MALAYSIA

FEASIBILITY STUDY ON SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN IN SABAH

FINAL REPORT

MAIN REPORT

OCTOBER, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of Malaysia, the Government of Japan decided to conduct a feasibility study on Small Scale Hydroelectric Development Project at Upper Liwagu River Basin in Sabah and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Malaysia a study team headed by Mr. Tokuji Tezuka of Electric Power Development Company, Ltd. seven times during the period from July 1991 to September 1992.

The team held discussions on the project with officials concern of the Government of Malaysia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

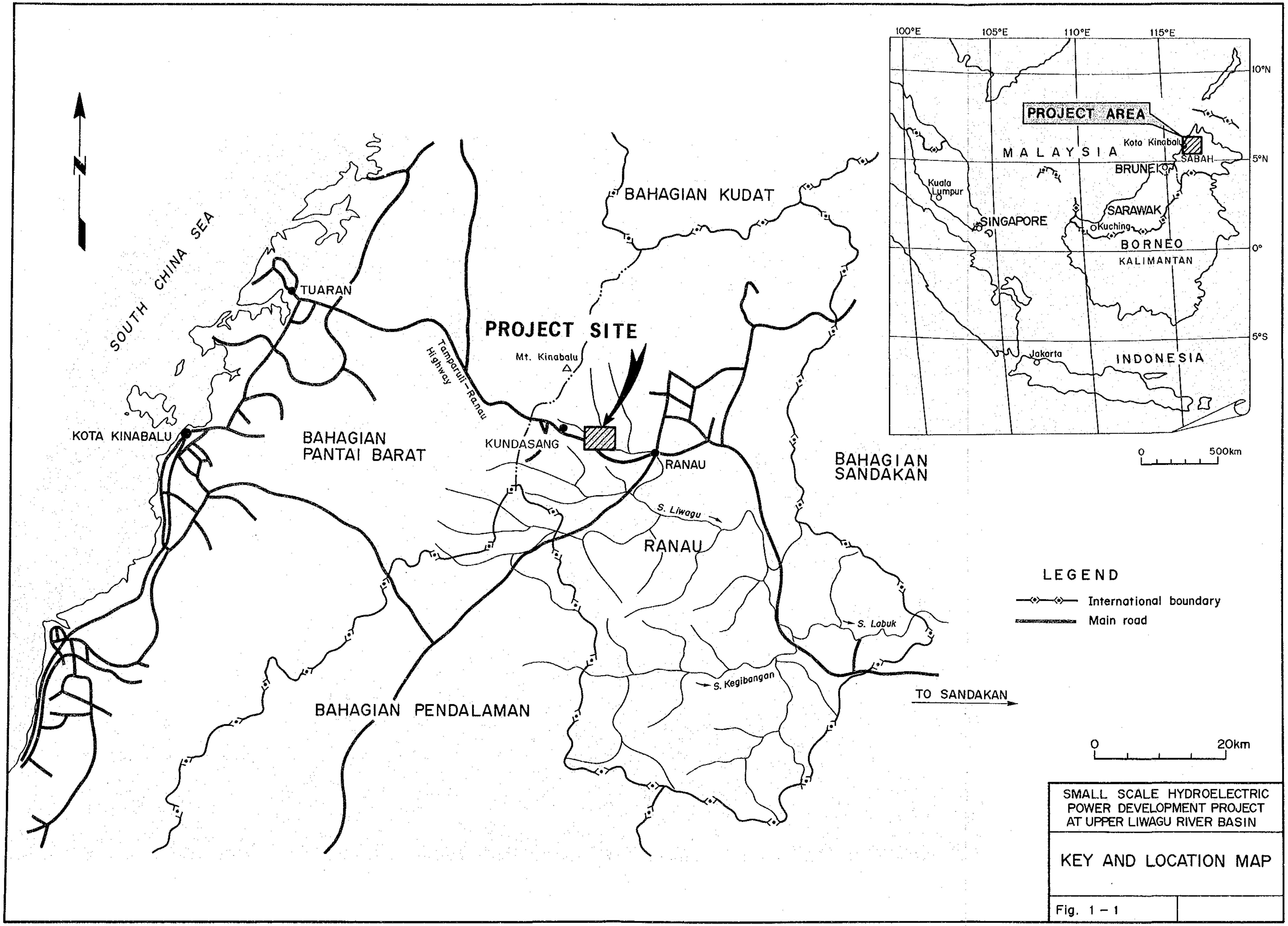
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

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

October 1992

Kensuke Yanagiya

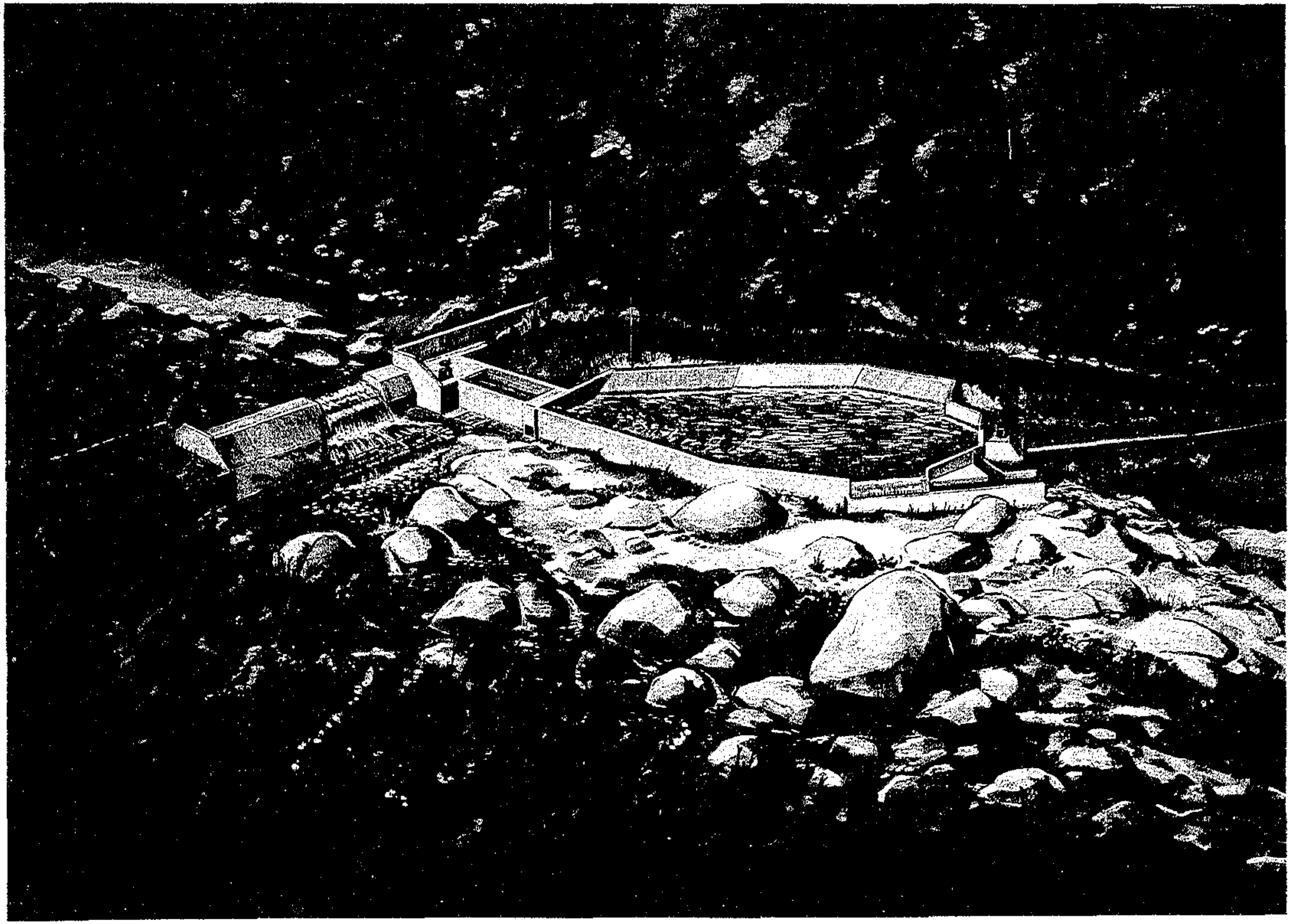
Kensuke Yanagiya
President
Japan International Cooperation Agency



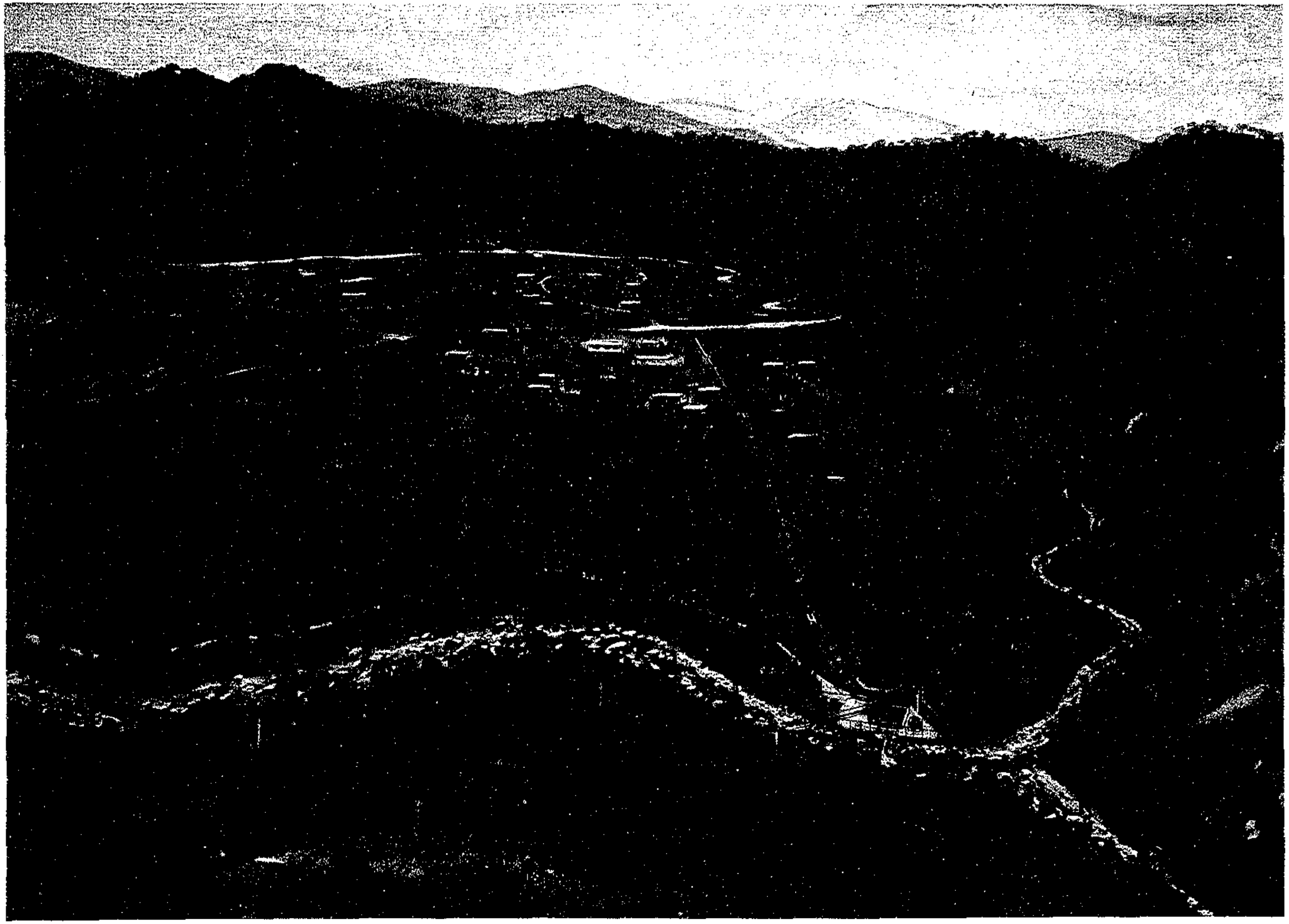
SMALL SCALE HYDROELECTRIC POWER DEVELOPMENT PROJECT AT UPPER LIWAGU RIVER BASIN

KEY AND LOCATION MAP

Fig. 1 – 1



Liwagu Intake Facility



Penstock and Powerhouse

Photo-1 Liwagu Intake Dam
(View from upstream)

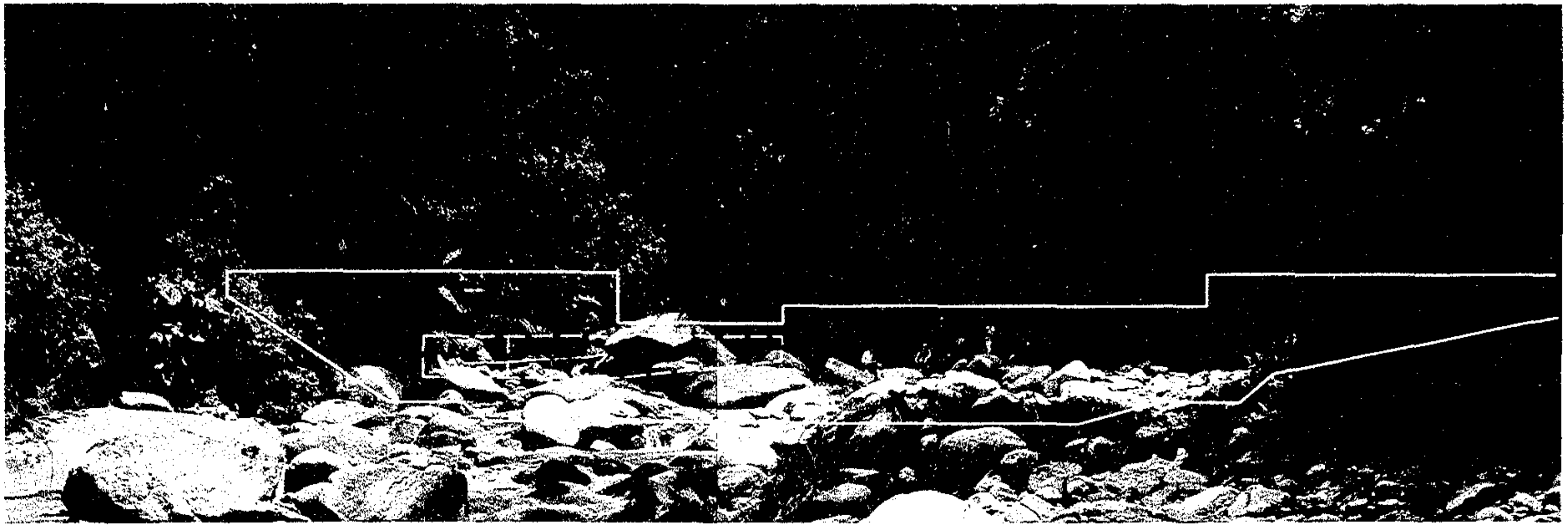


Photo-2 Mesilau Intake Dam
(View from dounstream)

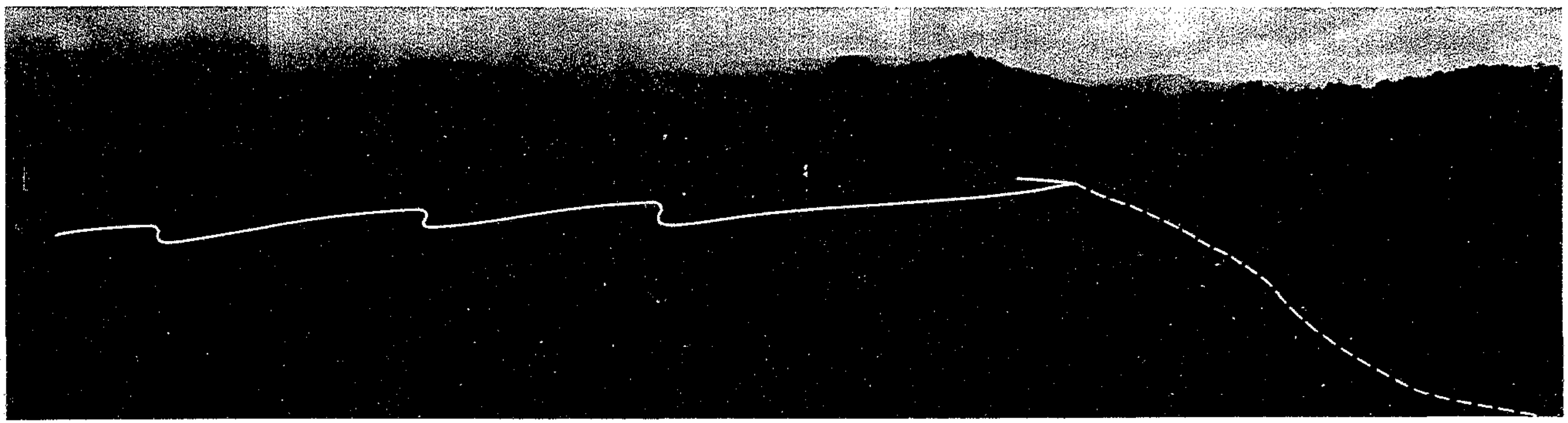


Photo-3 Liwagu Pipeline and Penstock

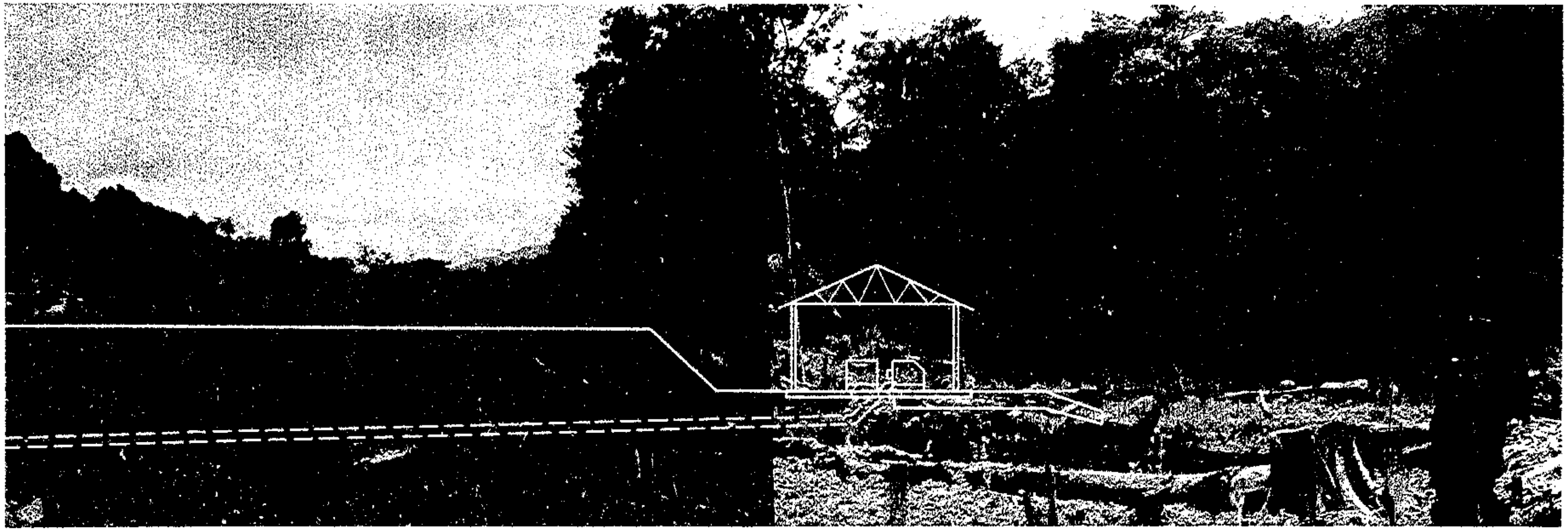


Photo-4 Powerhouse

CONTENTS

			Page
	SUMMARY		S - 1
	CONCLUSION AND RECOMMENDATION		S - 13
Chapt.			
1.	INTRODUCTION		1 - 1
	1.1	Preface	1 - 1
	1.2	History	1 - 1
	1.3	Objectives and Scope of Study	1 - 2
		1.3.1 Objectives of Study	1 - 2
		1.3.2 Object Area of Study	1 - 3
		1.3.3 Scope of Study	1 - 3
		1.3.4 Contents of Work	1 - 3
	1.4	Field Survey	1 - 5
	1.5	Personnel Related Study	1 - 6
	1.6	Collected Data	1 - 10
2.	GENERAL CONDITION OF SABAH STATE		2 - 1
	2.1	General Situation in Sabah State	2 - 1
	2.2	General Situation in Ranau Area	2 - 1
3.	PRESENT STATE OF ELECTRIC UTILITY INDUSTRY		3 - 1
	3.1	General	3 - 1
	3.2	Electric Power Development Program and Rural Electrification Policy in Sabah State	3 - 2
		3.2.1 Electric Power Development Program of Sabah State	3 - 2
		3.2.2 Rural Electrification Rate	3 - 3
	3.3	Electric Power Situation in Ranau Area	3 - 7

Page

3.3.1 Power Supply Facilities . . . . 3 - 8
3.3.2 Present State of Power Demand . . . . 3 - 12

4. POWER DEMAND FORECAST . . . . 4 - 1

4.1 Fundamental Conditions . . . . 4 - 1
4.1.1 Data and Survey of Present Situation . . . . 4 - 1
4.1.2 Service Area . . . . 4 - 2
4.1.3 Method of Estimating Potential Demand . . 4 - 3
4.2 Present State of Demand in Project Area . . . . . . 4 - 5
4.3 Forecasting Method . . . . 4 - 6
4.3.1 Basic Considerations . . . . 4 - 6
4.3.2 Parameters Required in Load Forecasting . 4 - 7
4.4 Result of Power Demand Forecast . . . . 4 - 8
4.4.1 Power Demand of Object District According to Increase in Unit Requirement and Electrification Rate . . . . 4 - 8
4.4.2 Unit Requirement of Object District and Comparisons with Other Districts . . . 4 - 13
4.4.3 Correlation between West Coast Grid and Ranau-Kundasang Grid . . . . 4 - 14
4.5 Timing of Development of Naradaw Small Hydroelectric Project . . . . 4 - 19
4.5.1 Basic Considerations . . . . 4 - 19
4.5.2 Timing of Development of Naradaw Small Hydroelectric Project . . . . 4 - 20
4.5.3 Saving in Diesel Fuel Cost . . . . 4 - 21

5. SITE SELECTION . . . . 5 - 1

5.1 Development Basic Concept . . . . 5 - 1
5.1.1 Basic Concept . . . . 5 - 1
5.1.2 Alternative Schemes . . . . 5 - 6
5.1.3 Study Procedure . . . . 5 - 7

Page

5.2	Study on Alternative Schemes		5 - 10
	5.2.1	Naradaw Site	5 - 10
	5.2.2	Gantong Site	5 - 14
	5.2.3	Pakai Site	5 - 17
	5.2.4	Kauluan Site	5 - 20
	5.2.5	Lamas Site	5 - 22
5.3	Selection of Optimum Site		5 - 25
5.4	Subjects to be Studied		5 - 26
6.	TOPOGRAPHIC MAPS		6 - 1
6.1	Existing Maps		6 - 1
6.2	Topographical Survey		6 - 1
7.	GEOLOGY		7 - 1
7.1	Outline of Investigation		7 - 1
	7.1.1	Field Investigations	7 - 1
	7.1.2	Geological Investigation Works	7 - 2
	7.1.3	Existing Data	7 - 3
7.2	Regional Geology		7 - 6
	7.2.1	Topography	7 - 6
	7.2.2	Geology	7 - 7
7.3	Geological Outline of Naradaw Area		7 - 11
	7.3.1	Topography	7 - 11
	7.3.2	Geology	7 - 11
7.4	Geology of Projects Site		7 - 13
	7.4.1	Liwagu Intake Facility Site	7 - 13
	7.4.2	Mesilau Intake Facility Site	7 - 16
	7.4.3	Liwagu Pipeline Route	7 - 18
	7.4.4	Mesilau Pipeline Route	7 - 21
	7.4.5	Penstock Route	7 - 23
	7.4.6	Powerhouse Site	7 - 25
7.5	Seismicity		7 - 26

Page

7.5.1 Geological Structure . . . . 7 - 26

7.5.2 Seismicity . . . . 7 - 27

8. METEOROLOGY AND HYDROLOGY . . . . 8 - 1

8.1 Meteorological Profile in the State of Sabah . . 8 - 2

8.1.1 General Conditions in the State of Sabah . 8 - 2

8.1.2 Precipitation and Temperature in the State of Sabah . . . . 8 - 2

8.2 Meteorology and Hydrology in the Upper Liwagu River Basin . . . . 8 - 4

8.2.1 Outline of the Liwagu River Basin . . . . 8 - 4

8.2.2 Meteorological and Hydrological Survey at the River Basin and its Vicinity . . . . 8 - 5

8.2.3 Precipitation in the River Basin . . . . . 8 - 5

8.3 Discharge at the Project Site . . . . 8 - 7

8.3.1 Discharge Calculation Method . . . . 8 - 7

8.3.2 Discharge Data at Bedukan Gauging Station . . . . 8 - 7

8.3.3 Result of Discharge Data Supplementation . 8 - 8

8.3.4 Calculated Discharge . . . . 8 - 9

8.4 Flood Discharge in the Project Site . . . . 8 - 11

8.4.1 Method of Flood Discharge Calculation . . 8 - 11

8.4.2 Calculated Flood Discharge . . . . 8 - 11

8.5 Sediment Load in Project Site . . . . 8 - 12

8.5.1 General Outline of the Resources of Sediment Load in the Upper Reaches of the Liwagu River . . . . 8 - 12

8.5.2 Estimation of Sediment Inflow . . . . 8 - 12

9. SELECTION OF OPTIMUM PLAN . . . . 9 - 1

9.1 Outline . . . . 9 - 1

Page

	9.2	Development Basic Concept	9 - 3
	9.3	Optimization Method	9 - 4
	9.4	Optimum Plan	9 - 7
		9.4.1 Optimum Net Head	9 - 7
		9.4.2 Optimum Installed Capacity (Maximum Discharge)	9 - 8
		9.4.3 Study on Commissioning Year	9 - 10
	9.5	Characteristics of Output and Energy	9 - 13
		9.5.1 Saleable Energy of the Naradaw Scheme . .	9 - 13
		9.5.2 Supply Capable Output of Hydro	9 - 14
		9.5.3 Monthly and Annual Energy of Naradaw . . .	9 - 14
10.	POWER TRANSMISSION LINE PLAN		10 - 1
	10.1	Selection of Power Transmission Pattern	10 - 1
	10.2	Principal Specifications of Transmission Line . .	10 - 3
	10.3	Transmission Line Route	10 - 6
11.	PRELIMINARY DESIGN		11 - 1
	11.1	Outline of Preliminary Designs	11 - 1
	11.2	Civil Structure	11 - 5
		11.2.1 Intake Dam	11 - 5
		11.2.2 Intake Section	11 - 18
		11.2.3 Desilting Basin	11 - 19
		11.2.4 Headpond	11 - 22
		11.2.5 Pipeline	11 - 26
		11.2.6 Penstock	11 - 33
		11.2.7 Power Station	11 - 37
		11.2.8 Access Road	11 - 38
	11.3	Electrical Equipment	11 - 40
		11.3.1 Basic Design Conditions	11 - 40
		11.3.2 Study Results	11 - 42

Page

12.	CONSTRUCTION PLAN		12 - 1
	12.1	Local Conditions	12 - 1
	12.2	Construction Plan	12 - 1
		12.2.1 Intake Facility	12 - 1
		12.2.2 Pipeline	12 - 4
		12.2.3 Penstock	12 - 5
		12.2.4 Powerhouse	12 - 7
		12.2.5 Electro-mechanical Equipment	12 - 7
	12.3	Condition for Transportation	12 - 8
	12.4	Construction Schedule	12 - 9
13.	COST ESTIMATION		13 - 1
	13.1	Construction Cost	13 - 1
		13.1.1 Basic Policy	13 - 1
		13.1.2 Reference of Estimate	13 - 1
		13.1.3 Estimate of Construction Cost	13 - 2
		13.1.4 Totals of Construction Costs	13 - 4
	13.2	Scheduling of Yearly Disbursement	13 - 5
14.	ENVIRONMENTAL IMPACT STUDY		14 - 1
	14.1	Outline	14 - 1
	14.2	Environmental Impact Study	14 - 3

Page

15. ECONOMIC AND FINANCIAL ANALYSES . . . . 15 - 1

15.1 Economic Evaluation . . . . 15 - 1
15.1.1 Outline . . . . 15 - 1
15.1.2 Method of Economic Analysis and Basic Assumptions . . . . 15 - 1
15.1.3 Cost . . . . 15 - 7
15.1.4 Benefit . . . . 15 - 8
15.1.5 Economic Evaluation . . . . 15 - 11
15.1.6 Sensitivity Analysis . . . . 15 - 14
15.2 Financial Analysis . . . . 15 - 15
15.2.1 Outline . . . . 15 - 15
15.2.2 Methods of Financial Analysis . . . . . . 15 - 16
15.2.3 Basic Conditions of Financial Analysis . . 15 - 17
15.2.4 Results of Financial Analysis . . . . 15 - 24
15.2.5 Average Generating Cost over Whole Operating Years . . . . 15 - 35

List of Appendixes

Volume I

Appendix 1	Topographic Survey Results
Appendix 2	Geological Investigation Data
Appendix 3	Meteorological and Hydrological Data
Appendix 4	Development Plan Data
Appendix 5	Permissible Transmission Capacity for 11 kV Existing Interconnection Line Ranau-Kundasang Grid
Appendix 6	Preliminary Design
Appendix 7	Construction Costs
Appendix 8	Environmental Impact Study
Appendix 9	Technical Specifications
Appendix 10	Further Investigation
Appendix 11	Operation Data of Carabau Hydroelectric Power Station

Volume II

Appendix 12	Technical Transfer

SUMMARY

SUMMARY

1. INTRODUCTION

This Report summarizes the results of the Feasibility Study on Small Scale Hydroelectric Power Development at Upper Liwagu River Basin in Sabah, Malaysia.

The Feasibility study was carried out in response to the request of the Government of Malaysia to the Japan Government. The Scope of Works for the Study was agreed upon between the Economic Planning Unit (EPU) on behalf of the Government of Malaysia and the Japan International Cooperation Agency (JICA) on March 13, 1991.

JICA entrusted the Electric Power Development Co., Ltd. (EPDC), Japan, to perform the study on the basis of the Scope of Works.

The JICA Study Team, headed by Mr. T. Tezuka, Team Leader, started the preparatory works for the study in July 1991. First, the Inception Report was prepared. The Report contained the policy of the study, method of the study, division of the technical undertakings between the EPU and the JICA. In the Report, the Study Team divided the study period into three stages on the basis of the Scope of Works, namely, Identification Stage, Field Investigation Stage and Preliminary Design Stage. Second, the site reconnaissances were carried out to select the optimum site for the project and prepared the Interim Report in September 1991. Third, the field investigation works were carried out at the selected site and the Progress Report prepared in March 1992. Finally, development plan and preliminary design were carried out. All study works were completed in July 1992.

The study was mainly performed at the Sabah Electricity Board (SEB) together with counterparts in SEB. During the study, technical transfer including seminars (by JICA and the Study Team) was given to SEB's engineers.

2. Study Results

2.1 Present State of Electric Facility in Ranau Area

Ranau area, to become the object area of the Small Scale Hydropower Development Project, is an isolated area in the power grid, and is approximately 170 km^2 spread out on the southeast side of Mt. Kinabalu (EL. 4,101 m), centered at Kundasang Town located at El. 1,500 m and Ranau Town located at EL. 500 m. The population of this area is estimated to have been approximately 32,600 as of the end of 1990, of which those receiving supply of electric power was 15,100 (2,960 customers x 5.1 capital/customer), from which, if the electrification rate were to be calculated, would correspond to an electrification rate of 46.3%.

The power demand of the installed Ranau-Kundasang Grid was 1,330 kW and the number of customers 2,960 as of the end of 1990. Electric power is being supplied to those customers by 11 kV HV transmission lines and 415 V/240 V distribution lines.

The electric power supply facilities are mainly the diesel power generation facility at Ranau (effective capacity: 1,120 kW) and the diesel power generation facility at Kundasang (effective capacity: 660 kW), while there is also Carabau Mini-hydro power station (installed capacity: 2,000 kW) which started operation in January 1991. Hence the total effective capacity of power generating facilities is 3,780 kW. Furthermore, three Mesilau Mini-hydro power stations (100 kW x 3) were completed at Kundasang from 1983 to 1984, but all three are presently stopped due to landsliding which occurred in 1985. SEB put out repairs of the three Mini-hydro power stations and the repair works are scheduled to be completed around the end of 1992.

2.2 Power Demand Forecast

Ranau-Kundasang Grid had 2,960 customers (an electrification rate of 46.3% at the end of 1990. It was thought the number of potential customers would be as many as 3,430. The Grid also has been 6,025 MWh of annual energy and 1,330 kW of annual maximum demand.

The power demand forecast for the Ranau-Kundasang Grid was made based on the two parameters of unit requirement (electric energy consumption per customer) and electrification rate taking into account the present state of electrification of the object district.

As the result of power demand forecast, the followings were obtained.

Year	Number of Customers Electrified	Annual Energy Requirement (kWh)	Annual Maximum Demand (kW)
1995	4,260	11,583	2,520
2000	5,620	18,958	3,930
2005	6,920	27,064	5,620
2010	8,480	36,585	7,590
2015	9,630	43,617	9,050

The optimum timing of commissioning the Naradaw project (1,600 kW) was determined in 1997 taking into consideration the power demand balance of kWh and kW.

By commissioning Naradaw project, the following fuel oil cost saving of the diesel power stations will be expected.

	1997	2000	after 2009
Oil saving (M$)	842,000	1,338,000	1,764,000
Naradaw P/S Generation (MWh)	4,600	7,300	9,500

2.3 Site Selection

An optimum site for the small scale hydropower development was selected by two basic concepts. First, the site does not prevent the construction of the major hydro project (165 MW) which is located at the middle stream of the Liwagu River. Second, the optimum site and alternative scheme were studied in consideration of the power demand forecast, the role of hydropower and diesel power.

The Team reviewed 20 sites taking into account requirements for small scale hydro plants to meet future demand in Ranau area; then chose 5 sites and 6 development plans to be studied in detail. They are Kualuan, Naradaw, Gantong A, Gantong B, Pakai and Lamas 2.

As the result of comprehensive study. Naradaw site was selected for the optimum site (hereinafter referred to as Naradaw project).

2.4 Topographic Maps

Existing topographic maps available for use in study of the project are of scale 1/50,000, 1/12,500 and 1/2,500.

For preliminary designing to be carried out on the selected project site, topographic maps of 1/500 scale around the main structures were made through topographic survey in the Field Investigation Stage. JICA Team prepared Technical Specifications for the topographic survey works and advised the survey works. The following areas were surveyed for the topographic maps of the scale 1/500.

▪ Intake dam site at Liwagu River	0.014 km^2
▪ Intake dam site at Mesilau River	0.015 km^2
▪ Penstock and Powerhouse sites	0.115 km^2

2.5 Geology

Regional geology and geology of project sites were studied using the existing geological information. Geological investigation works such as drilling, geological mapping were carried out at the selected sites in the Field Investigation Stage to get geological information for the preliminary design of main structures. JICA Team prepared the Technical Specifications for the geological investigation works and advised the works.

The following geological investigations were carried out.

Site	Description	Quantity
Liwagu intake	Drilling	2 holes, 30 m
Mesilau intake	Drilling	2 holes, 30 m
Headpond (Alternative)	Drilling	2 holes, 40 m
Penstock	Drilling	2 holes, 40 m
Powerhouse	Drilling	2 holes, 40 m
Project area	Geological mapping	10 km^2
Liwagu intake	Geological mapping	0.012 km^2
Mesilau intake	Geological mapping	0.017 km^2
Penstock-powerhouse	Geological mapping	0.069 km^2

2.6 Meteorology and Hydrology

For hydrological analysis, the regional meteorological data and hydrological data were collected. River flow data of Bedukan gauging station (closed in 1981) was applied for the analysis.

The following discharges were obtained from the hydrological analysis.

95% flow	Liwagu intake	0.24 m^3/s
	Mesilau intake	0.21 m^3/s
	Total	0.45 m^3/s
Return period 50 years	Liwagu intake	200 m^3/s
(Design flood discharge)	Mesilau intake	180 m^3/s
	Powerhouse	220 m^3/s

2.7 Selection of Optimum Development Plan

Naradaw project, the fifth run of river type small scale hydropower plant in Ranau area, has a major objective to save diesel oil and contribute electric power to Ranau-Kundasang Grid, economically.

Selection of optimum plan means to select a net head, a design maximum discharge and an installed capacity by comparing benefit and cost for alternative plans at Naradaw site.

AS the result, installed capacity 1,600 kW and design maximum discharge 1.20 m^3/s were selected as the optimum plan.

The commissioning year of Naradaw project depends on kW and kWh balance caused by supply capability of generating facilities and peak demand predicted in the Ranau-Kundasang Grid and especially on operation condition of Carabau hydropower station. The Carabau has a capability to generate much energy generated from two units, which were occasionally repaired. In the case that both two units work stably in future, the year 2000 is considered to be the commissioning year for Naradaw. In the case that one unit works, the year 1997 will be the commissioning year for Naradaw.

2.8 Transmission Line Route

The powerhouse site of Naradaw Small Scale Power Station is located several tens of meters upstream from the confluence of the Liwagu River and Mesilau River. An 11 kV HV line of 1 km is to be constructed from the 11,000/3,000 V step-up transformer located outdoors of the power station for a connection to be made with the existing 11 kV HV lines constructed along the road between Kundasang and Ranau.

2.9 Preliminary Design

Preliminary design for Naradaw project was carried out on the basis of the optimum development plan. Civil structures such as intake facility, headpond, waterway, powerhouse, access roads and electro-mechanical equipment such as turbine, generator were comparatively studied.

As the result, the stream bed type intake facility including desilting basin was selected at Liwagu and Mesilau Rivers. Concrete facing type headponds (regulating capacity 800 m^3 for Liwagu, 600 m^3 for Mesilau, respectively) were selected at the downstream of the desilting basin. Low head steel pipelines (horizontal routes) have been designed along the Liwagu River (0.70 m in diameter, 2,680 m in length) and Mesilau

River (0.60 m in diameter, 990 m in length). The buried steel penstock (0.80 m in diameter, 780 m in length) was adopted due to the geological condition. Two units of Turgo Impulse type turbine were adopted.

Salient futures of the Naradaw project are shown below.

Development Plan

(1)	Catchment area	Liwagu	31 km^2
		Mesilau	28 km^2
		Total	59 km^2
(2)	Design maximum discharge	Liwagu	0.70 m^3/s
		Mesilau	0.50 m^3/s
		Total	1.20 m^3/s
(3)	Elevation of intake crest	Liwagu	EL. 1,049.50 m
		Mesilau	El. 1,038.00 m
(4)	Headpond water level	Liwagu	EL. 1,048.30 m
		Mesilau	EL, 1,036.50 m
(5)	Tailrace water level		El. 852.00 m
(6)	Effective head		170 m
(7)	Installed capacity		1,600 kW
(8)	Firm peak power		460 kW
(9)	Supply capable energy		9.5 GWh

Facilities

(1) Liwagu Intake Facility

Intake dam

Type	:	overflow type concrete dam
Dimension	:	height 3.50 m, overflow crest length 24.00 m

Intake

Type	:	stream bed type (Tyolean type)

Desilting basin

Dimension	:	width 4.00 m, length 14.00 m

Headpond

Type	:	concrete facing type
Regulating Capacity	:	800 m^3

(2) Mesilau Intake Facility

Intake dam

Type	:	overflow type concrete dam
Dimension	:	height 4.00 m, overflow crest length 22.00 m

Intake

Type	:	stream bed type (Tyrolean type)

Desilting basin

Dimension	:	width 2.50 m, length 11.00 m

Connecting pipe (steel pipe)

Internal diameter	:	0.60 m
Length	:	90 m

Headpond

Type	:	concrete facing type
Regulating capacity	:	600 m^3

(3) Liwagu Pipeline

Type	:	surface type steel pipe
Dimension	:	internal diameter 0.70 m, length 2,680 m

(4) Mesilau Pipeline

Type	:	surface type steel pipe
Dimension	:	internal diameter 0.60 m, length 990 m

(5) Penstock

Type	:	buried steel pipe
Dimension	:	internal diameter 0.80 m, length 780 m

(6) Powerhouse

Type	:	surface type
Dimension	:	width 11.00 m, length 19.00 m

(7) Turbine

Type	:	Turgo Impulse Turbine
Number	:	2 units
Effective head	:	170 m
Max. discharge	:	0.60 m^3/s

(8) Generator

Type	:	3-phase Synchronous Generator
Number	:	2 units
Capacity	:	890 kVA

(9) Transformer

Type	:	outdoor 3 phase oil immersed, self-cooled
Number	:	2 units
Capacity	:	890 kVA

(10) Transmission Line

Voltage	:	11 kV HV
Length	:	1 km

(11) Access Road

New construction

Length	:	5,460 m

Improvement

Length	:	1,450 m

2.10 Construction Plan

Construction works of Naradaw project consist of access roads, intake facilities, pipelines, penstock, powerhouse and electro-mechanical equipment.

Construction period has been planned 2.5 years in total. Access roads to reach intake dams and powerhouse should be started at first. The pipelines will be installed at the same time at several sections of the both the Liwagu and Mesilau pipelines.

2.11 Cost Estimate

The construction cost of Naradaw project is comprised of all costs; civil works, electro-mechanical equipment, transmission line, project land cost/compensation and engineering management.

The construction costs were estimated at the time of June 1992. The unit prices were applied at market prices in Sabah referring to the actual results of the similar mini-hydro power projects of SEB and unit prices of the Public Works Department. The some particular works were estimated based on foreign country prices.

The locally made construction materials were adopted as much as possible to reduce the costs, because the Naradaw project is a small scale hydropower development project.

The total construction cost of the Naradaw project was estimated as follows.

Total construction cost M$ 11,500,000

2.12 Environmental Impact Study

Environmental impact study (EIA) for the project was conducted by Universiti Kebangsaan Malaysia. JICA Team prepared the Technical Specifications for the study and advised the assessment.

As the result, potential impacts of the project on the environment are not expected to be significant if the recommendations in the EIA report are followed and appropriate mitigation and abatement measures are taken.

2.13 Economic and Financial Evaluation

The economic evaluation was made comparing the present value of the total construction cost and OM costs of Naradaw project, shown as "Cost", and of the total construction cost, OM cost, fuel cost of its alternative diesel power plant shown as "Benefit".

The financial analysis was performed by comparing the present value of the total construction cost and OM costs of Naradaw project, "Cost", and the gross revenue to be earned by energy sales, "Benefit".

The period of calculation is twenty-five (25) years which are the composite service life of Naradaw project.

As the result, the following EEDR, FEDR and generating costs were obtained.

EEDR	:	10.71%
FEDR	:	10.86%

Generating cost: (average cost during 25 years)

	Case 1 (all government loan)	Case 2 (all government grant)
Cost	M$ 0.122/kW	M$ 0.068/kWh

CONCLUSION AND RECOMMENDATION

CONCLUSION AND RECOMMENDATION

CONCLUSION

(1) Annual energy requirement and annual maximum demand in the Ranau-Kundasang Grid in 1990 were 6,025 MWh and 1,330 kW respectively. According to the power demand forecast, the above figures will be increased to 18,958 MWh and 3,930 kW in 2000.

To meet the power demand forecast, an electric power development plan is required in the Grid.

In the Grid, two diesel power stations (Ranau 1,120 kW, Kundasang 660 kW derated capacity, respectively) and Carabau mini-hydro power station (installed capacity 2,000 kW) are operating at the pent. Mesilau mini-hydro (installed capacity 300 kW) is under repair work.

Naradaw project is proposed as a Small Scale Hydropower Development Project at Upper Liwagu River Basin, having the major objective to save fuel oil of existing diesel engine power stations and contribute electric power to Ranau-Kundasang Grid.

(2) The optimum timing of commissioning of Naradaw project (1,600 kW) was determined in 1997 taking into consideration the power demand balance of kWh and kW.

On the other hand, regarding kW balance based on the firm peak output of hydropower plans, it can be said that additional diesel power plants would be necessary to install before and after the commissioning of the Naradaw project in the Ranau-Kundasang Grid to meet peak power demand.

(3) Naradaw project site was selected from 20 sites which were studied previously. Topographic survey, geological investigation and environmental impact study were carried out in the project area. JICA Team prepared Technical Specifications for each of the investigation works and advised the works.

(4) The project has planned for the installed capacity 1,600 kW and consists of Liwagu intake facility and Mesilau intake facility, Liwagu pipeline and Mesilau pipeline, one penstock and powerhouse (two units of Turgo Impulse Type Turbine). Access roads to reach the intakes and powerhouse also have been planned. Short distance transmission line connected between the powerhouse and the existing line has been planned.

(5) Construction period for the project was planned as 2.5 years and construction cost of the project was estimated as M$11,500,000.

(6) Potential impact of the project on the environment is not expected to be significant if the recommendations in the EIA report are followed and appropriate mitigation and abatement measures are taken.

(7) As the results of economic and financial analyses, EEDR and FEDR are as follows.

EEDR	:	10.71%
FEDR	:	10.86%

RECOMMENDATIONS

(1) Naradaw project is feasible technically, economically and financially. The project is recommended to be put in service in the beginning of 1997.

(2) Detail design is needed for each structure including access roads because this report shows preliminary design.

(3) Prior to the construction, the following investigations are required for the detail design.

- Detailed route selection and centerline survey along the pipelines including access roads

- Survey of river cross-section at the intake dams.

- Seismic prospecting survey along the penstock route.

(4) For the detail design and during construction, particular attention is required for the slope protection at the steep topographical sections along the pipelines.

(5) During the construction work at the penstock route, security for the local residents who live around the route has to be considered.

Chapter 1 INTRODUCTION

Chapter 1

INTRODUCTION

Contents

		Page
1.1	Preface	1 - 1
1.2	History	1 - 1
1.3	Objectives and Scope of Study	1 - 2
	1.3.1 Objectives of Study	1 - 2
	1.3.2 Object Area of Study	1 - 3
	1.3.3 Scope of Study	1 - 3
	1.3.4 Contents of Work	1 - 3
1.4	Field Survey	1 - 5
1.5	Personnel Related Study	1 - 6
1.6	Collected Data	1 - 10

List of Tables

Table 1-1 List of Collected Data

1. INTRODUCTION

1.1 Preface

This Final Report includes the results of the feasibility study works undertaken in the period from July 1991 to July 1992 on the Small Scale Hydro-electric Power Development Project at Upper Liwagu River Basin, Sabah in Malaysia, as a part of technical assistance of the Japan International Agency (JICA). The Report is composed of the following four sets.

Summary
Main Report
Appendix Vol. I
Appendix Vol. II

1.2 History

The Government of Malaysia requested the Government of Japan to assist in carrying out the feasibility study on Small scale Hydroelectric Power Development Project at Upper Liwagu River Basin to improve rural electrification in Sabah and to save fuel oil for the existing diesel power station.

The Government of Japan agreed to provide assistance. JICA dispatched to Sabah State in Malaysia the preliminary study team headed by Mr. N. Kakuma (then Director, Mining Industrial Planning and Survey Department, JICA) in March 1991. The team undertook site reconnaissance, data collection, etc. and also had discussion with Sabah Electricity Board (EPU). Then the Scope of Work for the feasibility study on the project was prepared, the contents finally agreed on, and signed on March 12, 1991, between Economic Planning Unit (SEB) on behalf of the Government of Malaysia and Japan International Cooperation Agency (JICA) on behalf of the Government of Japan.

In order to promote the study works contemplated in above Scope of Work, JICA proceeded in selection of the consultant firm and awarded the study works to the Electric Power Development Co., Ltd. (EPDC) in July 1991, through prescribed documentary evaluation.

The study team organized in accordance with the above consultancy contract and headed by Mr. T. Tezuka (EPDC) immediately started the home works of the project. First, the study team prepared the Inception Report. The Report contained the policy, method of the study, and works to be undertaken by the EPU and the JICA. In the Report, the study team divided the works in three stages; Identification Stage, Field Investigation Stage and Preliminary Design Stage. Second, the study team carried out the reconnaissances to select the optimum development site. The result of the site selection has been reported in the Interim Report on September 1991. Third, the field investigation works such as topographic survey, geological investigation, environmental impact assessment were carried out at the selected site. Then the Progress Report was prepared by the study team on March 1992. Finally, selection of the development plan and preliminary design were carried out. All study works were completed in July 1992.

The study works were mainly carried out at SEB together with the counterparts in SEB. Through the study work at SEB, technical transfers concerning the small scale hydroelectric power development were carried out by the study team. In the meantime, technical seminars were held by JICA and the study team.

1.3 Objectives and Scope of Study

1.3.1 Objectives of Study

The objectives of this study are to carry out field survey and studies in Japan to formulate the technically, economically, and financially optimum development plan, to prepare a feasibility study report, and to transfer technology to the Malaysian counterparts through this study.

1.3.2 Object Area of Study

The object area of the study comprises the Upper Liwagu Basin in Sabah State, Malaysia, (catchment area, dam site, intake, headrace, head tank, penstock, powerhouse, tailrace, switchyard, transmission line route, materials and equipment, transportation route, etc.)

1.3.3 Scope of Study

Feasibility study on small scale hydroelectric power development project at the Upper Liwagu Basin.

1.3.4 Contents of Work

This study was carried out divided into the three stages below.

(1) Identification Stage

- Collection and review of existing data
- Site reconnaissance
- Power survey
- Site selection study
- Preparation of technical specifications for field investigation works

(2) Field Investigation Stage

The following survey works were carried out on the optimum site selected in the Identification stage:

- Topographic survey
- Geological investigation
- Environmental impact assessment

These surveys were carried out by SEB, while the JICA study team provided technical guidance concerning survey work and evaluations.

(3) Preliminary Design Stage

The following studies were made using the results of the various surveys at the Identification Stage and the Field Investigation Stage.

- Selection of optimum development plan
- Preliminary design
- Project cost estimation
- Construction program
- Economic evaluation and financial analysis

1.4 Field Survey

The field surveys were mainly carried out at SEB. The periods and contents of work carried out by the study team are as follows.

First Field Survey

Period: 30 days from July 15 to August 13, 1991

Contents of work:

- Submission and explanation of Inception Report
- Site reconnaissance (selection of project site, geological survey, power survey)
- Data collection
- Technical transfer

Second Field Survey

Period: 15 days from September 22 to October 6, 1991

Contents of work:

- Submission and explanation of Interim Report
- Submission and explanation of Technical Specifications
- Survey of Naradaw site
- Technical transfer

Third Field Survey

Period: 15 days from November 27 to December 11, 1991

Contents of work:

- Technical guidance of topographic survey
- Technical guidance of geological investigation

Forth Field Survey

Period: 15 days from February 5 to February 19, 1992

Contents of work:

- Hydrological analysis
- Technical guidance of environmental impact assessment
- Preparation of Progress Report

Fifth Field Survey

Period: 45 days from February 5 to March 20, 1992

Contents of work:

- Comparative study of development plan
- Preliminary design
- Preparation of Progress Report
- Technical seminar by JICA

Sixth Field Survey

Period: 33 days from June 2 to July 4, 1992

Contents of work:

- Preliminary design
- Construction plan
- Cost estimate
- Economic and financial analyses
- Technical seminar by study team
- Preparation of Draft Final Report

1.5 Personnel Related Study

The personnel related to the study on the Malaysia side, and the members of JICA study team are listed below.

(1) ECONOMIC PLANNING UNIT (EPU)

Energy Section

Ms. Siti Hadzar Mohd. Ismail	Director
Mr. Tham Ah Fun	Principal Assistant Director
Mr. Mohamad Yazi Md. Zin	Assistant Director

(2) SABAH ELECTRICITY BOARD (SEB)

Mr. Tuan Hj. Zaghlol Hj. Hanafiah	General Manager
Mr. Peter Lajumin	Deputy General Manager
Mr. Amat Aji	Chief Engineer, Hydro Civil Dept.
Mr. Mohd Sahril Jaraei	Senior Engineer, Hydro Civil Dept.
Mr. Nicholas Santani	Senior Engineer, Hydro Civil Dept.
Mr. Pang Nam Fong	Chief Engineer, Consumer Services Dept.
Mr. Cheng Sau Yee	Senior Engineer, Power Planning Dept.
Mr. Tuan Hj Abdul Ghani Ahmad	Manager, Finance Dept.
Mr. Peter Chin	Senior Engineer, Transmission Line Dept.
Mr. Abd. Razak Hussaini	Senior Engineer, Generation Development Dept.

Counterparts

Mr. Baharuddin Mansor	Civil Engineer
Mr. Siva	Electrical Engineer

Ms. Norlian Abd. Rahim	Electrical Engineer
Mr. Che Nan	Mechanical Engineer
Mr. Won Viu Kong	Transmission Line Engineer

Ranau Diesel P/S

Mr. Mundur Khan	Representative of Ranau P/S

(3) DEPARTMENT OF IRRIGATION AND DRAINAGE, SABAH (DID)

Hydrology Division

Mr. Dos Saguman	Drainage and Irrigation Engineering Assistant
Mr. Ho Tsun Lin	Drainage and Irrigation Engineer

(4) DEPARTMENT OF LAND SURVEY, SABAH (DLS)

	Survey Engineer

(5) WILDLIFE DEPARTMENT

Mr. Laurentius Nayan Ambu	Assistant Director

(6) FORESTRY DEPARTMENT

Mr. Tuan Hj. Ag Tajuddin Ag Kahar	Assistant Director

(7) FISHERY DEPARTMENT

Mr. Cho Yow Won	Director

(8) GEOLOGICAL SURVEY OF MALAYSIA IN SABAH

Mr. Lim Pen Siong	Principal Geologist

(9) JICA STUDY TEAM

Mr. Tokuji TEZUKA	Team Leader
Mr. Kuniaki YOSHIOKA	Civil Engineer (Planning)
Mr. Shimpei TOMITA	Civil Engineer (Civil Design)
Mr. Minaichi TAKEOKA	Civil Engineer (Civil Design)
Mr. Hiroshi KAGAMI	Electrical Engineer
Mr. Teruyoshi HATANO	Engineering Geologist
Mr. Daikichi NAKAJIMA	Survey Specialist
Mr. Takeshi WASHIZAWA	Civil Engineer (Hydrology)
Dr. Takashi OWADA	Environmental Specialist
Mr. Tetsuya FUKUDA	Electricity Economist

1.6 Collected Data

List of the main data collected is shown in **Table 1-1**.

Table 1-1 List of Collected Data

GENERAL

(1) Mini-hydro Pilot Project, General layout of Carabau Scheme, Dec. 1982. SEB

(2) Mini-hydro Pilot Project, General Layout of Sayap Scheme, Mar. 1982, SEB

(3) General Map of Pre F/S Sites in Sabah (Panai Barat, Sugut, Segama and Tawau), SEB

(4) Hydropower Options Study, Inventory of Identified Sites, Liwagu River Basin, SEB

(5) Mini Hydro Project in Sabah, SEB

(6) Upper Liwagu Basin, Mini Hydro Potential Study, SEB

(7) Preliminary Survey of Upper Liwagu Mini Hydro Potential, SEB

(8) Project Brief, Carabau Mini Hydro Pilot Project, Ranau, SEB

(9) Sabah Electricity Board, Organization Chart

(10) Tenom Pangi Hydro Project, SEB

(11) Hydropower Option Study and Institutional/Planning Consultancy, Interim Report, 1990, ADB

(13) Hydro Power study on the Liwagu River Basin (Phase-1 Report), May 1988, SEB

(14) Annual Report, 1987, SEB

(15) Hydro Power Projects in Sabah and Sarawak (Draft Final Report, Main Report), Oct. 1989, ADB

(16) Hydro Power Study of Liwagu River Basin (Feasibility Report, Jul. 1989, SEB)

(17) Mini-hydro Pilot Project in the State of Sabah, Feasibility Report, Dec. 1981, SEB

ELECTRICAL DATA

(1) Skeleton Diagram (Interconnection of Ranau and Kundasang Diesel Power stations with Carabau and Mesilau Mini-hydro Power Stations), SEB

(2) Demand of Domestic Industrial and Commercial, 1976-1989, Ranau & Kota Belud, SEB

(3) Load Forecast, Kota Belud, Feb. 1991, SEB

(4) Estimated Load Growth at Ranau, SEB

(5) Generating Data of Ranau Diesel Power Station

(6) Generating Data of Kundasang Diesel Power Station

METEOROLOGY AND HYDROLOGY

(1) Hydrological Station Registers

(2) Hydrological Data Rainfall Records for Malaysia, 1975-1985

(3) Hydrological Records of Sabah, 1969-1975

TOPOGRAPHIC MAPS

(1) Topographic map of Project Area, Scale of 1/50,000

(2) Topographic map of Project Area, Scale of 1/2,500

GEOLOGY

(1) Annual Report, 1988, Geological Survey of Malaysia

(2) Geological Map of Sabah

ENVIRONMENTAL IMPACT ASSESSMENT

(1) Fauna Conservation Ordinance, 1963 together with the Subsidiary legislation made thereunder

(2) Scheduled Species under Fauna Conservation ordinance, 1963

Chapter 2 GENERAL CONDITION OF SABAH STATE

Chapter 2

GENERAL CONDITION OF SABAH STATE

Contents

Page

2.1 General Situation in Sabah State . . . . 2 - 1

2.2 General Situation in Ranau Area . . . . 2 - 1

2. GENERAL CONDITION OF SABAH STATE

2.1 General Situation in Sabah State

Sabah State is one of the thirteen states of Malaysia and is located adjacent to Sarawak State in East Malaysia (Island of Borneo). The area of Sabah State is approximately 73,600 km^2 to make up 22.3% of entire Malaysia. The population was approximately 1,470,000 in 1990, the population density being approximately 17/km^2.

Sabah State is composed of the five divisions of Bahagian Pantai Barat, Bahagian Pendalaman, Bahagian Sandakan, Bahagian Tawau, and Bahagian Kudat. The state capital is Kota Kinabalu.

The climate of Sabah State is tropical, with high temperature and high humidity. Monsoons are prevalent from May to August at the west coast and November to March at the east coast, but seasonal variations in rainfall are not distinct. The annual rainfall is from 1,500 to 2,000 mm in inland areas, and more than 3,000 mm in mountainlands, as much as 4,000 mm where heavy. Air temperatures vary little throughout the year, being around 22°C in the early morning and 32°C in the daytime in coastal regions, and 12°C in the early morning and 22°C in the daytime in the mountains, there being large differences according to place and time of day.

2.2 General Situation in Ranau Area

Ranau area including Ranau town and Kandassang town, where the Project is contemplated, is the center area of the Ranau District that is one of the eight Districts in Bahagian Pantai Barat.

Ranau District is located approximately 60 km to the east of the state capital of Kota Kinabalu (approximately 120 km by road). The Ranau District is approximately 3,000 km^2 and the population approximately 40,000. Ranau area is approximately 30,000 in population and situated at the southeast-south slope of Mt. Kinabalu (EL. 4,101 m), the main peak of the Crocker Mountain Range.

The Liwagu River, the object stream of the present investigation, springs at the southeast-south slope of Mt. Kinabalu in the Crocker Range which forms the boundary between Ranau District and Tuaran District, and empties into the Sulu Sea to the east, having become the Labuk River at the downstream stretch.

Development has progressed in the Upper Liwagu Basin and there is little virgin forest remaining. Cultivated fields, scattered housing, and secondary forests can be seen widely between Kundasang and Ranau on the Tamparuli ~ Ranau Highway leading from Kota Kinabalu to Ranau. There is a large scale Mamut Copper Mine in Ranau Town. And the area around Kundasang Town are very famous as tableland vegetable production. The area around Mt. Kinabalu has been designated a national park and so it is also a tourism site.

Chapter 3 PRESENT STATE OF ELECTRIC UTILITY INDUSTRY

Chapter 3

PRESENT STATE OF ELECTRIC UTILITY INDUSTRY

Contents

		Page
3.1	General	3 - 1
3.2	Electric Power Development Program and Rural Electrification Policy in Sabah State	3 - 2
3.2.1	Electric Power Development Program of Sabah State	3 - 2
3.2.2	Rural Electrification Rate	3 - 3
3.3	Electric Power Situation in Ranau Area	3 - 7
3.3.1	Power Supply Facilities	3 - 8
3.3.2	Present State of Power Demand	3 - 12

List of Tables

Table 3-1 Development Allocation for Energy Programmes, 1986 and 1991-95

Table 3-2 Electricity Tariff Structure and Rates

Table 3-3 Existing Generating Facilities in Ranau District

Table 3-4 Existing Generating Facilities in Kundasang District

Table 3-5 Mesilau Reinstatement

Table 3-6 Number of Visitors

Table 3-7 Actual Power Demand at the End of Customers

List of Figures

Figure 3-1 11 kV Interconnection of Ranau and Kundasang Grid (as of July 1991)

Figure 3-2 Mesilau Reinstatement Plan

3. PRESENT STATE OF ELECTRIC UTILITY INDUSTRY

3.1 General

The electric utility industry of Malaysia is undertaken by national (Federal Government) electric enterprises respectively established in Peninsular Malaysia (11 states), Sarawak State, and Sabah State.

Electric power is being supplied by the National Electricity Board (NEB)in Peninsular Malaysia, by the Sarawak Electricity Supply Corporation (SESCO) in Sarawak State, and the Sabah Electricity Board (SEB) in Sabah State. All of these electric utility enterprises are under the jurisdiction of the Ministry of Energy, Telecommunications and Posts (METP), and carry out all activities concerning electric power supply, namely, construction and operation of facilities for power generation, power transmission, power transformation, and power distribution, and power sales.

The totals of power generation facility outputs of the three electric utility enterprises as of the end of 1990 were as follows:

	Hydro (MW)	Thermal (MW)	Total (MW)
NEB(TNB)	1,251	3,579	4,830
SESCO	110	320	430
SEB	71	286	357
Total	1,432	4,185	5,617

SEB was established by law in 1965 and presently has approximately 2,500 employees. The principal activities of SEB are as follows:

- Promoting development of electric power for development of the society and economy of Sabah State.

- Supplying electric power at reasonable prices.

- Constructing and operating power generation, power transmission, power transformation, and power distribution facilities, and selling electric power.

The General Manager and members of the Board of Directors of SEB are appointed by the Federal Government of Malaysia.

3.2 Electric Power Development Program and Rural Electrification Policy in Sabah State

3.2.1 Electric Power Development Program of Sabah State

The electric power development program approved as a national project in the Sixth Five-Year Plan from 1991 to 1995 is as follows:

(1) Power Generation Facilities

Liwagu Hydroelectric Project		165 MW
7 Mini-hydro projects	Approx.	6 MW

(2) Power Transmission and Transformation Facilities

275-kV Transmission Line	
(Kota Kinabalu-Liwagu-Sandakan)	2 cct: 160 km
132-kV Transmission Line	
(Kota Kinabalu-Kota Belud-Kudat)	2 cct: 150 km

Besides the above, SEB is proceeding with investigations for combined cycle power generation (power generation system with combination of gas turbine and steam turbine) at Sapangar Bay in which an undersea pipeline of 58 km would be laid from an undersea natural gas field (Offshore Erb West Field) located north of Kota Kinabalu.

Regarding the 7 Mini-hydro projects, three of the projects are presently at the stage of procedures such as tendering for construction work being taken. The Naradaw Small-hydro Power

Development Project now being studied by the JICA Study Team is one of the seven projects.

The Naradaw Small-hydro Power Development Project is located at a site 60 km (120 km by road) east of Kota Kinabalu, the capital city of Sabah State.

The scale of power demand of the Ranau-Kundasang Grid is presently only 1,330 kW, but is forecast to become 3,930 kW in 2000, and 7.590 kW in 2010.

The Liwagu Hydroelectric Power Development Project (165 MW) is planed in the Sixth Five-Year Plan (1991 - 1995), and it is scheduled for this project to supply electric power to the load center of Kota Kinabalu by direct interconnection with the existing West Coast Grid by a 275-kV, 2-cct transmission line.

See from the power generation scales of the Naradaw and Carabau Mini-hydro power stations and the size of the power demand of Ranau-Kundasang, and from the comparison of the current average electricity rate of 0.24 M$/kWh, and the power transformation cost per 1 kWh of 10%, it will be around the year 2010 (when the power demand of the Ranau-Kundasang Grid will be 7,000 kW) that the effect of the incremental transformation cost on the electricity rate can be judged to be extremely small, and therefore, it is thought the time of incorporation of the Ranau-Kundasang Grid in the West Coast Grid through interconnection with the Liwagu Hydroelectric Power Development Project cannot be expected before then.

3.2.2 Rural Electrification Policy

(1) Raising of Electrification Rate

The Malaysian Government intends to raise the present electrification rate of Sabah State of 48% to 73% through the Sixth Five-Year Plan. If this Sixth Five-Year Plan is completely implemented, the electrification rate of the Malaysian Peninsula will be 100%, and that of Sarawak State 77%, and the average electrification rate of entire Malaysia will be improved from the present 80% to 90%.

The financial expenditure plans such as of state funds scheduled for the electric power sector in the Sixth Five-Year Plan are shown in **Table 3-1**.

Table 3-1 Development Allocation for Energy Programs, 1986 and 1991 - 95 (M$ million)

Programma	Federal Government		NFPES*1		Total	
	Expenditure 5MP	Allocation 6MP	Expenditure 5MP	Planned Expenditure 6MP	5 MP	6MP
Power Sector	167.8	103.5	258.2	2,980.9	426.0	3,084.4
Hydro	143.6	77.9	1,901.2	5,097.4	2,044.8	5,175.3
Thermal & Gas						
Rural Electrification	569.6	764.6	156.0	0.0	725.6	764.6
Transmission & Distribution	28.4	18.9	3,426.3	5,233.5	3,454.7	5,252.4
Others	9.0	14.1	353.6	1,158.1	362.6	1,172.2
Total	918.4	979.0	6,095.3	14,469.9	7,013.7	15,448.9

Note: *1 Refers to TNB (NEB), SESCO, SEB and PETRONAS.

The national budged for the rural electrification plan will be allocated as construction funds for power generation facilities (diesel or small hydro power generation facilities) and power transmission, distribution, and transformation facilities required for rural electrification.

The national government funds used for electrification of Sabah State in the Fourth (1981 - 1985) and Fifth (1986 - 1990) Five-Year Plans were M$60 million and M$27.1 million, respectively.

In the Fifth Five-Year Plan, however, financial expenditures for rural electrification were not made in 1987 because of an austerity policy in national finances, and during the 3 years after 1987 until 1990, there was a contraction of one third of what had been scheduled.

In the Sixth Five-Year Plan, an increase of 5.3% has been planned as shown in **Table 3-1**, while in all of Sabah State, it is thought possible to take into account increases of about 2,000 to 3,000 new customers annually.

It is necessary to keep in mind that rural electrification is all to be done with national government funds. That is, if the necessary funds for rural electrification are to be handled as grants from the Government to SEB, the costs of SEB would be the annual operation and maintenance costs so that electricity charge revenues should be attractive to SEB.

(2) Current Electricity Tariff Structure

Electricity rates in Sabah State are uniform throughout the state wherever electric power is supplied by SEB, whether the West Coast Grid or independent grids.

Table 3-2 Electricity Tariff Structure and Rates

	Classifications		M$/kWh
1.	Domestic (DM)		
	0 - 40 kWh/month	M$	0.24
	41-200 kWh/month	M$	0.16
	201- above kWh/month	M$	0.28
	Minimum Charge	M$	5.00
2.	Commercial Class 1 (CM1)		
	0 - 1,000 kWh/month	M$	0.32
	1,000- above kWH/month	M$	0.27
	Minimum Charge	M$	15.00
3.	Commercial Class 2 (CM2)		
	Above 500 kW, Maximum Demand Charge	M$	15.00
	(M$/kW per month)	M$	0.25
	All Units		
	Minimum Charge	M$	1,000.00
4.	Industrial Class 1 (ID1)		
	0- 2,000 kWh/month	M$	0.32
	2,001-above kWH/month	M$	0.26
	Minimum Charge	M$	15.00
5.	Industrial Class 1 (ID2)		
	Above 500 kV, Maximum Demand Charge	M$	15.00
	(M$/kW per month)	M$	0.23
	All Units		
		M$	1,000.00
	Minimum Charge		
	Public Lighting (PL)		
	All Units	M$	0.30

The present average electricity charge in the Ranau-Kundasang Grid is M$0.24/kWh. The electricity tariff structure has a close correlation with power demand, and so far as seen from past growth in power demand, if the present electricity tariff structure is maintained and there is no great rise in rates, the growth in power demand of the Ranau-Kundasang Grid which will be the object of supply from the Naradaw Small-hydro Power Development Project can be expected to be high with the increase in the electrification rate.

The average electricity charge of SEB is 16% and 46% comparatively higher than in SESCO and NEB, respectively. This is thought to be because the ratio of hydro in the power demand is comparatively low, while the power generation facilities of independent grids in Sabah state make up a large proportion of 45.6%.

3.3 Electric Power Situation in Ranau Area

This area, to become the object area of the Naradaw Small-hydro Power Project, is the approximately 170 km^2 spread out on the southeast side of Mt. Kinabalu (EL. 4,101 m) centered at Kundasang Town located at EL. 1,500 m and Ranau Town located at EL. 500 m. The population of this area is estimated to have been approximately 32,600 as of the end of 1990, of which those receiving supply of electric power were 15,100 (2,960 customers x 5.1 capital/customer), from which, if the electrification rate were to be calculated, would correspond to an electrification rate of 46.3%.

The electric power supply facilities are mainly the diesel power generation facility at Ranau (rated capacity: 1,645 kW, effective capacity: 1,120 kW) and the diesel power generation facility of Kundasang (rated capacity: 945 kW, effective capacity: 660 kW), while there is also Carabau Mini-hydro Power Station (installed capacity: 2,000 kW) which started operation in January 1991. Hence, the total effective capacity of power generating facilities is 3,780 kW. Furthermore, three Mesilau min-hydro power stations (100 kW x 3) were completed at Kundasang from 1983 to 1984, but all three are presently stopped due to landsliding which occurred in 1985. SEB put out for tendering repairs of the three Mini-hydro power stations and repair work including altering of the location of the No. 2 power station which had been abandoned with landsliding as the cause, and the repair works of the three hydroelectric power stations are scheduled to be completed around the middle of 1992.

The power demand of the Ranau-Kundasang Grid was 1,330 kW and the number of customers 2,960 as of the end of 1990. Electric power is being supplied to these customers by 11-kV HV transmission lines and 415-V/240-V distribution lines.

3.3.1 Power Supply Facilities

The power generation facilities of the Ranau-Kundasang Grid will be described divided into the Ranau Grid and the Kundasang Grid in view of geographical location relationships.

(1) Ranau

There are the two power stations of Ranau Diesel Power Station located at the center of town and Carabau Mini-hydro Power Station re-commissioned in February 1991 located in the Ranau Grid, the outlines of the facilities being as given below.

Table 3-3 Existing Generating Facilities in Ranau District

Name of Power Plant	No. of Unit	Type	N.P. Output	Derated Output
Ranau Diesel P.S	1.	Caterpillar 3412d	315 kW	220 kW
	2.	Caterpillar 3412d	315 kW	220 kW
	3.	Dorman 8AQTCA	300 kW	200 kW
	4.	Caterpillar 3412d	315 kW	220 kW
	5.	Caterpillar 3408d	200 kW	130 kW
	6.	Caterpillar 3408d	200 kW	130 kW
Total	--	---	1,645 kW	1,120 kW
Carabu mini-hydro P.S	1.	Pelton Turbine	1,000 kW	1,000 kW
	2.	Pelton Turbine	1,000 kW	1,000 kW
Total	--	---	2,000 kW	2,000 kW

Note: 2 Double-jet Pelton Turbines, Rated Discharge 635 liters per unit

The diesel units of Ranau Diesel Power Station are already more than 10 years old. The generating efficiency of the power station as a whole is 31.1% which suggests the antiquation of the facilities.

Recorded in 1990

Diesel oil consumption : 1,589,645 ltrs
Energy production : 4,833,927 kWh
Energy production per liter: 3.042 kWh/ltr
Generating efficiency : 31.1%

Carabau Mini-hydro Power Station is located at the opposite bank of the Liwagu River running immediately by Ranau Town. Trial operation of this power station was started in January 1991, but the troubles below have occurred consecutively and the problems have not been resolved to this day.

- In order to cope with rapid load fluctuations it is indispensable for turbine water discharge to be regulated by spear valve besides by jet deflector, but this function has not been provided (although opening and closing manually is possible).

- The function of a level governor for detecting the water level of the regulating pond located above the penstock for adjusting the turbine output has not been provided.

- The head pond is rubber-lined, but leakage is already occurring at a part and it is difficult to effectively utilize the regulating capacity (2,000 m^3).

- The inflow at the intake site is small compared with the scale of the power station and the output is small at 720 kW with 95% recurrence stream discharge.

As stated above, Carabau Mini-hydro Power Station can be said not be provided with the functions to cope with sudden increase in load of the power grid and to provide adjustments.

Operation was resumed at Carabau Mini-hydro Power Station from February 1991, but breaking of Pelton turbine shaft occurred and operation is being done with one unit alternately while repairs are being made.

(2) Kundasang

Kundasang Diesel Power Station and three small hydros of Mesilau Mini-hydro Power Stations (PH-1, PH-2 and PH-3) located within about 4 km to the north of town make up the Kundasang Power Grid, the outlines of the facilities being as follows. **Fig. 3-1** shows present state of Ranau - Kundasang Grid.

Table 3-4 Existing Generating Facilities in Kundasang District

Name of Power Plant	No. of Unit	Type	N.P. Output	Derated Output
Kundasang Diesel P.S	1.	Caterpillar 3412d	315 kW	220 kW
	2.	Caterpillar 3412d	315 kW	220 kW
	3.	Caterpillar 3412d	315 kW	220 kW
Total	--	---	945 kW	660 kW
Mesilau mini-hydro P.S				
PH-1	1.	Turgo Turbine	99 kW	*99 kW
PH-2	1.	Turgo Turbine	85 kW	85 kW
PH-3	1.	Pelton Turbine	109 kW	109 kW
Total	--	---	293 kW	293 kW

* After the reinstatement of these mini hydro P.S.

The diesel units of Kundasang Diesel Power Station are already more than 10 years old similarly to Ranau Power Station. The generating efficiency of the power station as a whole is 27.1%, 4.0 percentage points lower compared with the 31.1% of Ranau Diesel Power Station. The cause of this is thought to be the efficiency drops of the diesel engines due to the difference in elevations.

Recorded in 1990

Diesel oil consumption	:	449,500 Ltrs
Energy production	:	1,192,016 kWh
Energy production per liter	:	2.652 kWh/Ltr
Generating efficiency	:	27.1%

The three Mesilau Mini-hydro Power Stations are incorporated in the irrigation program of the Kundasang District, and were built including the irrigation project on a full turn-key basis by the Jyoti firm of India. The three power stations were completed in 1984, but the waterway system was complex, while the functions of turbine governors for coping with power demands of the grid were in-adequate so that breakage occurred in only 4 months and these three power stations were stopped. Further, in 1985, the Mesilau Power Station PH-2 shown in **Fig. 3-2** was tilted over by a landslide and had to be abandoned.

The major specifications of the three hydro power stations after the remodeling being undertaken by SEB are as follows:

Table 3-5 Mesilau Reinstatement

		PH-1	PH-2	PH-3	Total
Gross head	m	108.5	106	193	
Pipe length	m	2494	950	1700	
Flow	m^3/S	0.198	0.140	0.098	
Diameter	mm	0.368	0.292	0.292	
Slope	m/m	0.015	0.020	0.018	
Total head loss	m	36.37	18.79	31.85	
Total had loss	%	33.52	16.93	16.94	
Velocity	m/s	1.864	2.093	1.465	
Nett head	m	72	87	161	
Turbine efficiency	%	81	76	76	
Generator Outut	kW	99	85	109	293

3.3.2 Present State of Power Demand

The Kundasang District is spread out at a highland of elevation 1,500 m and the economy revolves around agriculture concentrated on highland vegetables and around livestock raising. Since Kundasang is at a distance of about 2 hours by car from the capital city of Kota Kinabalu, it is also a recreation area for summering or for enjoying weekends at the national park and near Mt. Kinabalu. Regarding facilities for lodging, there are hotels in the national park and near the mountaintop at Kundasang Town which are of sufficient quality to attract summer visitors, and there are more than 100 hotel rooms.

The Ranau District is spread out on flat land of elevation 500 m around Ranau Town with livestock raising and agriculture (rice, maize, etc.) as the centerpieces of the economy. Other than these, the world famous Mamut Copper Mine is located 8 km to the north of the town, and the town has directly and indirectly enjoyed the economic influences of development of the mine (with approximately 1,000 persons employed). Meanwhile, an access road has been completed to Poring (hot springs) located approximately 9 km northeast of Ranau Town, and with construction of lodging facilities, there has been a sharp increase in tourists.

The number of visitors to Mr. Kinabalu National Park and Poring Hot Springs from 1985 to 1990 are given in **Table 3-6**.

Table 3-6 Number of Visitors

Year	National Park		Poring (Hot spring)
1985	174,077	(14,455)*1	39,479
1986	210,998	(15,842)	39,664
1987	187,368	(18,444)	38,416
1988	183,865	(16,727)	33,966
1989	173,459	(16,548)	75,103 *2
1990	233,965	(21,328)	129,520

Note: *1 Figures in ( ) indicate climbers of Mt. Kinabalu and are inclusive.

*2 Paved road completed and number of tourists abruptly increased.

As described above, the districts centered at the towns of Kundasang and Ranau are comparatively close to the capital city of Kota Kinabalu and are established as supply centers for the capital of agricultural products mainly consisting of highland vegetables, and also as summer resorts, and the living standards are fairly high compared with other rural districts.

The power demand of this region at the end of 1990 was a maximum 1,330 kW, and the annual energy production was 6,025 MWh. The figures at the consumer end are given in **Table 3-7**. As previously stated, the electrification rate of this region was 46.3% as of the end of 1990.

What is clear about the power demand of these three districts is that the unit requirements (energy consumption per customer) of general residential customers and commercial customers differ depending on the district. This is thought to reflect the differences in economic activities of the three districts.

The fact that the unit requirements of Bundu Tuhan are small is mainly because supply of electricity is limited to the 12 nighttime hours from 6 o'clock in the evening to 6 o'clock in the morning.

A large growth increase in the number of customers cannot be seen since 1988 and this is thought to be due to the effect of the austerity program of the Federal Government implemented in 1987.

Table 3-7 Actual Power Demand at the End of Customers

Number of Customers

Year	Ranau District					Kundasang District					Bundu Tuhan			Total
	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total	Houses Dm	Shops Cm_1	Sub-Total	
1985	7	1,410	224	7	1,648	7	232	19	–	258	119	13	132	2,038
1986	8	1,617	228	8	1,861	7	247	34	–	288	127	12	139	2,288
1987	8	1,797	258	8	2,071	7	248	39	–	294	129	13	142	2,507
1988	10	1,893	267	7	2,177	7	263	41	1	312	138	13	151	2,640
1989	11	1,934	281	7	2,233	8	280	42	1	331	144	14	158	2,722
1990	16	1,936	332	12	2,296	9	426	46	1	482	166	16	182	2,960

Energy Sold to Customers (MWh)

Year	Ranau District					Kundasang District					Bundu Tuhan			Total
	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total	Houses Dm	Shops Cm_1	Sub-Total	
1985	363	1,056	671	60	2,150	392	170	60	–	622	60	4	64	2,836
1986	379	1,127	778	64	2,348	429	186	62	–	677	74	4	78	3,103
1987	457	1,440	924	93	2,914	568	201	109	–	878	61	10	71	3,863
1988	493	1,963	1,243	78	3,777	580	240	198	7	1,025	62	11	73	4,875
1989	506	1,981	1,267	67	3,821	621	275	171	9	1,076	63	11	74	4,971
1990	583	2,234	1,324	131	4,272	629	300	174	7	1,110	89	13	102	5,484

Unit Energy Consumption per Customers (Average kWh per Month)

Year	Ranau District					Kundasang District					Bundu Tuhan			Total (Average)
	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total (Average)	Light Industry ID_1	Houses Dm	Shops Cm_1	Public Lighting PL	Sub-Total (Average)	Houses Dm	Shops Cm_1	Sub-Total (Average)	
1985	4,321	62	250	714	109	4,667	61	263	–	201	42	27	40	116
1986	3,948	58	284	667	105	5,107	62	152	–	196	49	28	47	113
1987	4,760	67	298	969	117	6,762	68	233	–	249	39	64	42	128
1988	4,108	86	388	929	145	6,905	76	402	7	273	37	71	40	154
1989	3,833	85	376	798	143	6,469	82	339	9	271	36	65	39	152
1990	3,036	96	332	909	155	5,824	59	315	7	192	45	68	79	154

Figure 3-1 11kV INTERCONNECTION OF RANAU AND KUNDASANG GRIDS (As of July 1991)

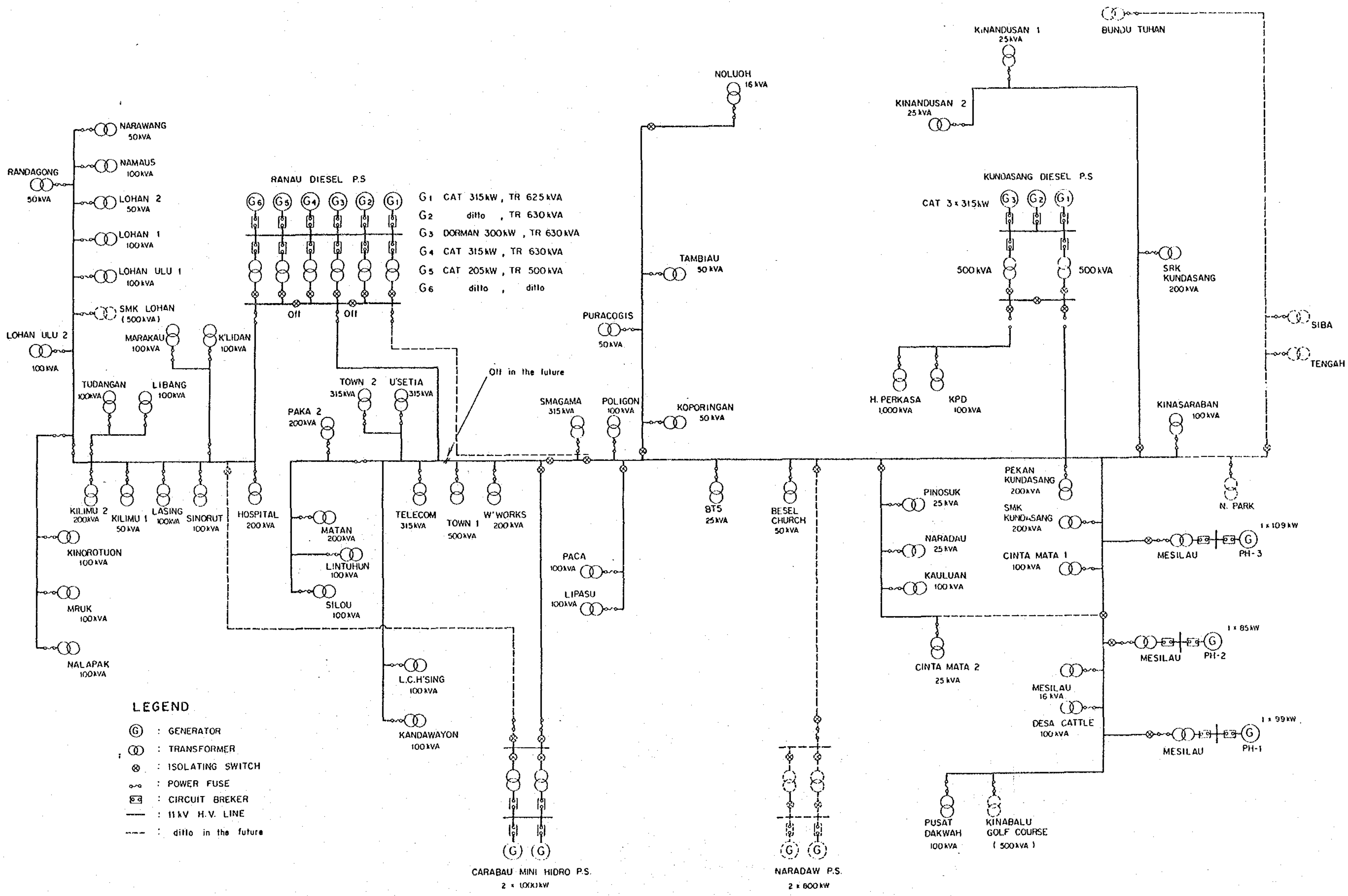
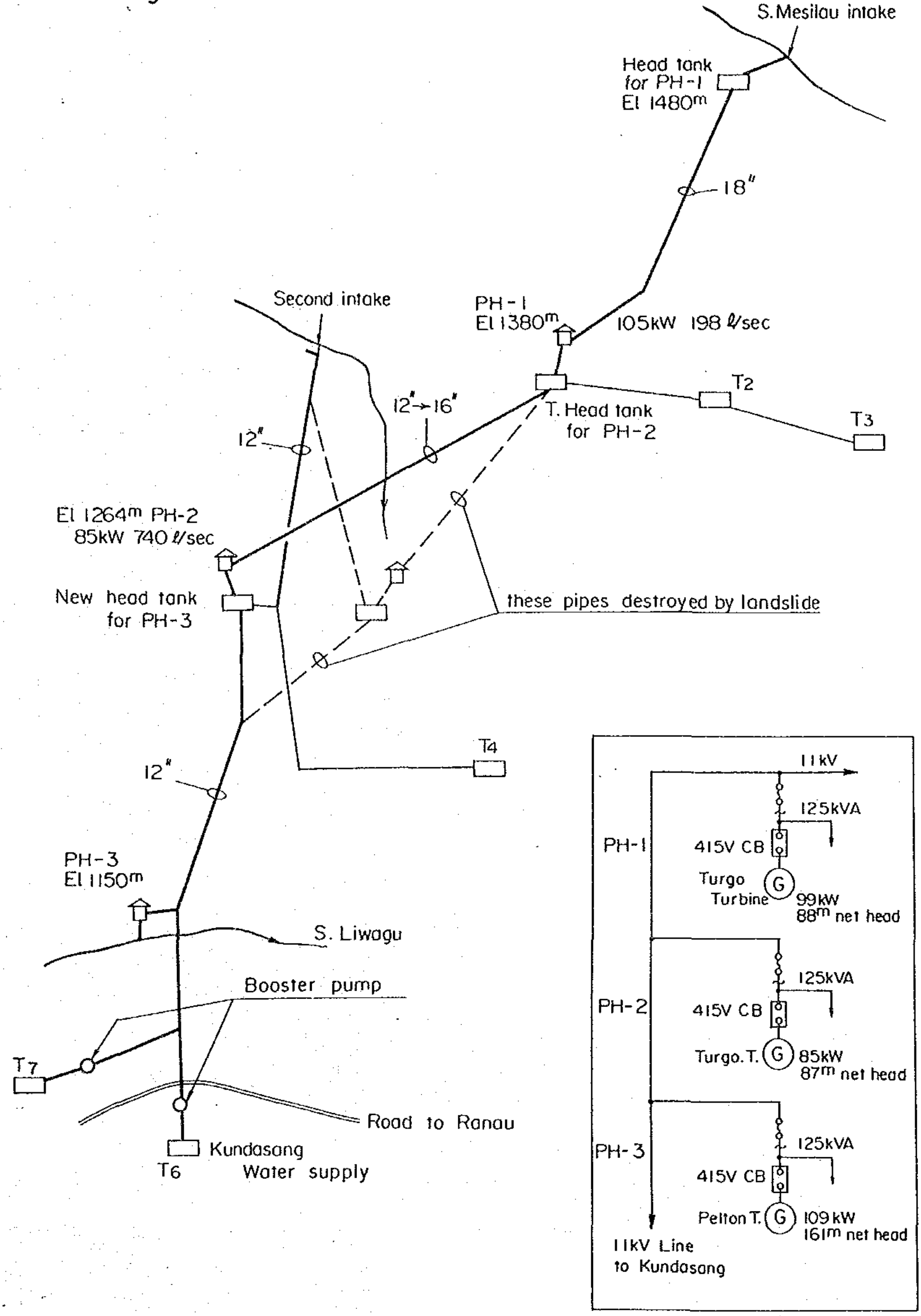


Figure 3-2 Mesilau Reinstatement Plan



Chapter 4 POWER DEMAND FORECAST

Chapter 4
POWER DEMAND FORECAST

Contents

		Page
4.1	Fundamental Conditions	4 - 1
4.1.1	Data and Survey of Present Situation	4 - 1
4.1.2	Service Area	4 - 2
4.1.3	Method of Estimating Potential Demand	4 - 3
4.2	Present State of Demand in Project Area	4 - 5
4.3	Forecasting Method	4 - 6
4.3.1	Basic Considerations	4 - 6
4.3.2	Parameters Required in Load Forecasting	4 - 7
4.4	Result of Power Demand Forecast	4 - 8
4.4.1	Power Demand of Object District According to Increase in Unit Requirement and Electrification Rate	4 - 8
4.4.2	Unit Requirement of Object District and Comparisons with Other Districts	4 - 13
4.4.3	Correlation between West Coast Grid and Ranau-Kundasang Grid	4 - 14
4.5	Timing of Development of Naradaw Small Hydroelectric Project	4 - 19
4.5.1	Basic Considerations	4 - 19
4.5.2	Timing of Development of Naradaw Small Hydroelectric Project	4 - 20
4.5.3	Saving in Diesel Fuel Cost	4 - 21

List of Tables

Table 4-1	Actual Power Demand at Ranau-Kundasang Grid
Table 4-2	Power Demand forecast for Ranau-Kundasang Grid from 1991 to 2015
Table 4-3	Actual Power Demand in 1985
Table 4-4	Annual Growth Rate of Generating Energy at West Coast Grid and Ranau-Kundasang Grid
Table 4-5	Correlation of Ranau-Kundasang Grid with West Coast Grid
Table 4-6	Supply Capability of Generating Facility

List of Figures

Figure 4-1	11 kV HV Existing Distribution Line (Ranau-Kundasang Grid)
Figure 4-2	Correlation of Ranau-Kundasang Grid with West Coast Grid
Figure 4-3	Peak Power Demand in Ranau-Kundasang Grid

4. POWER DEMAND FORECAST

4.1 Fundamental Conditions

4.1.1 Data and Survey of Present Situation

(1) Data and Information

With regard to the electric power demand forecast for the Ranau-Kundasang District, it is discussed in fairly great detail in "Hydro Power Projects in Sabah and Sarawak, March 1989" prepared at the request of the Asian Development Bank (ADB) by the New Zealand consultant firm of Tonkin & Taylor International Ltd. The JICA Study Team, while using this report as a reference, visited the local office of SEB at Ranau Town, the load center, and gathered data such as past power generation figures by power station, electric energy consumption by customer, number of customers, load curve by power station, etc. Further, data were collected on items such as the planned demands of new customers in the near future at Ranau Town and Kundasang Town, the load centers of this district.

(2) Survey of Present Situation

A power demand forecast must be made based on overall consideration of actual loads at the present time, suppressed demand due to shortage of supply capacity and other causes, planned demand based on plans for future expansion concerning public buildings, hotels, cinema theaters, commercial districts, etc., population distributions of load areas, demographic situation, and income levels. Accordingly, a survey of the present situation concerning the Ranau-Kundasang Power Grid was made for approximately one week in July 1991.

In this survey, the total length of the existing 11-kV HV transmission line of approximately 96 km was travelled by jeep, and efforts were made to obtain a general concept of the present state of the district, the state of spread of television, the state of the electrification rate, etc.

Also, Ranau Diesel Power Station, Kundasang Diesel Power Station, Bundu Tuhan Diesel Power Station, and Carabau Mini-hydro Power Station were visited, and the conditions of operation of the power stations, the states of maintenance and operation, and problematic points were investigated. Further, investigations were made concerning the three Mesilau mini-hydro power stations presently not in operation.

4.1.2 Service Area

As of the end of 1990 the ranau-Kundasang Grid had 2,960 customers for an electrification rate of 46.3%, and it was thought the number of potential customers would be as many as 3,430.

Within the object area, there are diesel power generating facilities (generator capacities 300 kVA x 1, 350 kVA x1) in operation to supply electric power to administrative buildings, hotels, lodges, mountain huts near the mountaintop, and the telecommunications tower inside the national park area centering on Mt. Kinabalu (EL. 4,101 m), and a power demand of approximately 200 kW is being met. These power generating facilities are owned by the Tourism and Environmental Dept. of Sabah State.

Bundu Tuhan located 4 km to the west of Kundasang Town has 182 customers, and electric power is being supplied only 12 hours during the nighttime by SEB (diesel power generating facilities, 75 kW x 2). However, in 1992, with construction of a new 11-kV HV transmission line through the national park, Bundu Tuhan will be connected to the Ranau-Kundasang Grid and 24-hours supply of electricity will be made. Judging by the distribution of unelectrified villages in this district which could be electrified hereafter, they would be in an area up to 10 km south from the Kundasang-Ranau road and 20 km east-west, for which expansion of the 11-kV HV transmission line and new construction of 415-V/240-V distribution line will be absolutely necessary (see **Fig. 4-1**).

4.1.3 Method of Estimating Potential Demand

Potential demand would be divided into power demand of unelectrified areas, and new customers in public facilities, commerce, small-scale industries, etc. expected at the centers of towns such as Ranau, Kundasang, and Bundu Tuhan.

Potential demand due to non-electrification includes houses, commercial buildings, public buildings, and public lighting, and with regard to these demands, it was considered that they would be incorporated in the power grid through increases in the electrification rate.

Raising of the electrification rate is one of the basic policies of the Malaysian Government, and it is aimed to improve the present electrification rate of Sabah State of 48% to 73% by the end of 1995 when the Sixth Five-Year Plan is to be completed. The JICA Study Team, taking into consideration the target of the rural electrification program in the Sixth Five-year Plan and the present states of the object areas, has forecast that an electrification rate of 60% in the year 2000, and further, 70% in 2010 would be achieved. When the morphological conditions of the object area, and the state of distribution of unelectrified villages are considered, it will be absolutely necessary for financial assistance to be provided SEB by the Malaysian Federal Government in order to attain these goals.

New demands expected in urban districts are the following:

- **Ranau Town**

  Shops, houses, hotels, cinema theaters
  Public buildings of the Fishery Department, Fire Department, Libraries, etc.
  SMK Lohan (new middle school)
  Sabah Tea Processing Factory

- **Kundasang Town**
  Shops, houses
  Post office building
  Kinabalu Golf and Country Club

- **Bundu Tuhan Town**
  Shops, houses
  Telephone office

It was considered that these new demands would be included in the increase in number of customers through rising of the electrification rate. It was assumed that the power demands of these customers would be considered in the growth in unit requirements (monthly average energy consumption per customer) obtained based on past power demand records.

4.2 Present State of Demand in Project Area

Basically, through the completion of Carabau Mini-hydro Power Station (1,000 kW x 2), it should have been possible to meet all of the power demand as of the end of 1990 of 1,330 kW with hydro. However, as previously mentioned in 3.3.1 Carabau Mini-hydro Power Station has had defects in governor functions for meeting power demand fluctuations of the Ranau-Kundasang Grid from the time of its completion, while moreover, due to lack of runoff of the river, the situation has been that the installed capacity of the power station cannot be effectively utilized.

Therefore, under present circumstances, Ranau Diesel Power Station and Kundasang Diesel Power Station are sharing the power demands of their respective districts, and Carabau Mini-hydro Power Station is functioning in only a supplementary role.

The effective installed capacity of diesel power stations is 1,780 kW with the two power stations of Ranau and Kundasang put together. The maximum output at the end of 1990 was 1,330 kW, so that if there were to be outage of the two largest units of diesel generating facilities (rated capacity 315 kW, effective output 220 kW), the electric power demand and supply balance cannot be maintained with only diesel generating facilities. Consequently, normalization of Carabau Mini-hydro Power Station is absolutely necessary.

Meanwhile, the diesel generating facilities of the two power stations are antiquated, and generating efficiencies have shown extreme declines.

Power generation facilities other than those of SEB in this district are the diesel generating facilities, 520 kW, inside Kinabalu National Park, and those of Mamut Copper Mine, 600 kW. Both are in the neighborhood of the Ranau-Kundasang Grid, and although plans for interconnection have been mentioned, the JICA Study Team decided not to consider Mamutmining here as objects of interconnection.

4.3 Forecasting Method

4.3.1 Basic Considerations

The basic policy of the Malaysian Government in rural electrification is to reduce fuel costs for diesel power generation through hydroelectric power generation as much as possible, thereby enhancing the effects of economic and financial improvement of entire Malaysia. Therefore, it is necessary for the optimum timing for interconnection of the Naradaw Small Scale Hydro Power Development Project to be determined predicated on the modification plans for Carabau Mini-hydro Power Station (2,000 kW) and the three Mesilau Mini-hydro Power Stations (total output 293 kW), and as a result, greatly contribute to reduction in fuel costs of the existing diesel generating facilities.

Meanwhile, since it is expected that the structure of the Ranau-Kundasang Grid as an independent power system will continue until around the year 2010 seen from the scale of the grid, a power demand forecast of extra long range (25-year period from 1990 to 2015) will be made, discussing also the electric power development plans of the Upper Liwagu River Basin Project beyond the Naradaw Small Scale Hydro Power Development Project.

The basic principles for forecasting described below are established in consideration of the foregoing.

- A power demand forecast at the customer end is made based on rising of the electrification rate, and the generating-end power demand taking into account transmission and distribution losses. (station service power supplies of power stations not to be included in power demand at generating end.)

- The power demand of the Ranau-Kundasang Grid forecast according to (1) above is to be cross-checked with the West Coast Grid. That is, the Ranau and Kundasang districts are in the economic sphere of Kota Kinabalu, the capital city of Sabah State, with prominent exchanges of commodities and people, and although there are differences in the scales of power demands, it was though there would be fairly strong correlation regarding growth of power demand. Therefore, the correlation between the two power systems are to be investigated and the appropriateness of the load forecast for the Ranau-Kundasang Grid checked by the past and future growths in power demand of the West Coast Grid.

4.3.2 Parameters Required in Load Forecasting

Parameters for indicating the geographical and economic features of the Ranau-Kundasang Grid are the following:

- Population and population growth rate of object district
- Present state of electrification rate of object district
- Future improvement in electrification rate of object district
- Electric energy sales by classification of customer
- Number of customers
- Unit requirement (electric energy consumption per customer)

It is necessary for checks to be made of the power demand forecast using the abovementioned parameters by checking in comparison with similar power systems in Sabah State. In this sense, it was decided to adopt the unit requirement in 1985 of Keningau of roughly the same number of customers in 1985 for the purpose of cross-checking.

As for the numbers of customers, electric energy sales, and unit requirements (electric energy consumption per customer) of the Ranau, Kundasang, and Bundu Tuhan districts discussed in 3.3.2, Present State of Power Demand, in Chapter 3 are not of great significance in making a load forecast. The reason is that large changes in proportions will not occur in these customer classifications even through the populations of the object areas increase so long as the social and economic bases are not changed. In other words, it is judged permissible to make a load forecast with unit requirement (electric energy consumption per customer) obtained from total number of customers and total electric energy sales as the parameter.

4.4 Result of Power Demand Forecast

4.4.1 Power Demand of Object District According to Increase in Unit Requirement and Electrification Rate

The power demand forecast for the Ranau-Kundasang Grid, as previously stated, was made based on the two parameters of unit requirement (electric energy consumption per customer) and electrification rate taking into account the present state of electrification of the object district. As shown in **Table 4-1**, the growth rate in number of customers from 1985 to 1990 was 7.8% and there was an increase of 922 customers in the 5-years period. In effect, this was an average annual increase of 180 customers. On the other hand, the growth rate in unit requirement (electric energy consumption per customer) recorded during the period from 1985 to 1990 was 5.8%.

In JICA Study Team, based on these two basic parameters obtained form past performances from 1985 to 1990, assumed that the electrification rate would increase 2 percentage points each year so that the 46.3% recorded in 1990 would reach 55% in 1995. As a result, the number of customers would increase from 2,960 to 4,260 during the period from 1990 to 1995. That is, the average for the 5-years period would be 260 customers. Electrification of 2,000 to 3,000 new customers is contemplated in all of Sabah State in the Sixth Five-Year Plan (1991-1995), and according to past performances and the electrification policy of the Malaysian Federal Government, the incorporation of the above-mentioned new customers in the Ranau-Kundasang Grid is though to be reasonable. Since the growth rate of unit requirement is 5.8%, a growth of 6.0% from 1990 to 1995 was assumed.

Table 4-1 Actual Power Demand at Ranau-Kundasang Grid

Year	Number of Consumers	Generated Energy (MWh)	Energy Sold to Consumers (MWH)	Energy Loss (%)	Monthly Unit Sold per Consumer (kWh)
1985	2038	3,210	2,836	11.7	116
1986	2288	3,530	3,103	12.1	113
1987	2507	4,150	3,836	6.9	128
1988	2640	5,303	4,875	8.1	154
1989	2722	5,532	4,971	10.1	152
1990	2960	6,025	5,484	9.0	154
Annual Growth Rate	7.8	13.4%	14.1%	-	5.8%

Regarding the growths from 1995 in electrification rates and unit requirements (electric energy consumption per customer), since it is thought there will be no large variations in geographical restraint and economic background of the object district, the following forecasts were made:

Table

Year	Electrification Rate (%)	Growth rate of Monthly Unit Requirement (%)
1990	46.3	
		6.0
1995	55.0	
		4.0
2000	60.0	
		3.0
2005	65.0	
		2.0
2010	70.0	
		1.0
2015	70.0	

The results of forecasting the power demand of the Ranau-Kundasang Grid are shown in **Table 4-2**. As a result, the growth in electric energy demand over the extra long range up to 2015 is thought will be 8.2%/yr, with a growth in maximum demand of 8.0%/yr to be expected.

Table 4-2 Power Demand Forecast for Ranau-Kundasang Grid from 1991 to 2015

No.	Year	Estimated Population in Kundasang -Ranau Grid	Potential Number of Consumers	Electrification Ratio (%)	Number of Consumers Electritied	*1 Monthly Average Consumption Per Customers (kWh)	Annual Energy Regeirement at Consumers End (MWh)	Energy Loss Factor (%)	at Generating End			Remarks
									Annual Load Factor (%)	Annual Energy Requirement (MWh)	Annual Maximum Demand (kW)	
Historical Data	1985	26,900	5,270	38.7	2,038	116	2,836	11.7	50.1	3,210	730	
	1986	28,000	5,490	41.7	2,288	113	3,103	12.1	51.0	3,530	790	Note *1
	1987	29,100	5,700	44.0	2,507	128	3,863	6.9	50.9	4,150	930	Growth Rate :
	1988	30,200	5,920	44.6	2,640	154	4,875	8.1	49.2	5,303	1,230	1990~1995 : 6 %
	1989	31,400	6,160	44.1	2,722	152	4,971	10.1	50.1	5,532	1,260	1995~2000 : 4 %
	1990	32,600	6,390	46.3	2,960	154	5,484	9.0	51.7	6,025	1,330	2000~2005 : 3 %
1	1991	33,900	6,650	47.0	3,130	163	6,122	10.0	52.0	6,734	1,480	2005~2010 : 2 %
2	1992	35,200	6,900	49.0	3,380	173	7,017	10.0	52.0	7,719	1,690	2010~2015 : 1 %
3	1993	36,600	7,180	51.0	3,660	183	8,037	11.0	53.0	8,921	1,920	
4	1994	38,000	7,450	53.0	3,950	194	9,196	11.0	53.0	10,208	2,200	Power demand in National Park
5	1995	39,500	7,750	55.0	4,260	206	10,530	11.0	53.0	11,583	2,520	is included from 1992.
6	1996	41,000	8,040	56.0	4,500	214	11,556	12.0	54.0	12,943	2,740	
7	1997	42,600	8,350	57.0	4,760	223	12,738	12.0	54.0	14,267	3,020	
8	1998	44,300	8,690	58.0	5,040	232	14,031	12.0	54.0	15,715	3,320	
9	1999	46,000	9,020	59.0	5,320	241	15,385	12.0	54.0	17,201	3,640	
10	2000	47,800	9,370	60.0	5,620	251	16,927	12.0	55.0	18,958	3,930	
11	2001	49,000	9,610	61.0	5,860	258	18,143	12.0	55.0	20,320	4,220	
12	2002	50,300	9,860	62.0	6,110	266	19,503	12.0	55.0	21,843	4,530	
13	2003	51,600	10,120	63.0	6,380	274	20,977	12.0	55.0	23,494	4,880	
14	2004	53,000	10,390	64.0	6,650	282	22,504	12.0	55.0	25,204	5,230	
15	2005	54,300	10,650	65.0	6,920	291	24,164	12.0	55.0	27,064	5,620	
16	2006	55,800		66.0		296		12.0	55.0			
17	2007	57,200		67.0		302		12.0	55.0			
18	2008	58,700		68.0		308		12.0	55.0			
19	2009	60,200		69.0		315		12.0	55.0			
20	2010	61,800	12,120	70.0	8,480	321	32,665	12.0	55.0	36,585	7,590	
21	2011	63,400		70.0		324		12.0	55.0			
22	2012	65,000		70.0		327		12.0	55.0			
23	2013	66,700		70.0		331		12.0	55.0			
24	2014	68,500		70.0		334		12.0	55.0			
25	2015	70,200	13,760	70.0	9,630	337	38,944	12.0	55.0	43,617	9,050	
Annual Growth Rate (%)		3.1	3.1	—	4.8	3.1	8.2	—	—	8.2	8.0	

4.4.2 Unit Requirement of Object District and Comparisons with Other Districts

It is of significance to evaluate how the unit requirement (electric energy consumption per customer) in the object district would increase through comparisons with past performances in other districts.

The numbers of customers, electric energy sales to customers and monthly units sold per consumer, or unit requirements (electric energy consumption per customer), of other districts in Sabah State are given in **Table 4-3**.

Table 4-3 Actual Power Demand in 1985

Cities or Town	Number of Consumers	Unit Sold to Consumers (MWh)	Monthly Unit Sold per Consumer (kWh)
Kota Kinabalu	45,638	276,132	504
Sandakan	18,947	98,717	343
Tawau	14,594	74,028	422
Lahad Datu	4,053	15,877	326
Keningau	4,747	11,712	206

The power demand in the object district in 1995 will reach the same level as in Keningau Town (number of customers: 4,747) as of 1985. In other words, the power demand of the object district will become of roughly the same level as Keningau Town 10 years later.

Furthermore, it is estimated that attainment of a power demand of the level of Lahad Datu City will be around the year 2010.

Seen from comparisons with the performances in power demands of other districts in Sabah State also, it may be judged that the power demand forecast for the object district is reasonable.

4.4.3 Correlation between West Coast Grid and Ranau-Kundasang Grid

The object district, as previously mentioned, is at a very close distance so as to be included in the economic sphere of Kota Kinabalu, the capital city of Sabah State, and with the consolidation in recent years of a paved road network, distribution of general commodities and interchanges among people have increased.

The JICA Study Team expected that there would be a close correlation between the object district and the West Coast Grid of Sabah State (the 138-kV power system spread out along the western coast centered on the power system of Kota Kinabalu) in the sense that they are of the same economic sphere. That is, although there would be a large difference in the scales of the two power systems, it was expected there would be a correlation with regard to the growth rate in power demand. The respective growth rates in generating-end power demands of the West Coast Grid and the Ranau-Kundasang Grid from 1985 to 2000 are given in **Table 4-4.**

Table 4-4 Annual Growth Rate of Generating Energy at West Coast Grid and Ranau-Kundasang Grid

Unit: %

Year	(A) West Coast	(B) Ranau-Kundasang	Σ (A)	Σ (B)
1985	17.9	14.2	17.9	14.2
1986	8.9	10.2	26.8	24.2
1987	12.0	17.6	38.8	41.8
1988	2.8	21.7	41.6	63.5
1989	10.7	4.3	52.3	67.8
1990	28.7	8.9	81.0	76.7
1991	8.5	10.8	89.5	87.5
1992	8.6	14.6	98.1	102.1
1993	8.7	15.6	106.8	117.7
1994	8.8	14.4	115.6	132.1
1995	13.2	13.5	128.8	145.6
1996	9.2	11.7	138.0	157.3
1997	9.3	10.2	147.3	167.5
1998	9.5	10.1	156.8	177.6
1999	9.7	9.5	166.5	187.1
2000	9.8	10.2	176.3	197.3
Total	176.8	197.3		
Average	11.0	12.3		

As shown in **Fig. 4-2**, a correlation coefficient of 1.07 was obtained for the two power systems. This value includes the large decline in growth rate of the West Coast Grid due to the cut-back in finances of the Malaysian Federal Government in 1987, and if a correction were to be made regarding this point, the correlation coefficient would become even closer to 1.0.

It was thus verified that there is a close correlation between the two power systems. It is to be noted here that the power demand forecast for the West Coast Grid from 1991 to 2000 was made by SEB itself based on past performances.

Based on the foregoing, if it were to be possible for the power demand of the West Coast Grid to maintain the growth rate forecast, it is meant that the same may be expected of the power demand of the object district.

The past performances in the West Coast Grid and the Ranau-Kundasang Grid along with the results of power demand forecasts for the future are shown in **Table 4-5**.

Table 4-5 Correlation of Ranau-Kundasang Grid with West Coast Grid

No.	Year	West Coast Grid Peak (MW)	Generated (GWh)	Load Factor (%)	Generated Growth (%)	Energy Sold (GWh)	Loss (%)	Ranau-Kundasang Grid Peak (kW)	Generated (MWh)	Load Factor (%)	Generated Growth (%)	Remarks
Historical Data	1980	35.3	187.1	60.5	–	153.1	18.2	370	1,460	45.0	–	
	1981	42.0	212.7	57.8	13.7	170.5	19.8	430	1,780	47.3	21.9	1984 : Tenom Pangi Hydrc Power
	1982	46.3	240.7	59.3	13.2	193.2	19.7	490	1,970	45.9	10.7	Plant + Kota Kinabalu +
	1983	51.8	272.7	60.0	13.3	201.8	26.0	600	2,420	46.0	22.8	Beanfor
	1984	57.3	311.2	62.0	14.1	211.4	32.1	640	2,810	50.1	16.1	1989 : Plas Keningau + Tenom
	1985	69.3	367.1	60.5	17.9	289.2	21.2	730	3,210	50.1	14.2	1990 : Plus Labuan
	1986	76.2	399.7	59.8	8.9	296.4	25.8	790	3,530	51.0	10.0	
	1987	82.0	447.7	62.3	12.0	337.6	24.6	930	4,150	50.9	17.6	
	1988	84.5	460.1	62.2	2.8	351.5	23.6	1,230	5,303	49.2	21.7	
	1989	89.3	509.2	65.1	10.7	411.1	19.3	1,260	5,532	50.1	4.3	(1) Annual Generated Energy
	1990	115.5	655.2	64.7	28.7	534.2	18.5	1,330	6,025	51.7	8.9	Growith Rate from 1985 to 1990
1	1991	129.7	738.2	65.0	8.5	568.4	27.1	1,480	6,734	52.0	10.8	West Coast Grid : 12.3%
2	1992	140.8	801.9	65.0	8.6	625.5	22.0	1,690	7,719	52.0	14.6	Ranau-Kundasang : 13.4%
3	1993	153.1	871.6	65.0	8.7	686.7	21.2	1,920	8,921	53.0	15.6	
4	1994	166.6	948.6	65.0	8.8	756.6	20.2	2,200	10,208	53.0	14.4	(2) Annual Generated Energy
5	1995	188.6	1,073.6	65.0	13.2	880.0	18.0	2,520	11,583	53.0	13.5	Growth Rate from 1990 to 2000
6	1996	205.9	1,172.7	65.0	9.2	973.3	17.0	2,740	12,943	54.0	11.7	West Coast Grid : 10.0%
7	1997	225.2	1,282.4	65.0	9.3	1,077.2	16.0	3,020	14,267	54.0	10.2	Ranau-Kundasang : 12.1%
8	1998	246.7	1,404.7	65.0	9.5	1,193.9	15.0	3,320	15,715	54.0	10.1	
9	1999	270.6	1,541.0	65.0	9.7	1,325.3	14.0	3,640	17,201	54.0	9.5	(3) Power demand in National Park
10	2000	297.4	1,693.5	65.0	9.8	1,473.3	13.0	3,930	18,958	55.0	10.2	is included from 1992
11	2001	331.1	1,885.7	65.0	11.3	1,640.5	13.0	4,220	20,320	55.0	7.2	
12	2002	369.3	2,103.2	65.0	11.5	1,829.8	13.0	4,530	21,843	55.0	7.5	
13	2003	412.7	2,349.9	65.0	11.7	2,044.4	13.0	4,880	23,494	55.0	7.6	
14	2004	461.6	2,630.0	65.0	11.9	2,288.1	13.0	5,230	25,204	55.0	7.3	
15	2005	517.6	2,948.6	65.0	12.1	2,585.3	13.0	5,620	27,064	55.0	7.3	
16	2006				12.0							
17	2007				12.0							
18	2008				12.0							
19	2009				12.0							
20	2010	912.6	5,196.5	65.0	12.0	4,521.0	13.0	7,590	36,585	55.0	–	
21	2011				10.0							
22	2012				10.0							
23	2013				10.0							
24	2014				10.0							
25	2015	1,469.2	8,366.3	65.0	10.0	7,278.8	13.0	9,050	43,617	55.0	–	
Annual Growth Rate (%)		10.7	10.7	–	–	11.0	–	8.0	8.2	–	–	

4.5 Timing of Development of Naradaw Small Hydroelectric Project

4.5.1 Basic Considerations

The optimum timing of development of Naradaw Small Hydroelectric Project must be determined based on the assumption that the Carabau Small Hydroelectric Power Plant (2,000 kW) and the three small hydroelectric power plants of Mesilau (with total output of 293 kW) are shutdown for repair, and based on the verification that Naradaw Project, to be commissioned at the optimum timing thereby determined, substantially contribute to the reduction of the fuel cost of existing diesel power generation facilities.

It is being planned that the rehabilitation work on the three small hydroelectric power plants of Mesilau will be completed by the end of 1992. Concerning Carabau Small Hydroelectric Power Plant, the JICA Study Mission had the opportunity of visiting this power plant for several times from July, 1990 to June, 1991, and the Study Mission found that one unit is shutdown almost all the time due to sand deposit on the head pond, failure of turbine shaft, malfunction of governor, etc. (Refer to **Appendix 11**.) Although the faulty plant equipment such as water turbines and generators may be repaired, the only feasible way of dealing with the sand deposit in the head pond is to remove the sand by human labor.

In studying the balance of electric power (kW) demand and supply in general, it is customary to study the power balance in a small power system based on the assumption that both the largest unit and the second largest unit in the power system are shut down. In the case of Ranau-Kundasang Power System, the effect of shutting down 1 unit of Carabau Small Hydroelectric Power Plant is very large considering the size of the power system.

On the other hand, concerning the timing of Naradaw Small Hydroelectric Plant, as the size of the power system grows (to have larger power demand), the generating capability of the plan can be more effectively utilized. As studied in **Chapter 9, "Selection of Optimum Plan"**, the time when the index "B/C", which is the measure of economy of Naradaw Small

Hydroelectric Power Plant, exceeds 1.0, will be in the year of 1997 if it is assumed that 1 unit of Carabau Power Plant is completely shut down, and will be in the year of 2000 if it is assumed that the both unit can be operated all the time.

4.5.2 Timing of Development of Naradaw Small Hydroelectric Power Project

In studying the power balance (kW balance) of Ranau-Kundasang Power System, the JICA Study Mission decided to select the assumption that 1 unit (1,000 kW) of Carabau Small Hydroelectric Power Plant is excluded. That is, it has been assumed that the maximum output that can be expected from Carabau Power Plant at all times is 1,000 kW which is the maximum output of one generating unit. The available power supply capability of each power plant in Ranau-Kundasang Power System is presented in **Table 4-6**.

The study of power balance (kW) which has been conducted based on the derated output of each power plant is presented in **Fig.4-3**.

Table 4-6 Supply Capability of Generating Facility

	Installed Capacity (kW)	Derated Output (kW)	Firm Peak Output (kW)
Kundasang Diesel	945	660	660
Ranau Diesel	1,645	1,120	1,120
Mesilau Mini-Hydro	293	293*1	15
Carabau Small-Hydro	2,000	1,000*2	430
Sub-total	4,833	3,073	2,225
Naradaw Small-Hydro	1,600	1,600	460
Total	6,433	4,673	2,685

*1 Expected to be put in service at the end of 1992
*2 Derated capacity due to the actual operation results

Based on this study, it is concluded that Naradaw Small Hydroelectric Power Plant (800 kW x 2) should be commissioned to service by the beginning of 1997. This is the time when the output of Naradaw Small Hydroelectric Power Plant can be effectively consumed within the power system in view of the kW balance, and the index "B/C", which indicates the economy of the plant for the service life of the plant exceeds 1.0.

On the other hand, regarding kW balance based on the firm peak out put of Carabau, Mesilau and Naradaw Small Hydro-power Plants, it can be said that additional diesel power plant of 900 kW would be necessary to install at the end of 1994 in Ranau or Kundasang district to meet peak power demand to be emerged from 1994 to 1999 at peak time.

4.5.3 Saving in Diesel Fuel Cost

The saving in diesel fuel can be evaluated by the annual energy generation of Naradaw Small Hydroelectric Power Plant. That is, the saving in fuel cost is expected as follows.

	1997	2000	after 2009
Oil saving (M$)	842,000	1,338,000	1,764,000
Naradaw P/S generation (MWh)	4,600	7,300	9,500

Figure 4-1 11 kV HV EXISTING DISTRIBUTION LINE

(RANAU - KUNDASANG GRID)

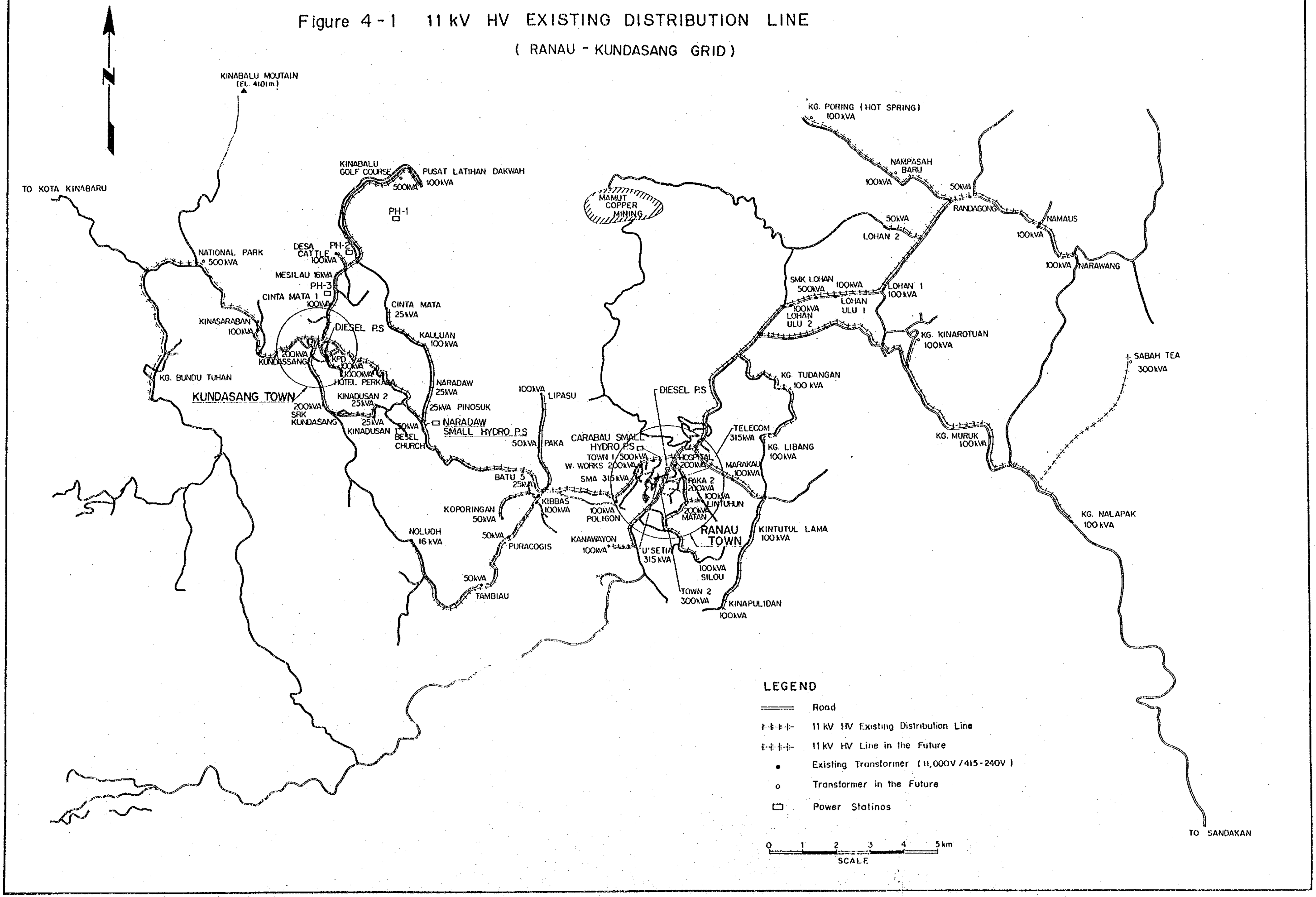
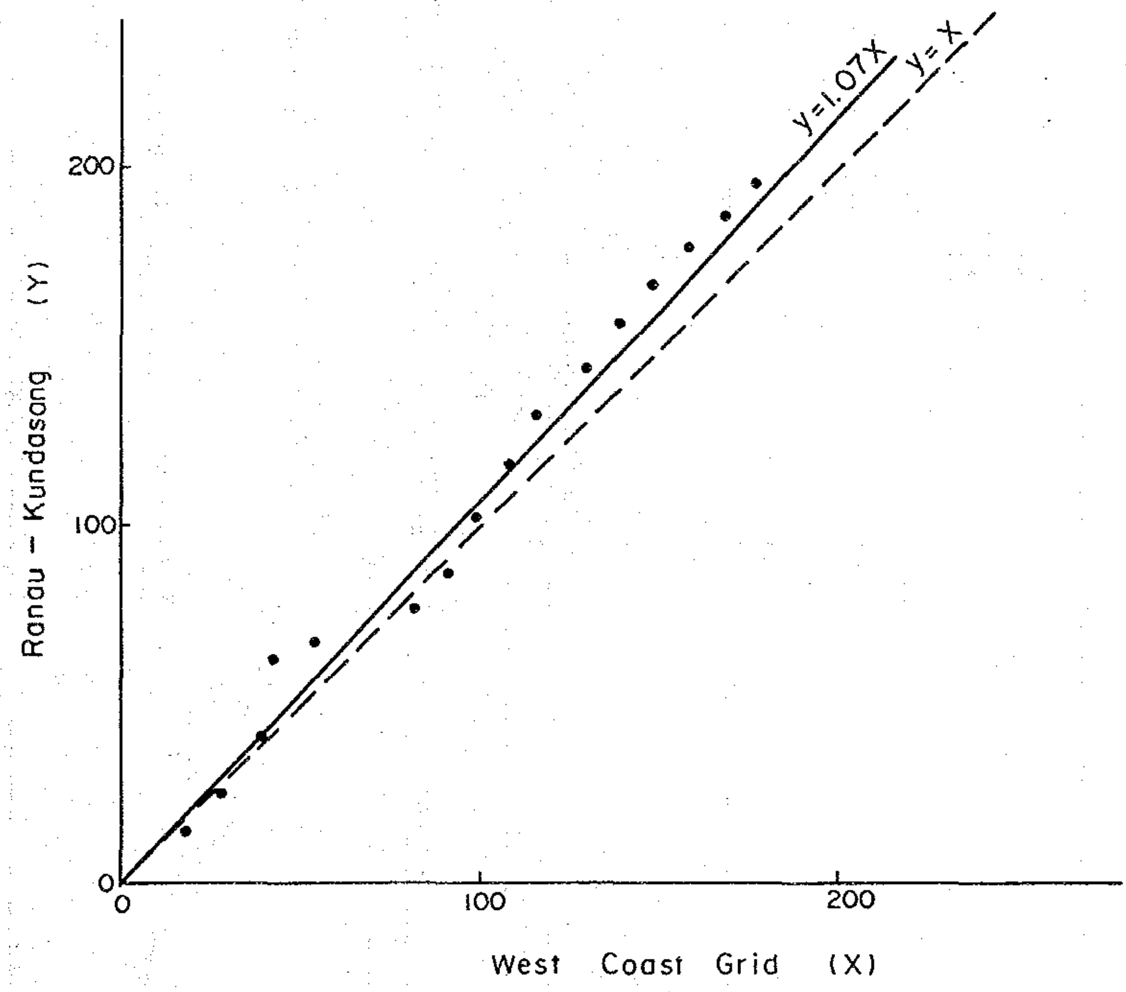
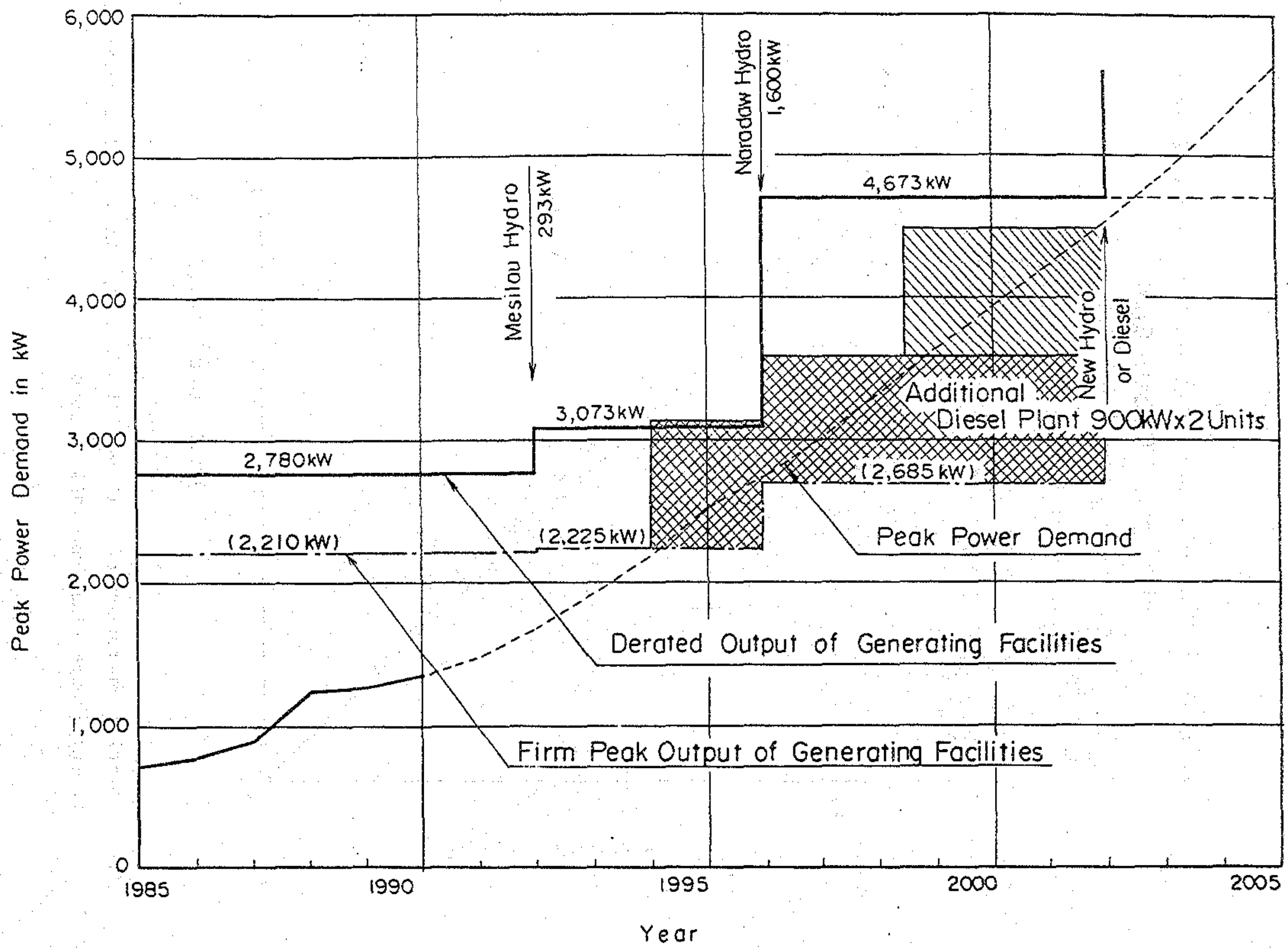


Figure 4-2 Correlation of Ranau-Kundasang Grid with West Coast Grid



Note: Correlation factor of 1.14 was obtained by the actual generating energy growth rate from 1985 to 1990.

Figure 4-3 Peak Power Demand in Ranau - Kundasang Grid



Chapter 5 SITE SELECTION

Chapter 5

SITE SELECTION

Contents

		Page
5.1	Development Basic Concept	5 - 1
5.1.1	Basic Concept	5 - 1
5.1.2	Alternative Schemes	5 - 6
5.1.3	Study Procedure	5 - 7
5.2	Study on Alternative Schemes	5 - 10
5.2.1	Naradaw Site	5 - 10
5.2.2	Gantong Site	5 - 14
5.2.3	Pakai Site	5 - 17
5.2.4	Kauluan Site	5 - 20
5.2.5	Lamas Site	5 - 22
5.3	Selection of Optimum Site	5 - 25
5.4	Subjects to be Studied	5 - 26

List of Tables

Table 5-1	Hydro Power Supply Capability
Table 5-2	Energy Demand and Supply
Table 5-3	Summary of 20 Sites at Upper Liwagu River Basin
Table 5-4	Data Summary Sheet (1), Small Hydro Power Project at Upper Liwagu River Basin
Table 5-5	Data Summary Sheet (2), Small Hydro Power Project at Upper Liwagu River Basin

List of Figures

Figure 5-1	Hydro Power Supply Capability in a Year
Figure 5-2(1)	Daily Load Duration
Figure 5-2(2)	Supply Capability of Carabau P.S and Mesilau P.S
Figure 5-3	Demand and Supply
Figure 5-4(1)	Alternative Schemes
Figure 5-4(2)	Alternative Scheme
Figure 5-5	Hydro Power Planning Procedure
Figure 5-6	Discharge Duration and Intake Water at a Site
Figure 5-7	Geological Map of Project Area

5. SITE SELECTION

5.1 Development Basic Concept

5.1.1 Basic Concept

An Optimum site for small scale hydro power will be selected by two basic concept. First, the site does not prevent the construction of a major hydro project (165 MW) which is projected at the middle stream of the Liwagu River. Namely, Layout and access road for the small scale hydro should be planned above the high water level of the major hydro project. Second, the optimum site and alternative schemes should be studied in consideration of total development at the upper Liwagu river basin. This clause mentions the later concept.

(1) Supply Capability of Existing Power Plants

Total installed capacity in the Ranau-Kundasang distribution system is 4,883 kW, and consists of 9 diesel plants of 2,590 kW and 5 hydro plants of 2,293 kW in 1991.

	Name	Installed Capacity		Derated Output	Supply Capability		
		Unit	Total (kW)	(kW)	Average (kW)	Peak (kW)	Ann. Energy (GWh)
Diesel Plant	Ranau	6	1,645	1,120	900	900	--
	Kundasang	3	945	660	530	530	--
	Sub. Total	9	2,590	1,780	1,430	1,430	--
Hydro Power	Mesilau	3	293	280	80	80	2.0
	Carabau	2	2,000	1,800	470	860	10.7
	Sub. Total	5	2,293	2,080	550	940	12.7
Total		14	4,883	3,860	1,980	2,370	--

Note: Diesel supply capability is estimated as 0.8 times derated output.

Hydro supply capability is estimated based on the river runoff of the time of 95% in a year.

The supply capability of the diesel plants are estimated based on data provided by SEB.

At the Carabau P.S, one plant has been generating power, however, the other plant is under repairing. At Mesilau P.S, all of 3 plants did not generate power for long time. According to SEB's schedule, Carabau P.S. will start generating power in 1991, All plants at Mesialu P.S will also start operating in 1992.

The Team estimated the supply capability of the hydro plants based on the following conditions:

- All hydro plants can generate their full output after repair.

- River runoff at each intake is calculated from the data measured at Bedukan gauging station. Amount of intake water at each intake is approximately estimated taking into consideration other water utilizations in the catchment area and leakage from the diversion weir.

- Maximum output for a lifetime of the plant decreases to 90% of the installed capacity due to corrosion of the steel headrace and penstock.

- Firm power is daily average output calculated using 95% flow in a year (347 days). Firm peak power means maximum output in a peak hour of 4 hours. Supply capability of firm power is evaluated as 0.9 times firm power calculated above taking into account energy used at the station, scheduled and forced outage.

Mesilau power station consists of PH-1, PH-2 and PH-3, run of river type, which divert maximum of 0.198 m^3/s from the Mesilau River and discharge maximum of 0.098 m^3/s to the Liwagu River. Water for drinking and agriculture, total amount of 0.1 m^3/s, is diverted from facilities of PH-1 and PH-2. Mesilau P.S, installed capacity 293 kW, has an ability to generate 250 kW in 80% of a year and firm power of 80 kW.

Carabau power station, installed capacity of 2,000 kW, diverts maximum of 1.27 m^3/s from the Bambangan River to the Liwagu River. Carabau P.S may generate full output in 40% of a year. Water for the Mamut copper mine and villages diverted from the catchment area of 32.1 km^2. Taking into account these water utilizations the firm power is estimated to be 470 kW. The pond with a capacity of 2,000 m^3 enables to add 390 kW on the firm power. The output duration shown **Fig. 5-1** tells us the output of Carabau P.S fluctuates in proportion with river runoff.

(2) Role of Diesel and Existing Hydro Plant

The big installed capacity of 2,000 kW and decrease in output in dry days at Carabau power station will affect the system in 1990s. The role of existing hydro plants and diesel plants are characterized as follows:

kWh Balance

Fig. 5-2 shows typical daily load duration in the system predicted in the **Chapter 4**. Future daily load duration is assumed that it follows the typical one. The daily load is divided into three areas, peak load, middle load, and base load.

The area of peak load contains 6% of daily energy, middle load 31%, and base load 63%.

In 1996, it is predicted that demand will grow up to 2,740 kW and annual energy will be 12.9 GWh.

The demand and supply in 1996 shown in **Fig. 5-2** tells us the follows:

- In wet days (40% to 50% of a year), the hydro plants meet base load and middle load as main source in the system. A part of intake water is not utilized for generating power.

- In dry days the hydro plants supply energy for a part of base load. All intake water is utilized for generating power. The diesel plants, as main source in the system, meet three loads.

As a result, of 12.9 GWh of demand, the hydro supply around 10 GWh, and the diesel supply 2.9 GWh. Carabau P.S and Mesilau P.S have the capability to generate energy of 12.7 GWh in a year. The system consumes 80% of that.

In 2000, Demand will reach 3,930 kW and 19 GWh. The followings are pointed out from the demand and supply.

- In wet days, the hydro plants meet base load and a part of middle load. Almost of intake water is used for generating power. While the diesel plants meet peak load and a part of middle load.

- In dry days, the hydro plants only supply energy for a small part of base load.

Consequently, 92% of the energy supply capability of the hydro is consumed in the system.

kW Balance

The hydro and diesel pants can generate a total of 2,370 kW through the time of 95% in a year, 1,430 kW from the diesel plant and 940 kW from the hydro plants. In 1990, the system recorded maximum demand of 1,330 kW.

According to predicted demand, maximum demand will grow up to 2,520 kW in 1995, 3,930 kW in 2000.

As demand exceeds the supply ability in terms of kW of existing plants, new plant should begin operating by the year 1994. Total of 2,500 kW should be developed to meet the demand by 2000.

(3) Future Power Source

Power Sources developed in the future will consist of diesel plants and hydro plants. Both plants will take on the similar role as mentioned in the item (2).

A feature of demand and supply by the year 2000 is that power plants should be developed in order to meet power (kW) in dry days with relatively little energy (kWh). This feature requires diesel plants because construction costs for diesel plants are cheaper than those of hydro plants, and also their fuel costs do not become heavy burden on the system.

Increase of diesel plants, however, will gradually cause increase of fuel cost in the system. Then this will call a hydro project which does not consume fuel. Much attention should be paid on the development schedule of the hydro power so that the system consume energy generated because of the higher construction cost of the hydro power project. Judging from the kWh balance, the hydro project might be developed by the beginning of 2000s, however, the schedule should be exactly checked from an economical viewpoint based on the optimum plan.

(4) Conditions for Small Hydro Project

The following conditions will be required for the small hydro project in order to contribute to realize the economical system in the future.

(a) The small scale hydro project should be run of river type in order to ensure the economy for the small Ranau-Kundasang distribution system isolated from others. Sites having storage is not suitable because construction cost of dam with reservoir is considerably high for the kind of small hydro projects. This high cost will result in rising unit price in the system.

(b) The small scale hydro should generate much energy under the condition that generated power and energy meet future demand in the system in order to take advantage of scale merit.

(c) Small scale hydro should not remarkably decrease its output in dry days. As the decrease in output of the hydro in dry days should be compensated by other plants, total plant capacity in the system will exceed a reasonable level.

It is important to minimize the decrease in output of the hydro plant in dry days by measures such as:

- Design maximum discharge of the hydro should be appropriate, be not too much in comparison with river runoff in dry days. This will result in preventing the remarkable decline in output (kWh and kW).

- A small pond along the headrace will enable to increase kW in a peak hour in dry days with reasonable cost.

5.1.2 Alternative Schemes

JICA and Economic Planning Unit agreed that 20 sites shown in the **Table 5-3** should be reviewed by the Team in the identification stage. Of 20 sites, 11 sites are reservoir or regulating reservoir type plants, 9 sites are run of river type plants.

The Team reviewed 20 sites taking into account requirements for small scaled hydro plants to meet future demand as mentioned below, then chose 5 sites 6 development plans to be studied in detail. That is Kauluan, Naradaw, Gantong A, Gantong B, Pakai, Lamas 2.

- Small scale hydro projects should be run of river type. Sites having storages are eliminated because construction costs of dams with reservoirs are considerably high for the kind of small hydro projects.