(2-2)	Electrical Equipments	62,700,000
	Subtotal	157,500,000
(3)	Transmission Line and Substations	
(3-1)	Sambor-Phnom Penh	10,700,000
(3-2)	Phnom Penh-Sihanouk Ville	8,900,000
(3-3)	Sambor-Saigon	6,300,000
(3-4)	Substations	19,400,000
	Subtotal	45,300,000
(4)	General Property	
(4-1)	Telecommunication Facilities	1,400,000
(4-2)	Maintenance Facilities for Transmission Line	500,000
	Subtotal	1,900,000
(5)	Engineering Fee	13,700,000
	Total	318,100,000

Table J-2 Breakdown of Estimated Construction Cost (2)

(Unit: $)

	Unit	Quantity	Unit Cost	Amount
(1) Reservoir and Dams				
(1-1) Land and Right-of-way				
Houses	house	2,500	280	700,000
Arable Land	ha.	3,000	170	510,000
Forest and Others	L.S	1		1,600,000
Contingency	L.S	1		430,000
Subtotal				3,240,000
(1-2) Relocation of Existing Property				
Road in Upstream of Reservoir	m	18,000	64	1,152,000
Road in Downstream of Reservoir	m	14,000	50	700,000
Contingency	L.S	1		288,000
Subtotal				2,140,000
(1-3) Earth Dam on Left Bank				
Earth-fill	cu.m	7,500,000	1	7,500,000
Filter under Riprap	cu.m	230,000	1.4	322,000
Sluice Zone	cu.m	390,000	1.4	546,000
Rock-fill in Toe	cu.m	260,000	1.4	364,000
Riprap on Upstream Slope	cu.m	280,000	2.2	616,000
Riprap on Downstream Slope	cu.m	200,000	2.2	440,000
Surfacing on Crest	cu.m	160,000	3.8	608,000
Miscellaneous Works	L.S	1		404,000
Contingency				1,600,000
Subtotal				12,400,000
(1-4) Rock-fill Dam in River Bed				
Rock, Boulders	cu.m	160,000	2.7	432,000
Rock	cu.m	3,000,000	1.5	4,500,000
Escavated Rock	cu.m	1,840,000	0.8	1,472,000
Filter (Semi-perviouse zone)	cu.m	1,820,000	1.0	1,820,000
Impervious Zone	cu.m	1,560,000	1.4	2,184,000
Blanket	cu.m	310,000	1.4	434,000

(to be continued)

(continued)

(Unit: $)

	Unit	Quantity	Unit Cost	Amount
Surfacing on Crest	cu.m	30,000	3.8	114,000
Miscellaneous Works	L.S	1		1,244,000
Contigency				1,800,000
Subtotal				14,000,000
(1-5) Earth Dam on Right Bank				
Earth	cu.m	6,550,000	1.0	6,550,000
Filter under Riprap	cu.m	260,000	0.8	208,000
Sluice Zone	cu.m	400,000	0.8	320,000
Rock in Toe	cu.m	320,000	0.8	256,000
Riprap on Upstream Slope	cu.m	310,000	2.2	682,000
Riprap on Downstream Slope	cu.m	180,000	2.2	396,000
Surfacing on Crest	cu.m	140,000	3.8	532,000
Miscellaneous Works	L.S	1		556,000
Contingency				1,400,000
Subtotal				10,900,000
(1-6) Spillway				
Excavation, Common	cu.m	500,000	0.6	300,000
Excavation, Common (Care of River)	cu.m	300,000	0.3	90,000
Excavation, Rock	cu.m	580,000	2.4	1,392,000
Concrete in Wings	cu.m	238,000	14	3,332,000
Concrete in Spillway Walls	cu.m	19,000	20	380,000
Concrete in Spillway Floor and Crest	cu.m	530,000	15	7,950,000
Concrete in Piers	cu.m	90,000	31	2,790,000
Concrete in Slab of Bridge	cu.m	3,000	42	126,000
Cement	ton	227,000	45	10,215,000
Reinforcement Bars	ton	6,000	240	1,440,000
Grouting	m	8,000	39	312,000
Gates	ton	11,400	1,230	14,000,000
Bridge	ton	2,120	1,000	2,120,000
Miscellaneous Works	L.S	1		3,053,000
Contingency				5,500,000
Subtotal				53,000,000

(to be continued)

(continued)

(Unit: $)

	Unit	Quantity	Unit Cost	Amount
(1-7) Spillway Channel				
Embankment	cu.m	3,170,000	0.2	634,000
Wet Masonry	sq.m	160,000	7.8	1,248,000
Concrete in Base	cu.m	20,000	24	480,000
Cement	ton	13,000	45	585,000
Miscellaneous Works	L.S	1		543,000
Contingency				530,000
Subtotal				4,020,000
Total – (1)				99,700,000
(2) Power Plant				
(2-1) Civil Works				
Excavation, Common (A)	cu.m	1,400,000	0.6	840,000
Excavation, Common (B)	cu.m	200,000	1.0	200,000
Excavation, Common (C)	cu.m	420,000	1.5	630,000
Excavation, Rock (A)	cu.m	3,900,000	1.7	6,630,000
Excavation, Rock (B)	cu.m	600,000	2.5	1,500,000
Excavation, Rock (C)	cu.m	380,000	3.6	1,368,000
Concrete in Intake	cu.m	530,000	18	9,540,000
Concrete in Draft	cu.m	260,000	21	5,460,000
Concrete in Casing Barrel	cu.m	223,000	28	6,244,000
Concrete in Outlet	cu.m	120,000	22	2,640,000
Concrete in Building	cu.m	28,000	36	1,008,000
Concrete in Retaining Wall	cu.m	20,000	19	380,000
Concrete in Wing Dam	cu.m	150,000	13	1,950,000
Cement	ton	379,000	45	17,055,000
Reinforcement Bars	ton	31,000	240	7,440,000
Finishing Work in Main Building	L.S	1		3,020,000
Access Road	L.S	1		145,000
Foundation Works for Outdoor Switchyard	L.S	1		108,000
Intake Gates	L.S	1		10,600,000
Outlet Gates	L.S	1		3,340,000

(to be continued)

(continued)

(Unit: $)

	Unit	Quantity	Unit Cost	Amount
Miscellaneous Works	L.S	1		2,322,000
Contingency				12,380,000
Subtotal				94,800,000
(2-2) Electrical Equipment				
Turbines	unit	7		20,550,000
Generators	unit	7		25,310,000
Transformers	unit	7		6,290,000
Switchboards, Cubicles, etc.	L.S	1		3,890,000
Accessories	L.S	1		2,230,000
Draft Tubes for Future Units	L.S	1		1,390,000
Contingency				3,040,000
Subtotal				62,700,000
Total – (2)				157,500,000
(3) Transmission Line and Substation				
(3-1) Transmission Line (Sambor-P. Penh)				
Land and Right-of-way	L.S	1		110,000
Materials	L.S	1		5,670,000
Transportation	L.S	1		760,000
Installation	L.S	1		3,360,000
Contingency				800,000
Subtotal				10,700,000
(3-2) Transmission Line (P. Penh-S. Ville)				
Land and Right-of-way	L.S	1		90,000
Materials	L.S	1		4,700,000
Transportation	L.S	1		600,000
Installation	L.S	1		2,800,000
Contingency				710,000
Subtotal				8,900,000

(to be continued)

(continued) (Unit: $)

	Unit	Quantity	Unit Cost	Amount
(3-3) Transmission Line (Sambor-Saigon)				
Land and Right-of-way	L.S	1		180,000
Materials	L.S	1		3,100,000
Transportation	L.S	1		380,000
Installation	L.S	1		2,100,000
Contingency				540,000
Subtotal				6,300,000
(3-4) Substation				
Transformers	L.S	1		3,770,000
Circuit Breakers, Disconnecting Switches, etc.	L.S	1		8,720,000
Other Equipments	L.S	1		3,420,000
Transportation and Installation	L.S	1		2,540,000
Contingency				950,000
Substation				19,400,000
Total – (3)				45,300,000
(4) General Property				
(4-1) Telecommunication Facility				
Materials	L.S	1		850,000
Transportation	L.S	1		90,000
Installation	L.S	1		280,000
Contingency				180,000
Subtotal				1,400,000
(4-2) Maintenance Facility for Transmission Line				
Sambor-P. Penh	L.S	1		150,000
P. Penh-S. Ville	L.S	1		150,000
Sambor-Saigon	L.S	1		150,000
Contingency				50,000
Subtotal				500,000
Total – (4)				1,900,000

J-2 Estimate of Annual Fund Requirement

The annual fund requirement (exclusive of engineering fees) on the basis of the construction schedule described in Chapter I is shown in Table J-3.

Table J-3 Annual Fund Requirement

(Unit: Million Dollar)

Item	Grand Total	Cost of Definite Study	First Stage (Years) 1st	2nd	3rd	4th	5th	6th	7th	8th	Subtotal	Second Stage (Years) 1st	2nd	Subtotal	3rd	4th	Subtotal
Reservoir and Dam																	
Foreign Currency	66.22		8.48	7.06	3.31	7.57	10.85	12.57	8.19	8.19	66.22						
Domestic Currency	33 48		3.40	3.01	2.30	4.92	6.34	6.29	3.63	3.59	33 48						
Total	99.70		11.88	10 07	5.61	12.49	17.19	18.86	11.82	11.78	99.70						
Power Station																	
Foreign Currency	118 18		8.95	7.33	3.06	9.95	10.60	19.45	25.71	17.67	102.72	4.86	5.44	10.30		5.16	5.16
Domestic Currency	39.32		3.65	3.15	2.25	4.74	6.07	6.43	4 62	4.00	34.91	2 73	0 88	3.61		0.80	0.80
Total	157.50		12.60	10.48	5.31	14.69	16 67	25.88	30.33	21.67	137.63	7.59	6.32	13.91		5.96	5.96
Transmission and Substation																	
Foreign Currency	39.10				2.14	1 06	4.53	4.80	12.22	10 00	34.84	1.48	2.78	4.26			
Domestic Currency	6.20				0.84	0.42	0.78	1.36	1.35	0.75	5.50	0.23	0.47	0.70			
Total	45.30				2.98	1.48	5 31	6 25	13.57	10.75	40.34	1.71	3.25	4.96			
General Property																	
Foreign Currency	1.40						0.12	0.18	0.80	0.30	1.40						
Domestic Currency	0.50						0.10	0 08	0.21	0.11	0.50						
Total	1.90						0.22	0.26	1.01	0.41	1.90						
Subtotal																	
Foreign Currency	224.90		17.43	14.39	8.51	18.58	26.10	37.09	46.92	36.16	205 18	6 34	8.22	14.56		5.16	5.16
Domestic Currency	79.50		7 05	6.16	5.39	10.08	13.29	14.16	9.81	8.45	74.39	2.96	1.35	4.31		0.80	0 80
Total	304.40		24.48	20.55	13.90	28.66	39.39	51.25	56.73	44.61	279.57	9.30	9.57	18.87		5.96	5.96
Engineering Fee	13 70	4.56	0.73	0 62	0 42	0.86	1.18	1.54	1.70	1 34	8.39	0 28	0.29	0.57		0.18	0.18
Total	318.10	4.56	25.21	21.17	14.32	29.52	40.57	52.79	58.43	45.95	287.96	9.58	9.86	19.44		6.14	6.14

CHAPTER K. ECONOMIC JUSTIFICATION

CHAPTER K. ECONOMIC JUSTIFICATION

K-1 Approach and Method of Economic Justification

K-1-1 Development of Mekong Mainstream and Internal Rate of Return of the Power Aspect of the Sambor Project

This chapter on economic evaluation concerns only with the electric power aspect of the Sambor Project by comparing the primary benefit and cost to obtain the internal rate of return. However, before dealing with the subject of internal rate of return, it would be worthwhile to consider in principle the significance of such an economic evaluation and what bearing it will have to the development of the Mekong River, and in a broader sense, the economic progress of Southeast Asia. This is because it must constantly be borne in mind what the internal rate of return to be obtained herein means in terms of a relative level of economic evaluation.

Development of the Mekong River itself is not the objective. Naturally, the same can be said of the Sabmor Project. The conceptions of these development programs all originate from the fundamental objective of economic and social progress, and the raising of the cultural standards of the riparian countries of the Lower Mekong Basin. Many approaches are conceivable in attempting to develop the economy, society and welfare of the peoples in the lower basin. Among those are investments in road, education, agriculture and development of the Mekong River. For the Mekong River, there would also be many methods and timing of the development. One of these approaches would be to select the Sambor Project as the forerunner of the mainstream development, or to carry out construction simultaneously with the Pa Mong Project, or to give priority to exploitation of tributaries.

In short, it must be recognized that the Sambor Project being studied herein is a component of the Mekong River development comprising only one aspect of investment in achieving the fundamental objective.

The standard manner of treating public investment in such a case should in principle be evaluation of the cost against the investment opportunity, in other words, the benefits of the investment if it was to be invested in other purposes. For example, if it was invested simultaneously with the construction of the Pa Mong Project, or if the amount was invested for educational purposes.

The benefits of investment in such cases must be known not only in the sense of internal economics, for example the influence on electricity charges, but also in respect to external economics of secondary benefits. Especially, in the case of secondary benefits, the effect on the international balance of payments, which often is very important to developing nations, and its manner of treatment is always considered to be a great problem in the fundamentals of public investment.

In the light of the above, it may be difficult to attempt a comparison in this chapter of the level of internal rate of return of the electric power aspect of the Sambor Project with, for instance, the level of interest charges in developing nations in the world. One thing which may be said, however, is that if the Sambor Project is considered as an object of investment for a private enterprise, the level of internal rate of return is only at the marginal rate of earning of private capital according to J. M. Keynes.

Therefore, the evaluation of the Sambor Project should be made from a broad standpoint enveloping economic evaluation of internal rate of return, and it should be understood that the calculation of rate of return is no more than part of the data for overall evaluation.

K-1-2 Internal Rate of Return 1/

The internal rate of return, i, of investment is obtained by the equation below.

$$K = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t}$$

Source: 1/ Report of the Third Meeting of the Joint Critical Examination of Feasibility Concepts, Criteria and Methods with Special Reference to Pa Mong and Sambor Project (29 March to 2 April 1967, Tokyo, Japan) 9 May 1967, ECAFE, Mekong Committee.

where, K: initial investment,
R_t: cash flow in t th year,
n: capital recovery period

The internal rate of return can be construed to mean the marginal earning rate of capital, and at the same time it can be thought of as the rate of return on book value which is generally used by public enterprises operating on the principle of cost.

Among other methods of evaluation of economic feasibility of investment.there are the present worth method, capital recovery method, and required revenue method. The reason the internal rate of return method is suitable as a method of evaluating an investment for the Sambor Project is that in the procedure of evaluation the mature of the enterprise must be first evaluated and then to evaluate the capital cost of the required investment.

However, the internal rate of return method basically is not for the examination of annual profit or loss and also does not give a picture of cash flow. Therefore, these will have to be studied separately.

K-2 Benefits

K-2-1 Method of Approach

According to the memorandum of the President of the U.S.A. on water resources development [1/], "The value of power to the users is measured by the amount that they should be willing to pay for such power. The usual practice is to measure the benefit in terms of the cost of achieving the same result by the most likely alternative means that would exist in the absence of the project."

The benefit of the electric power aspect of the project should be expressed by a level of power rates which is attractive to the consumer or by the cost of alternative electric power.

In the case of the Sambor Project, the benefits should be considered by dividing them into general demand and power-oriented industrial demand. First, regarding general demand, since the consumer is limited to within that country, it will suffice to examine levels of power rates attractive for domestic power or cost of alternative power sources. On the other hand, in the case of power-oriented industries, although it will depend on the type of consumer or enterprise, it would be more natural to assume they will be of an international nature.

In "cost of alternative power sources," the source need not necessarily be within that country, rather it should be an alternative source from a broad international viewpoint. In other words, it should not be of a type and scale which can be assumed for the power systems of the countries in the Mekong River Basin, but of a type and scale conceivable to be used by the industrially advanced countries of the world. The cost of nuclear power of a 1,500 MW installation would not serve as an alternative power source for general demand, but it may be an alternative source for the aluminum industry.

K-2-2 Unit Value of Benefit for General Demand

That an attractive level of power rates for general demand should at least be considerably lower than the present rates can be judged by the current situation in which there is much latent demand due to comparatively high rates. However, it is not an easy task to indicate this accurately.

It will be possible to make some estimate of cost of an alternative power source. In this case, the capacity of one unit will be considered as 125 MW, or 10% of the output of the system in the 1980's, and the alternative power source will consist of two units of 125 MW heavy oil-burning thermal station. At an interest rate of 6%, average thermal efficiency of 36.5% and capacity factor of 60%, the construction cost and power cost of the alternative thermal are estimated as shown in Tables K-1 and K-2. According to this table, the cost delivered

Source: 1/ "Letter of President John F. Kennedy to the Secretary of the Interior; the Secretary of Agriculture; the Secretary of Health, Education, and Welfare; and the Secretary of the Army" John F. Kennedy (May 15, 1962) "Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources."

at the demand center[1] will be roughly 9 mills per kWh.

The present rate at the consuming end is roughly 60 mills per kWh in the Saigon area, the cheapest in Vietnam, and about 60 to 80 mills per kWh in the Phnom Penh area, the cheapest in Cambodia, so that the 9 mills per kWh will be considerably lower than the present rates. Consequently, it should not be a grave mistake to use this as the unit value of benefit of the supply capability of the Sambor Project for general demand.

According to the White Report, [2] at a load factor of 50%, if power can be supplied not more than 10 mills per kWh, it can sufficiently match thermal power to supply domestic general demand, and from this point also, 9 mills per kWh would be a reasonable level.

Therefore, the unit value of benefit for general demand will be taken as 9 mills per kWh.

Table K-1 Construction Cost of Alternative Thermal Power Plant (125 MW x 2 units)

	Construction Cost (Unit: $1,000)
Land	52.8
Buildings	3,296.7
Structures	1,995.0
Steam Generating Facilities	12,236.1
Electricity Generating Facilities	12,658.3
Auxiliary Equipment	924.2
Miscellaneous Expenses	1,262.5
Subtotal	32,425.6
Interest During Construction	2,107.5
Overhead Expenses	1,438.6
Total	35,971.7

K-2-3 Unit Value of Benefit for Power-Oriented Industries

For power-oriented industries, the cost of an alternative power source or an attractive level of electrically rates is difficult to estimate, especially when the industry is of an international nature. Herein, an estimate is made from various data on aluminum which is the main industry, and from the difference in the nature of power used by aluminum and that used by other power-oriented industries, the unit value of benefit of the other industries are estimated.

From the comparison of electricity rates for aluminum reduction made on an international level as shown in Tables K-3 and K-4, the following observations are made.

(1) In Ghana, Cameroon and other developing nations, the cost is 1 to 3 mills per kWh for hydroelectric power which is the cheapest of all.

(2) The six largest aluminum refining companies (Alcoa, Reynolds, Kaiser, Alcan, Pechinery, Swiss Almi.) are generally using power costing about 2 to 4 mills per kWh.

Source. 1/ The demand center as referred to in this chapter will be the low-voltage side of primary substations.

2/ *Economic and Social Aspects of Lower Mekong Development*, Jan. 1962 Gilbert F. White and Thon V. Krutilla.

(3) Western European countries such as West Germany and Great Britain are using comparatively expensive power.

(4) Japan uses the most expensive power.

From the above international comparison, an attractive level of electricity rates for aluminum refining industry taking into consideration site conditions and other factors is estimated to be 2 to 3 mills per kWh at the most.

Table K-2 Power Generating Cost of Alternative Thermal Power Plant

		Amount	Remarks
Installed Capacity	(kW)	250,000	125 MW x 2 units
Energy Production	(10^6 kWh)	1,310	Load Factor 60%
Station Losses	(%)	5.5	
Sending-Out Energy	(10^6 kWh)	1,238	
Transmission and Substation Losses	(%)	2.0	
Energy at Consuming End	(10^6 kWh)	1,213	
Average Thermal Efficiency	(%)	36.5	Generating End (0.238*l*/kWh)
Heat Value of Heavy Oil	(kcal/*l*)	9,900	
Heavy Oil Consumption	(10^3 k*l*)	311.8	
Total Construction Cost	(\$$10^3$)	35,972	
Unit Construction Cost	($/kW)	144	
Personnel Required	(man)	96	0.384 man/MW
Interest	(%)	6	
Capital Costs	(\$$10^3$)	2,614	Serviceable Years 30, Residual Value 0
Operating and Maintenance Costs	(\$$10^3$)	922	
Wages and Salaries	(\$$10^3$)	131	
Repair and Maintenance Costs	(\$$10^3$)	719	2% of Total Construction Cost
Miscellaneous Expenses	(\$$10^3$)	72	0.2% of Total Construction Cost
Fuel Costs	(\$$10^3$)	6,817	21.87 $/k*l*
General Administrative Expenses	(\$$10^3$)	75	8% of Operating and Maintenance Cost
Total	(\$$10^3$)	10,428	
Transmission and Transforming Costs	(\$$10^3$)	278	
Grand Total	(\$$10^3$)	10,706	
Unit Cost at Consuming End	(mill/kWh)	8.83	

Table K-3 International Comparison of Unit Power Cost for Aluminum Refining Industry

Country	Unit Power Cost (mill/kWh)	Remarks
U.S.A.	2-4.1	(1) 1.5 mill/kWh for Alcoa (2) 1/4 of aluminum refining manufacturers at 2-2.26 mill/kWh (purchase of power) (3) 3 aluminum refining manufacturers on Pacific Northwest Coast at 2.1 mill/kWh (purchase of power) (4) New enterprises at 4.1 mill/kWh (purchase of power)
Canada	1.9	Alcan
France	3.5	Supplied at cost from old power stations of EDF
West Germany	7.0 1/	
Norway	2.5	Abundant hydro-power
Italy	6.0 1/	
Brazil	4.0 1/	
India	4.5 1/	
Spain	6.0 1/	
Cameroon	1.5-1.6	55,000 ton/year refining plant of Alucam firm (Peysinee & Eugene, France) operating since 1957
Ghana	2.625	Contract between electric power development public corporation of Ghana Government and Umarco firm
Katanga	1.0-2.0	
New Zealand	2.3	
Australia	4.6	
United Kingdom	5.6 2/	
Japan	8.9	Average of median two companies (average of Japan as a whole, 7.5-7.8 mill/kWh)

Source Japan Light Metals Refining Association Data (Original source: Revue de L'aluminum 1963, 1964

1/ Bache and Co. New York, Mar. 1964 2/ "Metals" Magazine

Table K-4 Transition in Unit Price of Power Purchased by Power-Oriented Industries (Japan)

Unit: mill/kWh

Year	Aluminum Refining	Carbide, Nitrate of Lime	Soda	Carbon, Graphite Products
1958	8.3	5.6	8.3	7.7
'59	8.3	5.8	8.5	8.5
'60	8.4	6.7	8.7	8.8
'61	8.4	7.1	8.9	9.3
'62	8.4	7.0	9.0	9.5
'63	8.9	7.3	9.2	9.5
'64	8.6	7.4	9.4	9.6
'65	8.9	7.4	9.3	-

Source: Monthly Report, *Electric Power Statistical Survey*, Ministry of International Trade and Industry

On the other hand, large-scale hydro-power in developing nations or atomic power which has already entered the practical stage can be considered as alternative power sources for Sambor in aluminum refining, In the case of hydro-power, projects at 2 to 3 mills per kWh are said to be planned in New Zealand, Indonesia and the U.S.A. Regarding atomic power, generating costs for light water reactors in the U.S.A. made public in recent years are as shown in Table K-5. These are all scheduled for start-up the next several years, and a summary of the whole shows generating costs to be estimated as follows:

500 to 600	MW unit	4.5	mill/kWh
750	MW unit	3.9	mill/kWh
1,000	MW unit	3.4 to 3.7	mill/kWh

Table K-5 Power Generating Cost of Light Water Reactors of U.S.A.

Year	Month	Power Station	Manufacturer, etc.	mill/kWh	MWe	Power Company
1963	Oct.	Nine Mile Point	Ordered from G.E.	6.7	500	Niagara Monhawk
	Dec.	Oyster Creek	G.E. selected	3.8-4.2	540	JCP & L
'64	Feb.	San Onofre	Construction approved	6.4	375	Southern Cal. Ed.
	Apr.	Maribu	Contracted with WH	4.8	490	Los. Dep. W & P
	Apr.	Hadam Neck	Passed hearings	5.0-5.8	490	Con. Yankee Atm. P.
'65	Oct.	Milestone Point	Application submitted	5.0	578	Milestone Point Co.
'66	Jan.	Indian Point – 2	WH	5.0	873	
	Jun.	Browns Ferry – 1, 2		2.4	1,060 x 2	TVA
	Jul.	Point Beach – 1	WH	5.0	477	Wisconsin Michigan
'67	Apr.	Brown Ferry – 3		2.75	1,152	TVA

Source: Atomic Power Committee, Japan Atomic Industrial Forum

According to the above data, generating costs in the U.S.A. are estimated to be as follows in several years.

500-600	MWe unit	4.5	mill/kWh
750	MWe unit	3.9	mill/kWh
1,000	MWe unit	3.4-3.7	mill/kWh

Based on the above data and giving consideration to the statement in the previously mentioned White Report that it will be necessary to generate power in a cost range of 3.5 mills per kWh or less for power-oriented industries such as aluminum aimed at world markets, the unit value of benefit for aluminum refining can be safely taken at 2.5 mills per kWh, the median value between 2 and 3 mills per kWh.

Next, in connection with the other power-oriented industries, it appears from the present situation in Japan shown in Table K-4 that there is not much difference in energy cost with aluminum refining. However, as stated in Chapter C, in the power consumption program for the Sambor Project, the other industries will be absorbing periodical firm power of slightly poorer quality than that used by aluminum, and therefore a slightly lower unit cost than the 2.5 mills per kWh for aluminum refining should be assumed. Therefore, for power-oriented industries other than aluminum, a uniform unit value of benefit of 2 mills per kWh will be used.

K-2-4 Benefit

As a result of the above studies, the annual benefit by type of power uses during the period beginning from 1978 for an economic life of 50 years would be as shown in Tables K-6, K-7 and K-8.

In Type I consumption pattern, the benefit for general demand will gradually increase in proportion to the growth of demand from $1,269,000 in 1978 to $17,712,000 in 1986, after which it will level off as the supply capacity of the Sambor Power Station would have reached its full capacity.

For integrated aluminum refining and other industries, the benefit will not change from 1978, and will be $5,040,000 and $3,494,000 respectively.

The combined benefit will gradually increase from $9,803,000 in 1978 to $26,246,000 in 1986 and remain constant during the remainder of the serviceable life.

In Type II consumption pattern, the general demand is the same as in Type I up to 1985, but in Type II this demand continues to grow up to 1990 and levels off, thereafter, at $34,515,000. On the other hand, demands of power-oriented industries will be maintained constantly at $1,786,000 after 1978. The combined benefit for general demand and power-oriented industries will increase from $3,055,000 in 1978 to $36,301,000 in 1990, and will level off thereafter.

In Type III consumption pattern, the benefit will increase annually in step with the growth of demand from $1,269,000 in 1978 to $39,735,000 in 1991, and after which the value will be constant.

K-3 Annual Cost

Annual cost during a 50-year economic life after 1978 are estimated as follows:

Salaries and wages	:	80 employees – $522,000 (at 875 MW installation)
Maintenance and repair of civil structures and transmission lines	:	0.75% of the total construciton cost of these facilities.
Maintenance and repair of equipment	:	0.6% of the total cost of the equipment.
Other expenses	:	10% of the total expenses above.
Expenses for auxiliary thermal plants	:	105.6 mill/kWh [1/] (at consuming end)

For replacement costs, the serviceable years of the various facilities were considered as follows:

Dam and other civil structures	50 years
Turbines, generators and transformers	35 years
Transmission lines	50 years

and assuming the residual value to be zero, appropriations were made for items requiring replacement during the economic life of 50 years. (See Table K-10)

1/ Breakdown of expenses for Type III only is shown in Table K-9. Because of low utility factor, annual costs will be extremely high.

Table K-6 Electric Energy Demand and Benefit (Type I)

	1978	1979	1980	1981	1982	1983	1984	1985	after 1986
Energy Demand (million kWh)	3,904	4,065	4,258	4,479	4,742	5,020	5,302	5,604	5,731
General Demand	141	302	495	716	979	1,257	1,539	1,847	1,968
Aluminum	2,016								
Other Industries	1,747								
Caustic Soda	484								
Vinyl Chloride	125	Same for years following							
Calcium Carbide	761								
Ferro-silicon	203								
Silicon Carbide	174								
Benefit ($1,000)	9,803	11,252	12,989	14,978	17,345	19,847	22,385	25,103	26,246
General Demand	1,269	2,718	4,455	6,444	8,811	11,313	13,851	16,569	17,712
Aluminum	5,040								
Other Industries	3,494								
Caustic Soda	968								
Vinyl Chloride	250	Same for years following							
Calcium Carbide	1,522								
Ferro-silicon	406								
Silicon Carbide	348								

Note 1) Unit Value of Benefit: General Demand 9 mill/kWh, Aluminum 2.5 mill/kWh, Others 2 mill/kWh

2) Internal Rate of Return 4.4%

Table K-7 Electric Energy Demand and Benefit (Type II)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	after 1990
Energy Demand (million kWh)	1,034	1,195	1,388	1,609	1,872	2,150	2,432	2,734	3,093	3,472	3,890	4,324	4,728
General Demand	141	302	495	716	979	1,257	1,539	1,841	2,200	2,579	2,997	3,431	3,835
Power-oriented Industries	893												
Caustic Soda	484	Same for years following											
Vinyl Chloride	125												
Calcium Carbide	284												
Benefit ($1,000)	3,055	4,504	6,241	8,230	10,597	13,099	15,637	18,355	21,586	24,997	28,759	32,665	36,301
General Demand	1,269	2,718	4,455	6,444	8,811	11,313	13,851	16,569	19,800	23,211	26,973	30,879	34,515
Power-oriented Industries	1,786												
Caustic Soda	968												
Vinyl Chloride	250	Same for years following											
Calcium Carbide	568												

Note: 1) Unit Value of Benefit: General Demand 9 mill/kWh, Others 2 mill/kWh

2) Internal Rate of Return: 5.3%

Table K-9 Power Generating Cost of Auxiliary Thermal Plant

		Amount	Remarks
Installed Capacity	(kW)	150,000	75 MW x 2 units
Energy Production	(10^6kWh)	29.80	Converted to generating end of hydro 28.90 (include starting and stopping losses of boiler)
Station Losses	(%)	5.0	Converted to consuming end 28.90 x (1 - 0.04) = 27.74
Sending Out Energy	(10^6kWh)	28.31	Converted to generating end of thermal 27.74/(1 - 0.02) (1 - 0.05) = 29.80
Transmission and Transforming Losses	(%)	2.0	25.68 for demand converted to consuming end = 25.68 x (1 - 0.04) = 24.65
Energy at Consuming End	(10^6kWh)	27.74	24.65 for demand (balance is loss accompanying starting and stopping converted to consuming end
Average Thermal Efficiency	(%)	30.0	
Heat Value of Heavy Oil	(kcal/*l*)	9,900	Generating end fuel consumption ratio = 0.290 *l*/kWh
Heavy Oil Consumption	(10^3k*l*)	8,642	
Total Construction Cost	($$10^3$)	22,447	
Unit Construction Cost	($/kW)	150	
Personnel Required	(man)	58	0.384 man/MW
Interest	(%)	6	
Capital Expense	($$10^3$)	1,631	Serviceable years 30, Residual value 0
Operating and Maintenance Cost	($$10^3$)	572	
Wages and Salaries	($$10^3$)	78	
Repair and Maintenance Cost	($$10^3$)	450	2% of Total construction cost
Miscellaneous Expenses	($$10^3$)	44	0.2% of Total construction cost
Fuel Cost	($$10^3$)	189	21.87 $/k*l*
General Administrative Expenses	($$10^3$)	44	8% of Operating and maintenance cost
Total	($$10^3$)	2,436	
Transmission and Transforming Costs	($$10^3$)	167	
Grand Total	($$10^3$)	2,603	
Unit Cost at Consuming End	(mill/kWh)	105.6	Total expense/24.65 for demand converted to consuming end (10^6kWh)

Table K-8 Electric Energy Demand and Benefit (Type III)

Year	Energy Demand (million kWh)	Benefit ($1,000)
1978	141	1,269
'79	302	2,718
'80	495	4,455
'81	716	6,440
'82	979	8,811
'83	1,257	11,313
'84	1,539	13,851
'85	1,841	16,569
'86	2,200	19,800
'87	2,579	23,211
'88	2,997	26,973
'89	3,431	30,879
'90	3,880	34,920
after 1991	4,415	39,735

Note: 1) Unit Value of Benefit: 9 mill/kWh

2) Internal Rate of Return: 5.3%

Table K-10 Replacement Cost for Type I, II and III Consumption Pattern

(Unit: $1,000)

Year	Type I	Type II	Type III
2012	67,400	47,600	39,300
2015	11,200	8,300	8,300
2017		6,100	6,100
2018	6,100		
2019		10,500	10,500
2021		6,100	8,300
2022			6,100
2023		6,100	
2024			6,100

K-4 Internal Rate of Return

Formula $K = \sum_{t=1}^{n} \frac{R_t}{(1+i)^t}$ (See K-1-2)

was applied to the construction cost, annual benefit, annual costs and replacement costs, which were obtained in Chapters J, K-2 and K-3 to arrive at the internal rate of return (i), for each consumption pattern, which are given below:

Type I	4.4%
Type II	5.3%
Type III	5.3%

And, initial investment (k) includes an amount equivalent to "construction cost x 0.4 x construction period x i" as interest during construction and added to the construction cost calculated in Chapter J. All construction expenditures after 1978 are capitalized in 1978.

Also for replacement costs, interest during construction calculated at "0.4 x construction period x i", is included in addition to the expenses mentioned in K-3.

CHAPTER L. SUPPLEMENTAL STUDY

CHAPTER L. SUPPLEMENTAL STUDY

L-1 Preliminary Estimate of Funds Required for Power-Oriented Industries

The funds required to introduce the power-oriented industries described in C-1-2 in the project area and financial analysis cannot be ascertained without various pertinent studies, so a rough estimate for funds is given below.

Table L-1 Summary of Construction Cost for Power-Oriented Industries

Power-oriented Industries	Construction Cost in $1,000			Remarks
	Type I	Type II	Type III	Annual production (ton)
Aluminum	125,000	-	-	125,000
Caustic Soda			18,000	130,000
Vinyl Chloride		36,000	11,000	125,000
Calcium Carbide	58,000		7,000	242,000
Ferro-silicon		-	-	20,300
Silicon Carbide		-	-	17,400
Total	183,000	36,000	36,000	

L-2 Influence of Nam Ngum Project on Sambor Project

L-2-1 Pertinent Data and Assumption 1/

The normal high water level of the Nam Ngum reservoir is 212.0 m; low water level is at 196.0 m. The effective storage capacity is 4,700 million cubic meters. The relevant storage capacity and area curves are shown in Fig. L-1.

The available flow record spans only five years, from 1962 to 1966. The study is based on flows reconstituted for the dam site for the period November 1950 - October 1965 by the Portland Office of U.S. Corps of Engineers. The estimated evaporation and precipitation corrections for each month have been added to or deducted from the reservoir inflow. Water will not be released for irrigation. A constant loss of flow of 5 cu.ms is assumed for the reservoir leakage and leakage through gates.

According to a report of the consulting engineers 2/, the final stage installed capacity will be 135 MW and the rated head 32 m.

L-2-2 Operating Rule Curve 2/

The driest period in the reconstituted flow series was found between November 1956 and June 1958.

Source:: 1/ Quoted from "Reservoir Operation and Power Output of Sambor Project with the Flow Regulation of Nam Ngum and Pa Mong Reservoir," by Mekong Secretariat, September 10, 1968.

2/ "A Study of Final Stage Installation and Rated Head of Water Turbines of the Nam Ngum Project," Nippon Koei Co., March 1967

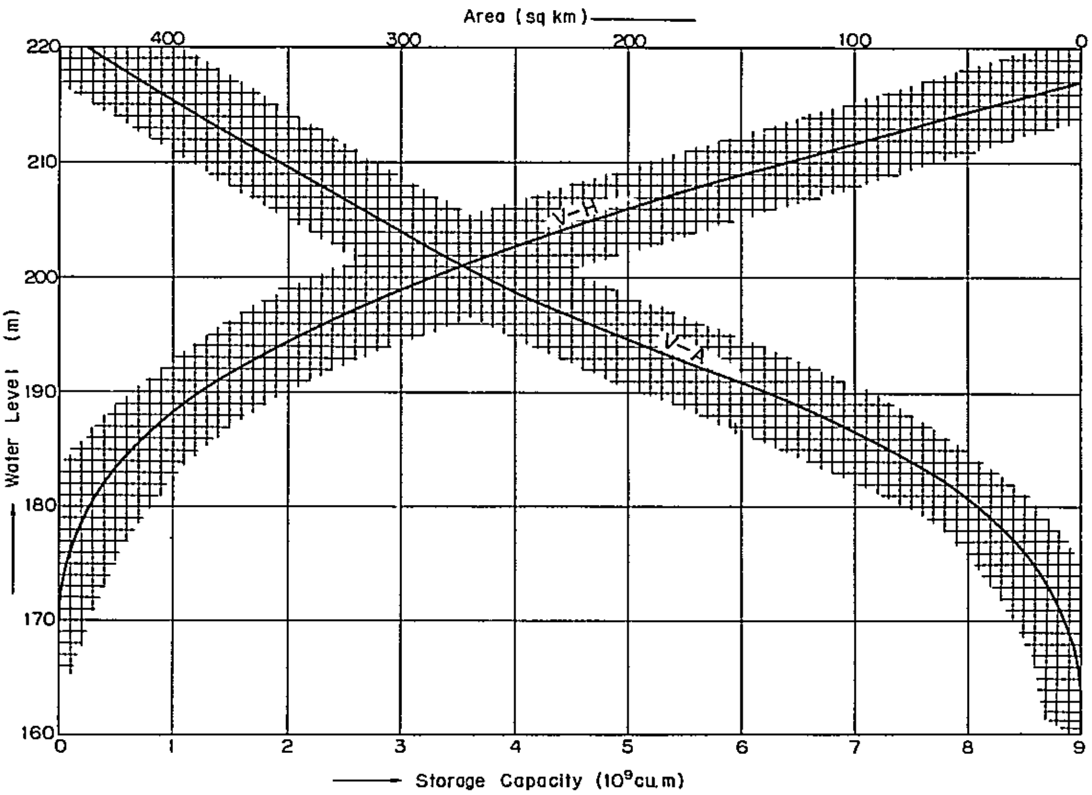
During this critical period the reservoir would have been drawn from full capacity level down to the minimum water level. The operating rule curve, based on the stream flow recession observed during this period and the filling levels the reservoir could be expected to reach in dry years, is shown in Fig. L-2. The rule curve represents the minimum reservoir level required to generate firm power at all times.

L-2-3 Reservoir Operation 1/

The flow released from the reservoir is determined in accordance with the water level at the time of operation and the rule curve. If the water level is below the rule curve, the flow released will not be more than that required to generate firm power; if the water level is higher than the rule curve, however, more water will be released through the turbines until the reservoir water level falls to the level defined by the rule curve. The monthly operation from November 1950 to October 1965 is shown in Fig. L-3.

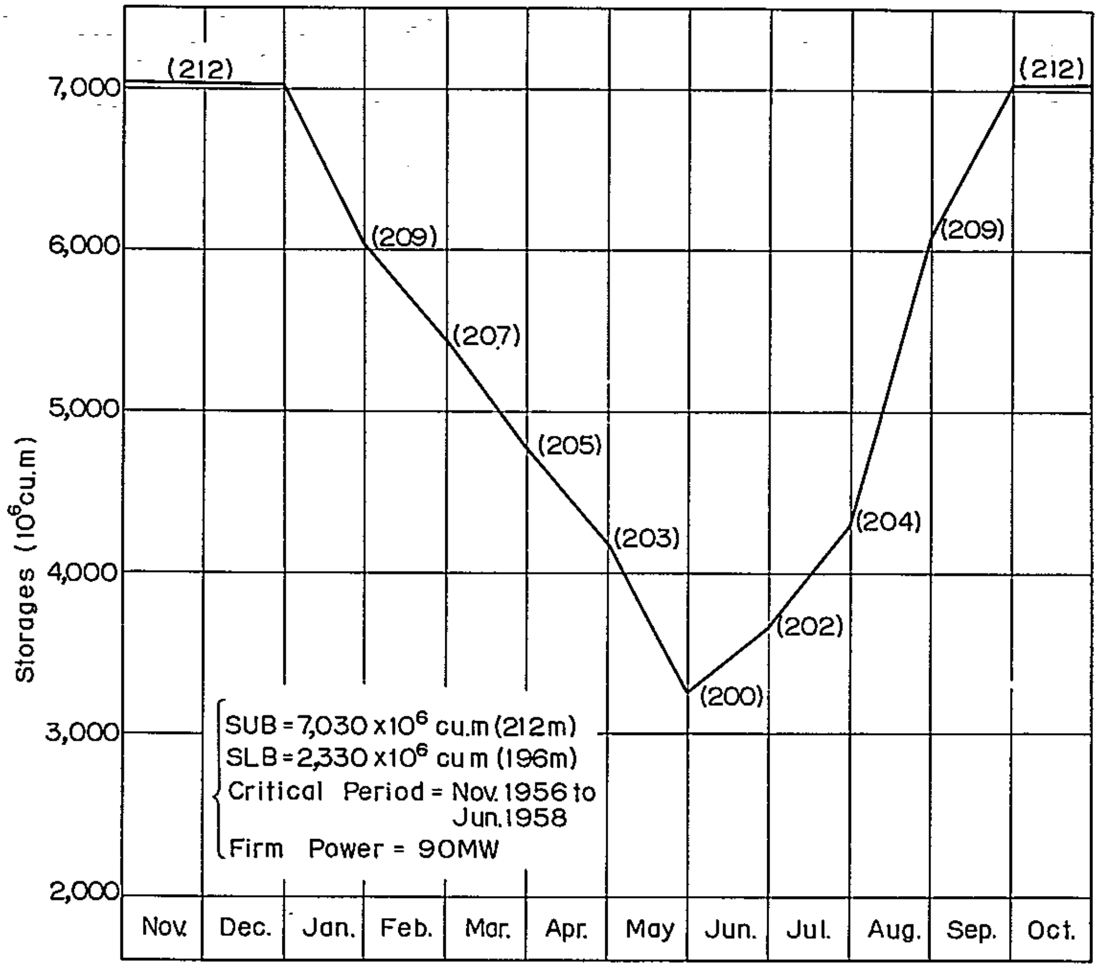
The difference between the natural inflow and the regulated outflow indicates the increase or decrease of the flow at the site caused by regulation of the reservoir. It is assumed that the same decrease or increase of flow will occur at Sambor dam site during the month under consideration.

Fig. L-1 Area Capacity Curve of Nam Ngum Reservoir



Source: 1/ Quoted from "Reservoir Operation and Power Output of Sambor Project with the Flow Regulation of Nam Ngum and Pa Mong Reservoir," by Mekong Secretariat, September 10, 1968.

Fig. L-2 Nam Ngum Operation Rule Curve



NOTE : ( ) = Reservoir Elevetion in Meters

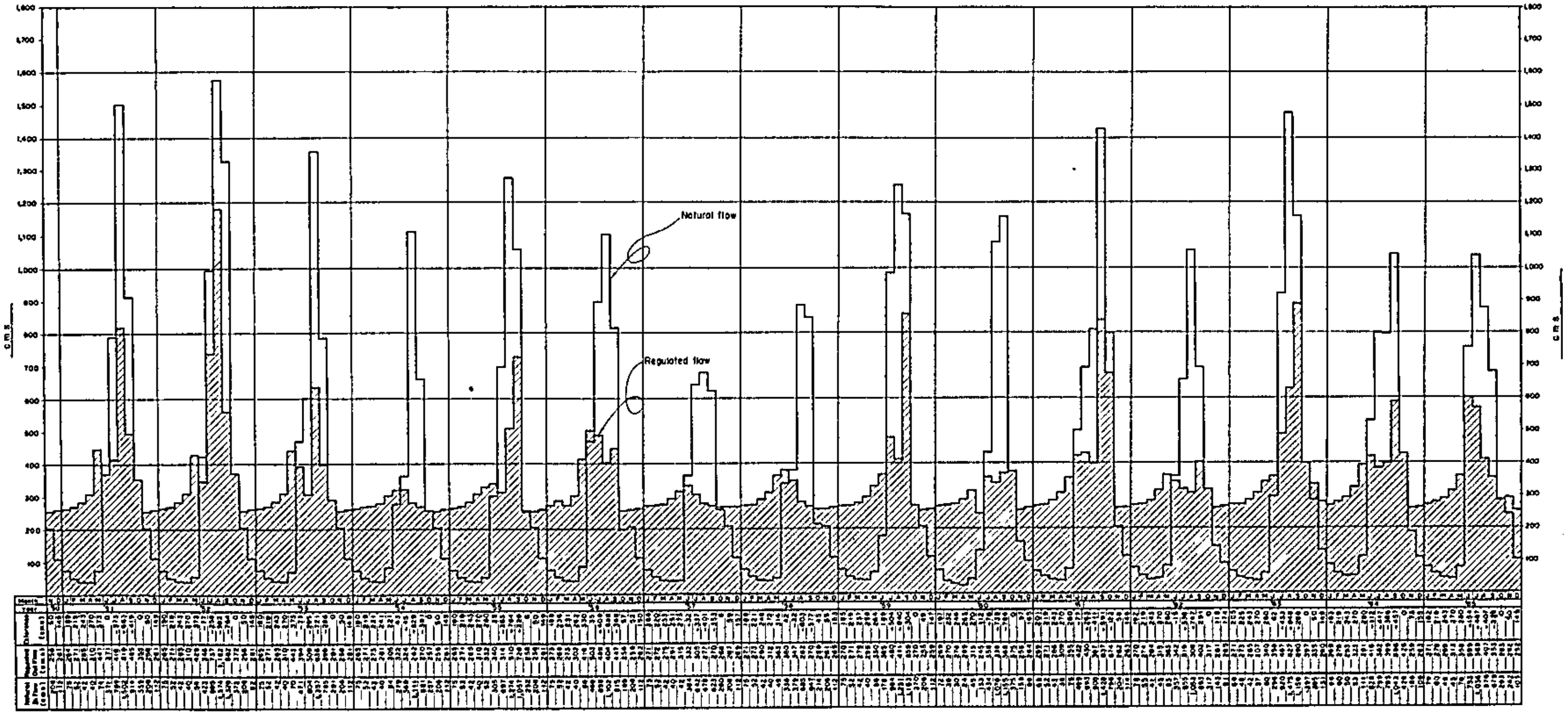
L-2-4 Influence on Sambor Power Station

As seen in Fig. L-3, the increased flow at the Sambor site in the dry season resulting from operation of Nam Ngum Reservoir will be 150 cu.ms to 380 cu.ms which is not very great compared to the runoff of the Mekong River. (See Fig. F-5)

Therefore, with the installed capacity of Sambor Power Station maintained at 875 MW, the increment in power and energy output in the dry season will be as shown in Table L-2, that is, 50 MW to 70 MW and an annual average of 170 million kWh respectively, so that the firm output of Sambor Power Station will increase from 473 MW to 538 MW and the annual energy production from 7,000 million kWh to 7,200 million kWh.

Furthermore, if the runoff is increased by 150 cu.ms to 380 cu.ms in the dry season, there will be no case where the water level of Sambor reservoir will fall below the lower limit of 38 m.

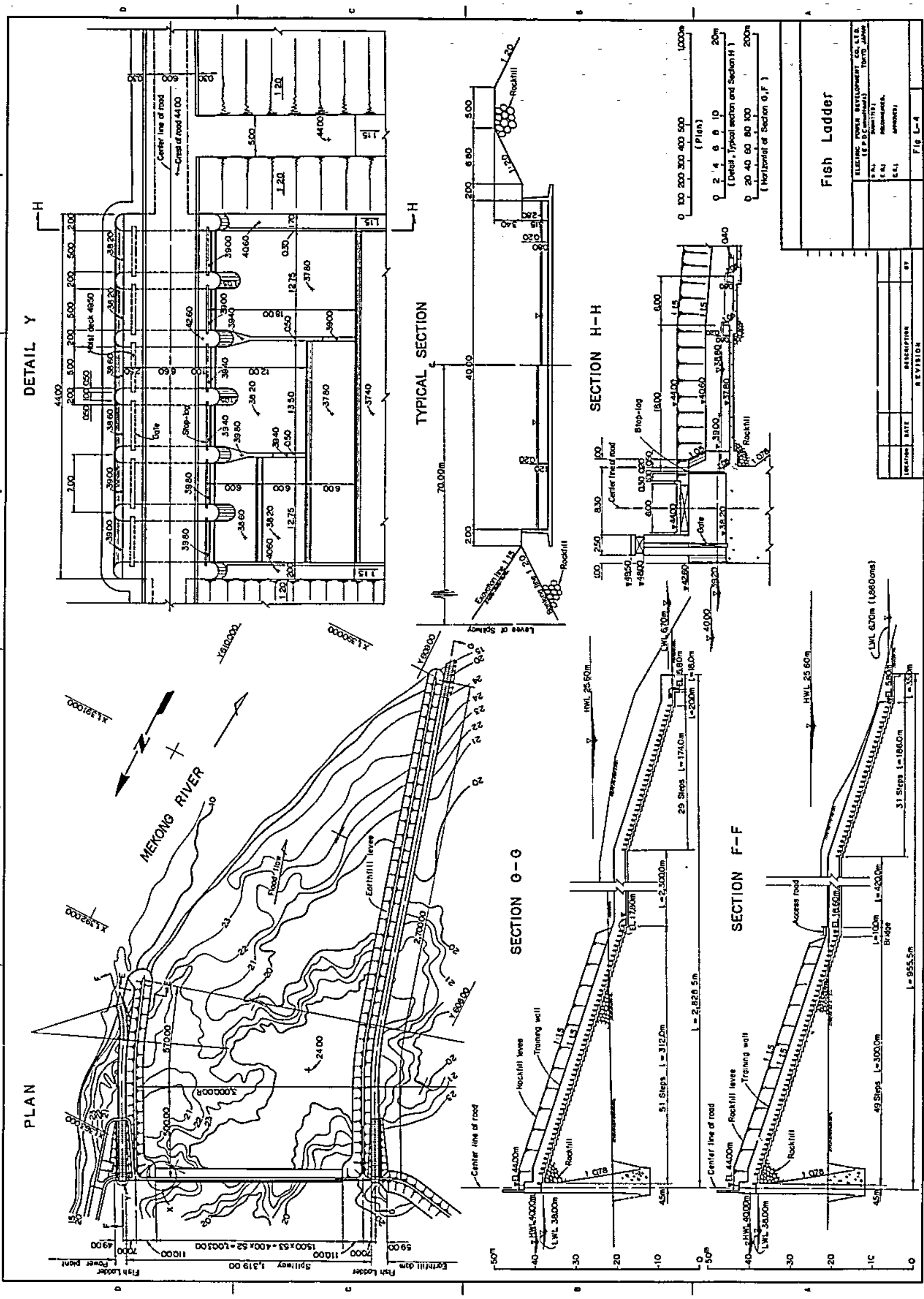
Fig. L-3 Nam Ngum Project Reservoir Operation



Source : Reservoir Operation and Power Output of Sambor Project with the Flow Regulation of Nam Ngum and Pa Mong Reservoirs by Mekong Secretariat, 18 September 1968

Table L-2 Available Output and Energy of Sambor Power Station in the Dry Season

Year	Month	(1) Increased flow (cu.ms)	(2) Effective Head (m)	(3) Output per Unit Amount of Discharge (kW/ cu.ms)	(4) Increased Output (MW)	(5) Available Output in Col (4) (MW)	(6) Available Energy in Col (4) (million kWh)
1950	Dec.	149	29.1	247	36.8	0	0
51	Jan	189	30.7	261	49.3	0.4	0.3
	Feb.	219	31.3	267	58.5	46.9	31.5
	Mar.	243	31.6	269	65.4	65.4	48.7
	Apr	270	30.9	263	71.0	71.0	51.1
	May	383	29.4	249	95.4	2.9	2.2
						186.6	133.8
1951	Dec.	149	29.7	252	37.5	0	0
52	Jan	190	31.1	265	50.4	0	0
	Feb	119	31.8	271	32.2	32.2	21.6
	Mar	243	31.6	269	65.4	65.4	48.7
	Apr	270	31.2	266	71.8	71.8	51.7
	May	373	30.7	261	97.4	36.0	26.8
						205.4	148.8
1952	Dec.	149	30.6	260	38.7	0	0
53	Jan.	190	32.0	273	51.9	51.9	38.6
	Feb	219	31.8	271	59.3	59.3	41.3
	Mar	243	31.6	269	65.4	65.4	48.7
	Apr.	270	30.9	263	71.0	71.0	51.1
	May	373	30.1	256	95.5	0	0
						247.6	179.7
1953	Dec.	149	30.2	256	38.1	0	0
54	Jan	190	31.2	266	50.5	50.5	37.6
	Feb	219	31.8	271	59.3	59.3	39.8
	Mar	231	31.6	269	62.1	62.1	46.2
	Apr	241	30.5	259	62.4	62.4	44.9
	May	221	29.8	253	55.9	55.9	41.6
						290.2	210.2
1954	Dec.	149	30.3	258	38.4	0	0
55	Jan	190	31.1	265	50.4	45.4	33.8
	Feb	219	31.8	271	59.3	59.3	39.8
	Mar	243	31.6	269	65.4	65.4	48.7
	Apr.	270	31.4	267	72.1	72.1	51.9
	May	280	31.4	267	74.8	74.8	55.7
						317.0	229.9
1955	Dec.	149	29.2	248	37.0	0	0
56	Jan	198	30.7	261	51.7	0	0
	Feb	236	32.0	273	64.4	64.4	43.3
	Mar	231	31.8	271	62.6	62.6	46.6
	Apr	262	31.7	270	70.7	70.7	50.9
	May	330	31.5	268	88.4	0	0
						197.7	140.8
1956	Dec.	150	30.8	262	39.3	0	0
57	Jan	196	31.0	264	51.7	0	0
	Feb	220	32.0	273	60.1	60.1	41.8
	Mar	233	31.8	271	63.1	63.1	46.9
	Apr	251	31.6	269	67.5	67.5	48.6
	May	273	31.5	268	73.2	74.2	55.2
						264.9	192.5
1957	Dec.	157	30.2	256	40.2	0	0
58	Jan.	196	31.0	264	51.7	0	0
	Feb	221	32.0	273	60.3	60.3	40.5
	Mar	248	31.8	271	67.2	67.2	50.0
	Apr.	272	31.6	269	73.2	73.2	52.7
	May	314	31.1	265	83.2	83.2	61.9
						283.9	205.1
1958	Dec	153	30.8	262	40.1	0	0
59	Jan	195	31.9	272	53.0	53.0	39.4
	Feb.	219	31.8	271	59.3	59.3	39.8
	Mar	237	31.6	269	63.8	63.8	47.5
	Apr	256	31.1	265	67.8	67.8	48.8
	May	264	30.4	258	68.1	68.1	50.7
						312.0	226.2
1959	Dec	147	30.6	260	39.7	0	0
60	Jan	193	31.2	266	51.3	51.3	38.2
	Feb.	232	31.8	271	62.9	62.9	42.3
	Mar.	246	31.6	265	65.2	65.2	48.5
	Apr	265	31.4	267	70.8	70.8	51.0
	May	270	29.8	253	68.3	68.3	50.8
						318.5	130.8
1960	Dec.	165	29.9	254	41.9	0	0
61	Jan	201	31.0	264	53.1	6.0	4.5
	Feb.	219	31.1	265	58.0	58.0	40.4
	Mar	243	30.5	259	62.9	62.9	46.8
	Apr.	270	29.4	249	67.2	67.2	48.4
	May	280	27.9	237	66.4	0	0
						194.1	130.1
1961	Dec.	149	29.5	251	37.4	0	0
62	Jan	192	30.6	260	49.9	0	0
	Feb	219	31.3	267	58.5	36.8	24.7
	Mar	243	31.6	269	65.4	65.4	48.7
	Apr	270	31.4	267	72.1	72.1	51.9
	May	280	30.4	258	72.2	0	0
						174.3	125.3
1962	Dec.	174	30.1	256	44.5	0	0
63	Jan	205	31.1	265	54.3	30.5	22.7
	Feb	225	31.8	271	61.0	61.0	41.0
	Mar	243	31.6	269	65.4	65.4	48.7
	Apr	270	31.4	267	72.1	72.1	51.9
	May	280	31.0	264	73.9	73.9	55.0
						302.9	219.3
1963	Dec.	149	29.5	251	37.4	0	0
64	Jan	183	30.8	262	47.9	0	0
	Feb	219	31.3	267	58.5	58.5	39.3
	Mar	243	31.0	264	64.2	64.2	47.8
	Apr	270	29.9	254	68.6	68.6	49.4
	May	280	28.0	237	66.4	0	0
						191.3	136.5
1964	Dec	155	29.2	248	38.4	0	0
65	Jan	142	30.7	261	37.1	0	0
	Feb	219	31.3	267	58.5	58.5	40.7
	Mar.	243	31.6	269	65.4	65.4	48.7
	Apr	270	31.3	267	72.1	72.1	51.9
	May	280	29.7	252	70.6	70.6	52.5
						266.6	193.8
					Annual Average	250.2	173.5



DETAIL Y
TYPICAL SECTION
SECTION H-H
PLAN
MEKONG RIVER
Flood flow
Earthfill levee
SECTION G-G
SECTION F-F
Fish Ladder
ELECTRIC POWER DEVELOPMENT CO., LTD. (E.P.D.C.) TOKYO JAPAN
Fig L-4
SHEET NO
REVISION

L-3 Fish Ladder fo Sambor Dam

L-3-1 General

There are said to be eight varieties of fish including pangasius, cirrhinus and jhynichthys possibly migrating up the Mekong River, passing the Samboc Rapids and going further upstream. These fish are important economically to the inhabitants along the river.

It is not presently known how far upstream these fish migrate in the high-water season (spawning season) and how far downstream the fry go in the low-water season. Naturally, it is thus difficult to estimate the disadvantages in blocking the natural migration of fish at upstream and downstream by the dam.

However, since fish is presently the sole protein source of the inhabitants along the river, a study was made of facilities for passage of fish at the dam.

As passage facilities, locks would be most suitable. However, since the habits of the fish are unknown and construction costs of locks would be high, fish ladders have been considered, instead.

Since fish have the habit of avoiding the main current when swimming upstream, fish ladders will be constructed along both sides of the spillway.

L-3-2 Structure

The fish ladders will be made of reinforced concrete as shown in Fig. L-4. The effective width of one ladder will be 30 m, and the gradient will be 1/15 with an 0.4 m step every 6 m.

At the upstream end, gates (5 m x 6 units x two locations) will be installed which can be closed at times of abnormal flood (water level above 40 m).

Also, in order to accommodate fluctuations in water level of the reservoir, the crest elevation of the upstream ends will be set at three different heights of 39.8 m, 39.4 m and 39.0 m, and to further control the overflow depth of water (standard 0.2 m), stoplogs will also be provided.

Water discharged annually during the approximately 10 months from June to around March from the two fish ladders will be an average of 12 cu.ms.

Although no water will be passed down the fish ladders in the dry months of April–May, since this is not a season when fish migrate, it will not create any problem.

L-3-3 Preliminary Estimate of Construction Cost

The preliminary estimate of construction costs are shown in Table L-3.

Table L-3 Preliminary Estimate of Construction Cost

	Unit	Amount	Unit Cost ($)	Construction Cost ($)
Excavation, Common	cu.m	860,000	0.6	516,000
Embankment of Rockfill	cu.m	730,000	0.2	146,000
Concrete	cu.m	93,000	20	1,860,000
Cement	ton	25,000	45	1,125,000
Reinforcement Bar	ton	400	240	96,000
Gate	ton	80	1,230	98,400
Bridge	ton	230	1,000	230,000
Other Works	L.S			100,000
Contingency	L.S			628,600
Subtotal				4,800,000
Engineering Fee				200,000
Total				5,000,000