No. 1

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEDERATED STATES OF MICRONESIA
DEPARTMENT OF EXTERNAL AFFAIRS

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR UPGRADING OF ELECTRIC UTILITIES IN THE FEDERATED STATES OF MICRONESIA

NOVEMBER 1992

PACIFIC CONSULTANTS INTERNATIONAL

JICA BASIC DESIGN STUDY REPORT ON THE PROJECT FOR THE UPGRADING OF ELECTRIC UTILITIES IN THE FEDERATED STATES OF MICRONESIA NOVEM

GRF
[redacted]
92-169

JICA LIBRARY
1107756[7]

国際協力事業団
25335

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEDERATED STATES OF MICRONESIA
DEPARTMENT OF EXTERNAL AFFAIRS

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR UPGRADING
OF
ELECTRIC UTILITIES
IN
THE FEDERATED STATES OF MICRONESIA

NOVEMBER 1992

PACIFIC CONSULTANTS INTERNATIONAL

PREFACE

In response to a request from the Government of the Federated States of Micronesia (FSM), the Government of Japan decided to conduct a basic design study on the Project for the Upgrading of Electric Utilities in the Pohnpei State and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to FSM a study team headed by Mr. Takahiro Ikari, Officer, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs and constituted by members of Pacific Consultants International Co., Ltd., from July 5 to 31, 1992.

The team held discussions with the officials concerned of the Government of FSM, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to FSM in order to discuss a draft report 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 FSM for their close cooperation extended to the team.

November, 1992

Kensuke Yanagiya
President
Japan International Cooperation Agency

November 30, 1992

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for the Upgrading of Electric Utilities in the Federated States of Micronesia.

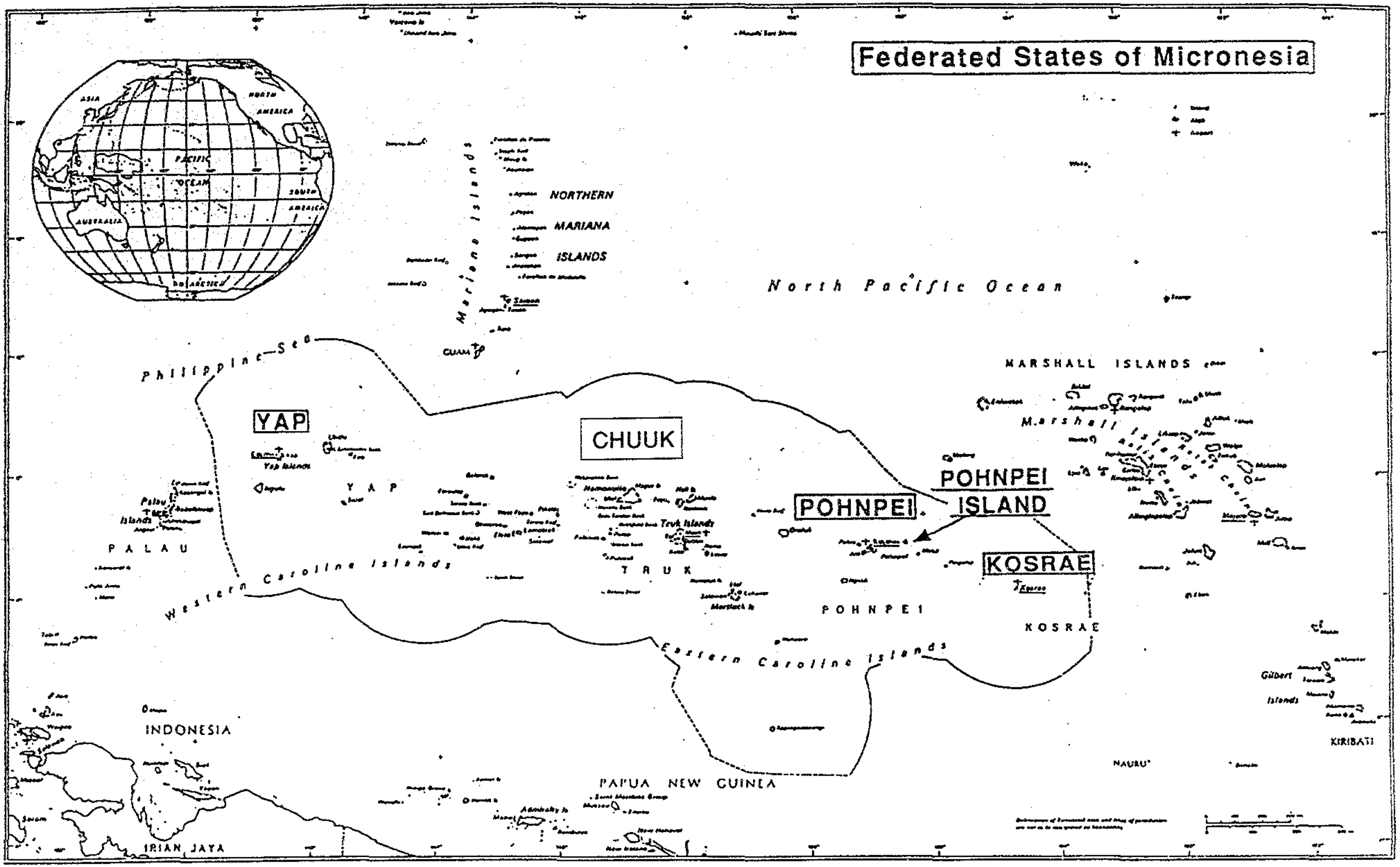
This study has been made by Pacific Consultants International, Tokyo, based on a contract with JICA, from July 1, 1992 to November 30, 1992.
Throughout the study, we have taken into full consideration of the present situation in the Federated States of Micronesia, and have planned the most appropriate project in the scheme of Japan's grant aid.

We with to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, the Ministry of International Trade and Industry and Embassy of the Federated States of Micronesia.
We also with the express our deep gratitude to the officials concerned of the Department of External Affairs, Budget, Planning and Statistics, Pohnpei Utilities Cooperation, Japan Overseas Cooperation volunteers and Consulate-General of Japan in Agana for their close Cooperation and assistance during our study.

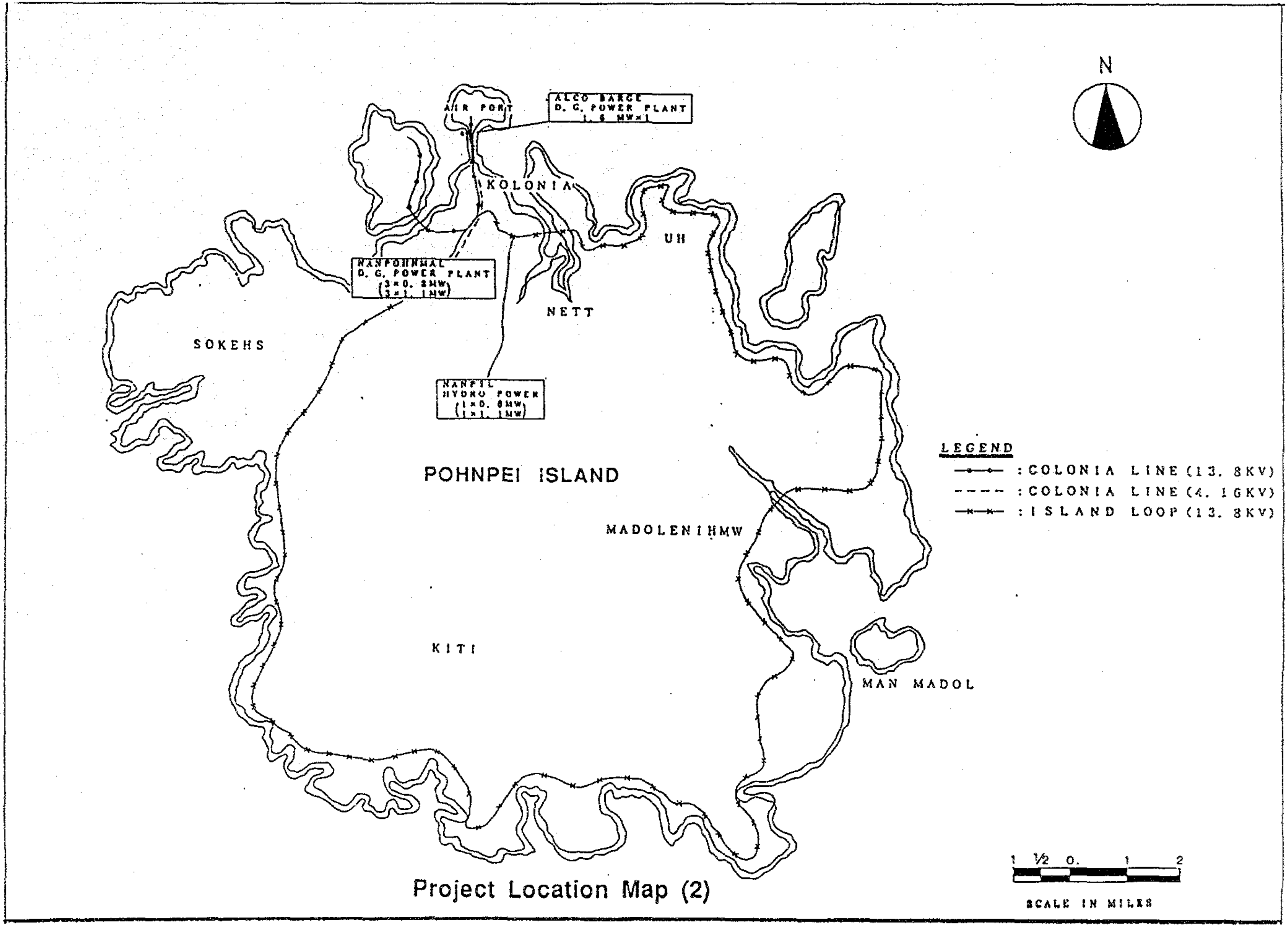
At last, we hope that this report will be effectively used for the promotion of the project.

Very truly yours,

Team Leader, YUKIO TOYOSHIMA
Basic design study team
The Project for Electric
Utilities Upgrading
Pacific Consultants International

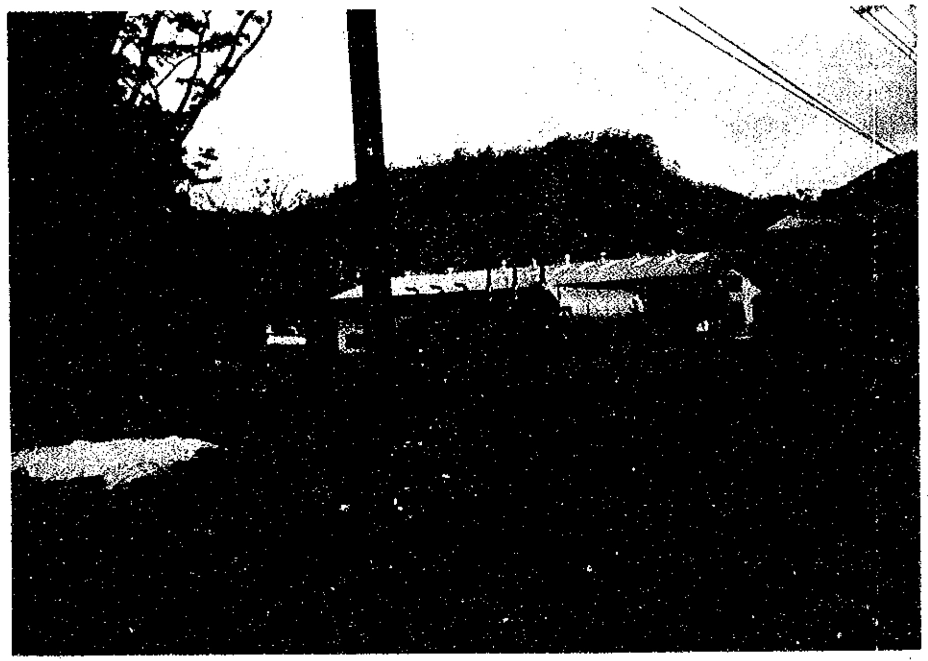


Project Location Map (1)

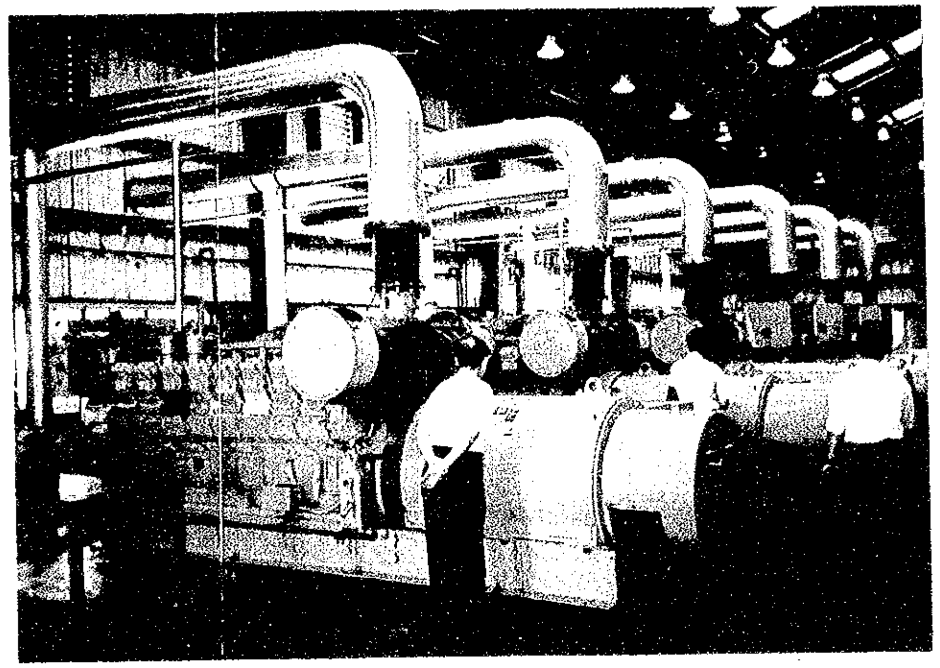


Project Location Map (2)

EXISTING NANPOHNMAL POWER PLANT



External View of Existing Power Plant



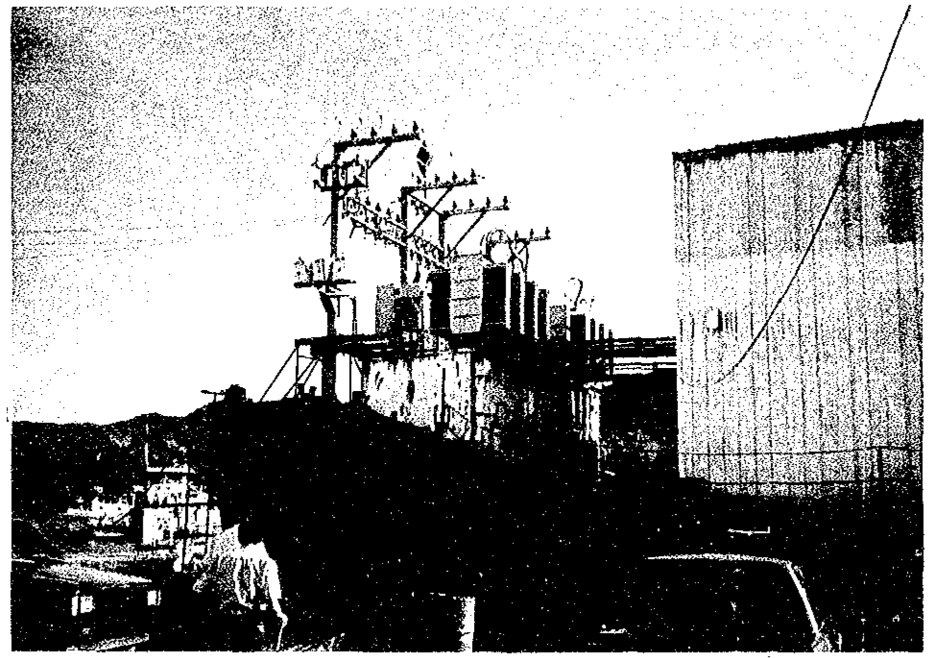
High Speed Generation Facility (1,200rpm)

Name Plate Rating:	:	1.1 MW - 3 Nos.
		0.8 MW - 3 Nos.
Actual Generation of Electricity	:	0.9 MW - 3 Nos.
		0.5 MW - 1 No.
Manufacturer	:	Caterpillar

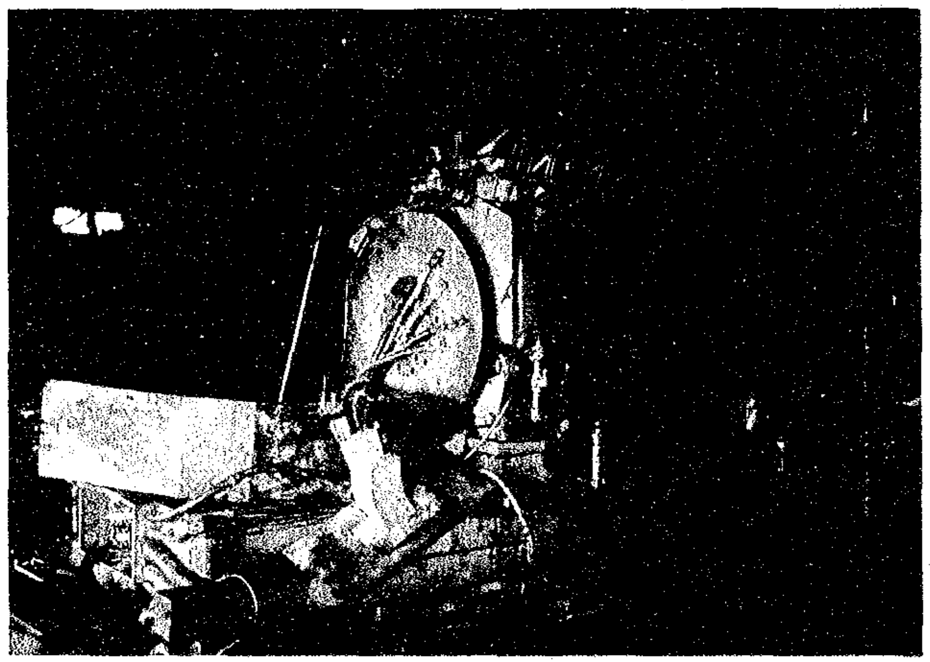
Silencers of Existing Power Plant

Interior View of Existing Power Plant

EXISTING ALCO-BARGE
POWER PLANT

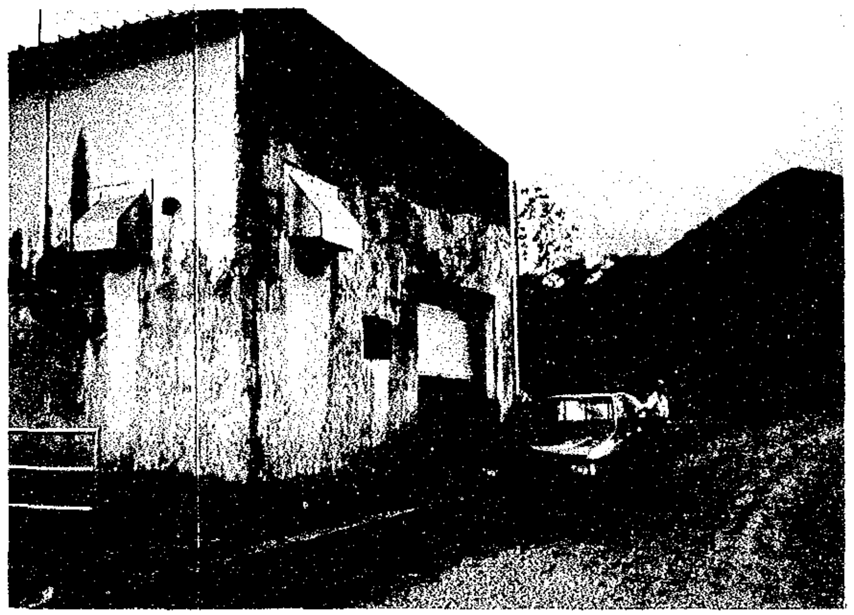


Name Plate Rating	:	2.0 MW - 4 Nos
Actual Generation of Electricity	:	1.7 MW

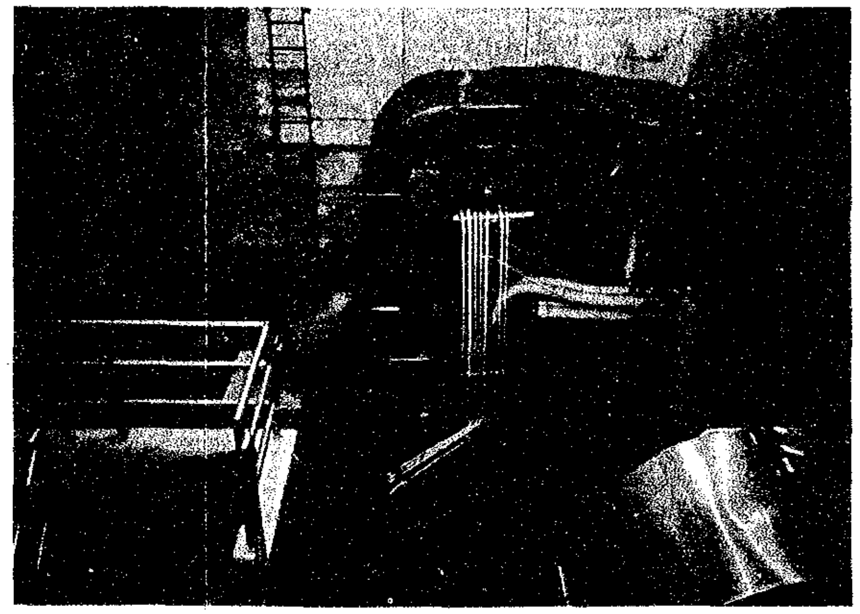


Dismantled Diesel Engine.
Parts used for Other Machines.

EXISTING NANPIL HYDRAULIC
POWER PLANT



Power Plant Building



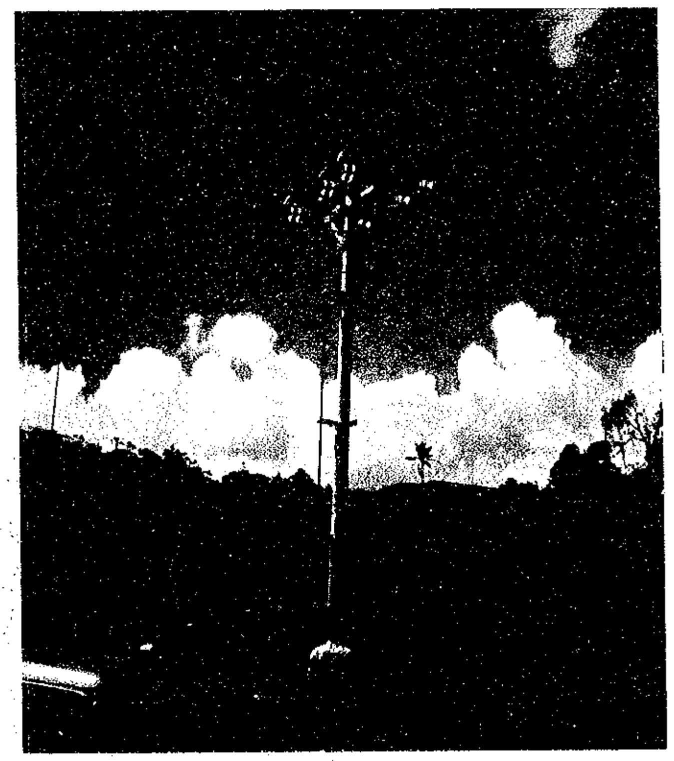
Name Plate Rating	:	1.1 MW - 1 No.
		0.6 MW - 1 No.

EXISTING DISTRIBUTION LINES AND POLES

Wooden Pole located near to the Airport

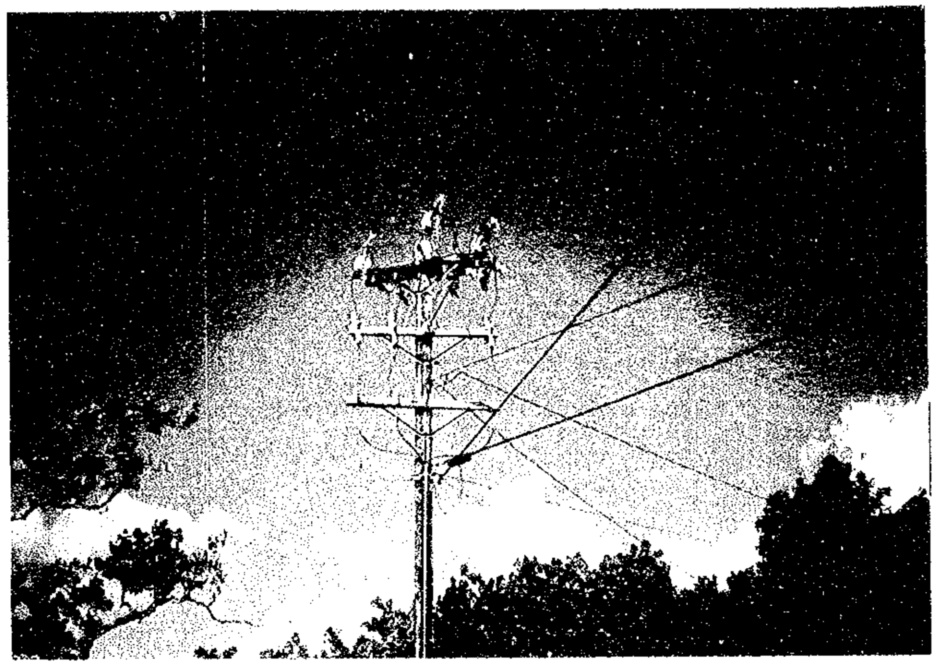
Wooden Pole located beside Nanpohnmal Power Plant
13.8 KV Lines (Upper) and 4.16 KV Lines (Down)

Concrete Pole installed in 1990
(South Area of Island)

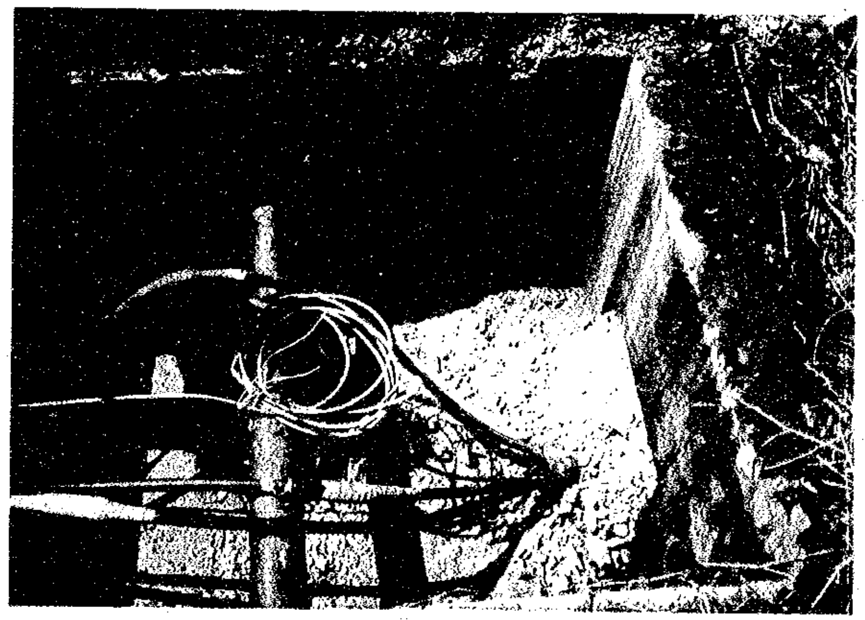


Concrete Pole and Distribution Lines installed in 1990
(South Area of Island)

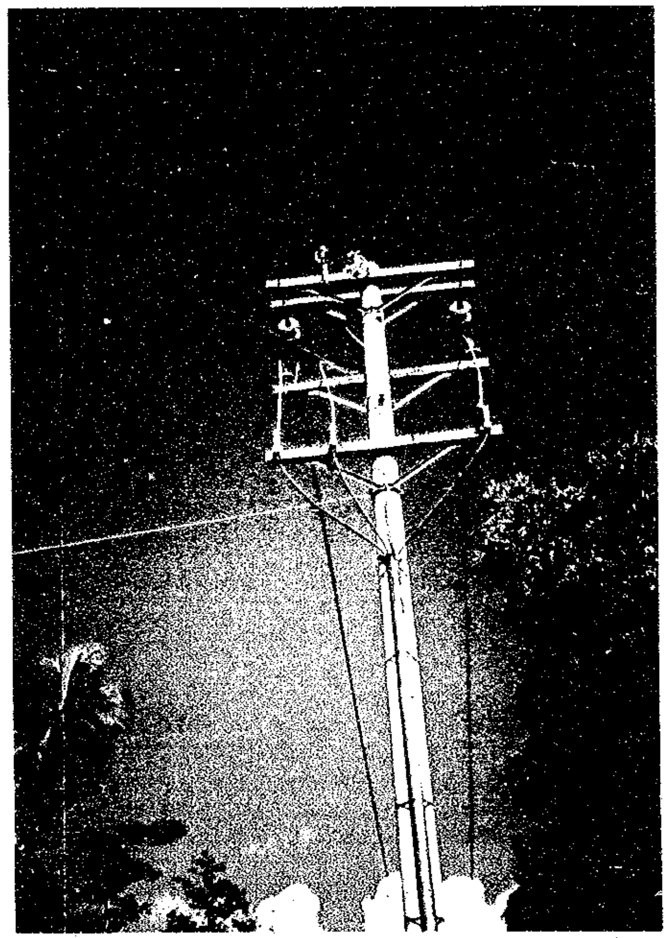
Dousokele Bridge



Wooden Pole near to Dousokele Bridge

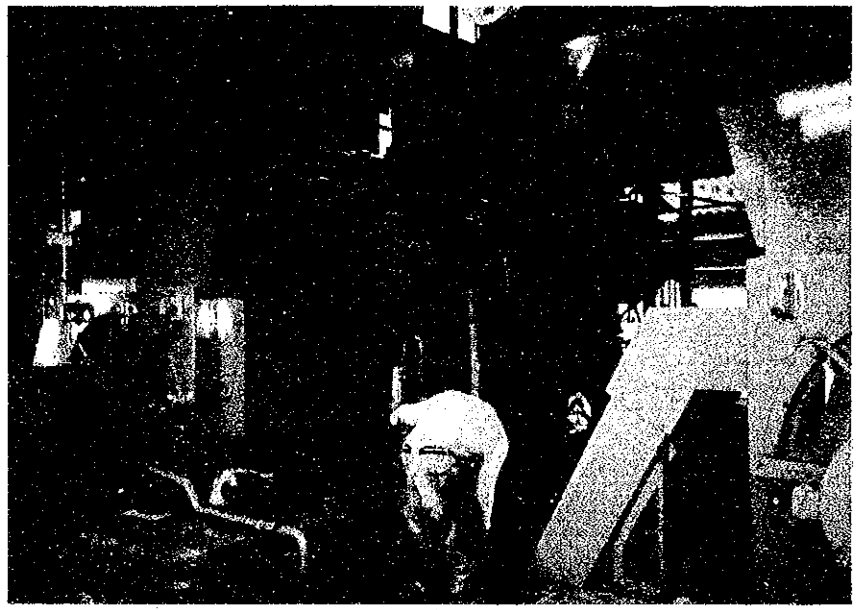


Cable Connection in Manhole

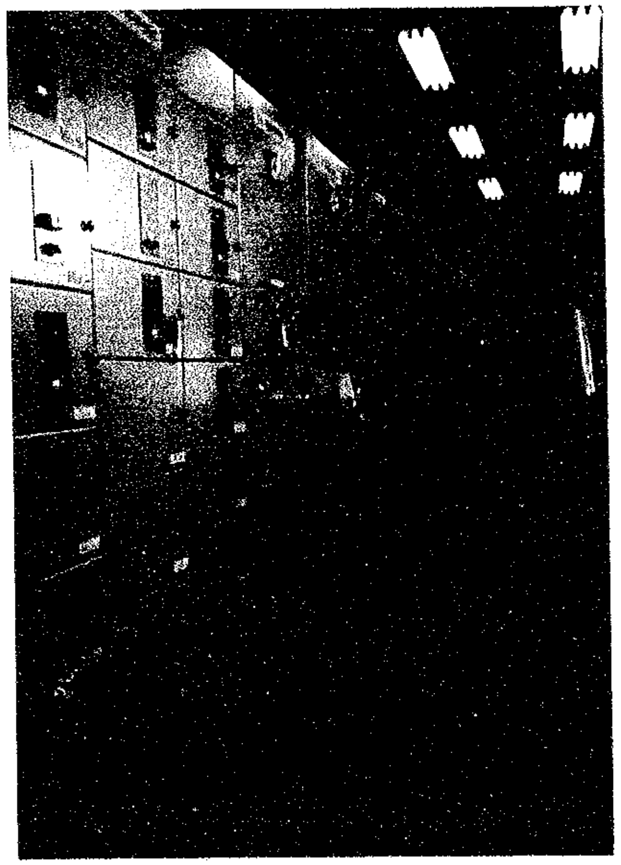


Concrete Pole near to Dousokele Bridge

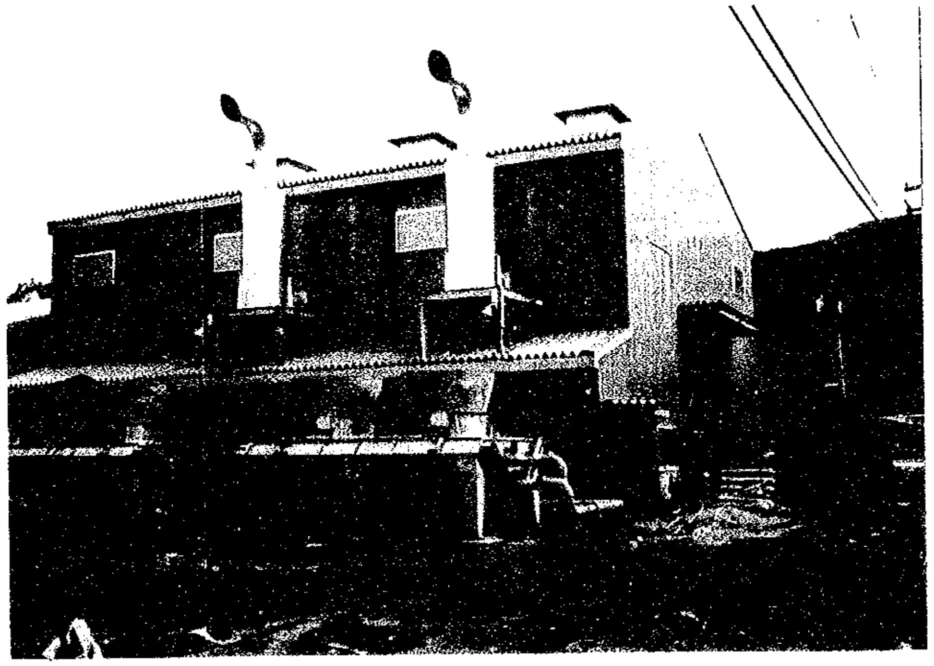
UNDER CONSTRUCTION POWER PLANT
(2.5 MW X 2 NOS.)



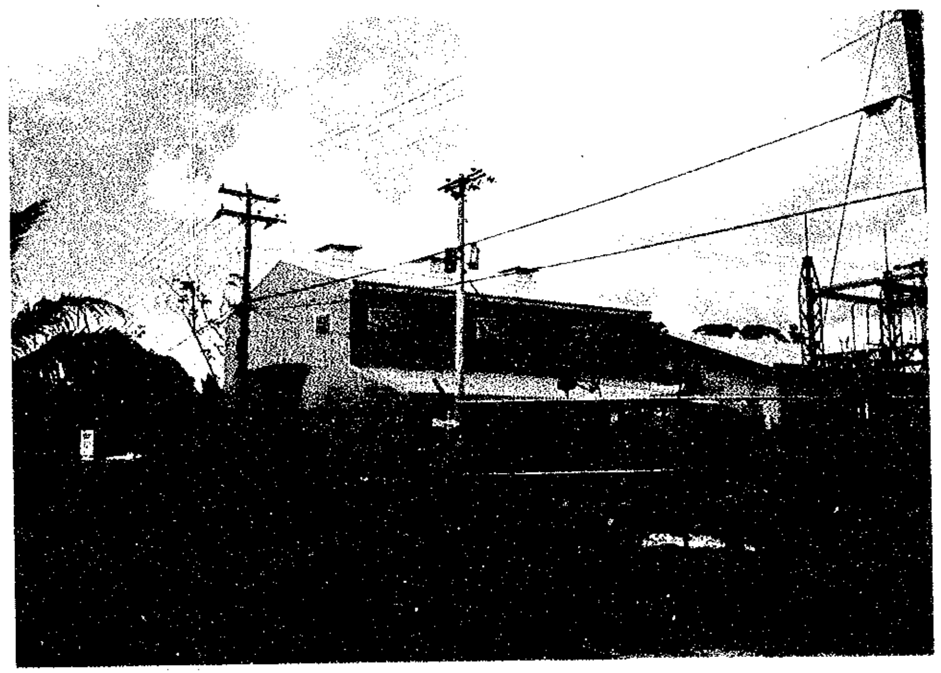
Installation of Generation Facilities



Generator Panel and Distribution Feeder Panel



External View of Power Plant under Construction.



External View of Power Plant under Construction.

SUMMARY

SUMMARY

The Federated States of Micronesia (hereinafter called "the FSM") is an island nation with 607 islands of various sizes located in the West Pacific Ocean between the equator and 14 degrees of north latitude and 135 degrees and 166 degrees of east longitude. The FSM has a total population of 108,490, a total land area of 702 km^2 and an economic territorial water area of 2,600,000 km^2, with the islands being scattered widely over this territorial area.

The nation's major industries are copra production and fishing, and the biggest in terms of employment are the Government offices, employing 25 % of the total working population as of 1989. The nation's GNP in 1989 was US$ 130,000,000. The FSM receives an average annual grant of US$ 90,000,000 from the United States of America in accordance with the provisions of the Compact of Free Association entered into with the United States of America on November 3, 1986. The Second 5-Year National Development Plan of the FSM is now in progress with the aim of achieving a self-supporting economy by the year 2001 when the Compact expires.

The National Development Plan is implemented by each of the four states of the nation, i.e. Chuuk, Yap, Pohnpei and Kosrae States, independently of each other.

The State of Pohnpei, which has the largest land area among the States at 345 km^2, a total population of about 34,000 or approximately 30 % of the total population of the FSM, and wherein the FSM's capital town Palikir is located, has been making efforts to develop and improve it's infrastructural systems, especially for electric energy supply. However, the state has been facing a serious shortage in electricity, due to a sharp increase in electricity consumption following the implementation of the National Development Plan and due to a decrease in power generation by the existing facilities as a result of their deterioration due to superannuation. The shortage in electricity has not only been causing inconvenience to the population, but also creating bottlenecks in economic development which is essential for the State to become self-supporting.

The State of Pohnpei has been implementing their 5-Year State Development Plan based on the National Development Plan referred to previously. According to this State Development Plan, 15 projects of various sizes are planned to be introduced within the period of 2 years of 1992 and 1993, and therefore a sharp increase in electricity demand is forecast for this period.

The Pohnpei Utilities Corporation forecast indicates that the electricity demand for the year 1994 will reach to 10 MW which is almost double the present demand. On the other

hand, the existing facilities are presently not capable of generating sufficient electricity to meet the current demand, not only because of deterioration due to superannuation and shortage of spare parts, but also because of damage caused by the typhoons which hit the State in November 1991 and January 1992. In addition, due to the deficiency of the existing electricity transmission and distribution facilities in the State, there have been frequent interruptions of electricity supply. For these reasons, it is almost impossible to expect a stable and uninterrupted supply of electricity under the current conditions.

Having acknowledged the poor condition of the current electricity supply facilities as described above, the Government of the FSM requested the Government of Japan for grant aid for the procurement of equipment and materials needed for an urgent implementation of a project for the upgrading of the electricity supply facilities in the State of Pohnpei.

In response to this request, the Government of Japan despatched to the State, in April of 1992, a preliminary study mission for the evaluation of the project through on-site investigations of the current conditions, analyses of the details of program, the project implementation procedures, etc. Having received the mission's report that project could be properly implemented by grant aid from Japan, and in consideration of the electricity supply requirements in the State as well as the project implementation procedures proposed by the FSM Government, the Government of Japan decided to proceed with the basic design of the facilities with the assumption that the project, possibly inclusive of the construction of the facilities, would become a Japanese grant aid project. Following this decision, the Japan International Cooperation Agency, the agency responsible for basic design of grant aid projects, implemented "The Study For The Basic Design Of The Project For Electric Utilities Upgrading In The Federated States Of Micronesia" during the period between July 5 and July 31, 1992. Following this Study, the Agency despatched a mission to the FSM from September 20 to September 29, 1992 for the presentation of the Draft Final Report of the Study.

The Study was made through cooperation of both the Office of Budget, Planning and Statistics (OBPS) which is the agency of the State of Pohnpei in charge of execution of the project and the Pohnpei Utilities Corporation (PUC) which is responsible for the operation and maintenance of the facilities upon completion of the project. The Study was to survey the current electricity demand, forecast future demands, investigate the current transmission and distribution facilities, and review and analyze the program prepared by the FSM Government. Based on the results of the Study, an agreement was reached with the FSM Government on the scope of the work to be financed by Japan's grant aid.

The electricity demand forecast in the Study and required net installed capacity of power generating facilities are as follows:

Year	Electricity Demand (MW)	Net Installed Capacity (MW)
1994	7.5	9.0
1996	9.1	11.0
1998	11.0	13.0
2000	13.0	16.0

On the other hand, the electricity generation capacity of the Nanpohnmal power plant at the end of 1992 was calculated as follows:

The existing facility	:	3.2 MW	(1,200 rpm)
The facility under construction (Scheduled to be completed in December 1992)	:	5.0 MW	(600 rpm)
Total		8.2 MW	

If the existing facility, which has a low efficiency, is put on stand-by so as to obtain the target of a stable power supply, the capacity remaining useful is only the 5 MW of the facility under construction, and therefore not sufficient to meet the 9 MW capacity required for 1994. An additional 4 MW generating facility is therefore required.

By the supply of a 5 MW power generation facility as requested by the FSM, the net installed capacity of the Nanpohnmal power plant becomes 13.2 MW provided the existing facility is maintained in a good working condition, and therefore the plant can meet demands up to the year 1998.

Upon completion of the project for upgrading the electricity generation, transmission and distribution facilities as proposed based on the results of the Study, it will become possible for the PUC to provide a stable electricity supply to the respective consumers.

The scope of the work agreed to be financed by Japan's grant aid is as follows:

1) Installation of 2 new units of 2.5 MW (600 rpm, including spare parts) each diesel engine generators and construction of the power plant building,

2) Addition of backfeeders consisting of:
   (1) Installation of a new distribution line of 13.8 KV, 3-phase, 4-wire for a distance of about 2 Km between Nanpohnmal and Sekera,

(2) Installation of a new distribution line of 13.8 KV, 3-phase, 4-wire for a distance of about 4.9 Km between Nanpohnmal and the Kolonia Connection Point, and

(3) Renewal of the existing cables and conduits on the Dousokele Bridge (Approx. 250 m),

3) Addition of an automatic distribution protection system including:

(1) 24 Pole-mounted Switches, and

(2) 4 sets of automatic re-closing relays and a fault section indicator in the control room of the power generation building, and

4) Supply of a bucket truck for maintenance of the electricity distribution facilities.

The scope of works to be implemented by the FSM Government's own finance contains the following:

1) Land acquisition and grading of the project sites,

2) Construction of access roads,

3) Supply and construction of fences for the project sites,

4) Supply and installation of fuel oil storage tanks, and

5) Supply and construction of cooling water make-up facilities.

As mentioned previously, the agency responsible for execution of the project is the OBPS of the State of Pohnpei, while the PUC is responsible for operation and maintenance of the facilities upon complemention of the project. It is considered appropriate to assume that the present organization of the PUC is capable of operating and maintaining the new facilities, since the said organization has been in charge of the operation and maintenance of facilities of a similar magnitude (2 units of 2.5 MW each diesel engine generator) to the new facilities.

The estimated period of construction for the project, including the period for the transportation of equipment and materials, is twelve (12) months. If the periods for the detailed design and tendering process are included, the period from the Exchange of Notes to the completion of the constriction is estimated at sixteen(16) months.

By the implementation of this project, it will become possible to provide all the waiting individual consumers with electricity. About 7,900 individuals of the State will enjoy the benefits after completion of the project. It will also become possible to provide other consumers such as a fish processing factory and hotels with electricity, thus facilitating the implementation of the Second Five-Year National Development Plan which is now in progress for the nation's economic independence, and contribute to the stabilization and upgrading of the living environment for the people of the State.

In view of the above, it is considered appropriate to provide Japan's grant aid for the implementation of the project. In order to secure and maximize the benefits of the Project, it is recommended that the following policies be implemented:-

- To maintain proper functioning of the facilities and equipment and to secure proper operation, a maintenance program is to be established and the maintenance is to be done in accordance with the program.

- To implement proper maintenance and operation, PUC has to secure a source of income sufficient to cover the cost of the maintenance.

- To upgrade the skill of the operation and maintenance staff, planned, periodical training is to be executed.

In addition, for the proper operation of the facilities and equipment after completion of the project, it is necessary that two operating personnel from the electrical and mechanical staff of the PUC receive training in Japan for a period of 3 months as trainees of JICA at the equipment supplier's plants.

TABLE OF CONTENTS

PREFACE

LOCATION MAP

SUMMARY

Page

CHAPTER 1. INTRODUCTION ---------- 1 - 1

CHAPTER 2. BACKGROUND OF THE PROJECT ---------- 2 - 1

2.1 Outline of the Federated States of Micronesia and the Pohnpei State ---------- 2 - 1

2.2 Outline of the Request ---------- 2 - 2

2.3 Outline of Electric Generation Facilities ---------- 2 - 3

2.3.1 Present Conditions of Electric Generation Facilities in FSM ---------- 2 - 3

2.3.2 Present Conditions of Electric Generation Facilities in Pohnpei ---------- 2 - 5

2.3.3 Present Conditions of Distribution Facilities in Pohnpei ---------- 2 - 7

2.3.4 PUC Revenue and Expenditure Plan ---------- 2 - 8

CHAPTER 3. OUTLINE OF THE PROJECT ---------- 3 - 1

3.1 Objective ---------- 3 - 1

3.2 Study and Examination on the Request ---------- 3 - 2

3.2.1 Necessity and Appropriateness of the Project ---------- 3 - 2

3.2.2 Implementation and Management Plan ---------- 3-13

3.2.3 Similar Projects and Projects Financed by the other Foreign Donors ---------- 3-14

3.2.4 Consideration on Contents of the Project ---------- 3-15

3.2.5 Consideration on Facility and Equipment of the Request ---------- 3-15

3.2.6 Necessity of the Technical Cooperation ---------- 3-20

3.2.7 Basic Principle for Project Implementation ---------- 3-20

3.3 Description of the Project ---------- 3-21

3.3.1 Executing Agency and Operational Structure ---------- 3-21

3.3.2 Plan of the Project ---------- 3-21

3.3.3 Outline of Facilities and Equipment ---------- 3-21

3.3.4 Operation and Maintenance Plan ---------- 3-23

3.4 Technical Cooperation ---------- 3-25

CHAPTER 4. BASIC DESIGN ---------- 4 - 1

4.1 Design Policy ---------- 4 - 1
4.1.1 Electricity Generation Facilities ---------- 4 - 1
4.1.2 Electricity Distribution Facilities ---------- 4 - 1
4.1.3 Power Plant Building ---------- 4 - 2

4.2 Design Criteria ---------- 4 - 2

4.3 Basic Planning ---------- 4 - 3
4.3.1 Site and Layout Plan ---------- 4 - 3
4.3.2 Architectural Design ---------- 4 - 3
4.3.3 Power Equipment Plan ---------- 4 - 6
4.3.4 Selection of Equipment ---------- 4-14
4.3.5 Basic Design Drawing ---------- 4-15

4.4 Implementation Plan ---------- 4-16
4.4.1 Implementation Policies ---------- 4-16
4.4.2 Implementation Method ---------- 4-17
4.4.3 Construction and Supervisory Plan ---------- 4-18
4.4.4 Procurement Plan ---------- 4-19
4.4.5 Implementation Schedule ---------- 4-21
4.4.6 Scope of Works ---------- 4-24

CHAPTER 5. PROJECT EVALUATION AND CONCLUSION ---------- 5 - 1

APPENDICES

1. Lists of Members of the Study Team ---------- A-1-1
2. Study Schedule ---------- A-2-1
3. Persons Met by the Study Team ---------- A-3-1
4. Minutes of Meetings ---------- A-4-1
5. Data Collection List ---------- A-5-1

LIST OF TABLES

Table 2-1	Annual Power Generation	2-6
Table 2-2	Operation Records of Generators	2-6
Table 2-3	Electrical Characteristics	2-7
Table 2-4	Revenue and Expenditure Plan	2-8
Table 2-5	Planned Expenses by the Divisions	2-9
Table 3-1	Projected Demand (1992/1993)	3-2
Table 3-2	Projected Demand (1994)	3-6
Table 3-3	Forecast of Waiting Customers	3-7
Table 3-4	Peak Power Demand Forecast/Net Installed Capacity of Electric Generating Plant (Micro Method)	3-8
Table 3-5	Population/Net Installed Capacity	3-9
Table 3-6	Net Installed Capacity of Power Plant (Macro Method)	3-10
Table 3-7	Revenue and Expenditure Plan	3-14
Table 3-8	Maintenance Schedule	3-27

LIST OF FIGURES

Fig. 3-1	Estimated Net Installed Generating Capacity (Micro Method)	3-11
Fig. 3-2	Estimated Net Installed Generating Capacity (Macro Method)	3-12
Fig. 3-3	Pohnpei Utilities Corporation Organization Chart	3-29
Fig. 4-1	Project Implementation Schedule	4-23

CHAPTER 1 INTRODUCTION

Chapter 1. Introduction

In February, 1992, the Government of the Federated States of Micronesia (FSM) made a request for Grant Aid Assistance to the Government of Japan, for the Project for Electric Utilities Upgrading in Pohnpei State. The Government of Japan decided to conduct a Preliminary Study for the Project entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to FSM the Preliminary Study Team headed by Mr. Yoshio Yabe, Deputy Director, Study Review and Coordination Division, Grant Aid Study and Design Department, JICA, from April 10 to April 21, 1992, to conduct field survey and to discuss with the concerned officials of FSM to confirm roughly the back ground of main item of the request.

Based on the result of the Preliminary study, JICA decided to conduct a Basic Design Study on the Project. JICA sent to FSM the Basic Design Study Team headed by Mr. Takahiro Ikari, Officer, Grant Aid Division, Economic Cooperation Bureau, Ministry of Foreign Affairs, from July 5 to 31, 1992.

The Team conducted the field surveys to identify the background and contents of the Project and to collect the information necessary to conduct a basic design of the Project. At the same time, the Team had a series of discussions with the officials concerned of FSM to have a mutual understanding on the procedure of the Japan's Grant Aid Program and the scope of the Project. The result of the discussions and basic agreement were written up as the Minutes of Discussions and were signed by both parties.

The draft final report for the basic design study were prepared in Japan and JICA despatched a mission for the explanation of the draft final report headed by Mr. Shumon Yoshiara, First Project Management Division, Grant Aid Project Management Department, JICA to FSM from September 20 to 29, 1992. Based on the discussions made between the Mission and the concerned officials of FSM, the Minutes of Discussion was prepared and signed by both parties.

Upon returning to Japan, the Team conducted further study and prepared this Final Report. The Report contains the background of the Project, the outline of the Project, basic design, project evaluation and conclusion, and some appendices.

The member list of the Team, the schedule of the surveys, the member list of the concerned party of FSM and the Minutes of Meetings are attached in appendices.

CHAPTER 2 BACKGROUND OF THE PROJECT

Chapter 2 Background of the Project

2.1 Background of the project

The State of Pohnpei, which has a biggest land area among the States at 345 km^2, a total population of 34,000 or approximately 30 % of the total population of the FSM, and wherein the FSM's capital town Palikir is located, has been making an effort for development and improvement of the infrastructural systems, especially the electric energy supply system. However, the state has been facing with a serious shortage in electricity, due to sharp increase of electricity consumption following the implementation of the National Development Plan and due to decrease of the generation capacity by the existing facilities as a result of deterioration due to superannuation of the facilities, thus not only causing inconvenience to the people, but also creating bottlenecks in the economic development essential for the economic self-supportability of the State.

It is estimated by the PUC that the electricity demand in the State of Pohnpei in 1994 increases to 10 MW which is almost double the current demand. On the other hand, the existing facilities are presently not capable of generating sufficient electricity to meet the current demand, because not only of deterioration due to the superannuation and shortage of the spare parts, but also of the damages caused by the typhoons in November 1991 and January 1992. In addition, due to deficiency of the existing electricity distribution facilities in the State, there are frequent interruptions of electricity supply.

Therefor, it is almost impossible in the State to expect stable, uninterrupted supply of electricity under the current conditions.

Having acknowledged the poor conditions of the electricity supply as described above, the Government of the FSM has requested the Government of Japan for a grant aid for procurement of equipment and materials needed for an urgent implementation of a program for upgrading of electricity supply facilities in the State of Pohnpei.

2.2 Outline of the Request

As the result of the background of the project mentioned 2.1, the following request were made;

(1) Installation of 2 new units of a 2.5 MW (600 rpm, including spare parts) diesel engine generator and construction of the Power plant building,

(2) Addition of backfeeders consisting of,

1) Installation of a new distribution line of 13.8 KV, 3-Phase, 4-wire for a distance of about 2 km between Nanpohnmal and Sekera,
2) Installation of a new distribution line of 13.8 KV, 3-phase, 4-wire for a distance of about 4.9 km between Nanpohnmal and Kolonia Connection Point, and
3) Renewal of the existing cables and conduits at the Dousokele Bridge, (Approx. 250 m)

(3) Addition of automatic distribution system including;

1) 24 Pole-mounted Switch;
2) 4 sets of an automatic re-closing relay and an fault section indicator in the control room of the power plant building, and

(4) Supply of a bucket truck for maintenance of electricity distribution facilities.

2.3 Outline of Electric Generation Facilities

2.3.1 Present Conditions of Electric Generation Facilities in FSM

Present conditions of electric generation facilities in each of the states of Yap, Chuuk, Kosrae and Pohnpei is as follows:
Two problems which are common to all of the facilities of these states are a decrease of generating capacity due to deterioration of facilities itself and a shortage of spare parts for maintenance.

(1) The State of Pohnpei

Refer to 2.3.2.

(2) The State of Yap

Generation Facilities:

There are 6 (six) diesel generators with a total installed generating capacity as approximately 7 MW. However, half of them are out of order and the actual output is now about 3 MW.

Operation and Maintenance:

Electricity generation and distribution in the State of Yap is undertaken by the Department of Public Works. Watt Hour Meters are provided to the consumers. However, the collection rate from the meters is below 50 % of the terrified figure.

(3) The State of Chuuk

Generation Facilities:

The total installed capacity is approximately 13 MW from Diesel Generators and actual output is now 6 MW. Based on the FSM's budget plan, a 2 MW generating plant which is being funded by the State itself is now under construction. After the completion of this Plant, the total installed capacity will become 8 MW and the installed capacity per capita is expected to be about 160 W. The figure of 160 W seems very low, showing that there is still a shortage of electricity in the State.

Operation and Maintenance:

Electricity generation and distribution in the State of Chuuk is undertaken by the Department of Public Works. Watt Hour Meters are provided to the consumers.
However, electricity charges are rarely collected due to payment rejection by the inhabitants.

(4) The State of Kosrae

Generation Facilities:

The total installed capacity is approximately 1.8 MW from Diesel Generators and actual output is 1 MW. In this State, only diesel-type generators have been installed.
There is a possibility of developing the potential hydro power in the State.

Operation and Maintenance:

Electricity generation and distribution in the State of Kosrae is undertaken by the Department of Public Works. Watt Hour Meters have not been provided to the consumers.

2.3.2 Present Conditions of Electric Generation Facilities in Pohnpei

(1) Generation Facilities

1) The following table shows outline of the existing electric generation facilities.

Plant Name	Name Plate Rating	No. of Units	Actual Output (*1)	Remarks
Alco Barge	2.0 MW	4	1.7 MW x 1	
Nanpohnmal	0.8 MW	3	0.5 MW x 1	
	1.1 MW	3	0.9 MW x 3	
	2.5 MW	2		Under construction (Scheduled for completion in November, 1992)
Nanpil	0.6 MW	1		No generation, insufficient precipitation
	1.1 MW	1		
Total			4.9 MW	

*1 Indicates actual output presently expectable. If operated at the name plate rating, the engine overheats in a short period.

Note: No stable output is expectable for the Alco Barge Plant which has made troubles frequently. Therefore, the stable generation capacity of the plants is estimated at 3.2 (= 4.9 - 1.7) MW.

2) Annual Power Generation

The annual power generation from 1986 to 1991 is as shown in Table 2.1. Within these 6 years, the annual power generation has been increased at the rate of about 6 percent (%) per annual. The annual power generation in 1991 was 27,413 MWH. The installed capacity was calculated as follows;

27,413 MWH/(365 day x 24 hr) = 3.13 MW

The installed capacity of 3.13 MW is approximately the same as the stable generation capacity (3.2 MW) mentioned previously.

Table 2.1 Annual Power Generation

Year	Power Generation (MWH)
1986	20,000
1987	20,683
1988	21,956
1989	24,408
1990	25,183
1991	27,413

Source: PUC

3) Operation Records of Generators

The table 2.2 shows the operation records of genertors at the Alco Barge and Nanpohnmal plants.

Table 2.2 Operation Records of Generators

Year/	Month	ALCO				Nanpohnmal					
		No. 1	No. 2	No. 3	No. 4	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
1992	May	X	X	X	O	X	X	O	O	O	O
	Apr.	X	X	O	O	X	X	O	O	X	O
	Mar.	X	X	O	O	O	O	O	X	O	X
	Feb.	O	X	O	X	O	X	O	X	O	O
	Jan.	O	X	O	X	O	X	O	X	O	O
1991	Dec.	O	X	O	X	O	O	O	O	O	X
	Nov.	O	X	O	X	O	X	O	O	O	X
	Oct.	O	X	O	X	O	X	O	O	O	O
	Sep.	O	X	X	X	O	X	O	O	O	O
	Aug.	O	X	X	X	O	X	O	O	O	O
	Jul.	O	X	X	X	O	X	O	O	O	O
	Jun.	O	X	X	X	O	X	O	O	O	O
	May	X	X	X	X	O	X	O	O	O	O
	Apr.	X	X	X	X	O	O	O	O	O	O
	Mar.	X	X	X	X	O	O	O	O	O	O
	Feb.	O	X	X	X	O	X	O	O	O	O
	Jan.	O	X	X	X	O	O	O	O	O	O

(PUC, Power Generation Monthly Report)
O : Operatonal
X : Down or Idle

2.3.3 Present Conditions of the Distribution Facilities in Pohnpei

An outline of the existing distribution facilities is show in Fig. 2.1 and below.

(1) Distribution Voltage

3 Phase 4 Wire	:	4.16 kv (only in Kolonia town area)
3 Phase 4 Wire	:	13.8 kv
2 Phase 2 Wire	:	7.69 kv (Spur Line)

(2) Distribution System

The 13.8 kv looped distribution system was completed in Jan. 1990. The distribution line from Nanpohnmal goes to Kolonia town and divides two distribution lines. One distribution line goes to the western area of the Island and the other goes to the eastern area. The distribution line which is located in the southern area of the Island was installed in 1991 with prestressed concrete poles being employed. In the northern area, a lot of timber poles still exist but PUC is trying to replace these pole with prestressed concrete pole whenever PUC has the budget. A distribution line of 4.16 kv exists in the Kolonia town area only but this 4.16 kv distribution line is being replaced by one of 13.8 kv. The looped 13.8 kv around the Island is connected to the distribution line which comes form Nanpohnmal.

A cable is employed along the Dousokele Bridge for a distribution line. However, this cable does not have enough capacity compared with the existing overhead distribution line. The electrical characteristics of the cable and the overhead distribution line (Aluminum wire) are shown in Table 2-3.

Table 2.3 Electrical Characteristics

	Cable	Overhead Wire
Type	15 kv, MV - 90, 1/0	Aluminum, 336.4 MCM
Cross sec. area of conductor	54 mm^2	170 mm^2
Allowable current	190 Amp.	467 Amp.
Conductor resistance	0.320 Ω/km	0.1686 Ω/km

The capacity of the cable was calculated as follows;

$$\sqrt{3} \times 13.8 \text{ kv} \times 190 \text{ Amp} \times 0.85 = 3{,}860 \text{ kw}$$

From the above calculation, the allowable current of 190 Amp seems enough, however, resistance of cable is greater than the resistance of aluminum wire. The existing cables have also been connected to each other in the manhole without a proper joint kit.

2.3.4 PUC Revenue and Expenditure Plan

The Revenue and Expenditure Plan of the PUC for the fiscal years from 1992 to 1996 are as shown in Table 2.4. However, the said plan has been prepared based on the following tariff system.

Table 2.4 Revenue and Expenditure Plan

Unit: US$ Mill.

	Fiscal Year Oct. 1 ~ Sep. 30 of the next year				
	1992	1993	1994	1995	1996
Revenue					
Engineering Grant	1.00	1.00	1.00	1.00	1.00
Tariff	1.79	2.29	2.63	2.92	3.28
State Subsidy	2.20	0.30	0	0	0
Sub total	4.99	3.59	3.63	3.92	4.28
Expenditure					
Salaries	0.96	1.17	1.21	1.27	1.31
Burning oil	2.18	2.34	2.49	3.16	4.22
Repairing and Maintenance	0.86	0.15	0.10	0.18	0.18
Insurance, Fixed Assets, Consumable Goods, Travel, etc.	1.47	0.23	0.26	0.24	0.26
Sub total	5.47	3.89	4.06	4.85	5.97
Total	-0.48	-0.30	-0.43	-0.93	-1.69

Tariff System (Jan. 1, 1992 ~ Jun. 30, 1992)

Minimum monthly charge	2.5$
Meter rate charge	
0 ~ 1,000 KWH/month	0.05$/KWH
1.001 ~ 10,000 KWH/month	0.12$/KWH
10,000 over	0.23$/KWH

The planned expenses by the divisions are shown in Table 2.5

Table 2.5 Planned Expenses by the Divisions

Unit: million $

	1992	1993	1994	1995	1996
Generation Div.	3.41	2.92	3.08	3.86	4.95
Distribution Div.	1.28	0.28	0.30	0.31	0.32
Maintenance Div.	0.16	0.17	0.14	0.14	0.15
Administrative Div.	0.62	0.52	0.54	0.54	0.55
Total	5.47	3.89	4.06	4.85	5.97

(Source: PUC Five Year (F92 - F96) Budget)

According to PUC Revenue and Expenditure Plan shown in table 2.4, fuel expenditure comes approximately 60 percent of the total revenue of PUC and it is obvious that the balance of revenue and expenditure would become worse every fiscal year, and PUC is considering revising tariff system in order to improve this condition. The expected revenue after revision are given in Chapter 3, Paragraph 3.2.2.

CHAPTER 3 OUTLINE OF THE PROJECT

Chapter 3 Outline of the Project

3.1 Objective

Electric power demand in Pohnpei in 1994 is estimated to increase to two times of the present demand.

The existing power generation system does not meet the present power demand due to deterioration of the generating capacity caused by its old age, shortage of spare parts which are necessary for proper maintenance, and interruption of power supply caused by mulfunctioning of the power plant.

The power generation system was considerably damaged by typhoons that hit Pohnpei in November, 1991 and January, 1992.

From the above, it was obvious that there are insufficient power generation facilities in Pohnpei.

There are many interruptions of the power supply due to accidents in the power distribution system and, therefore, it is impossible to provide a continuous power supply.

The present power supply situation described above is very inconvenient for the life of people and prevents the necessary development for the economic independence of Pohnpei.

In order to solve the above problems and to cope with the increased power demand, the following facilities will be provided by Japan's Grant Aid Assistance.

- Two sets of diesel generator installed in a power house to be constructed adjacent to the existing power plant building (Nanphonmal).

- Improvement of the power distribution system.

- New power distribution lines.

The objective of the project is to procure necessary plant equipment and materials, and to construct the above mentioned facilities in order to supply continuous and stable power in Pohnpei.

3.2 Study and Examination on the Request

3.2.1 Necessity and Appropriateness of the Project

(1) Power Demand Forecast

The power demand forecast was carried out as shown below by means of both micro and macro methods on the basis of the present power demand data obtained from Pohnpei Utility Corporation (PUC) and information obtained through the actual demand survey which was carried out during the field survey.

1) Demand forecast by means of Micro Method

i The present power demand (1992)

Operation records of the existing power plant shows that the maximum power demand was 5.4 MW.

ii Projected demand

The projected demand for 1992 to 1993 is 5,119 KW according PUC's data.

Table 3.1 Projected Demand

No.	Consucer Keoe	(KW)
1	Fish Processing Plant	1,500 *1
2	CCM Complex Palikir	400
3	PATS High School	80
4	220 Pending Residential Hook-ups	660
5	Sokehs Industrial Park	300
6	Pohnpei Housing Autthority Project	288
7	Pepper Project	22
8	Petronic Walter's Hotel	75
9	Palikir Housing Project	210
10	Quarry Site	350
11	FSM Development Bank Project	500
12	Private Housing Project	70
13	Caroline Fisheries Project	500
14	Broiler Cold Store	350
15	Additional Residential Hook-ups	699
	Total	6,004

Source: PUC, Projected Demand for 1992/1993

The actual power demand of the Fish Processing Plan (Item No. 1 of the table) was 615 KW according to the survey (1,500 KW is the planned power demand). The projected demand can be calculated as follows:

6,004 KW - 1,500 KW + 615 KW = 5,119 KW

Breakdown of the projected demand is as follows:

Housing	:	220 Pending Residential Hook-ups	660 KW
		Pohnpei Housing Authority Project	288 KW
		Palikir Housing Project	210 KW
		Private Housing Project	70 KW
		Additional Residential Hook-ups	699 KW
		Sub total	1,927 KW
Others	:	Fish Processing Plant	615 KW
		CCM Complex Palikir	400 KW
		PATS High School	80 KW
		Sokehs Industrial Park	300 KW
		Pepper Project	22 KW
		Petronic Walter's Hotel	75 KW
		Quarry Site	350 KW
		FSM Development Bank Project	500 KW
		Caroline Fisheries Project	500 KW
		Broiler Cold Store	350 KW
		Sub total	3,192 KW
		Total	5,119 KW

With respect to the demand for Housing during 1992 to 1993, PUC explained the following:

- Number of houses wishing to hook-up to power line in 1992 was estimated as 677 houses.

- Power lines have already been hooked-up to 345 houses and 401 houses have submitted hook-up requests to PUC at the present time.

- In addition to the above, it is expected that 280 houses will make requests to PUC in 1993.

- The power demand for Housing can be estimated as given below from the above information:

(401 + 280) houses x 3 KW/house ≒ 2,043 KW

The power demand of each house of 3 KW/house can be calculated as follows:

Maximum load	Lighting	300 W
	Refrigerator	1,000 W
	Freezer	1,000 W
	Rice cooker	800 W
	Microwave oven	1,000 W
	Exhaust fan	300 W
	T.V.	200 W
	Washing machine	300 W
	Total	4,900 W

A demand factor of 60 % is normally applied to the total demand.

4,900 W x 0.6 ≑ 3 KW

The demand for Housing calculated above is almost the same as that given in the Breakdown of the Projected Demand (1,927 KW).

Among the projected demand list, the following projects may need power supply during the year of 1992 according to their present construction stages.

Housing	:	Palikir Housing Project	210 KW
Others	:	Fish Processing Plant	615 KW
		Petronic Walter's Hotel	75 KW
		FSM Development Bank Project	500 KW
		Total	1,400 KW

Therefore the projected demand in 1993 is 3,719 KW.

Housing	:	1,927 KW - 210 KW = 1,717 KW	
Others	:	3,192 KW - (615 + 75 + 500 KW) = 2,002 KW	
		Total	3,719 KW

The Projects to which power supply will be made during the year of 1993 can be estimated as 2,570 KW when completion rates such as 80 % for Housing projects and 60 % for others, are taken into account.

Housing	:	1,717 KW x 0.8 ≑ 1,370 KW	
Others	:	2,002 KW x 0.6 ≑ 1,200 KW	
		Total	2,570 KW

iii Estimation of Power Demand

From the projected demand in previously discussed, an estimate of the peak power demand was made.

- Peak power demand in 1992

present peak power demand	:	5,400 KW
projected demand	:	700 KW
	Total	6,100 KW

(The projected demand of 700 KW was given by equation with the demand factor of 50 %, 1,400 KW x 0.5 = 700 KW.)

- Peak power demand in 1993

peak power demand in 1992	:	6,100 KW
projected demand for Housing (demand factor of 50 % is applied		
1,370 KW x 0.5 ≑ 690	:	690 KW
Projected demand for others (demand factor of 46 % is applied		
1,200 KW x 0.46 ≑ 560 KW	:	560 KW
	Total	7,350 KW

- Peak power demand in 1994 and beyond

  The peak power demand is estimated on the basis of the projected demands shown in Table 3.2 and the forecast waiting customers shown in Table 3.3.

  The peak power demand to be estimated based on the following assumptions, is shown in Table 3.4.

The completion rates of the projects in each year are as follows;

For Housing : 80 %

For Others : 60 %

The remainder will be brought over into the following year.

The demand for housings is calculated as follows:

Number of hook-ups x 3 KW

The demand factor of Housing : 50 %

The demand factor of other projected demand : 46 %

Table 3.2 Projected Demand

No.	Consumer Name	Demand KW
1	Private High School in U	200
2	Hotel in U	300
3	Well Pumps	100
4	Palm Terrace	150
5	Button Factory	50
6	Nakasone Department Store	300
7	Golf Course	200
8	Asphalt Plant Palikir	150
9	PCP Hotel	150
10	Extensions at Cliff Rainbow Hotel	100
11	Martin Enterprises	75
12	265 Residential Hookupes	795
13	Development Institute	300
14	Australian Embassy	75
15	Asphalt Plant at U	100
16	Yamada Apartment Project	50
17	Extension at Social Security Building	50
18	Extension at Bernard Enterprises	50
19	Adams Pepper Shop	50
20	Public High School at Madolenihmw	300
21	Sewer Treatment at Capital	300
22	Pruno Anor Hotel	200
23	PITC New Building	50
24	Sylverster's Ladore Apartments	30
25	Costan's Apartments	30
26	ETA Water Pumps	100
	Total	4,255

Source: PUC, Project Demand for 1994

Table 3.3 Forecast of Waiting Customers

YEAR	NUMBER OF CUSTOMER COMMERCIAL	NUMBER OF CUSTOMER RESIDENTIAL	TOTAL NUMBER	ESTIMATE OF POWER DEMAND (KW)
1992/1993	15	650	665	6,004
1994	25	265	290	4,255
1995	30	291	321	1,863
1996	35	321	356	2,118
1997	40	353	393	2,379
1998	45	390	435	2,655
1999	50	431	481	2,943
2000	55	478	533	3,249

Source: PUC

Table 3.4 Peak Power Demand Forecast/Net Installed Capacity of Electric Generating Plant given by MICRO METHOD

YEAR	Projected Demand(KW)			Completion Rates of Project (KW)		Demand Factor (KW)		Total Demand (KW)	Peak Power Demand (Base Power Demand in 1992 is 6,100KW)	Net Installed Capacity (Peak Power Demand x 1.2) (KW)
	Total Demand	Housing	Others	Housing(80%)	Others(60%)	Housing(50%)	Others(46%)			
1993	3,719	1,717	2,002	1,370	1,200	690	560	1,250	7,350	8,820
1994	4,255	(347) 795	(802)3,460	914	2,557	457	1,176	1,633	8,980	10,780
1995	1,863	(228) 873	(1,705) 990	881	1,617	441	744	1,185	10,170	12,200
1996	2,118	(220) 963	(1,078)1,155	946	1,340	473	616	1,089	11,260	13,500
1997	2,379	(237)1,059	(893)1,320	1,037	1,328	519	611	1,130	12,390	14,870
1998	2,655	(259)1,170	(774)1,485	1,143	1,422	572	853	1,425	13,810	16,570
1999	2,943	(286)1,293	(948)1,650	1,263	1,559	632	717	1,349	15,160	18,190
2000	3,249	(316)1,434	(1,039)1,815	1,400	1,712	700	788	1,488	16,650	19,980

Note: Figures in brackets show the demand brought over from the previous year.

2) Power Demand Forecast by Means of MACRO Method (population statistics)

Population and Peak Power Demand were shown in YEAR BOOK 1991 Table 10.1 "Electricity Production FY 1983 ~ FY 1999".

Based on the population and the peak power demand, the per capita installed capacity of power plant was estimated.

Table 3.5 Population/Net Installed Capacity

YEAR	Population	Peak Power Demand(KW)	Net Installed Capacity of Electric Generating Plant(KW)	Untilization Factor	Per Capita lustalled Capacity	Growth Factor
1983	23,733	2,570	5,400	210%	0.108	
1984	24,965	2,740	5,400	197%	0.110	1.9%
1985	26,193	3,000	5,400	180%	0.115	4.5%
1986	27,063	3,200	5,400	169%	0.118	2.6%
1987	27,956	3,120	8,400	269%	0.112	-5.1%
1988	28,878	4,200	5,000	119%	0.145	29.5%
1989	29,831	4,840	6,000	124%	0.162	11.7%
1990	30,816	5,200	6,000	115%	0.169	4.3%

The per capita peak power demand will increase due to such factors as urbanization, increasing income, up-grading of living standard, etc.

The per capita GDP of Federated States of Micronesia is US$ 1,467 (Refer to UNITED NATIONS STATISTIC DATA).

When the per capita installed capacity of power plant for their countries in which GDP is the same as that in Micronesia is taken into consideration, the per capita peak power demand in Pohnpei is expected to increase rapidly to the level of 0.3 KW per person.

The peak power demand is estimated by use of the average growth rate of 6.18 %.

The capacity factor of 120 %, which is the average factor during the period from 1988 to 1990, is also applied to estimate the future net installed capacity of power plant.

Table 3.6 Net Installed Capacity of Power Plant on the basis of MACRO METHOD

YEAR	Population	Per Capita Peak Power Demand (KW / Person)	Net Installed Capacity (KW)
1992	32,883	$(1.0618)^2 \times 0.169 = 0.191$	6,280^KW x 1.2 = 7,540
1993	33,969	$(1.0618)^3 \times 0.169 = 0.202$	6,860 x 1.2 = 8,230
1994	35,090	$(1.0618)^4 \times 0.169 = 0.215$	7,544 x 1.2 = 9,050
1995	36,247	$(1.0618)^5 \times 0.169 = 0.228$	8,264 x 1.2 = 9,920
1996	37,444	$(1.0618)^6 \times 0.169 = 0.242$	9,061 x 1.2 = 10,870
1997	38,679	$(1.0618)^7 \times 0.169 = 0.257$	9,941 x 1.2 = 11,930
1998	39,956	$(1.0618)^8 \times 0.169 = 0.273$	10,908 x 1.2 = 13,090
1999	41,274	$(1.0618)^9 \times 0.169 = 0.290$	11,970 x 1.2 = 14,360
2000	42,636	$(1.0618)^{10} \times 0.169 = 0.308$	13,132 x 1.2 = 15,760

The growth rate of the population is 3.3 % according to YEAR Book-1991.

According to PUC's forecast, power demand in 1994 is estimated to be approximately double of the present demand of 5.4 MW. The estimated power demand in 1994 under this basic design study gives 9 MW and 7.5 MW by Micro and Macro Methods respectively.

In order to provide a stable power supply, the capacity power factor is usually considered. As described in clause 3.2 (2), the required power demand (peak power demand x 1.2) in consideration of capacity factor of 120 % which is the average factor during the period from 1988 to 1990 is 10.8 MW and 9 MW by Micro and Macro Methods respectively.

When the FSM present Rule of economics relaying upon the financial aid from other countries is considered, the trend in demand for power is assumed to follow the Macro economic tendency rather than the Micro economic trend. Hence the size of the generating facility is considered to be selected based on the demand forecasted by macro economic forecasting method in this study.

Fig. 3.1 Estimated Net Installed Generating Capacity (Micro Method)

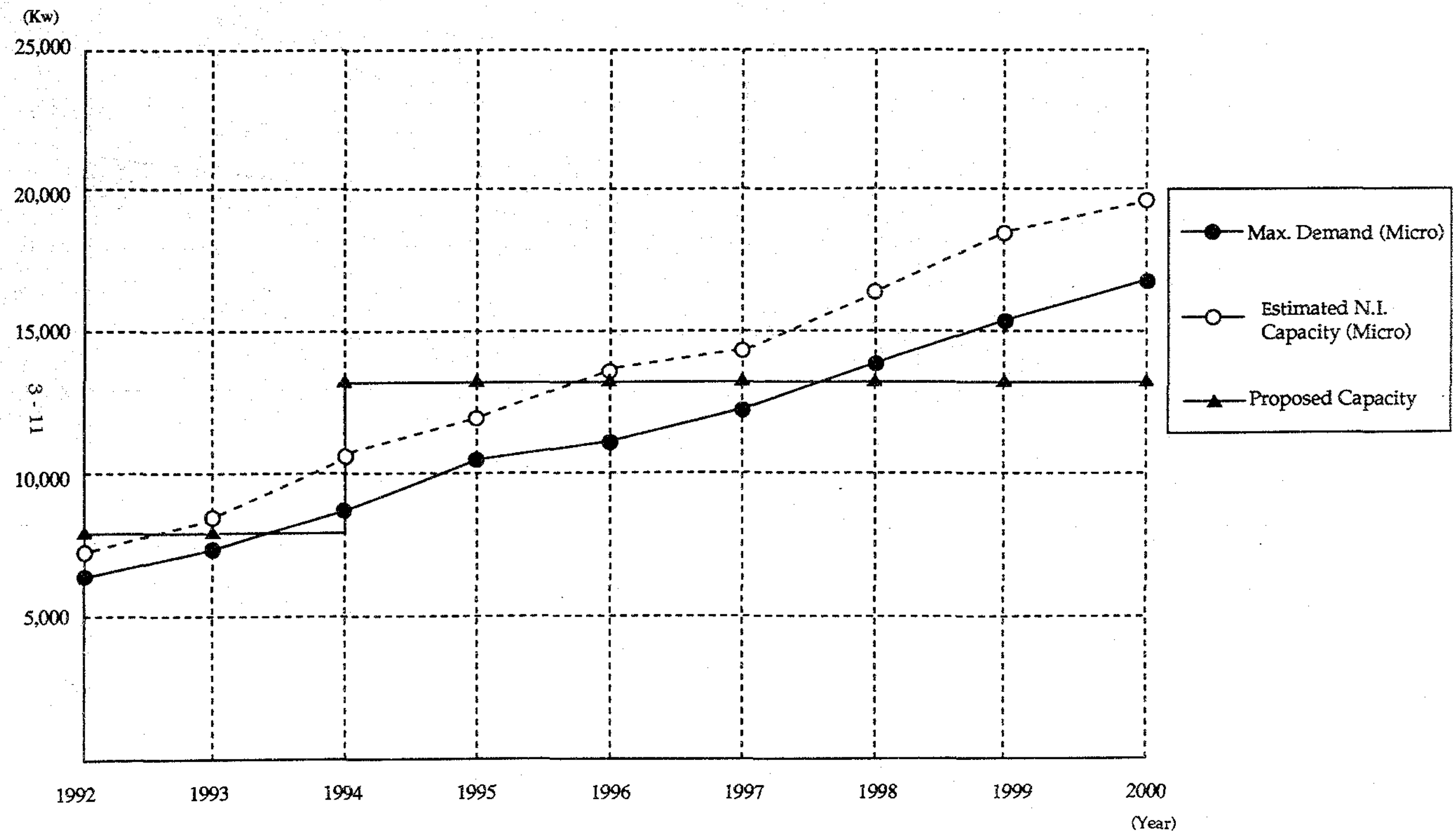
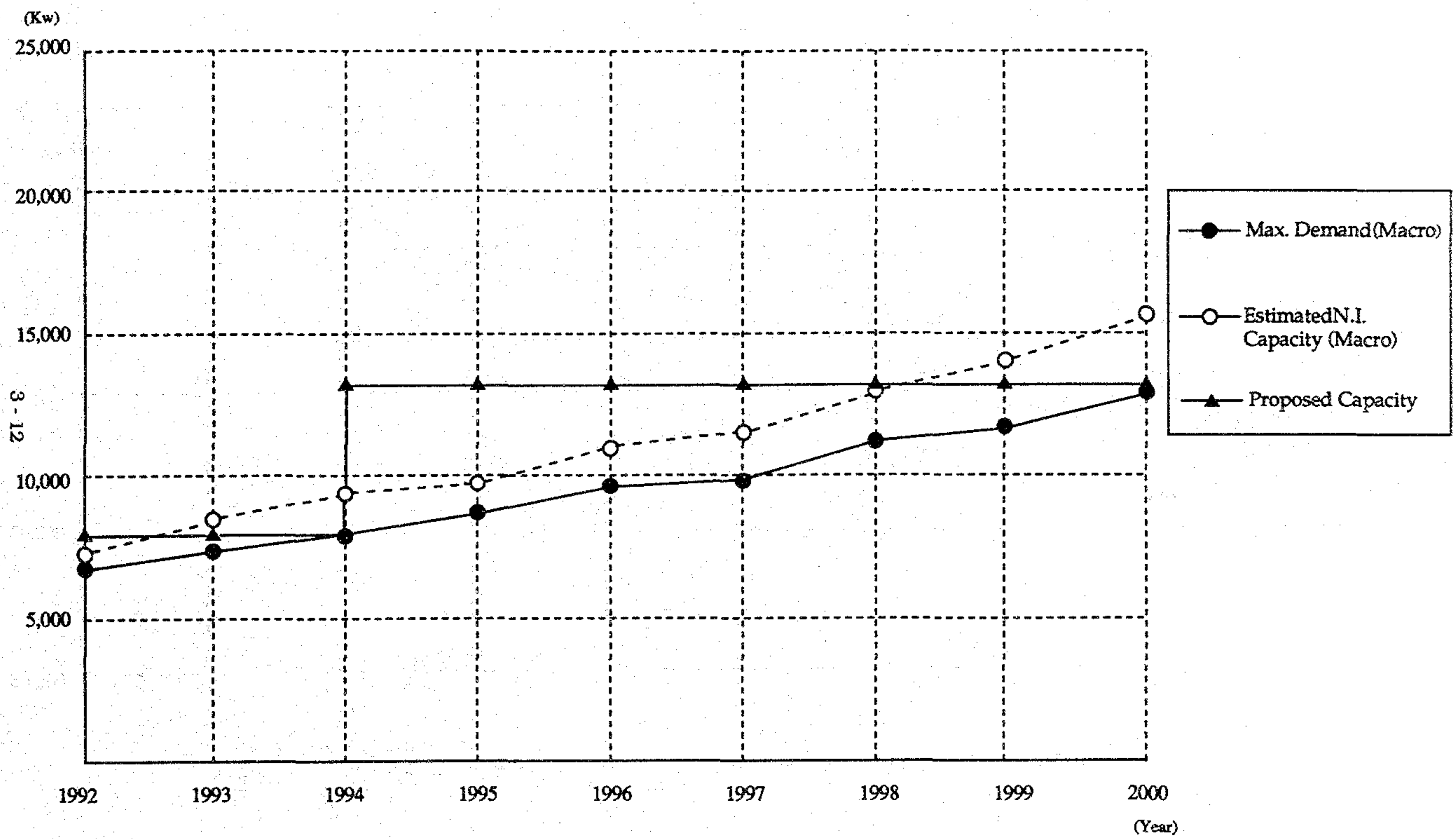


Fig. 3.2 Estimated Net Installed Generating Capacity (Macro Method)



3.2.2 Implementation and Management Plan

This project will be implemented by the Office of Budget, Planning and statistics; (OBPS) of the Government of Pohnpei, Federated States of Micronesia and the complete plants and facilities will be operated and maintained by Pohnpei Utilities Corporation, (PUC).

PUC was established in 1991 according to the Pohnpei State law No. 46-88, and is under the control of the acting board appointed by the Governor of Pohnpei.

PUC employed an Australian engineer as its General Manager.

There are the administration division, the power generating division, the power distribution division and the maintenance division under him.

After completion of the power generating plant which is under construction and will be operational at the end of 1992, PUC will close the ALCO BARGE POWER PLANT and 10 numbers of PUC's operator will work at Nanpohnmal power plant for the operation of the new generating plant.

They will also operate new plant which will be provided by Japan's Grant Aid.

Their experience in operation of the existing and new generating plant is considered to be sufficient to operate this project.

PUC's revenue and expenditure plan after the fiscal year of 1992 is as follows;-

The revised tariff system was taken into account in the revenue and expendiure plan shown in Table 3.7, and changes in comsumption within the respective meter rate ranges are as follows:

With the application of the revised tariff system, the financial condition which was in the red has now turned to the black. This indicates that efforts are being made by PUC to become independent financially.

Meter rate charge	Prior to revision (Jan. 1, '92 to Jun. 30, '92)	After revision (after Jul. 1, '92)
0.05$/KWH	37 %	17 %
0.12$/KWH	51 %	20 %
0.23$/KWH	12 %	63 %

Table 3.7 Revenue and Expenditure Plan

Unit: US$ Mill.

	Fiscal Year Oct. 1 ~ Sep. 30 of the next year				
	1992	1993	1994	1995	1996
Revenue					
Engineering Grant	1.00	1.00	1.00	1.00	1.00
Tariff	3.09	3.95	4.53	5.03	5.65
State Subsidy	2.20	0.30	0	0	0
Sub total	6.29	5.25	5.53	6.03	6.65
Expenditure					
Salaries	0.96	1.17	1.21	1.27	1.31
Burning oil	2.18	2.34	2.49	3.16	4.22
Repairing and Maintenance	0.86	0.15	0.10	0.18	0.18
Insurance, Fixed Assets Consumable Goods, Travel, etc.	1.47	0.23	0.26	0.24	0.26
Sub total	5.47	3.89	4.06	4.85	5.97
Total	0.82	1.36	1.47	1.18	0.68

Revised Tariff System:

	From July 1, 1992
Minimum monthly charge	2.50$/month
Meter rate charge	
0 ~ 500 KWH/month	0.05$/KWH
501 ~ 1,000 KWH/month	0.12$/KWH
10,001 KWH/month over	0.23$/KWH

3.2.3 Similar Projects and Projects Financed by the Other Foreign Donors

The power generation plant having 2.5 MW 2 Nos. is under construction by the State Government of Pohpei to corp with increasing demand in 1994 which is estimated to be two times of the present demand, and to solve the lack of the power generation facilities in the State. The above project is being implemented by their own budget and in this moment the state government has no power generation project financially aided by the international agencies except the above project.

3.2.4 Consideration on Contents of the Project

The purpose of the Project is to construct a power generation plant and to improve of the power distribution system in the State, and outline of the project consists of the following;

(1) Provision of diesel generating equipment, low velocity and constant power generation type, and construction of its power house
(2) Provision of backfeeders and their improvement
(3) Provision of automatic power distribution system
(4) Provision of backet truck

The objective of the project is to maintain constant power generation and distribution and it is prerequisit conditions to provide power generation and distribution facilities with automatic power distribution devices for the total power generation and distribution system. The contents of the project is, therefore, appropriate since each item of the equipment and facility to provide and or improve satisfies the above vital conditions necessary for the total power generation and distribution system.

3.2.5 Consideration on Facility and Equipment of the Requested

The major facilities and equipment are as mentioned in clause 3.2.4 and those are same as requested by the Federated States of Micronesia and are also minimum required facility and equipment for the constant power generation and distribution system which is the objective of the Project.

(1) Power Generation Equipment

As mentioned in clause 2.3.2, power generation capability of Nanponmaru Power Plant is as follows;

Present facility	:	3.2 MW	
New facility under construction	:	5.0 MW	(2.5 MW 2 Nos., 600 r.p.m., expected to run on Dec. 1992)
Total capacity	:	8.2 MW	

from the above, total capacity of the existing plant will be 8.2 MW. However, actual generation capacity of the plant is only 5 MW which can not serve necessary estimated capacity of 9 MW, since existing generator, 1,200 r.p.m., made by Caterpillar, U.S.A. is not suitable to consider for base load continuous operation. It is to be considered to provide additional generation facility for 4 MW accordingly.

In case of the continuous operation by the high revolution type diesel generator, working life of the major components of the engine such as piston, connecting rod, crank shaft, cum shaft etc. is supposed to be reduced. It is, therefore, recommended to consider medium or low revolution type, less than 600 r.p.m., diesel engine for generator. Incidentally, existing generator of 3.2 MW can be utilized as stand-by for and while peak-cut operation and accident or maintenance on the new generator and it becomes possible to provide effective operation of the power plant for constant power distribution, thus provision and construction of the power generation and distribution equipment for 5 MW is considered appropriate.

There has been a generator facility already installed with a capacity of 5 MW of power, and this project will add another 5 MW of power which will be capable of providing a total of 10 MW of power up to the period of 1997/1998 as indicated in Fig. 3.2. The existing plant facility will be rehabilitated and placed in reserve status for emergency use, which will enable to provide a total of 13.2 MW at the Nanpohnmal Power Plant when the need should arise. It is concluded that constant power generation and distribution can be achieved for the demand from 1994 to 1998 by the provision and construction of a new power plant for 5 MW.

(2) Power Distribution System

1) Back Feeder

The existing main power distribution system consists of 13.8 KV feeders and the system is interrupted by tripping in the Circuit Breaker provided in the power plant only when an accident occurs within the feeders. Consequently, all power supply in Pohnpei is interrupted.

In order to avoid such power supply interruptions, it is necessary to provide the following new back feeders.

① Nanpohnmal and Sekera, 2.0 km in distance. One new feeder of 13.8 KV, 3 Phase 4 Wire, is newly provided.

② Nanpohnmal - Kolonia Connection Point, 4.9 km in distance. One new feeder of 13.8 KV, 3 Phase 4 Wire, is newly provided.

The back feeders of (1) and (2) above improve the power distribution system, and the following independent feeders are provided in this system.

- Kolonia feeder
- East feeder
- West feeder

A normal-open Pole-mouned Switch will be mounted on a pole which is to be installed at the position near the connection point between the existing feeder and the new feeder.

If an accident occurs in one of the above feeders, power supply will be made through other feeders by closing of the normal-open Pole-mounted Switch, and this improvement will reduce the occurrence of power supply interruptions.

③ Dousokele Bridge about 250 m in distance. One feeder of 13.8 KV, 3 Phase 4 Wire cable is provided.

2) Automated Distribution System

① Installation of Pole-mounted Switch with Delay Timer Magnet.

Installation of the above switch makes possible the following-;

- The accident can be located easily.
- Power Supply to other parts rather than the accident portion can be made by opening of the Pole-mounted Switches provided at both sides of the accident portion.
- Minimization of the time of interruption.

Installation of the Pole-mounted Switches with delay timer magnet, which has been requested by PUC, is therefore considered necessary and reasonable for increasing reliability of the power supply in Pohnpei.

Installation of 4 numbers of the normal-open Pole-mounted switches requested by PUC is reasonable since the number of feeders out going from the power plant is 4 feeders.

Installation of 20 numbers of the normal-close Pole-mounted switches requested by PUC is also reasonable since at least 6 numbers of the switches are required for the new feeders. (20 No. > 6 No x 3 new feeders)

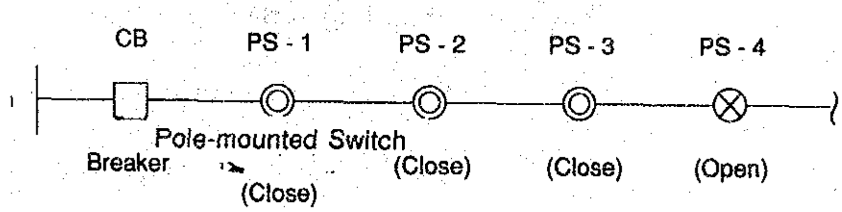
② Level of Automation

Since PUC did not indicate the level of automation in the power distribution system in their Request to Japan's Grant Aid, The discussion for the level of automation was held.

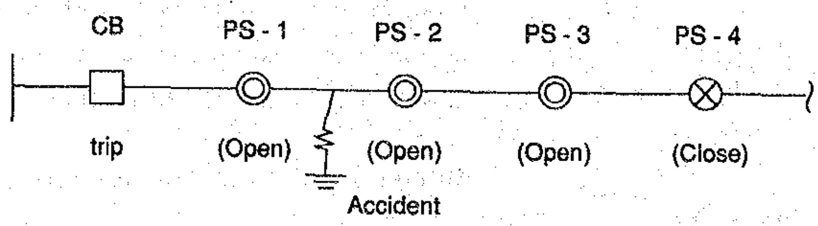
PUC initially considered that the level should be midway between the conventional system and the remote control system. However, PUC finally chose the conventional system level, from the ease of operation and maintenance points of view.

The conventional system is outlined as follows;

- Normal Operation

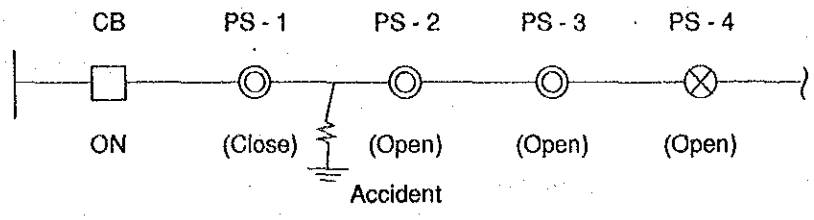


- Accident



When a fault occurs, CB will trip and Pole-mounted Switch PS-1, PS-2, PS-3, which are normal close will change to the open condition.

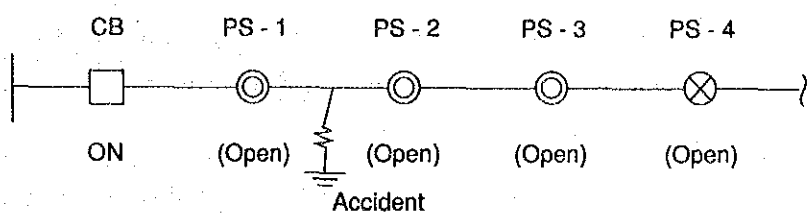
- CB first reclosing



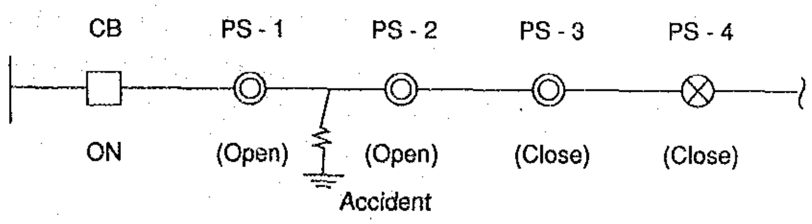
When CB is reclosed, PS-1 will be in the closed condition due to actuation of the voltage sensor in it after 7 seconds from reclosing of CB, However, electricity current transmits to the accident side and the fault current will cause CB to trip again.

PS-1 and PS-2 are locked in the open condition

- CB second reclosing



When CB is reclosed again, PS-1 is still locked in the open condition.



PS-4 will be automatically closed after voltage sensor finds that there is no electricity voltage for a certain time.

PS-3 will be closed after 7 seconds from the closed condition of PS-4.

Since PS-2 was locked the power can be supplied up to PS-2.

After repairing the fault section, PS-4 will be manually opened and the other PS-1, PS-2, PS-3 will be closed.

There is an Fault Section Indicator in the control room and the fault section is automatically indicated. The indication is shown in terms of time. This means that if the indication is 7 seconds, the accident portion is between PS-1 and PS-2, while 14 sseconds means it is between PS-2 and PS-3.

3.2.6 Necessity of the Technical Cooperation

PUC is operation the existing power plants and power distribution system without the help of operation and maintenance specialists despatched from the other countries.

PUC is despatching two numbers each of the electrical and mechanical engineers for three (3) months training to the manufacturers who supplied two sets of 2.5 MW power generation plant and equipment currently under construction, and PUC also wishes to give their engineers the some type of the training for this Project.

It is, therefore, recommended to give operators and maintenance staff necessary training in order to perform proper operation and maintenance of the new plant and equipment.

It is necessary in usual two groups of the skilled operation and maintenance staff, one electrical and mechanical engineers, in shift of twelve hours for twenty-four hours operation of the power plant. It is, therefore, necessary in total of four numbers of skilled engineers, and to be considered that the training for two each numbers of the electrical and mechanical engineers at least will be required for the operation and maintenance of the power generation plant which is going to be constructed under the Project accordingly.

3.2.7 Basic Principle for Project Implementation.

The implementation of this prjoect has been examined for its adequacy, need, and technical possibility, together with the capability of the Government of Pohnpei, and the effects of the Project has been found to be well suited for a Grant Aid project, and the Basic Design will be investigated for implementation as a Grant Aid project.

A stable supply of electric power will depend on adequate euqipment facilities and suitable operation and proper maintenance. This project will provide adequate facilities, but in order to supply a stable source of power, it will be necessary to provide the appropriate operation and maintenance based on plant operators who have received the proper training and knowledge of the equipment.

3.3 Description of the Project

3.3.1 Executing Agency and Operational Structure

The executing agency is the State Government of Pohnpei. Pohnpei Utilities Corporation (PUC) will operate and maintain the Project after its completion.

Organization chart is given on Fig. 3.3.

3.3.2 Plan of the Project

The proposed project is based on the power demand forecasted for 1994 of 9 MW as described in Paragraph 3.2. (1), and it will provide for the construction of a electric generation plant to supply a stable source of electric power together with improvements in the power distribution system.

The planning of the project will be carried out on the basis of the design conditions and requirements, taking into account necessary interface with the existing facilities, and the project will consist of the minimum required facilities provided with sufficient functions to meet the requirements of the Project.

The project includes the following;

1) 2.5 MW x 2 units Diesel Power Plant
2) Installation of Back Feeders
3) Installation of Automated Distribution System
4) Supply of one Bucket Truck for repair maintenance of distribution lines.

3.3.3 Outline of Facilities and Equipment

The facilities and the equipment which will be supplied by Japan's Grant Aid are outlined as follows;-

1) 2.5 MW x 2 unit (600 rpm) diesel power generating plant with radiators, control system and others required for the plant, and a power house of which the floor area is given below.

Power House

Name of room	Area (m^2)
Power Generating Room	297
Electrical Room	90
Control Room	30
Total	417 m^2

2) Installation of Back Feeders

- Nanphonmal - Sekera (Approx. 2.0 km)
  power distribution lines, 13.8 KV 3 Phase, 4 Wire.
- Nanphonmal - Kolonia Connection Point (Approx. 4.9 km)
  power distribution lines, 13.8 KV 3 Phase, 4 Wire.
- Dousokele Bridge (Approx. 0.25 km)
  power cable 13.8 KV 3 Phase 4 Wire.

3) Automated Distribution System

- 24 number Pole-mounted switches.
- Automatic reclosing relay and four (4) number fault section indicator (in digital) to be provided in the control room in the power house.

4) One (1) Bucket truck for repair and maintenance of the power distribution lines.

3.3.4 Operation and Maintenance Plan

After completion of the project, the power plant and facilities will be operated and maintaind by Pohnpei Utilities. Corporation (PUC) as described in 3.2.4.

The operation and maintenance requirements of the new plant and facilities would be similar to those for the existing plant and facilities, since the newly completed system would provide additional power generating plant of the same type and would be an improvement to the existing power distribution system.

Ten (10) members of operator and maintenance crew will be transferred to Nanphonmal from ALCO BERGE POWER PLANT which will be closed at the time the new power plant is ready for operation (it is expected that plant will be operated from the end of 1992).

The required member of operators among the above 10 crew will be assigned to the operation of the new power plant.

The plant and facilities must be properly operated and maintained in order to function correctly, and the standard inspection and maintenance for the plant required to ensure smooth operation is shown in Table .

Operation costs of the new plant are estimated approximately as follows;

- <u>Conditions of estimation</u>

Rated Output of the generator	:	2,500 KW x 2 Units	=	5,000 KW	- (1)
Engineer output	:	3,750 PS x 2 Units	=	7,500 PS	- (2)
Yearly operating time	:	24 hr x 250 days	=	6,000 hr/year	- (3)
Yearly generating power	:	6,000 hr x 5,000 kw	=	30,000,000 KW	- (4)
Fuel oil consumption	:	141 gr/ps/hr (= 0.2359 l/KW. hr)			- (5)

Equation : $\frac{141}{1000 \times 0.7355 \times 0.956 \times 0.85}$

where :
0.7355 = PS/KW
0.956 = efficiency of generator
0.85 = Specific gravity of A heavy oil

Lub oil consumption : 0.8 gr/ps·hr - (6)

Specific gravity : 0.95 - (7)

Fuel oil : A heavy oil
(Net calorific value : 10,200 kal/kg

1) Fuel oil cost (Yearly)

Consumption (4) x (5) = 30,000,000 KW x 0.2359 l/kw

Cost = 7,077,000 x 0.23 US$/l

US$ 0.23/l is given by the following conditions

One US gallon = 3.785 l

0.88 US$ = One US gallon

2) Lub oil cost (Yearly)

Consumption (2) x (6)/(7) $= \frac{7500ps \times 0.88gr/PS{\cdot}hr}{0.95}$

= 35,924 l

35,924 l x 1.30 US$

= 46,701 US$

3) Cooling Water Cost

Cost will not be taken into account for the following reasons:

- *There is no tariff system for the supply of portable water in Pohnpei*
- Make-up water quantity is very little (0.1 %/hr of the circulating cooling water of 240 m^3/hr for 2 units).

4) Regular Maintenance cost

150,000 US$ (30,000,000 KW x 0.05 US$/KWh)

5) Wages

28,000 US$ for 4 No. operators (average yearly income is 7,000 US$/operator) total of 1) to 5) inclusive,

1,852,411 US$ (0.06 US$/KWh)

Total sum of operating Expenses: $1,852,411 ($0.06/KWH, ¥8.03/KWH) of the running costs, the share of fuel costs was more than 80 %.

The expenses of PUC will be kept in balance with a rise in the electric charge rates, but for a proper operation of the power plant, it should be planned to reduce the diesel fuel costs, to bring the expenses into a better balance with the revenue.

One general method to bring down the cost of the diesel fuel is to convert the Type A diesel fuel to a Type C diesel fuel. In order for a smooth start and stop of the diesel engines, it is recommended to use Type A diesel fuel when starting and stopping the diesel engines, and to use Type C diesel fuel for continuous running.

The rough costs when the method above is used will be as follows:

1) Fuel Costs:

$1,186,440

$$7{,}077{,}000\ l \times \frac{0.95}{0.85} \times \$0.15 = \$1{,}186{,}440$$

where: 7,077,000 l: Yearly total fuel consumption

Type A Diesel Fuel (Specific Gravity 0.81): 1 l = $0.23

Type C Diesel Fuel (Specific Gravity 0.95): 1 l = $0.11

The total yearly cost of Type A Diesel Fuel will be $1,627,710, whereas, the cost for Type C Diesel Fuel will be $1,186,440. This will represent a yearly saving of approximately $400,000 ($1,627,760 - $1,186,440 = $440,000).

Note: The figure are based on data provided by PUC.

2) The Expenses required to Convert to Type C Diesel Fuel Oil:

$600,000

- Modification to the Engine Proper: $150,000

  • Injection Nozzle
  • Exhaust Valves and other facts

- Cost Modification to Type C Diesel Fuel Processing Equipment: $450,000

  - Fuel Storage Tank
  - Settling Tank
  - Service Tank
  - Pumps
  - Purifier
  - Air Separator
  - Fuel Changeover Valve
  - *Lubrication Oil Purifier*
  - Pipes, Tubing, Miscellaneous Item

The changeover of the facilities will cost approximately $600,000 to convert to the Type C Diesel fuel, but when it is considered that there will be a savings of $400,000, this conversion cost could be repaid within 2 year's time.

Table 3.8 Maintenance Schedule

Running Hour	Division of Inspection	Contents
500	A Division	Each filter cleaning (Fuel, Lub. oil, Lub. oil for rocker arm, valve cooling) Turbo-charger (Blower wash, Turbine wash)
2,000	B Division	Fuel nozzle adjustment Exhaust valve lapping Exchange of Lub. oil (Governor, Turbo-charger, Rocker-arm, C.W. pump) Turbo-charger (Filter cleaning) Inspection moving parts crank case inside Inspection of Valve clearance
4,000	C Division	Cylinder head maintenance with all valves re-grinding and fuel nozzle replacement Lub. oil control with analysis Connecting rod bolts re-tightening Inspection of cam-shaft
8,000	D Division	Piston maintenance (rings replacement, ring land and cyl. liner measurement) Cleaning for coolers (Lub. oil F.W. and air coolers) Maintenance for pumps (fuel infection, Lub. oil, rocker arm Lub. oil and cooling water) Checking up function of eng. shut down device, balancing weight bolt re-tightening and measurement of crank shaft deflection Lub. oil replacement and turbo-charger overhaul
20,000 ~ 24,000	E Division	Main bearing, crank pin bearing replacement Fuel injection pump plunger and barrel replacement Connecting rod bolt replacement Inspection timing gears

3.4 Technical Cooperation

As described in clause 3.2.6, it is considered that dispatch of experts is not necessary for the operation of the new power plant and the distribution system after the completion of the Project. However, it is recommended to give operators and maintenance staff necessary training in order to perform proper operation of the new plant and equipment in Japan.

The training in Japan will be made for at least two numbers each of their electrical and mechanical as trainee by the manufacturer of the generator and diesel engine, who will supply their equipment for this Project, and the training program will in general be as follows;

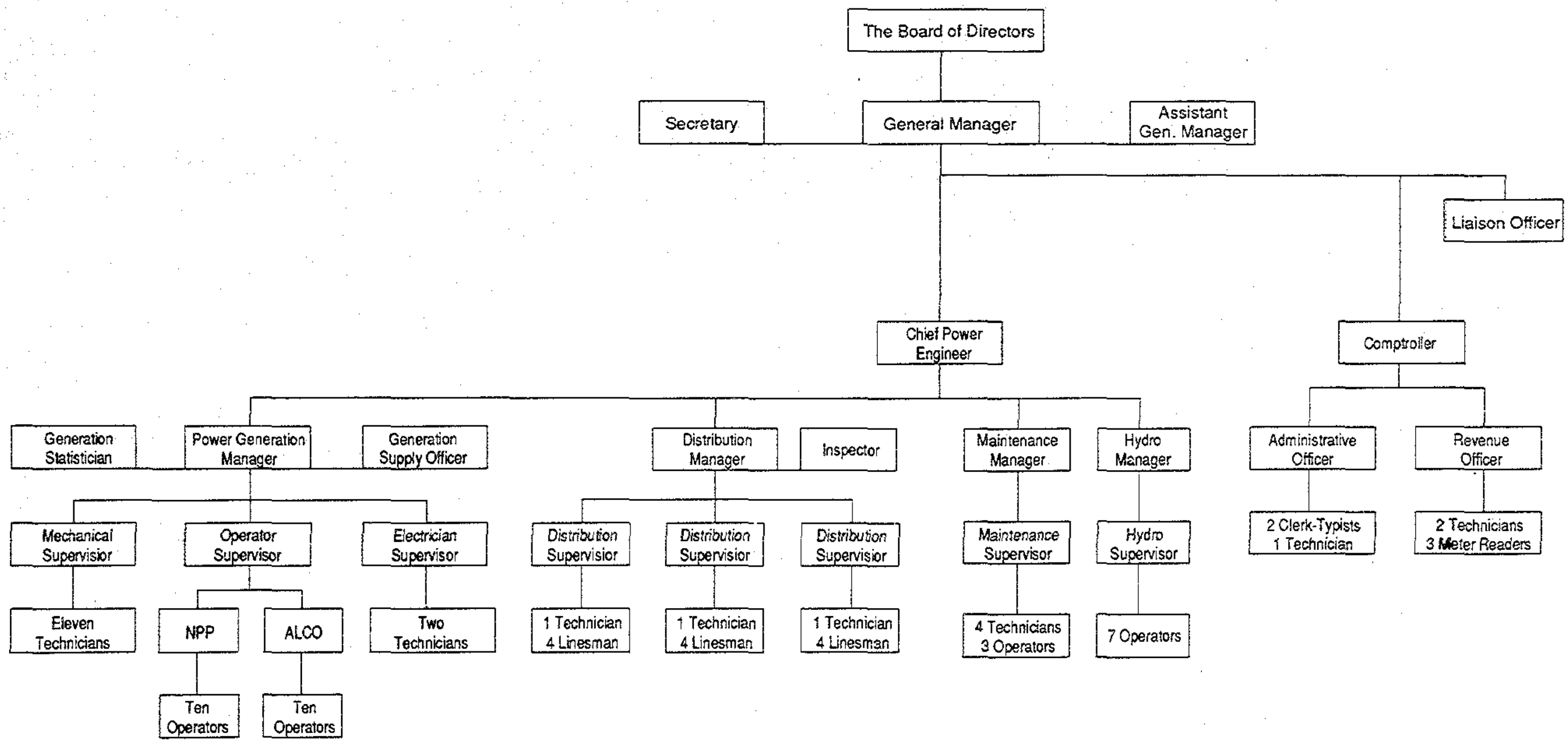
Electrical engineer:
- Operation and maintenance of generator and control panel
- Trial practice of operation and control

Mechanical engineer:
- Operation and maintenance of engine and aux. equipment
- Trial practice of operation and control

It is planned to execute training for the above trainees for three months, two person in physical year of 1992 and the other two in that of 1993.

Fig. 3.3 Pohnpei Utilities Corporation

Organization Chart



CHAPTER 4 BASIC DESIGN

Chapter 4 Basic Design

4.1 Design Policy

The Basic Design was prepared under the following design guidelines given below.

4.1.1 Electricity Generation Facilities

1) System, Operation Method, etc.

A study shall be made on the design of electricity generation facilities which are presently under construction and scheduled for commissioning at the end of December, 1992. There were no particular technical problems found in the overall design, and so the new facilities will be designed for a system, operation methods, etc., equal to those of the facilities under construction.

2) Moisture- and Corrosion-proofing

The facilities shall be designed for moisture- and corrosion-proof construction, taking into account the local climate of high ambient air temperature and high relative humidity.

3) Damage due to Saline Conditions

Outdoor facilities shall be designed against the effects of briny air.

4.1.2 Electricity Distribution Facilities.

1) New Backfeeders

For ease of maintenance, the backfeeder wires shall be of the same specifications as those of the existing aerial wires. The distribution poles shall be precast reinforced concrete poles in order to avoid damages by termites. Locations of the poles shall be carefully selected taking into consideration the special local conditions such as the regulations of prohibition of cutting of bullet fruit trees, etc.

2) Installation of Automated Distribution System

As far as practicable, the switches on poles shall be of the type which needs little maintenance. In addition, the switches shall be installed on poles which are readily accessible for the maintenance crews to perform manual operation of the equipment at times of interruption of electricity supply. Furthermore, locations of the switches shall be planned in such a way that the equipment are easily accessible, without major modifications, even after alteration from 4.16 KV system to 13.8 KV system mounted on poles which is in progress in the Kolonia area.

4.1.3 Power Plant Building

1) Water- and Corrosion-proofing

Particular attention shall be paid for water-proofing, flooding and corrosion of the building facilities, taking into account the annual precipitation of approximately 6,000 mm.

2) Use of Local Building Materials

As much as possible and as far as technically practicable, locally available building materials such as concrete aggregates and concrete blocks shall be used for the building construciton.

3) Units of Measurements

In principle, the units of measure used in the design shall be the metric system, however, non-metric units such as yards and pounds may be used for particular items for which the non-metric units are commonly used.

4.2 Design Criteria

The design of the equipment and facilities will be in accordance with the following standards and codes:

- Japanese Industrial Standards (JIS),
- Standards of the Japanese Electro-technical Committee (JEC),
- Standards of the Japan Electrical Manufacturers' Association (JEM),
- International Eelctro-technical Commission (IEC),
- Uniform Building Code (UBC),
- AIJ Standard for Structural Calculation of Steel Structures, Architectural Institute of Japan (AIJ)
- AIJ Standard for Structural Calculation of Reinforced Concrete Structures, Architectural Institute of Japan (AIJ)
- American National Standards Institute (ANSI), and
- American Society for Testing and Materials (ASTM) Standards.

4.3 Basic Plan

4.3.1 Site and Layout Plan

The site for the electricity generation facilities is within the Nanphonmal Power Station as planned by the States Government taking into account the interrelationship between the existing and the new facilities. The locations of the new building and the outdoor facilities were determined in such a way that they will be in line with the existing ones in order to achieve a harmony among them. A covered corridor was provided to facilitate movements between the existing and the new buildings.

The proposed site is presently a road. It has been agreed in writing that the State Government will be responsible for relocation of the road, removal and demolition of other obstacles, and land grading of the site at its own cost.

4.3.2 Architectural Design

(1) Floor Plan

The configuration and the column spacing of the buildings were made the same as those of the existing buildings in order to match the appearance of both buildings. Description of the respective rooms in the new building are given below.

1) Generator Room (approx. 305 m^2)

This room is the main space for installation of the generators and the auxiliary equipment, therefore, the configuration of the entire building was determined taking primarily the requirements of this room into account. The layout of the generators in relation to the building walls was determined in consideration of the requirements of maintenance spaces and access corridors of hauling in the equipment for transportation vehicles. For entry of the equipment, a wall opening of 5 m x 5 m with a roll-up door was planned respectively at the front and the rear of the building.

2) *Electrical Panel Room (approx. 93 m^2)*

In this room, the generator panels, feeder panels, auxiliary equipment panels, etc. are installed taking into consideration the arrangement of the cables. Cable trenches in the floor were proposed for ease of installation and maintenance. The space requirements were determined in consideration of the access to the front and the rear of the panels for maintenance.

3) Control Room (approx. 30 m^2)

The control room was elevated to the second floor in consideration of the apportionment of the entire building. The vacant space available above the electrical panel room was efficiently used for installation of this room without increasing the building size. In this room, the electric panels necessary for observation and control of the new facilities and for observation and metering of a portion of the existing facilities including 2 units of the 2.5 *MW* generator.

Noise insulation, lighting and air-conditioning systems for this room were so designed as to provide the operators to be stationed therein with comfortable working environments. For observation of the equipments in the generator room from this room, a sound-proof view-window was planned in the wall.

4) Outdoor Facilities

The outdoor facilities are two radiators on the north, and location of the station transformers on the south of the building. These facilities were arranged in a similar configuration with the existing facilities.

(2) Section Plan

1) The height of the building was determined taking into consideration the dimensions and the required clearances of the overhead crane in the generator room.

2) The ceiling height of the control room was determined to be 3,400 mm above the floor to avoid the operators' feeling of suppressed by a low ceiling height, although the minimum clear height required of the control panel is 2,750 mm.

(3) Structural Design

1) A steel-frame structural system was used for the building construction. The main frames were arranged in the same direction as the main frames of the existing building.

2) In consideration of the fact that there are no national standards available and that the majority of the structural materials will be procured from Japan, Japanese design standards were applied to the design of steel structures of the building. The applicable Japanese standard for structural calculation and the national standards for the materials were also applied to the structural design of the foundations.

3) The existing subsoil at the site is fine silty sand. In the subsoil investigation data prepared for the proposed building, the allowable bearing capacity of the soil was estimated at 19 tons/m^2, although the capacity used in the structural calculation was 12 tons/m^2. In the basic design of the new facilities, the allowable design capacity of 12 tons/m^2 was adopted. The said capacity must be confirmed by detailed subsoil investigations during the detailed design period. The generator foundations were designed based on a vertical spring constant of the soil (Kv) of 3 kmg/cm^3 assumed in consideration of the soil characters, since there was no data on the KV available for use in vibration analysis of the foundations. The data will be made available for the detailed design.

4) Design Loads

Static and dynamic loads of the equipment for the basic design of the structures were obtained on the relevant Japanese standards. In consideration of the fact that the site was attacked by typhoons several times, the wind loading determined based on the wind speed of 55 m/sec. as proposed in the States' "Requirement for 1992 Japanese Grant Aid" with a covering letter dated February 7, 1992.

5) Building Facility Plan

The forced ventilation system by the use of ceiling fans was planned for the generator and electrical panel rooms which are contiguous with each other without any dividing walls.

The control room was planned to have an air conditioning system suitable for the operators' full-time stationing. The lighting system was designed to provide a luminous intensity of 150 to 200 lux in the generator room and 400 to 500 lux in the control room.

6) Main Building Materials Plan

It was planned to procure the building materials such as concrete, wood products, concrete blocks and steel reinforcing bars locally. Other materials were planned to be imported from Japan. Major items of the building materials planned to be imported are the steel sheet roofing, steel sheet siding, steel doors, aluminum windows and steel roll-up doors. For details of the materials, reference should be made to the basic design drawings.

4.3.3 Power Equipment Plan

The principal specification and the particulars of the electricity generation equipment proposed are given below.

(1) Generators

1) Specifications

Type	: Open-Screen protected, revolving field, Salient Pole with damper windings.
Rated output	: 2,500 KW (3,125 KVA)
No. of poles	: 12
Rotation speed	: 600 rpm
Rated voltage	: 4,160 V
Frequency	: 60 Hz
Power factor	: 0.8
Phase	: 3-phase
Rating	: Continuous
Insulation	: Class F
Exciter	: Brushless, AC exciter

2) Voltage Variation Characteristics

- The stable voltage characteristics proposed is such that the terminal voltage at the rated power factor with a discretionary load between the full and no loads is maintained within plus or minus 1.5 % of the rated voltage.

- The design characteristics of the instantaneous voltage variation is that the voltage returns to 97 % of the rated voltage within 2 second of and instantaneous throwing of the load equivalent to 50 % of the generator's rated amperage at the rated power factor.

3) Synchronized Operation of Generators

The proposed generators were designed to allow for synchronized operations, automatically or manually, with the existing generators as described below.

- *Automatic Synchronization*
  Voltage and frequencies of the respective generators are automatically regulated, and the switchgears are closed automatically upon confirmation of the synchronization of the generators.

- Manual Synchronization
  The operator detects the synchronization point by a detector and manually closes the switchgears.

(2) Diesel Engines

1) Specifications

Type	: V-type, 4 cycle, with turbochargers
Rated output	: 3,750 PS minimum
Overload capacity	: 1 hour of 110 % loading at every 12 hours
Rotation speed	: 600 rpm
Start-up method	: Compressed air starter
Fuel	: Type A light oil

2) Characteristics

- Fuel Consumption
  Fuel consumption of the diesel engine proposed is 141 gallons/PS/hr plus or minus 5 % at the time of the rated output operation.

- Lubricant Consumption
  The lubricant consumption is not more than 0.8 gallons/PS/hr at the rated output operation

- Characteristics of Governor
  Rate of instantaneous speed changes and the stable speed change shall be plus or minus 10 % and plus or minus 5 % of the rated speed respectively, at the times of no load and 50 % of the full load.

3) Protection System

The proposed system of protection of the diesel engines from damage due to various causes is as follows:

Type of troubles	Stop engine	Trip circuit breaker	Sound buzzer	Light lamp
Lub. Oil Pressure low	Yes	Yes	Yes	Yes
Over speed	Yes	Yes	Yes	Yes
Cooling water temp. high	Yes	Yes	Yes	Yes
Start failure	Yes	Yes	Yes	Yes
Fuel level low or high for fuel daily service tank	No	No	Yes	Yes
Generator over voltage	Yes	Yes	Yes	Yes
Generator over current	No	Yes	Yes	Yes
Starting air pressure low	No	No	Yes	Yes
Emergency stop	Yes	Yes	Yes	Yes

4) Interface with Existing Generation Equipment

Taking into account that the main control room is located in the proposed Power Plant building, interfaces between the existing and the proposed equipment for observation and control thereof were planned as follows.

- Start-up and shut-down operations of the existing electricity generation equipment are to made in the existing power house. However, a switch for emergency shut-down of the existing equipment is provided in the control panel in the main control room.

- Indicators of operation status and troubles of the existing equipment are installed in the control panel in the main control room.

- Wattmeters and Varmeters for the existing equipment are provided in the control panel in the main room.

- Load-balancing governor switches for use at the time of synchronized operations of the existing and proposed equipment are installed in the control panel in the main control room.

- The existing feeder panels are controlled in the existing power house.

- Operation status and troubles of the existing feeders are indicated on a panel in the main control room.

- Wattmeters for the existing feeres must be observable in the proposed power house.

(3) Distribution Facilities

1) Backfeeders

The proposed backfeeders were planned with the aerial wires of the specifications same as the existing 13.8 KV aerial wires, for the reasons that PUC has ample experience in maintaining the existing aerial wires and that the maintenance tools PUC possesses can be used for maintenance of the backfeeder aerials. The proposed specifications of the wire are as follows.

Items	13.8 KV wires	Neutral wires
Conductor	Aluminum	Aluminum
Size	333.6 MCM (170 mm^2)	3/0 AWG (85 mm^2)

a. Between Nanpohnmal and Sekera (approx. 2.0 km)

A 3-phase, 4-wire, 13.8 KV overhead distribution system will be newly provided. Since the route of the distribution lines are steep and precipitous, mountainous, the distribution poles will be spaced at 40 m instead of the average 50 m; in order to keep the sag of the wires low to keep them from corning into contact with the trees. The distribution poles will be present concrete poles of 14 m length. The number of pole required in this section will be generally as follows:

14 m poles:	49 poles
16 m poles:	1 pole

The 16 m pole will be used to connect the substation with the power generating house.

b. Between Nanpohnmal and Kolonia Connection Point (approx. 4.9 km)

For this portion, 13.8 KV, 3-phase, 4-wire overhead distribution system will be newly provided. The existing road in the 2.8 km long portion between the Nanpohnmal and the water tank is a winding road, and the existing aerial wires intersect with the road at 10 locations. The existing poles are 14 m long wooden poles at 50 m spacing.

In normal cases, the additional wires are installed beside the existing wires, however, the proposed backfeeder wires are planned to run along the road, therefore, they intersect with the existing wire system at several locations. In order to maintain the separation between groups of the existing and the new wires, precast concrete poles of 16 m length are proposed at the average intervals of 50 meters.

Where the wires are required to cross the river between the water tank and Kolonia Connection Point, the separation between the poles on each bank of the river becomes 70 to 80 meters. Taking into account the sag of the wires between the poles, estimated at around 2.2 meters, 16 m long poles were proposed. The clearance of the wires above the grade was estimated at about 9.9 meters (16 m pole length -2.7 m embedment in the ground -1.2 m below top of pole -2.2 m dip = 9.9 m), therefore, it was assumed appropriate to use 16 m long poles.

Other than the above-mentioned particular sections, 16 m long poles with average spacing of 50 meters were proposed in the design.

The number of poles in this section will generally be as follows:

14 m poles:	43 poles
16 m poles:	57 poles

c. Renewal of the existing cables along Dousokele Bridge

The results of investigations of the existing cables are given in Section 2.3 3) hereof. In order to maintain the uniformity of the electrical characteristics of the cables and the aerial wires, replacement of the existing cables in this portion with 20 KV, CVT 100 mm^2 cable of 250 meters was proposed. Electrical characteristics of the proposed cables and the aerial wires are as follows.

Type	Proposed cables 20 KV, CVT	Aluminum Aerial wires 336.4 MCM
Sect. area of Conductors	100 mm^2	170 mm^2
Rated amperage	270 Amp.	467 Amp.
Conductor resistance	0.187 Ω/km	0.1686 Ω/km