GOVERNMENT OF MALAYSIA
LEMBAGA LETRIK SABAH
(SABAH ELECTRICITY BOARD)

FEASIBILITY STUDY REPORT
ON
TENOM PANGI HYDROELECTRIC POWER DEVELOPMENT PROJECT, PHASE III
(SOOK RESERVOIR)

VOLUME I

MAIN REPORT

SEPTEMBER 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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LIST OF REPORTS

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PREFACE

It is with great pleasure that I present this Feasibility Study Report on the Tenom Pangi Hydroelectric Power Development Project, Phase III (Sook Reservoir) to the Government of Malaysia.

This report embodies the result of a field survey which was carried out in the State of Sabah, from June to November, 1985 by a 14-man survey team sent to Malaysia by Japan International Cooperation Agency following the request of the Government of Malaysia to the Government of Japan.

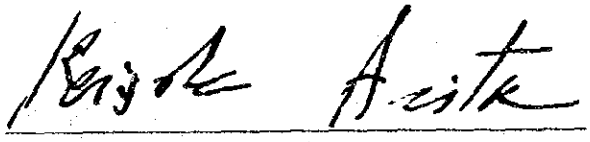
The survey team, headed by Mr. Seiichi Omura, Nippon Koei Co., Ltd., held a series of close discussions with the officials concerned of the Government of Malysia and conducted a wide scope of field survey.

After the team returned to Japan, further studies were made and the present report has been completed.

I hope that this report will be useful as a basic reference for the project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Malaysiea for their close cooperation extended to the team.

September 1986



KEISUKE ARITA
President
Japan International Cooperation Agency

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LEGEND

- INTERNATIONAL BOUNDARIES
- AIRFIELDS
- RIVER
- ROAD

KEY MAP

JAPAN
PACIFIC OCEAN
PHILIPPINES
MALAYSIA
INDONESIA
AUSTRALIA

SOUTH CHINA SEA
SULU SEA
BRUNEI
SARAWAK
KALIMANTAN TIMUR INDONESIA

WEST COAST RESIDENCY
INTERIOR RESIDENCY
SANDAKAN RESIDENCY
TAWAU RESIDENCY

PULAU BANGGI
KUDAT
MARUDU B.
KOTA BELUD
TUARAN
KOTAKINABALU
PAPAR
P. LABUAN
BEAUFORT
KENINGAU
TENOM
SOOK
SIPITANG
BRUNEI BAY
LABUK BAY
SANDAKAN
LAHAD DATU
DARVEL BAY
TAWAU
PULAU SEBATIK

115° 116° 117° 118° 119°
7° 6° 5° 4°

SCALE 0 100Km
(1: 2,000,000)

TENOM PANGI PHASE III

LOCATION MAP

SEB / JICA

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

1. Along with steadily growing economy of Sabah with about 7.2 per cent of annual increase rate for past 10 years from 1975 to 1985, electric power demand of Sabah has grown up with an average of more than 12 per cent per annum for the same period. In 1984 the peak demand reached at 120 MW and energy sold at 503 GWh.

2. The Sabah Electricity Board (SEB) forecasts that the powr demand of whole Sabah will reaches at 210 MW in peak demand in 1990 and 520 MW in 2000, of which the demand for west coast area including capital city of Kota Kinabalu, where is planned to be integrated into one transmission and distribution network in near future, is estimated at 130 MW in 1990 and 300 MW in 2000.

3. To cope with the increasing power demand, the Tenom Pangi hydropower project was realized. The Tenom Pangi project is the first major hydropower project in Sabah. It has an installed capacity of 66 MW in total. At present, the Tenom Pangi power station is supplying power to a part of the west coast area including Kota Kinabalu.

4. Because of topographical features, the Tenom Pangi power station is designed as a run-of-river type hydro plant. During low flow periods, therefore, its power generation falls down considerably.

5. The sook reservoir and power station known as Tenom Pangi Project Phase III, are proposed as a supporting facility for the Tenom Pangi power station. It is situated upstream of the Tenom Pangi power station. Storing water in the reservoir and releasing it during low flow periods, the Sook reservoir will augment discharge for the downstream Tenom Pangi power station to firm up its power generation.

6. The existing Tenom Pangi project is located at about 100 air km and the proposed Sook reservoir and power station project at about 70 air km south of Kota Kinabalu. The former is on the

Padas main stream and the latter is on the tributary Sook River. Their catchment areas are 7,815 km^2 and 1,705 km^2 respectively.

7. As the result of the preliminary study on the scale of the Sook reservoir and power station, the optimum scale of the Sook reservoir is to have a normal high water level (NHWL) of El. 310 m and an effective storage capacity of 550 x 10^6 m^3. The optimum installed capacity of the Sook power station will be 20 MW. Due to increased streamflow from the Sook reservoir during the low flow period, the existing Tenom Pangi power station is proved to extend its installation by 44 MW, and the total installed capacity is increased to 110 MW. The proposed Sook power station as well as the Tenom Pangi power station are planned to be operated integrally as a central hydro system. Its total installation is 130 MW.

8. As the result of the comparative study on the alternative means of the power supply scheme involving diesel, gas turbine, oil or coal-fired thermal and hydro, the combination of the hydro scheme, namely the Sook-Tenom Pangi hydro system, is proved to be the most recommendable scheme of power supply for its inexpensive project cost and being well matched for the energy policy of Malaysia.

9. Preliminary designs for the optimum scales of the Sook dam and power station as well as the extension of the Tenom Pangi power station are made, and the types and sizes of the principal structures are determined. They are summarized as below:

1) <u>Sook reservoir and power station</u>

- A 70 m high and 345 m long rockfill dam with a 1,000 m^3/s capacity spillway
- Two 600 m long diversion tunnels
- An intake and a 450 m long headrace tunnel with a surge tank
- A 140 m long penstock line
- A power house with two units of 10,000 kW turbine and generator

- 10 km long 132 kV single circuit transmission line
- 18 km long permanent access and relocation roads
- Other structures and related facilities

2) Tenom Pangi power station (extension)

- A preconstructed intake and a 4,200 m long headrace tunnel with a surge tank
- A 220 m long penstock line
- Extension of power house with two units of 22,000 kW turbine and generator (extension only)
- Other structures and related facilities

10. Construction of the Sook dam and power station and the extension of Tenom Pangi power station (Tenom Pangi Project, Phase III), will take 5 years to be completed including preparatory works; Full 5 years for the Sook dam and power station and 4 years for the extension of Tenom Pangi power station. In addition, another 2.5 years will be needed for preconstruction activities including financial arrangement, supplemental investigation, detailed design, tender and contract procedures.

11. Total construction cost of the project excluding price contingency is estimated to be US$ 174,139,000 at 1985/86 price level. This consists of US$ 101,555,000 for the Sook dam and power station and US$ 72,584,000 for the extension of the Tenom Pangi power station. Compensation cost for resettlement from the Sook reservoir area is estimated to be US$ 18,400,000, and it is included in the above construction cost. The existing Tenom Pangi power project required the construction cost of US$ 148,200,000 including the interest paid up to the year 1985.

12. The project benefit is estimated by the power benefit attributable to the Tenom Pangi Project, both cases for the Tenom Pangi Project, Phase III, only and for the integulated Tenom Pangi Project, Phase III, plus existing Tenom Pangi Project, (Phases I, II and III together). The energy output, power generation, annual benefit and its capitalized value to 1989

(project commencement year) using 10 per cent of discount rate and 50 years of project life are summarized as below:

Economic Project Benefit

		Phase III only	Phases I, II, III
1.	Power generation (MW)	71.0	116.0
2.	Energy output (GWh)		
	1) Firm	329.3	660.9
	2) Dump	6.3	190.9
	Total	335.6	851.8
3.	Annual power benefit		
	1) Power benefit (10^3 US$)	9,700 - 16,800	1,400 - 27,500
	2) Energy benefit (10^3 US$)	8,600	8,500 - 19,700
4.	Capitalized to the year of project commencement (10^3 US$)	163,000	432,200

13. The results of economic cost-benefit comparison are summarized as below:

Economic Cost - Benefit Comparison

		Phase III only	Phases I,II,III
1.	Capitalized economic cost (C) : (10^3 US$)	129,104	343,034
2.	Capitalized economic benefit (B) : (10^3 US$)	163,000	432,200
3.	Net benefit (B-C) : (10^3 US$)	33,896	89,166
4.	Benefit-cost ratio (B/C)	1.26	1.26
5.	EIRR : (%)	12.6	13.9

As shown above, the net benefit, benefit-cost ratio and EIRR are enough to conclude that the project is economically feasible.

14. According to the financial statement, debt of the project turns to surplus in the third year for the incremental case (Phase III only) and from the beginning year for the integral case (Phases I, II and III) respectively from the commencement of project operation. The financial internal rate of return (FIRR) is calculated to be 10.8 per cent for Phase III only and 18.3 percent for Phases I, II and III. These figures prove that the project has the sufficient loan repayability and is financially viable.

15. The project is also evaluated from the socio-environmental view points. The results are summarized as below:

1) As for the resettlement, about 2,200 inhabitants in the proposed reservoir area are required to be resettled. However, by such resettlement, no serious problem will occur if adequate administrative arrangement is made to the neighbouring area where potential land for resettlement exists widely.

2) Impact of the project on the natural environment is not significant since the kinds of natural vegetation and wildlife found in the reservoir area are of very popular and widely distributed around the project area, and the scale of the affected area is not so large.

3) It is confirmed by the field investigation that the project will have minimal affect to the water use in the downstream area of the dam. Contrarily, anticipated are some beneficial effects on the socio-environmental aspect such as flood control effect of the reservoir, rural electrification around the project area, increase of opportunity for new recreation and sight-seeing, water sports, etc.

Thus the project is justified from the socio-environmental point of view.

16. Based on the above findings of the feasibility study, the Tenom Pangi Hydroelectric Power Development Project, Phase III, is now proven to be technically feasible, financially and economically viable and socio-environmentally acceptable.

17. Therefore, early realization of the project is hereby recommended. Implementation of the project is recommended to be carried out in the following manners:

1) Engineering design including additional field investigation, detailed design, preparation of tender documents, etc., should be started at the beginning of 1987 so that the project can be commissioned by the end of 1993 to meet expected power demand.

2) Proper procedures for gazetting the reservoir area should be taken now so that new development in the areas can be minimized.

3) Plan for resettlement of the families affected by the proposed project should be undertaken by a committee during the Engineering Study.

4) Preparatory works such as construction of access roads, offices and quarters should be started at the beginning of 1989.

5) Main civil works which require five years to be completed, should be commenced in the middle of 1989.

18. Principal features of the proposed Sook reservoir and power station as well as the extending Tenom Pangi power station are summarized as below:

1) Sook Reservoir and Power Station

(1) Reservoir

•Catchment area:	1,705 km^2
•Annual mean runoff:	29.4 m^3/s
•FWL:	El.311.1 m
•NHWL:	El.310.0 m
• LWL:	El.285.0 m
•TWL:	El.250.0 m
•Sedimentation surface level:	El.277.0 m
•Drawdown:	25.0 m
•Gross storage capacity (at NHWL):	732 x 10^6 m^3
•Effective storage capacity:	550 x $10^6 m^3$
•Reservoir surface area (at NHWL):	35 km^2

(2) Sook Dam

(a) Main dam

•Type:	Rockfill with center core
•Dam height:	70 m
•Crest elevation:	El.314.0 m
•Crest length:	345.0 m
•Crest width:	10 m
•Upstream slope:	1:2.5
•Downstream slope:	1:1.9
•Embankment volume	
Core:	240,000 m^3
Filter:	190,000 m^3
Rock:	1,300,000 m^3
Total:	1,730,000 m^3

(b) Spillway

•Type:	Gated chuteway with stilling basin
•Gate:	Two roller gates, 11.5 m wide x 7.0 m high each
•Capacity:	1,000 m^3/s at FWL 311.1 m

(c) Diversion system

•Type:	Concrete-lined tunnel diversion
•Section:	5.0 m dia. horseshoe section (two lines)
•Length:	579 m for tunnel No.1 and 613 m for tunnel No.2
•Design flood:	410 m^3/s

(d) Saddle dam

•Type:	Homogeneous earthfill
•Dam height:	12 m
•Crest elevation:	El.314.0 m
•Crest length:	1,481 m in total
•Crest width:	6 m
•Upstream slope:	1:3.5
•Downstream slope:	1:3.0
•Embankment volume:	370,000 m^3

(3) Waterway and Powerhouse

(a) Intake

•Type:	Horizontal intake with inclined gate shaft
•Gate:	One roller gate 4.5 m wide x 5.5 m high

(b) Headrace tunnel

•Type:	Concrete-lined pressure tunnel:
•Section:	3.9 m dia. circular section (one line)
•Length:	449 m

(c) Surge tank

•Type:	Restricted orifice type
•Dimension:	12 m dia. x 49 m high

(d) Penstock

•Type:	Surface type with partial tunnel portion
•Dimension:	3.1 m dia. x 139 m long

(e) Powerhouse

•Type:	Surface type
•Dimension:	26.5 m wide x 36.5 m long x 35.5 m high

(4) Generating Equipment

(a) Hydraulic turbine

•Type of turbine:	Vertical shaft Kaplan type
•Gross head:	60 - 35 m
•Rated head:	51 m
•Plant discharge:	47.1 m^3/s
•Installed capacity:	20 MW = 10 MW x 2 units
•Turbine rated speed:	429 rpm (provisional)

(b) Alternating current generator

•Type of generator:	Three phase vertical shaft synchronous generator
•Capacity:	11.5 MVA x 2 units
•Rated speed:	429 rpm (provisional)
•Terminal voltage:	11 kV
•Frequency:	50 Hz

(c) Main transformer

•Type:	Three phase, 50 Hz, oil immersed self-cooled/forced-oil-circulation with cooling fan

•Rated output:	11.5/23 MVA
•Voltage:	11/132 kV

(d) Average annual energy output

Firm:	45.5 GWh
Dump (Secondary):	6.3 GWh
Total:	51.8 GWh

(5) Transmission Line

•Voltage:	132 kV
•Number of circuit	single circuit
•Conductor:	175 mm^2 (Lynx) ACSR
•Length:	10 km to Keningau substation

2) Tenom Pangi Power Station (Extension)

(1) Pondage

•Catchment area:	7,815 km^2
•Annual mean runoff:	210 m^3/s
•NHWL:	El.173.9 m
•LWL:	El.170.7 m
•TWL:	El. 99.2 m
•Drawdown:	3.2 m
•Effective storage capacity:	4.7 x 10^6 m^3

(2) Waterway and Powerhouse

(a) Intake for extension

•Type:	Intake with underground settling basin
•Gate:	Roller gate
	6.0m wide x 9.0m high x 3 nos

(b) Tunnel

•Type:	Concrete lined pressure tunnel
•Section:	5.2 m dia. circular section (one line)
•Length:	4,200 m

(c) Surge tank

•Type:	Restricted orifice type
•Dimensions:	14 m inside diameter, 60 m high

(d) Penstock line

•Type:	Tunnel type
•Dimensions:	4 m inside diameter 220 m long

(e) Powerhouse

•Type:	Surface type
•Dimension (extension):	26.5m wide x 30.6m long x 40.5m high

(3) Generating Equipment

(a) Hydraulic turbine

•Type of turbine:	Vertical shaft Francis type
•Gross head:	74.7 - 71.5 m
•Net head:	63.1 - 59.9 m
•Maximum plant discharge:	
Extension:	84.9 m^3/s
Existing:	127.3 m^3/s
Total:	212.2 m^3/s
•Installed capacity:	
Extension:	44 MW
Existing:	66 MW
Total:	110 MW
•Turbine rated speed:	300 rpm

(b) Alternating current generator

•Type of generator:	Three phase, vertical shaft, semi-umbrella type synchronous generator
•Capacity:	25 MVA
•Terminal voltage:	11 kV
•Frequency:	50 Hz
•Rated speed:	300 rpm
•Power factor:	0.88 (lagging)

(c) Main transformer

•Type:	Three phase, 50 Hz, oil immersed, self-cooled/forced-oil-circulation with cooling fans
•Rated output:	12.5/25 MVA
•Voltage:	11/132 kV

(d) Average annual energy output

Firm:	283.8 GWh
Dump (Secondary):	-
Total:	283.8 GWh

(4) Penampang Substation

(a) Main transformer

•Type:	Three phase, 50 Hz, oil-immersed, self-cooled/forced-oil-circulation with cooling fans
•Rated output:	12/24 MVA
•Voltage:	132/66 kV

(b) Static capacitor

•Capacity:	40 MVA (Provisional)
•Voltage:	66 kV

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ABBREVIATIONS

(1) Domestic Organization

DID (JPT)	:	Drainage and Irrigation Department
DOA (JP)	:	Department of Agriculture
EPU	:	Economic Planning Unit
MMS	:	Malaysian Meteorological Service
SEB (LLS)	:	SABAH ELECTRICITY BOARD
SEDC	:	State Economic Development Corporation
SEPU	:	State Economic Planning Unit

(2) International or Foreign Organization

JICA	:	Japan International Cooperation Agency

(3) Measurement

Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer

Area

ha	=	hectare
km^2	=	square kilometer

Volume

l	=	liter
m^3	=	cubic meter
cft	=	cubic feet

Weight

kg	=	kilogram
ton	=	metric ton

Time

sec, s	=	second
min	=	minute
hr	=	hour
yr	=	year
SST	=	Sabah Standard Time

Electrical Measures

V	=	Volt
kW	=	Kilowatt
MW	=	Megawatt
kWh	=	Kilowatt hour
MWh	=	Megawatt hour
GWh	=	Gigawatt hour

Money

M$	=	Malaysian dollar
M¢	=	Malaysian cent
US$	=	US dollar
US¢	=	US cent
¥	=	Japanese Yen

Other Measures

%	=	per cent
o	=	degree
'	=	minute
"	=	second
m^3/sec, m^3/s	=	cubic meter per second
cusec	=	cubic feet per second

(4) Economy and Finance

EIRR	:	Economic Internal Rate of Return
FIRR	:	Financial Internal Rate of Return
FC	:	Foreign Currency
LC	:	Local Currency
GDP	:	Gross Domestic Product
GRDP	:	Gross Regional Domestic Product
OMR	:	Operation, Maintenance and Replacement
L.S.	:	Lump Sum

(5) Other Abbreviations

El.	:	Elevation above mean sea level
NHWL	:	Normal high water level
HWL	:	High water level
LWL	:	Low water level

1. INTRODUCTION

1.1 Project History

Tenom Pangi Hydroelectric Power Development Project, Phase III (Sook Reservoir) was first proposed in the Feasibility Study of the Padas River Hydroelectric Power Development Project.[1/] It is planned to augment to low flow of the Padas River during the low flow periods and to firm up power generation at the Tenom Pangi power station which was completed in 1984 and started commercial operation. At the proposed Sook damsite another hydro power station is also planned to be constructed for power generation.

In 1983 the Government of Malaysia requested the Government of Japan for implementation of the feasibility study for the Sook Reservoir Project or the Tenom Pangi, Phase III, Project. In response to it, the Government of Japan decided to extend the technical assistance for the Project and appointed the Japan International Cooperation Agency (JICA) to carry out the feasibility study of the Project.

In October 27, 1984, "Scope of Work for Feasibility Study on Tenom Pangi Hydroelectric Power Development Project, Phase III (Sook Reservoir)" was agreed upon between the Economic Planning Unit (EPU) of the Prime Minister's Department of the Government of Malaysia and JICA, and the work was promised to be implemented by the JICA survey team in cooperation with SEB counterpart engineers for about 18-month period from mid-March 1985 to mid-September 1986.

1/: "A Feasibility Report on the Padas River Hydroelectric Power Development (Asian Development Bank)", prepared by Nippon Koei Co., Ltd., February 1974

For the commencement of the study JICA despatched the 6-member survey team to the site for preliminary investigation in March 1985, and the "Inception Report"[2/] was prepared as the result of the survey and study of the preliminary investigation stage. In June 1985, JICA despatched again the 14-member survey team headed by the team leader Mr. S. Omura to the site for detailed field investigation such as ground surveying, geotechnical, hydrological and environmental surveys, etc. as well as the studies on the project conditions and requirements, power market situation, project plan formulation, etc. Whole of the field investigation and studies were successfully completed in cooperation with the SEB counterpart engineers by the end of November 1985.

Home office works have been carried out in the survey team's Tokyo head office from November 1985 to June 1986 by the experts so assigned including two SEB staffs sent from Malaysia to join the survey team, and all the works of the feasibility study for the Project were completed.

"Feasibility Study Report on the Tenom Pangi Hydroelectric Power Development Project, Phase III (Sook Reservoir)" is prepared to summarize the results of field investigation and studies conducted up to the date, and shows the basic concept of the development of the Project and its viability.

2/ : "Inception Report for Feasibility Study on Tenom Pangi Hydroelectric Power Development Project, Phase III (Sook Reservoir)", by JICA, March, 1985.