BASIC DESIGN STUDY REPORT

ON

BABELTHUAP ELECTRICAL

TRANSMISSION AND DISTRIBUTION LINES PROJECT

IN

THE REPUBLIC OF PALAU

APRIL 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Palau, the Government of Japan decided to conduct Basic Design Study on the Babelthuap Electrical Power Transmission and Distribution Lines and entrusted the study to Japan International Cooperation Agency (JICA). JICA sent to Palau a study team headed by Mr. Toshichika Kuroki, the Ministry of International Trade and Industry from January 9th to 29th 1985.

The team had discussions with the officials concerned of the Government of the Republic of Palau and conducted a field survey in Babelthuap area in Palau. After the team returned to Japan, further studies were made and the present report has been prepared.

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

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

April 1985

Keisuke Arita

Keisuke Arita
President

Japan International Cooperation Agency

SUMMARY

SUMMARY

The land of the Republic of Palau with a total population of 12,000, consists of roughly 200 islands of various sizes that lie in the south-western Pacific. Infrastructures have not been highly developed except in the Koror Island on which the capital of the Republic is situated.

The Government of Palau, in encouraging advancement of the country, places great emphasis on development of the Babelthuap Island, which is the largest in Palau and stretches adjacent to the Koror Island to the south. With the aim of creating a new electric power system in the Babelthuap Island, the Government of Palau is currently constructing a new power plant under loans from the United Kingdom. Under these circumstances, the said Government requested the Government of Japan to furnish Japanese Grant Aid for the implementation of the Babelthuap Transmission and Distribution Lines Project (hereinafter referred to as the "Project"). In response to this request, the Government of Japan sent a preliminary study team of the Project through the Japan International Cooperation Agency (hereinafter referred to as "JICA") to Palau in October 1984 and the scope of work related to the Project was settled. Thereafter the Basic Design Study Team for the Project (hereinafter referred to as the "Team") was also dispatched by JICA to Palau in January 1985 in order to determine details of the work including the scope of the requested Project.

The electric power system in Palau is only the one available in Koror and adjacent areas. Malakal Power Plant belonging to this system has eight (8) units of diesel generators with an installed capacity of approximately 8,000 kW. (Note 1) The facilities of this power plant is so superannuated that failures take place frequently. In fact, occasional blackouts occurred during the field survey although an intensive overhaul was made on the plant in 1984. It was hardly possible to obtain the operation records and the like of the plant to show its actual operation condition before the said overhaul due to inadequate sorting of the operation records and/or lack of such data. However, it could be pointed out that there was a serious chronical shortage of power supply capability in view of the daily load curve on the third Wednesday of each month (Note 2) obtained at the power plant during the period from May 1983 through April 1984. The Government of Palau stated that the maximum demand at present is 4,000 kW. The figure raised by the said Government is considered reliable since the Team confirmed a maximum demand of 4,110 kW on their visit to Malakal Power Plant during the field survey.

As far as the load is concerned, about 30% of the total load (16,406 MWH as of 1984) comes from energy consumption by government offices and the rest from household and commercial uses. The generating cost is reported to be 22 cents/kWH and almost the same cost has been obtained by the Team through their own calculations. The electricity charge is 9 cents/kWH up to 2,000 kWH per month. The difference between the generating cost and electricity charge as stated above is borne by the Government of Palau. Thus a total sum of the subsidy amounted to 2,133 thousand dollars (530 million yen) (Note 3) as of 1984. It must be noted that the above-mentioned generating cost does not include any depreciation cost.

The electric power demand forecast in this Report has been made for the target year of 1995, which is ten years later from 1985, on condition

that the present maximum demand is 4,000 kW. The power demand in the final year is estimated at 9,000 kW on the assumption that 1,550 kW; load from self-generating facilities is to be transferred, incremental power demand from development of industries 1,210 kW, incremental demand from households 1,500 kW, load of various projects 610 kW and demand from electrification schemes 130 kW. The figure of 9,000 kW was accepted to the Palau side. A series of the figures enumerated above are confirmed by the Team through the field survey and upon examination of the results of hearing of the present situation of self-generating facilities and incremental power demand to arise from electrification and other projects.

At present, the Government of Palau is in the course of constructing a new power plant in Aimeliik State of Babelthuap, which is to be replaced with Malakal Power Plant, under a contract with a British company named IPSECO INTERNATIONAL POWER SYSTEMS LTD. (IPSECO). This new power plant is expected to be completed in June 1985. The total construction cost of this power plant is 28,965.8 thousand dollars (7.24 billion yen). It is presumed that the above cost includes construction cost of installing eight (8) oil tanks with a total storage capacity of 6 million gallons which probably amounts to 6,000 thousand dollars (1.5 billion yen). These oil tanks will be used for storage of oil for the power plant and ships on the ocean. The said facilities are expected to be managed by a joint corporation between the Government of Palau and IPSECO. In case the service life of each generator at the plant is 15 years and the average growth rate of load is 5.6% per annum, the average annual energy production in the coming fifteen (15) years will reach 48,288 MWH. Therefore, it is estimated that the generating cost of this power plant will amount to 12 cents per kWH on condition that repayment of the principal and interest amount is made.

A calculation proves it more economical to fully utilize the new power plant for power supply through the transmission line therefrom, resulting in saving of 4,170 thousand dollars (1.04 billion yen) per annum for the coming 15 years, as compared with a hypothetical case in which the existing generating facilities are used for power supply (and power demand to exceed the existing installed capacity is met at the same cost as that of the new power plant). The utilization of the new power plant in concert with this Project will ensure the stable supply of electric power thereby achieving not only economic benefits but also social ones in vitalization of industrial and economic activities and in enhancement of the welfare of inhabitants. Hence, it is believed meaningful that the Government of Japan will render its grant aid for the implementation of the Project.

As for selection of a transmission line route for sending an ultimate load of 9,000 kW three (3) alternatives; two (2) routes for overhead transmission lines to pass on the ground and the other route of a submarine transmission line, were conceived. After comparative studies thereof, the route along the seashore as shown in Figure 6-1 that passes the electrification area of this Project has been selected.

The voltage of the transmission system has been selected to be 34.5 kV, which is one step higher than the existing voltage, considering the amount of power transmitted and the transmission distance. In designing electrical facilities, natural environmental conditions along the seashore, such as salt contamination and corrosion, have been taken into account. Concrete poles of high durability were selected as supporting structures and corrosion resistance cables for conductors. It has been planned to construct a step-up substation (with two 10 MVA transformers) in the new power plant and to install a 10 MVA transformer in the step-down substation at K-B Bridge site.

In planning the distribution lines, the most appropriate routes, distribution capacity and arrangement have been worked out, based on the results of the field survey.

The salient features of the Project, are as shown in "Outline of the Project".

IPSECO will be in charge of operation and maintenance of the new power plant upon its completion. Likewise, the Japan side is expected to take care of necessary technical guidance during the construction of the Project and test operation of the transmission and distribution lines as well as the substations. After completion of the said facilities, IPSECO is anticipated to conduct operation and maintenance thereof.

In connection with the implementation of this Project, it is desired that the Government of Palau undertake reinforcement including construction of roads, take necessary procedures for imports of materials, equipment and supplies for the Project and be responsible for ensuring allocation of required budgets thereto.

(Note 1) In addition, a 3,000 kW gas turbine generator leased from IPSECO is temporarily installed in the neighborhood of the Malakal Power Plant.

(Note 2) It is a common practice in Japan to use power flow data on the third Wednesday of every month to know the status of system operation.

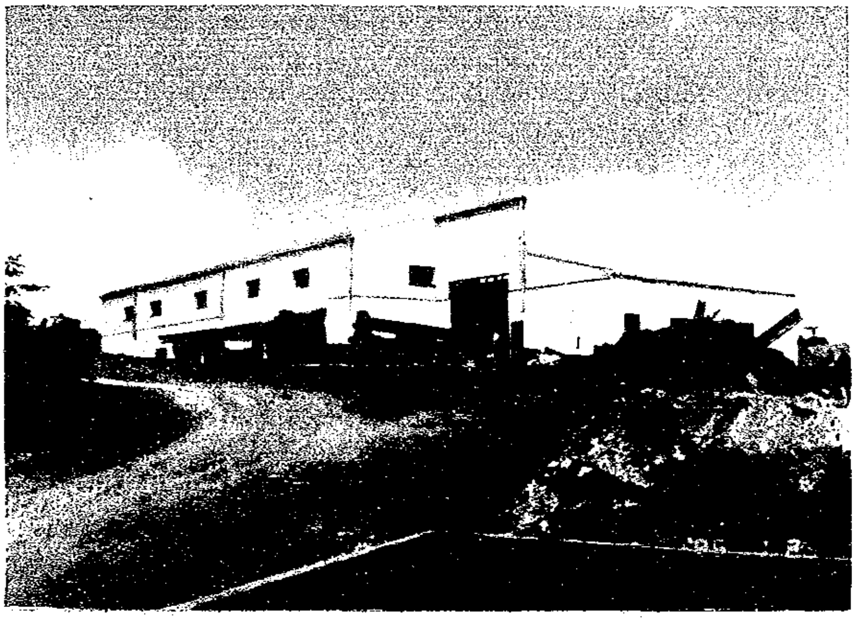
(Note 3) US$1 = ¥250

(Note 4) Consumers, such as large hotels which supply necessary power from their own generators at present but are expected to purchase power from the Government of Palau in the future if stable and inexpensive power supply is ensured from a public power system.

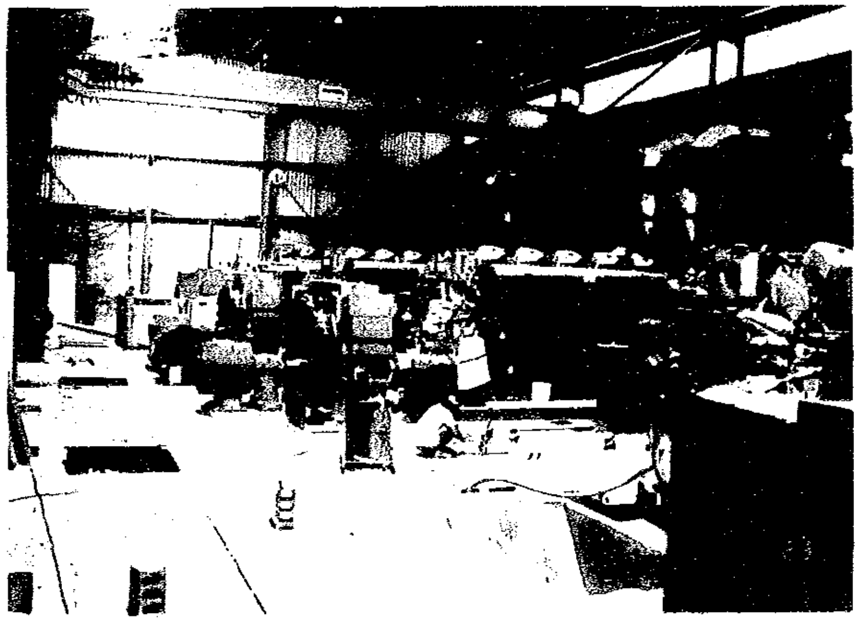
Outline of the Project

Items	Equipment and Facility	Remarks
Step-up substation	Transformer, 10 MVA (13.8/34.5 kV); 2 Circuit breaker, 36 kV; 4 Line switch, 36 kV; 7 Protective relay system; 1 set Outdoor structure and bus; 1 set	At new power plant
Step-down substation	Transformer, 10 MVA (34.5/13.8 kV); 1 Circuit breaker, 36 kV; 1 24 kV; 3 Line switch, 36 kV; 1 24 kV; 2 Protective relay system; 1 set Outdoor structure and bus; 1 set	At K-B Bridge site
Transmission line	34.5 kV single circuit; Approx. 8.8 km 34.5 kV double circuit; Approx. 4.9 km 34.5 kV/13.8 kV common line; Approx. 5.6 km	Total length; 19.3 km
Distribution line	13.8 kV; 14.9 km Distribution transformers 34.5/13.8 kV; 10 34.5/0.24-0.12 kV; 2 13.8/0.24-0.12 kV; 47	
Materials and equipment for low voltage distribution	Low voltage drop wires; Approx. 17,000 m Watthour meter; Approx. 220 Materials; 1 lot	Construction work including erection of wood poles by Palau
Telecommunications equipment	Very high frequency radio equipment Base station; 4 Mobile station; 3 Portable set; 3	
Vehicles	Digger derrick; 1 4 wheel drive vehicle; 2	

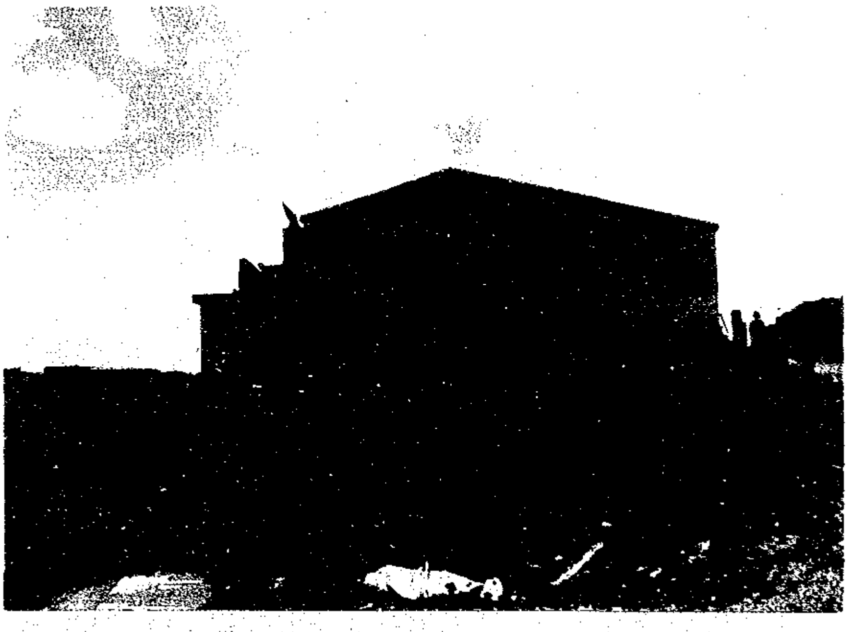
General View of Malakal Power Plant



General View of New Power Plant



Machinery Arrangement Inside of New Power Plant



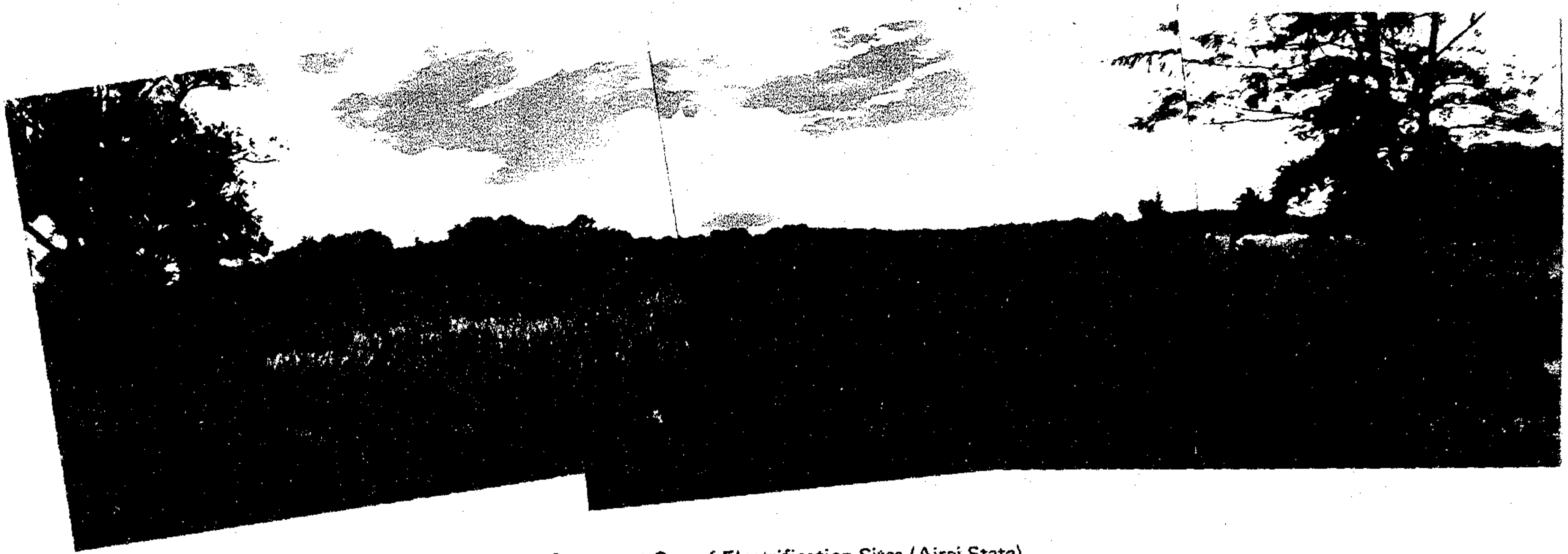
Step-up Substation Site
(Foreground of New Power Plant Building)

Step-down Substation
(in the vicinity of K – B Bridge)

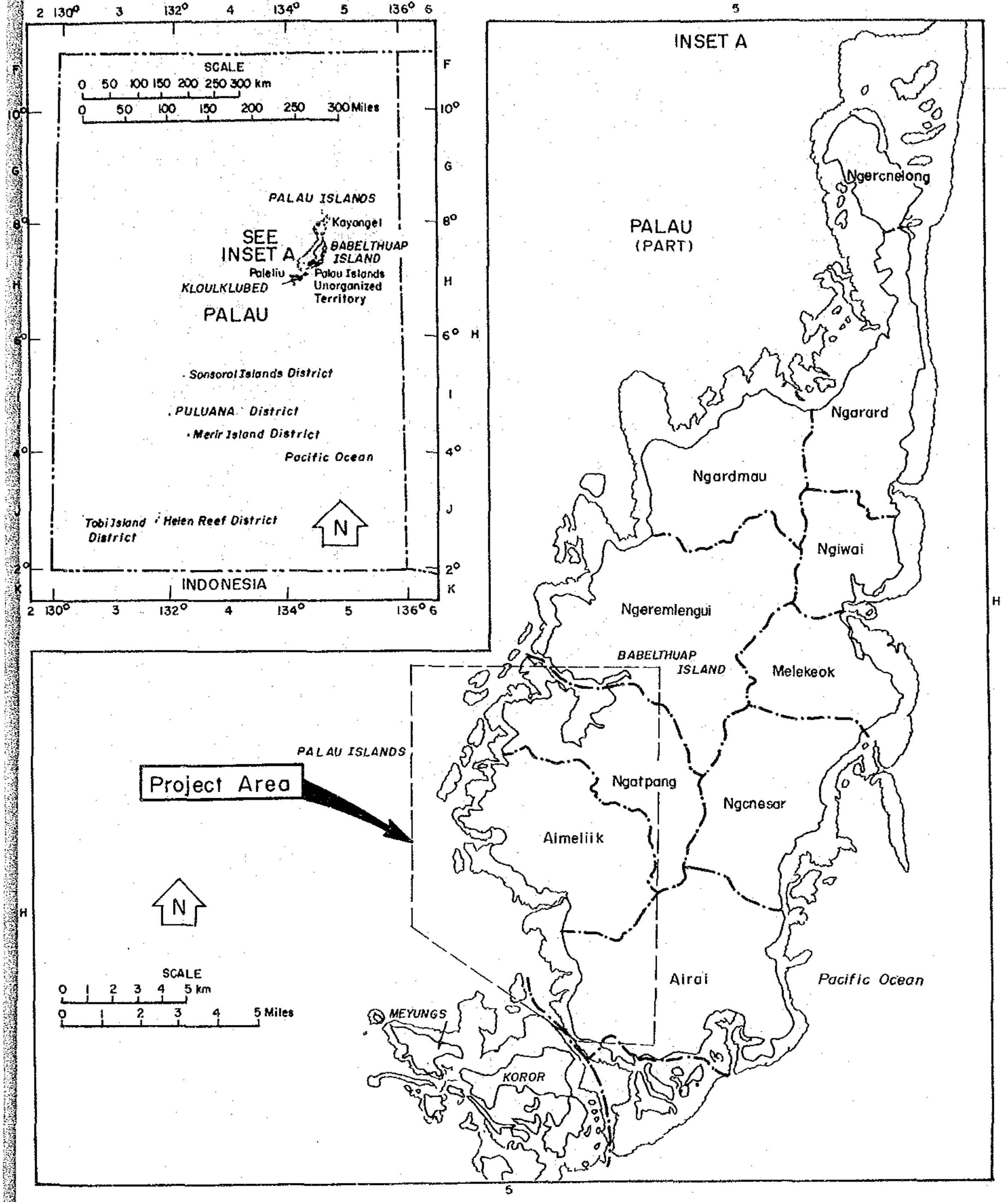
Transmission Line Route

Scenery in and around Nekkeng

Scenery around the Seashore

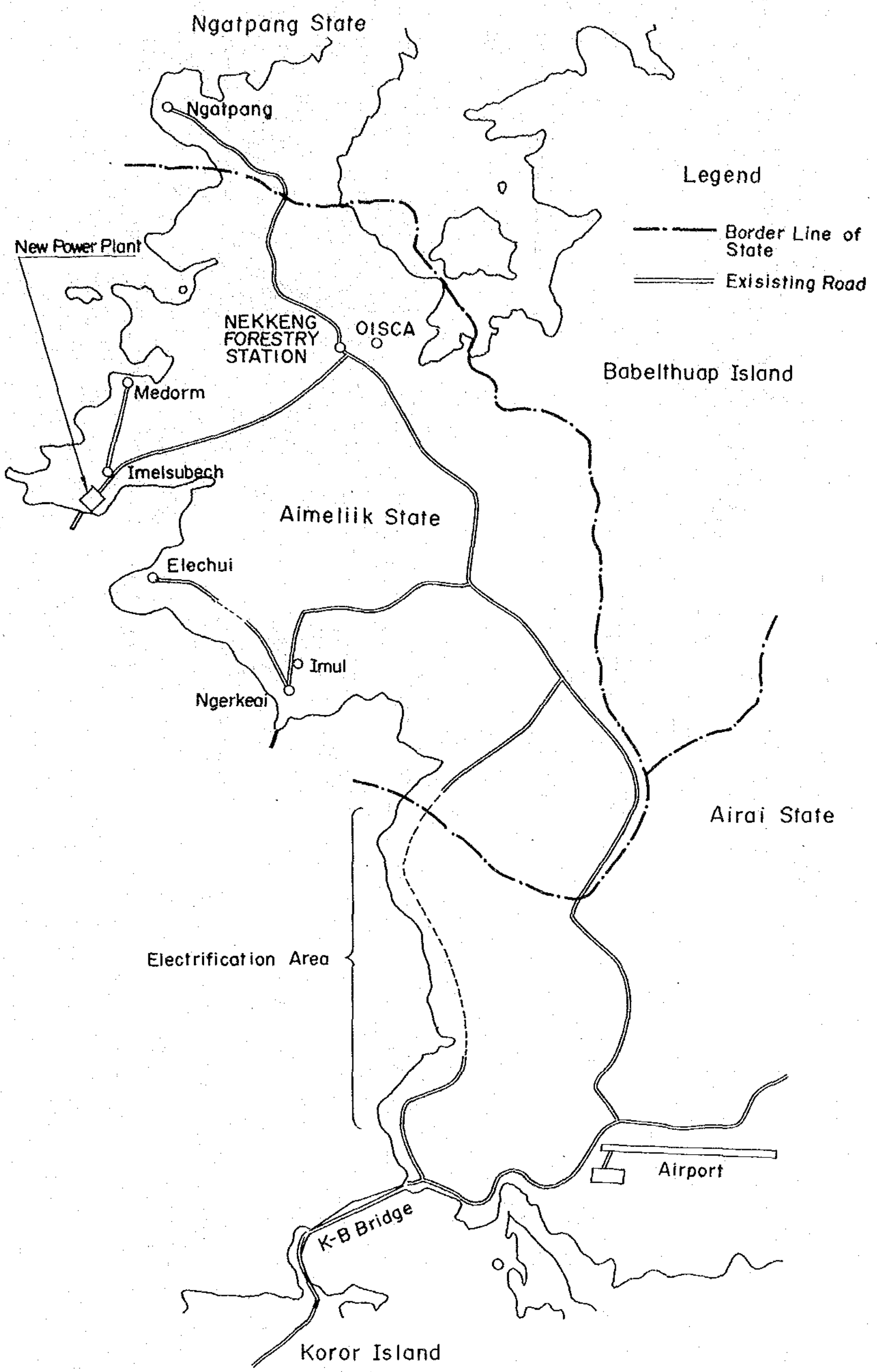


Scenery at One of Electrification Sites (Airai State)

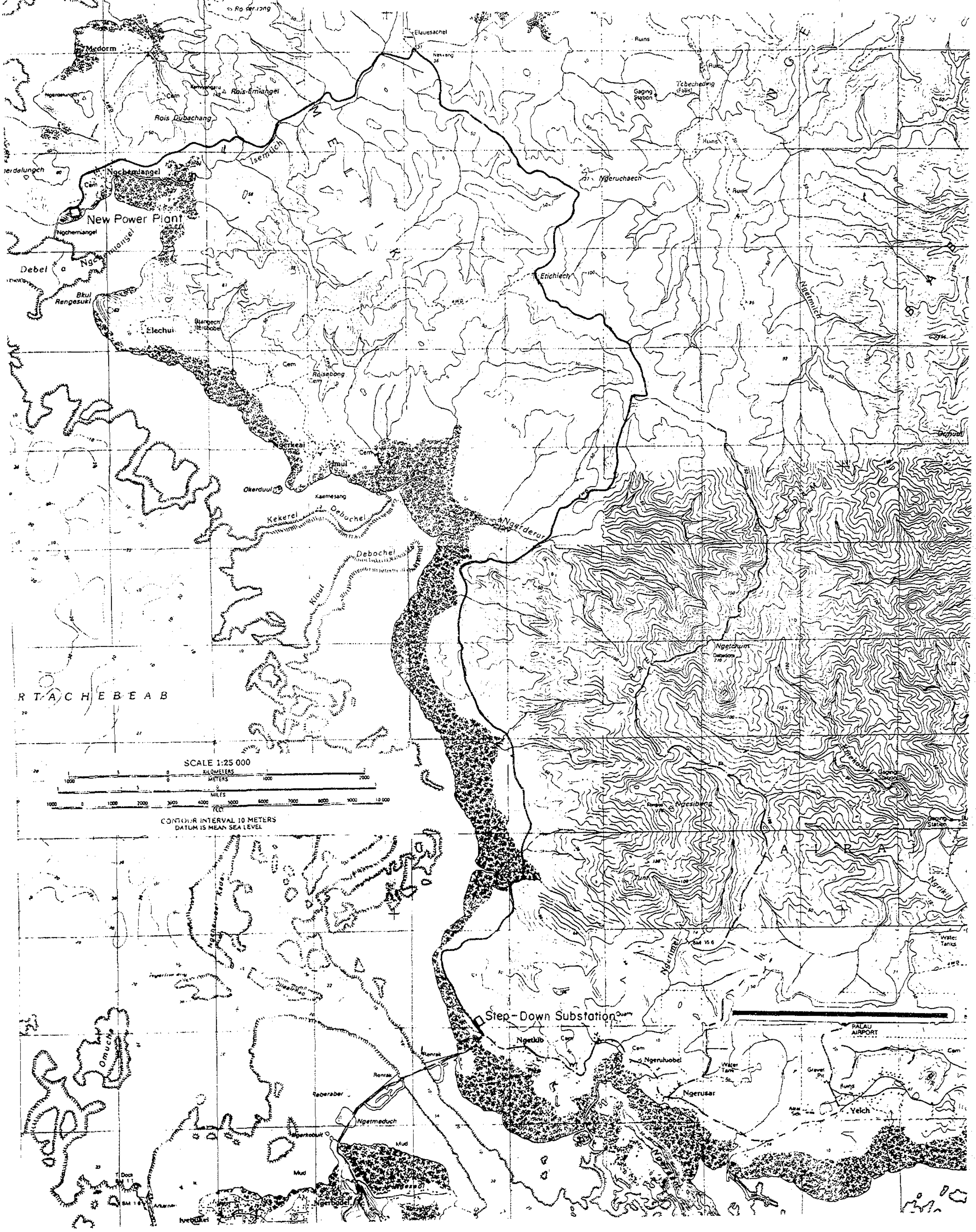


INSET A
PALAU (PART)
SCALE
0 50 100 150 200 250 300 km
0 50 100 150 200 250 300 Miles
PALAU ISLANDS
Kayangel
SEE INSET A
BABELTHUAP ISLAND
Peleliu
Palau Islands Unorganized Territory
KLOULKLUBED
PALAU
Sonsorol Islands District
PULUANA District
Merir Island District
Pacific Ocean
Tobi Island District
Helen Reef District
N
INDONESIA
Ngercnelong
Ngarard
Ngardmau
Ngiwai
Ngeremlengui
BABELTHUAP ISLAND
Melekeok
PALAU ISLANDS
Project Area
Ngatpang
Ngcnesar
Aimeliik
Airai
Pacific Ocean
MEYUNGS
KOROR
SCALE
0 1 2 3 4 5 km
0 1 2 3 4 5 Miles

Project Area Map



Routemap of Transmission Line



CONTENTS

CHAPTER 1

INTRODUCTION

Chapter 1 Introduction

The Republic of Palau is a sovereign nation of which territory consists of nearly 200 islands with a population of approximately 12,000. The Republic of Palau signed a draft Agreement of Fee Association and formally signed the Agreement with the United States on November 7, 1980 and in January 1982, respectively. Thus Palau came to establish itself as a new independent nation in January 1981. This country has not yet been self-reliant and is still dependent on financial assistance from the United States.

Infrastructures in Palau are not necessarily sufficient, except for the Koror Island where the capital of Palau is situated. Even in the Koror Island, electricity supply to inhabitants are severely constrained because the existing electric power generating facilities are extremely old, which hampers their daily life. In addition, the inefficient power generating system makes the generating cost of the present power plant high, and this fact further deteriorates the financial situation of the Government of Palau.

The Government of Palau recognizes the necessity of the agricultural, economic and social development of Babelthuap as one of the most important and urgent tasks for the said Government to execute. The Government of Palau is in the course of constructing a new power plant under loans from the UK with the aim of establishing a new electric power system. This power plant is expected to be put into operation around the end of June 1985.

The Government of Palau had requested the Government of Japan to render its grant aid for the implementation of the Project.

In response to this request, JICA dispatched a team for the preliminary study to Palau in October 1984, and major items to be included in the Project were determined as follows:

(1) A step-up substation in the new power plant

(2) A single circuit, 33 kV transmission line from the new power plant to the existing power system for a distance of approximately 20 km

(3) A step-down substation for interconnection with the existing power system

(4) Materials and equipment for distribution systems, including distribution lines and distribution pole transformers, for the purpose of electrification

Following the above-mentioned preliminary study, JICA sent the Team to Palau for a period of twenty-one (21) days from January 9 to 29, 1985 in order to determine details and extent of work in connection with the Project. The Team conducted field surveys, collected necessary data and information and held a series of meetings with officials of the Government of Palau.

This report submitted herein incorporates the basic design and implementation plan for executing the Project which have duly been prepared and compiled, based on the results of analyses of the above data and information and according to the outcome of the discussions with the officials of the said Government.

The names of key officials with whom discussions were made, members of the Team, their itinerary and Minutes of Meetings (photo copy) are as per Appendixes 1-1 through 1-4 attached to this report.

CHAPTER 2

BACKGROUND OF THE PROJECT

Chapter 2 Background of the Project

2-1 Geography

The Palau Islands are one of six archipelagos that constitute the Caroline Islands, situated at the western end of the archipelago group, or approximately 1,000 kilometers to the east of the Philippines. Consisting of 200 islands of various sizes, scattered from 7 to 8 degrees latitude north and from 134 to 135 degrees longitude east, the total land area of Palau is 313 square kilometers. The population is about 12,200, 60% of which is living in Koror, the capital. The climate of Palau is warm and humid all the year round, with the dry season being from February to April and October to December, and the wet season the rest of the year. The islands enjoy sunshine even in the season of the heaviest rainfall from May to September. Although tropical cyclones are born and go through this region, the large destructive typhoons are quite rare.

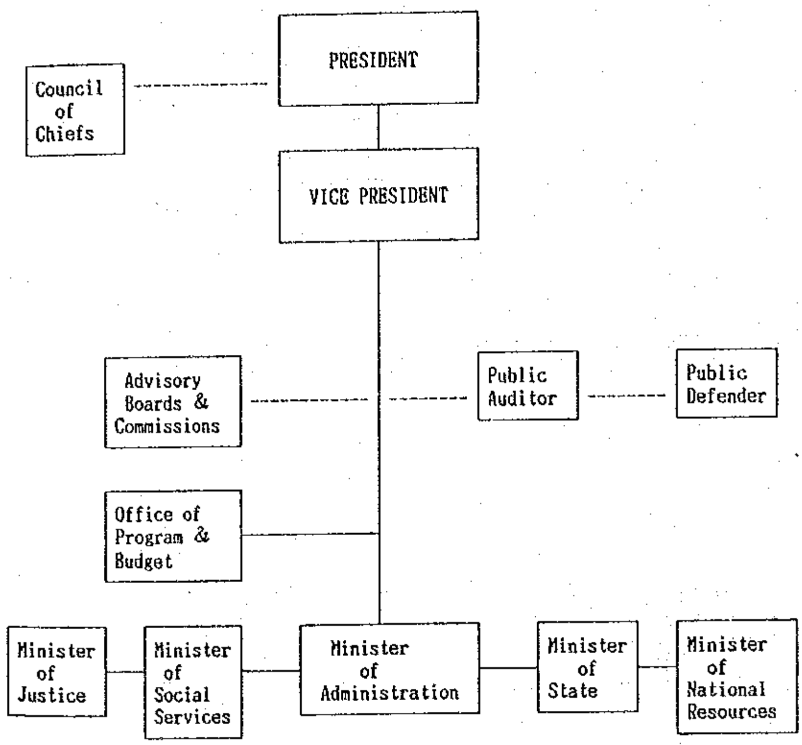
2-2 History

The Palau Islands had been the territory of Spain since 1668, and were turned over to Germany after the American-Spanish War in 1889. In 1914, Japanese armed forces occupied the Caroline Islands at the outbreak of the World War I, to end the German sovereignty and to have the islands mandated by the League of Nations from 1921, and established its "South Sea Agency" on Palau. Then the islands were mandated to the United States as World War II ended in 1946, and has been governed by the Department of Interior. In 1979, the Committee for Enacting Autonomous Constitution drafted the Draft Constitution of the Republic of Palau, and then it has been approved and enforced since the national referendum of July 1980. The presidential, vice presidential and congressional elections were held in November of the same year according to the provisions of the Constitution, and the Government of the Republic of Palau formally started in January 1, 1981.

2-3 Government

The Constitution of Palau stipulates the independence of the administration, the legislation and the judiciary. The president, elected by direct voting for a 4 years' term, heads the administration. The cabinet consists of 5 ministers who support the president, each responsible for foreign affairs, justice, administration, welfare and natural resources respectively. (Refer Figure 2-1). The vice president, also elected by direct voting, supports the president as a member of the cabinet. The council of chieftains, consisting of chieftains nominated in each state by traditional procedures, advises the president on matters related to traditional rules, the constitution and the contemporary Palauan laws.

Fig. 2-1 Organization of the Government



The legislation is called "Olbiil Era Kelulau". Being bicameral, it is composed of the House of Representatives in which 16 members, one from each constituency, are represented, and the Senate consisting of 18 Senators elected in the senate constituencies, which are determined in proportion to population. The judiciary consists of the Supreme Court, the Higher Court and the District Courts.

In November 1980, the Government of Palau decided to conclude an agreement of "Free Association" with the United States, with which the defense and security of Palau would be entrusted to the United States as before, but the sovereignty including the diplomatic representation will be transferred to Palau. The draft of the agreement has been signed, and the formal agreement has been signed in 1982. However, in the two referendums for the approval of the agreeement, held at the end of January 1983 and September 4, 1984, the percentage of the votes approving the agreement was 67% in the second referendum, although the percentage increased from the first. This is less than the 75% votes required for the approval of the agreement, and the next referendum is not scheduled yet.

It has been agreed that, as soon as the Agreement of Free Association goes into effect, the United States will render financial assistance of 19 million dollars per year for 15 years, an investment finance (60 million dollars in a single payment), an investment for development of infrastructure (41 million dollars), and compensations for construction of military facilities (5.5 million dollars). In addition, the United States proposes to start the construction of road network in the Bebelthuap Island within 5 years after the enactment of the Agreement.

2-4 Population

The population of Palau was 6,279 men and 5,837 women, or the total of 12,116 in the census in 1980. 7,585 people, or 63% of the total population live in Koror State. In addition, it is reported that approximately 5,000 Palauans live abroad. At the time of the preliminary study (October 1984), the Government of Palau official reported that the inferred population is 12,176.

Employment in the offices and institutions of the central government is 1,292 as of December 1983, while that in the private sector is 1,470 as of June 1983. The total labor pupulation is reported to be approximately 4,500, meaning that the difference, approximately 1,700, is either the independent worker, the employees in local governments, or the unemployed. The high percentage of employment in the government activities, indicates the underdeveloped status of the private sector industries.

The trend of the past population is presented below.

1960	9,320
1965	10,832
1970	12,000
1975	12,541
1980	12,116
1984	12,176

(From Abstract of Statistics, 1983)

It seems that the low industrial and economic activities in Palau make it difficult for the people to find jobs suitable for their ability, and induces the immigration of the young labor forces to abroad. Young people of sufficient caliber often go to high schools and universities in Guam, Hawaii and the U.S. mainland when their compulsory education is completed, and find their jobs there, not returning to Palau.

A projection of future population, formulated by the United Nations Specialists dispatched to the Office of Planning and Statistics of Palauan Government in June 1984, is available. The projection is based on the actual population in 1980 census, and gives 4 cases, each with different number of immigrants to abroad.

	Case 1	Case 2	Case 3	Case 4
1980	12,116	12,116	12,116	12,116
1990	12,238	12,381	12,524	14,400
1995	12,300	12,725	13,197	15,888

Case 1: The number of immigrants to abroad stays at the present level.

Case 2: The proportion of the immigrants decreases gradually.

Case 3: The proportion of the immigrants decreases sharply.

Case 4: The number of immigrants is assumed to be zero.

Assuming that the industrial and economic developments of Palau are to be encouraged under the Agreement of Free Association with the United States, which will be concluded fairly soon, the survey team regards the population in Case 2 is the most plausible. In the projection of the electric demand to be presented in the succeeding chapter, Case 2 is adopted, assuming the population in 1995 to be 12,725.

2-5 Industry and Economy

The industrial and economic activities of Palau are concentrated to the Koror Island where 60% of the total population inhabits. Still, there is no remarkable industry in Palau, except 5 tourists hotels and small shops. In such status, the talented young labor can not be effectively employed, as mentioned before. Young Palauans tends to look for the education in high schools and universities in the United States when they complete the compulsory education, and they prefer to seek their jobs in the place of their higher education, instead of going back to Palau. Regrettably, this trend is more and more pronounced.

The future development of industrial and economic activities of Palau depends on the advancement of the Babelthuap Island, which is the largest island in Palau and which so far has scarcely been developed. The constitution of Palau postulates that the capital of the Republic will be moved from the present Koror Island to Babelthuap Island before 1990. The expectation of the Palauans to make effective use of the financial assistance of the United States, to be supplied after the conclusion of the Agreement of Free Association as mentioned before, for the development of indigenous industries as well as the required infrastructure, is clearly expressed by this postulate in the Constitution. Certainly, the Palauans must solidify a basis for economic self-reliance while the financial assistance is available. Unfortunately, an effective and specific planning for the future development is lacking. The plan for development, approved by the Congress in 1977, is already outdated. In 1981, the Government of Palau has committed a new development plan to a consulting firm in the United States, but this plan has not been formally approved either by the Government or the Congress. The development plan mentioned is not exactly a program for development, but a vision in which the picture of Palau, after the conclusion of the Agreement of Free Association, is envisaged, assuming certain possibilities of industrial development, and hence not based on realistic reasoning. Formulation of specific programs may be difficult at this moment for Palau, because its financial status requires the assistance of the United States for industrial and economic development, and the timing for the enforcement of the Agreement of Free Association is uncertain.

Even though a comprehensive development plan is not available for the time being, it is expected that growth of tourism, agriculture and fishing industry will help the development of industries and economy of Palau in the future, provided that infrastructures are built up appropriately.

The tourism is most promising, considering the resources in the possession of Palau. The trend of foreign visitors to Palau, for the period from 1979 to 1983, is presented below.

Foreign Visitors Classified as for the Purpose of Visit

Year	Toursim	Business	Religion	Employment	Others*	Total
1979	4,589	612	67	248	360	5,876
1980	4,516	685	63	165	211	5,640
1981	3,902	708	62	177	208	5,057
1982	3,995	778	74	236	247	5,330
1983	4,449	1,066	76	406	391	6,388

* Including marine crews and members of Peace Corps.

(From Abstract of Statistics, 1983)

The total number of visitors decreased in 1981 and 1982 due to decrease of the tourists, but the number has been increasing ever since. Although the most recent statistics is not available, it looks that the visitors are increasing as the treand. The nationalities of the tourists are as follows.

Nationalities of Tourists

Year	Japan (%)	U.S. (%)	Philippines	Europe	Others	Total
1979	2,431(53.0)	1,865(40.6)	20	142	131	4,589
1980	2,619(58.0)	1,593(35.3)	20	143	141	4,516
1981	2,418(62.0)	1,062(27.2)	28	162	232	3,902
1982	2,482(62.1)	1,109(27.8)	28	131	245	3,995
1983	2,574(57.9)	1,149(25.8)	106	228	392	4,449

(From Abstract of Statistics, 1983)

The table above indicates that about 60% of the tourists are the Japanese.

At present, Palau has only 5 hotels, with 2 of them operated by the Japanese capital. And 1 of the 2 Japanese hotles was completed last year. It is expected that a substantial increase in the number of Japanese tourists will be observed once regular flight(s) from Japan are opened in the near future. The main hotels are presented below.

Hotel Nikko Palau;	Number of guest rooms,	52.
Grace Hotel;		60.
Palau Pacific Resort;		100.
New Koror Hotel;	approx.	20.
Palau Hotel;	"	20.

Some of the existing hotels are expanding or planning to expand their facilities. There are also plans for construction of new hotels. The tourism industry looks very promising, especially after the hotels are improved or new hotels are built. It would be necessary, however, to increase a variety of tourism resources for a drastic growth of the industry in the future.

At present, the agriculture of Palau is mostly conducted by cultivators who work for their own self-reliance, with practically no commercial or industrialized farming. However, agricultural and industrial development, utilizing the land area of Babelthuap, is expected when the road networks in that island completed by the conclusion of the Agreement for Free Association, and in addition, if the modern agricultural technology is introduced and the market for the product is established. In particular, processing of commercial agricultural products, such as rice, copra, coconuts, pineapple, banana, etc., and farming of livestock and poultry, should be encouraged. As most of these products are now being imported, the development of such industry can take over the import, and further opens the way to the export industry in the future.

The income of Palau from the fishing industry is mostly the levies placed on the Japanese, Taiwanese, Filipinos and American fishing in the 200 nautical mile territorial water, which amount to around 350,000 dollars per annum, while practially no fishing industry of Palau as such is observed. As the fish resources are relatively abundant for Palau which is surrounded by the Pacific Ocean, the fishery development is feasible if the marketing and other problems are solved. It is desirable to re-open the fish refrigeration plant that has been operating until a few years ago and exporting tuna mostly to the United States. It seems promising to develop fish processing industries.

2-6 Financial Status of Government

The revenue and expenditure of the Government of Palau are illustrated in Table 2-1. The breakdown of the revenue is presented in Table 2-2 below.

Table 2-1 Revenue and Expenditures of Government of Republic of Palau

(unit: thousand in US dollars)

FUNDS	1981	1982	1983	1984	1985 (Budget)[Note 3]
1) DOI GRANT: [NOTE 1]					
Revenue	7,651	8,644	9,654	12,883	10,600
Obligations	9,866	11,143	13,899		
Balance at year-end	(2,215)	(2,499)	(4,245)		
2) REIMBURSEMENT:	1,207	1,195	1,136		1,400
Revenue	1,207	1,195	1,136		
Obligations	-0-	-0-	-0-		
Balance at year-end					
3) SUB-TOTAL:	8,858	9,839	10,790		12,000
Revenue	11,073	12,338	15,035		
Obligations	(2,215)	(2,499)	(4,245)		
Balance at year-end					
4) LOCAL REVENUE: (Taxation)	3,575	3,535	4,292		4,800
Revenue	3,412	4,136	5,704		
Obligations	163	(601)	(1,412)		
Balance at year-end					
5) TOTAL REGULAR OPERATIONS 3) +4):					
Revenue	12,433	13,374	15,082		16,800
Obligations	14,485	16,474	20,739		
Balance at year-end	(2,052)	(3,100)	(5,657)		
Balance Increase over previous year		(1,048)	(2,557)		
6) OTHER FUNDS:					
Revenue	3,797	5,011	3,887		4,000
Obligations	3,160	3,985	2,931		
Balance at year-end	637	1,026	956		
7) CIP (SMALL PROJECTS): [NOTE 2]					
Revenue	3,263	2,291	2,125	1,748	5,400
Obligations	972	266	1,021		
Balance at year-end	2,291	2,025	1,104		
8) GRAND TOTAL, 5) +6)+7):					
Revenue	19,493	20,676	21,094	24,888	26,200
Obligations	18,617	20,725	24,651	24,193	
Balance at year-end	876	(49)	(3,597)	695	

Source: Unified National Budget FY 1984-1986

[Note 1] DOI ... The Department of the Interior
[Note 2] CIP ... Capital Improvement Projects
[Note 3] Figure of 1984 and 1985 (Budget) got from the Government of Palau

Table 2-2 Revenue of Government of Republic of Palau

(in 1,000 U.S. dollars)

	1981	1982	1983	1984***	1985 (budget)
U.S. Financial Assistance	14,711 (75.5%)	15,946 (77.1%)	15,666 (74.3%)	unknown	20,000 (76.3%)
(Subsidy)	(7,651)	(8,644)	(9,654)	(12,883)	(10,600)
(CIP funds)*	(3,263)	(2,291)	(2,125)	(1,748)	(5,400)
(Others)**	(3,797)	(5,011)	(3,887)	unknown	(4,000)
Tax Revenue	3,575 (18.3%)	3,535 (17.1%)	4,292 (20.3%)	unknown	4,800 (18.3%)
Public Service Revenue	1,207 (6.2%)	1,195 (5.8%)	1,136 (5.4%)	unknown	1,400 (5.3%)
Total Income	19,493 (100%)	20,676 (100%)	21,094 (100%)	24,888	26,200 (100%)

* CIP Funds; Capital Improvement Project Funds (Finance for investment on infrastructures such as roads)

** Others; Scholarship Funds and Energy Conservation Funds (Including maintenance fee of power plant.)

*** Detailed items for 1984 are not available.

As indicated in the table 2-2, 75% of the revenue of the Government of of Palau is supported by the financial assistance of the United States. As for the revenue from the domestic sources, the tax revenue accounts for 17 to 20% of the total revenue, and the public service revenue 5 to 6%, including the levies on the fishing and charges on the public service such as electricity and water supply. It can be said that the Government's financial structure is such that it can not balance without the financial assistance of the United States.

In the list of revenue and expenditure above, the loan from Britain for the construction of the new Aimeliik Power Plant (loaned in June 1983), and the repayment of the loan is not included. (Refer to Appendix 8-2 for the amount of loan and the schedule of repayment.) The loan amounts to 32.5 million dollars, which is well over the annual expenditure of the Government Government of Palau. That is to say, the scale of the construction work of this power plant is a colossal project in terms of the financial scale of the Government of Palau. The Government is planning to depend on the subsidy from the U.S. Government for the repayment of the loan from Britain. However, the repayment starts from March, 1985, and continues until March, 1992. Thus, if the enactment of the Free Association with the United States is delayed, the repayment might squeeze the finance of the Government of Palau. It can be surmised that the Government of Palau is aware of the situation, and that is the reason why it called for a grant aid of the Government of Japan for execution of the Project, instead of financing it with a loan or with funds raised in the international money market.

If the Agreement is enacted, stable financial assistance will be supplied by the United States, and the implementation of social and economic development programs, as well as the repayment of the British loan, will be possible.

The content of the financial assistance to be supplied from the United States, after the enactment of the Agreement of Free Association, is as follows:

(i) Subsidy for government expenditure; 19 million dollars per year for 15 years.

(ii) Investment fund; 60 million dollars (a single payment).

(iii) Fund for improvement of infrastructure; 41 million dollars.

(iv) Compensatin for the U.S. millitary base and the related facilities; 5.5 million dollars.

(v) Others; construction of road network in the Babelthuap Island (within 5 years).

As explained in 8-1, the completion of this Project will reduce the financial burden placed on the Government of Palau concerning the electric supply service will be reduced appreciably. In addition, a more stable supply of electricity will be assured by the completion of this Project, which in turn will accelerate a variety of industrial and economic development programs. Thus the implementation of this project seems to be essential to the Government of Palau with its adverse financial status. The completion of the Project will not only have the direct effect of reducing the financial burden on the Government, but contribute a great deal to its finance by forming the new basis for the social and economic development of Palau.

At the end of this chapter, the past record of assistance to Palau by the Japanese Government is listed.

* Tuna fisheries development; 0.2 billion yen
* Small scale fisheries develoment; 0.32 billion yen
* Coconuts farming; 0.24 billion yen

CHAPTER 3

PROJECT AREA

Chapter 3 Project Area

3-1 Project Site and Its Geography

This Project will cover 3 states in the south-western part of the Babelthuap Island, or Airai State, Aimeliik State and Ngatpang State, and will occupy an area about 25 kilometers from north to south along the seashore, and 4 kilometers from east to west. This area can be divided into 3 zones in view of its geology and state of vegetation.

(1) Seashore Area

This area is covered by a sedimentary layer of very fine particles, that were washed down from the inland, on which a jungle of mangrove is formed. The land is almost flat, at nearly zero altitude from the sea level.

(2) Stepped Plateau on Sea shore

This is the transition zone from the sea shore to the inland plateau. Full of undulation, the land is covered by trees of mahogany, teak, oak, etc. The soil is suitable for farming, but the area for farming is small as compared to the inland, and practically no cultivation is performed.

(3) Inland Steppe

The land is a plain with stretches of gentle undulations, either with scattered shrubs of grasses. The soil is sedimentation of weathered rocks on the base of volcanic base rock. Hence the soil is strongly acid and not suitable for farming.

The population in these areas is approximately 1,100 for the all 3 states mentioned above, or 7.7 persons per area of square kilometers. Most of the population lives along the sea shore belt. Commerce, industry, or commercial agriculture has not started to develop, and most of the inhabitants make a self-sustained living by farming fruits, taros, tapioka, coconuts, etc., or by fishing.

This area is adjacent to the capital Koror, and hence favored both geographically and politically, having a road constructed, for example, although it is a single lane, unpaved one. The Government of Palau plans to accelerate the economic and social development of this area, taking the opportunity of the development of transmission/distribution lines of this project.

3-2 Meteorology

As the Palau Islands is located in the southwestern Pacific, they have a typical marine climate, with little annual change of temperature. The yearly seasons can be divided into the rainy season, when it is humid with abundant rainfall, and the dry season when the humidity is low and there is little rain. The rainy season is from May to September, while the dry season is from February to April. As this region belongs to the area of the Pacific where the typhoons are generated, the monthly and daily rainfall often records a remarkable amount, even in a dry season.

The humidity is generally about 80% in the rainy season, while it is 70% in the dry season. The maximum rainfall in a day in the records of the past 37 years was 431 mm (in April 1979).

The wind blows from the northeast from December to April and from southwest from July to around October. The wind velocity is generally from 3 to 5 meters per second throughout year, but winds of 20 to 30 meter per second velocity are recorded around December and March or July, when the westerly is prevailing.

Thunderstorms are observed once or twice a month, except during the dry season. There is no record, however, that the lightning has caused a substantial damage on an electric facility.

The meteorological statistics for the period from 1978 to 1984 is presented in Appendix 3-1.

3-3 Geology

The islands of Palau are generally based on two types of strata, one being a stratum having the base rock of basalt and andesite, prevailing in such islands as Babelthuap and Koror, and another the stratum on the base rock of limestone, as in Malakal, Rock Island and Peleliu.

The southwest part of Babelthuap island, where this project is planned, is mostly covered by weathered sedimentation of volcanic origin, although exposures of bed rocks are observed in some locations, the thickness of the sedimentation being as thick as 5 to 10 meters. That is, the foundations of the structures of this project will be built on this stratum of sedimentation.

In the areas of the project, the bed rocks are andesite and basalt, with volcanic breccia, tuff breccia and cracked tuff, with most of the surface covered by the weathered sedimentation of these rocks. The soil geology of the area of the project can be roughly classified to 5 classifications according to the soil characteristics and the grain size. (Refer to Appendix 3-2)

3-4 Seismic Activities

It is said that earthquakes are relatively rare, although some small quakes have been experienced.

The seismic design criteria for the electric apparatus is 0.4G (G being the acceleration of the gravity, or 1G=980 cm/sec^2), which is smaller than the value which used in Japan 0.5G. It is reported however, that no seismic damage on the electric facilities has been experienced.

3-5 Environment for Construction Works

As there is no substantial industry in Palau, as has been described, the economic activities in the private sector is inevitably limited, and the opportunity of employment is very little, unless one finds a job in the government institutions.

In the construction business, practically all orders are placed by the government, except for the construction of a limited number of buildings and facilities for commercial activities.

(1) Construction Contractors

The only general contractor in Palau at present is a Korean company that is engaged in the civil works for the construction of Aimeliik Power Plant, as a subcontractor to IPSECO. This company was established about 10 years ago, and deals with major civil engineering and architectural works in Palau.

Major Contracts: K-B Bridge, Malakal Bridge, M.O.C. Building, (school), Aimeliik Power Plant.

There are other small civil and building contractors, but they have experience only on 2 to 3 storied steel reinforced concrete buildings and manufacture of concrete products (such as ready-mixed concrete and concrete blocks).

Their technological capacity is modest. Even the Korean contractor mentioned above do not have experience of contracting a whole project including designs.

(2) Labor Resources

Labors for jobs not requiring engineering knowledge or skill can be recruited in the island. Ther personnel having engineering and skill are recruited from the Philippines, Taiwan and Korea for construction works now under way. Although there is no legal restriction against hiring foreign labors, the Government of Palau conducts some administrative guidance to increase the employment opportunity of its citizens.

(3) Construction Material and Equipment

The Palauan indigenous products that can be procured for a construction work are limited to sand and gravels for concrete aggregate. Cement, wood, reinforcing bars and fuel including gasoline are available, but all of them are imported products. One must pay attention on the quality, and the possibility of deterioration of cement in transportation and storage. Common construction machines can be procured in the islands, although the conditions, the available technology for repair, and the availability of spare parts has to be clarified.

(4) Harbor Unloading Facility and Transportation Roads

- Harbor Unloading Facility

Unloading from ships can be performed at the Malakal Commercial Port in Koror Island. The port has the following facility.

Berth Length:	155 meters
Water Depth:	8 meters
Unloading Cranes:	Two 25 ton cranes

In addition, the following two piers can be used for unloading the station transformers and materials and equipment for transmission/ distribution lines.

- New pier for Aimeliik Power Plant construction (with the water depth of approximately 2 meters at full tide).

- K-B Bridge Lower Pier (water depth approximately 2 meters at full tide).

- Transportation Road

The roads from Koror and Babelthaup Islands to the Koror air port, including the bridges, are in good condition.

Effective road width: 7.2 meters (2 lanes, asphalt paved)

Weight limit on bridge: 45 tons (including vehicle weight)

The road from the airport in Babelthuap Island to the new Aimeliik Power Plant, extending about 16 kilometers, has the width of 3.5 meters with a single lane. It is not paved, and barely meet the requirement of a road in terms of the width, contour and slope. Materials and equipment for the construction of the new power plant are being transported by this road, except heavy items such as the diesel engine. This road can be used for the constructions in this Project, but restrictions will be placed on the weight and volume of the cargo, and the size of the vehicles.

CHAPTER 4

PRESENT SITUATION OF POWER SUPPLY

Chapter 4 Present Situation of Power Supply

4-1 Electricity Supply Organization

Electricity supply in Palau is not made by a single independent body, such as an electricity supply corporation, solely responsible for undertaking of power management including operation and maintenance of generating facilities and relevant ones but is under the jurisdiction of the Ministry of Natural Resources comprising several units in charge of respective administrative work in different sectors.

The Ministry of National Resources has the Bureau of Pubic Works, in which there are 3 divisions including the Division of Public Utilities.

The organization chart of the Bureau of Public Works, and the organization and the personnel in the Division of Public Utilities and the Division of Maintenance are illustrated in Figure 4-1 through Figure 4-3.

4-2 Power Generating Facilities

The power plants in Palau and their capacities are presented in Table 4-1.

Table 4-1 Power Generating Facilities

Name of Plant	Location	Capacity	Remarks
Malakal	Koror State	3x1250 kW 2x 800 kW 2x 750 kW 1x1000 kW	In addition, a 3000 kW turbine generator is installed temporarily.
Angaur	Angaur State	2x 90 kW	
Peleliu	Peleliu State	1x 175 kW 1x 120 kW	
Ngeremlengui	Ngeremlengui State	2x 60 kW 1x 120 kW	
Ngiwal	Ngiwal State	2x 90 kW	
Ngkeklau*	Ngkeklau State	1x 90 kW	
Ngerbau	Ngerchelong State	1x 90 kW	
Airai*	Airai State	2x5200 kW	50 Hz generators

Note: Plants marked (*) are operated by the state governments.

Fig. 4-1 Organization of Bureau of Public Works

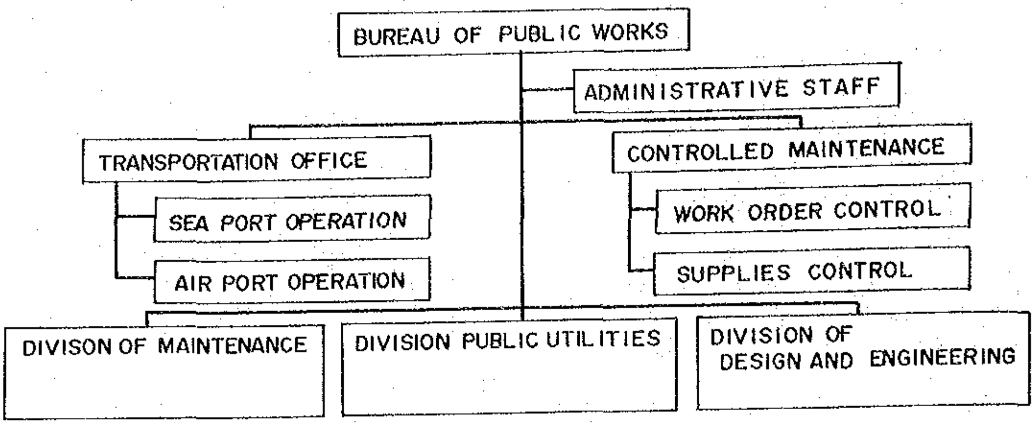


Fig. 4-2 Organization of Division of Public Utilities

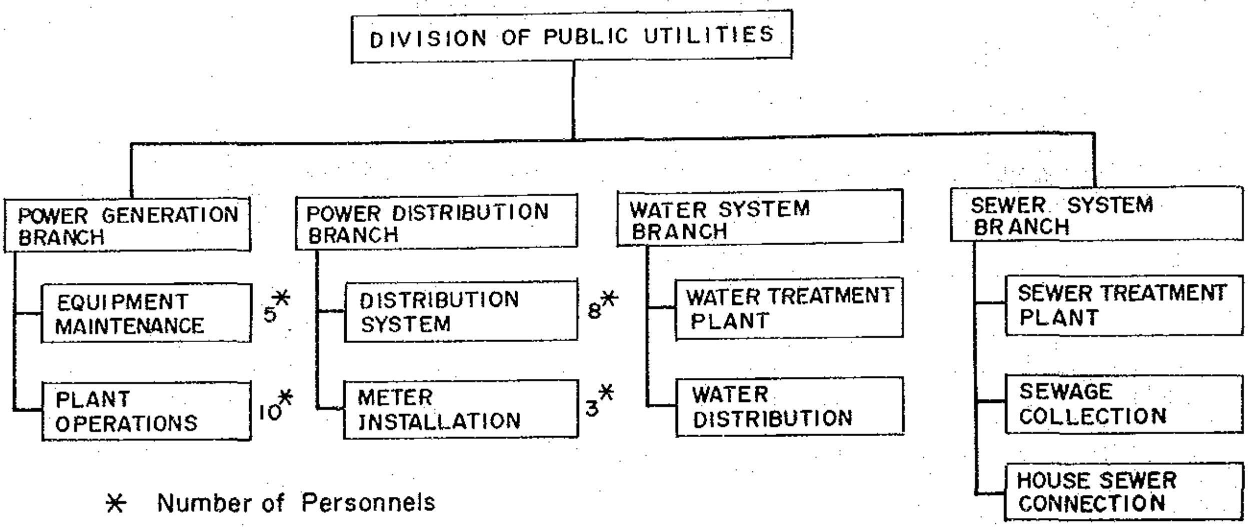
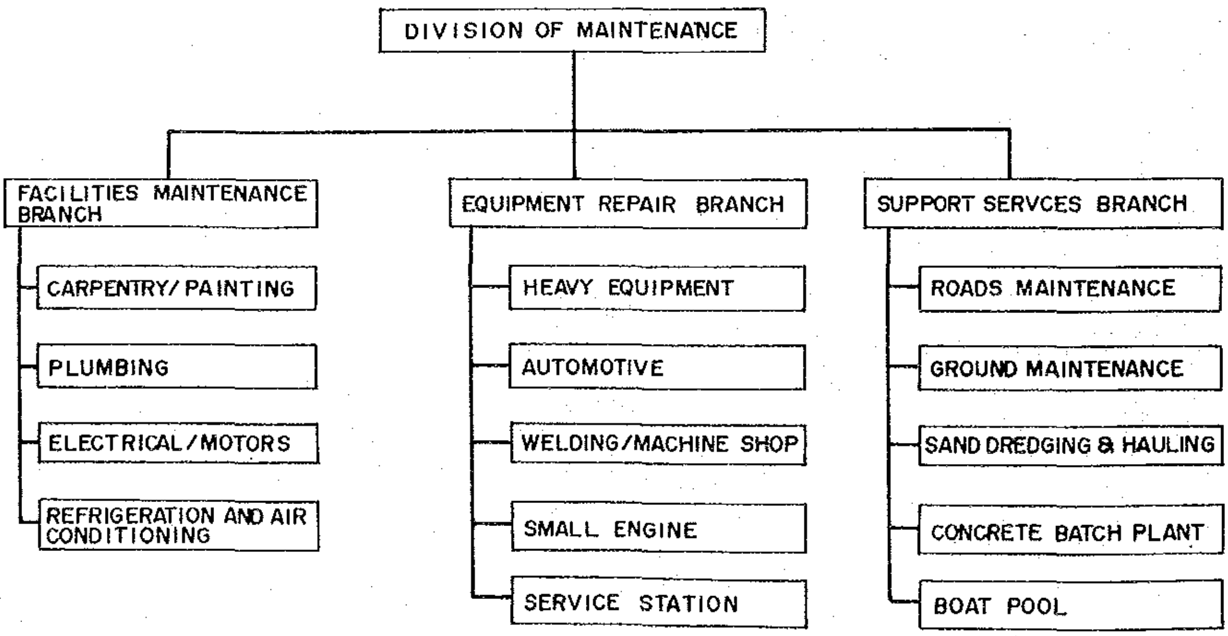


Fig. 4-3 Organization of Division of Maintenance



The facilities in Malakal Power Plant in Koror State are given in Table 4-2 below.

Table 4-2 Generating Facilities

Equipment	Output	Conditions
i) Caterpillar generator	800 kW	Overhauled 3 months ago and equipped with a new engine, rating 900 kW (output 700 kW).
ii) Caterpillar generator	800 kW	Overhaul completed 5 months ago, rating 900 kW (output 700 kW).
iii) White superior generator	750 kW	Overhauled in 2 years ago.
iv) White superior generator	750 kW	Under overhaul.
v) White superior generator	1000 kW	Overhauled 3 months ago.
vi) ALCO generator	1250 kW	Not overhauled for 3 years, equipped with new engines at
vii) ALCO generator	1250 kW	that time, and in operation.
viii) ALCO generator	1250 kW	" "
ix) Gas turbine generator	3000 kW	Leased from IPSECO, to be removed after the new power plant is completed, operational.

4-3 Substation Facilities

The voltage and capacity of substations are as presented in Table 4-3. The substations are in good condition.

Table 4-3 Substation Facilities

Substation Name	Transformer Capacity or Voltage	Capacity
Malakal	4,160 V/13.8 kV	7,500 kVA
Angaur	75 kVAx3	225 kVA
Peleliu	167 kVAx3	501 kVA
Ngeremlengui	37 kVAx3	111 kVA
Ngiwal	50 kVAx3	150 kVA

4-4 Transmission and Distribution Facilities

The voltage, line length, type of conductor, etc. of the transmission and distribution lines are presented in Table 4-4.

Table 4-4 Transmission and Distribution Facilities

Power Plant	Voltage (V)	Length (km)	Conductor Diameter (Note)
Malakal	13,800	6.4 5.1 3.2 4.8 1.6	* #6 (7 strands) * #2 (7 strands) ** #6 (single conductor) ** #2/0 (single conductor) ** #2 (single conductor)
Angaur	2,400	3.0	* #2 (7 strands)
Peleliu	2,400	3.6	* #2 (7 strands)
Ngeremlengui	2,400	1.14	* #2 (7 strands)
Ngiwal	2,400	1.5	* #2 (7 strands)
Ngerchelong	120-240	1.05	* #2 (7 strands)
Ngkeklau	120-240	0.96	* #2 (7 strands)

Note: * : Aluminum
** : Copper
#2 : 13.30 mm^2
#2 : 33.62 mm^2
#2/0: 67.42 mm^2

4-5 Distribution Voltage, Frequency, etc.

Power from Malakal Power Plant is supplied to Koror State, with a distribution voltage of 13.8 kV and a frequency of 60 Hz. The power is supplied to household consumers at 120 V, 60 Hz.

The 13.8 kV distribution lines are 3 phase 4 wire system, with star connections. The neutral points are grounded at each pole. The supply to the household consumers is provided by a step-down transformer, which steps down one of the phases of the 13.8 kV to 120 V at the pole.

There is no explicit regulation stipulating the voltage regulation and deviation of the frequency.

4-6 Number of Personnel for Maintenance and Operation

The number of personnel in charge of operation and maintenance of Malakal Power Plant is presented in Table 4-5. In other power plants, only operators are placed, and the personnel for maintenance is dispatched from the Division of Public Utilities of the Government when a fault occurs.

Table 4-5 Number of Personnel for Operation and Maintenance

Name of Power Plant	Responsibility	Number	Remarks
Malakal	Administration	1	
	Operation	9	3 shift with 2 men per shift.
	Maintenance	4	
	Distribution line work	8	
	Others	2	
Angaur	Operator	1	
Peleliu	Operator	1	
Ngiwal	Operator	1	
Ngeremlengui	Operator	1	
Ngkeklau	Operator	1	

4-7 Power Supply Capability and Record of Demand

The power supply capability during the 5 years from 1980 to 1984 is illustrated in Table 4-6.

Table 4-6 Trend in Power Supply Capability

Year	Maximum Power	Power Factor
1984 (projection)	4,000	.8
1983	4,000	.8
1982	3,800	.8
1981	3,000	.8
1980	2,800	.8

The past trend of the electricity consumption is presented in Table 4-7.

Table 4-7 Trend of Electricity Consumption

Year	Electricity Consumption (in kWH)
1984 (projection)	16,406,520
1983	16,406,120
1982	16,405,100
1981	16,390,800
1980	16,380,560

Figure 4-4 and 4-5 are the daily load curves of Malakal Power Plant, which were obtained during the field surveys. The generators were generally operating in good condition, as overhauls of the said generators that were intensively conducted in 1984. The characteristics of load being met by the existing facility in Koror is summarized as below, based on these load curves.

Week days: Maximum demand; approximately 4000 kW
Load factor ; 80%
(The maximum demand observed was 4,110 kW, as of 11 a.m. on January 21, 1985)

Holiday: Maximum demand; approximately 2500 kW
Load factor; 90%

Weekly average: Load factor; 70%

Fig. 4-6 illustrates the daily load curves of the existing power system, which have been prepared based on the load curve of the third Wednesday of each month from May 1983 to April 1984, although collected data on this subject is not necessarily sufficient. As conjectured from these load curves, it seems that power demand during weekdays during the above-mentioned period was likely to be 3,200 kW (4,000 kW x 0.8) on the average. However, the peak output for meeting this demand was observed only in June and September 1983. The actual generation records for other months show that the power supply satisfies only around 40 to 70% of the required power demand. This indicates that the power system has been experiencing a severe shortage of power supply capability.

The records of annual electricity consumption for the years from 1980 to 1984 indicate that the latent load is only 16,400 MWH as shown in Table 4-7, while it is surmised to be 24,000 MWH (NOTE 1). This is apparently because the consumption has been suppressed by the shortage of supply capability.

(NOTE 1) 4000kW x 0.7 x 24 hours x 365 days = 24,500 MWH

Fig. 4 - 4 Malakal Power Plant Daily Load Curve

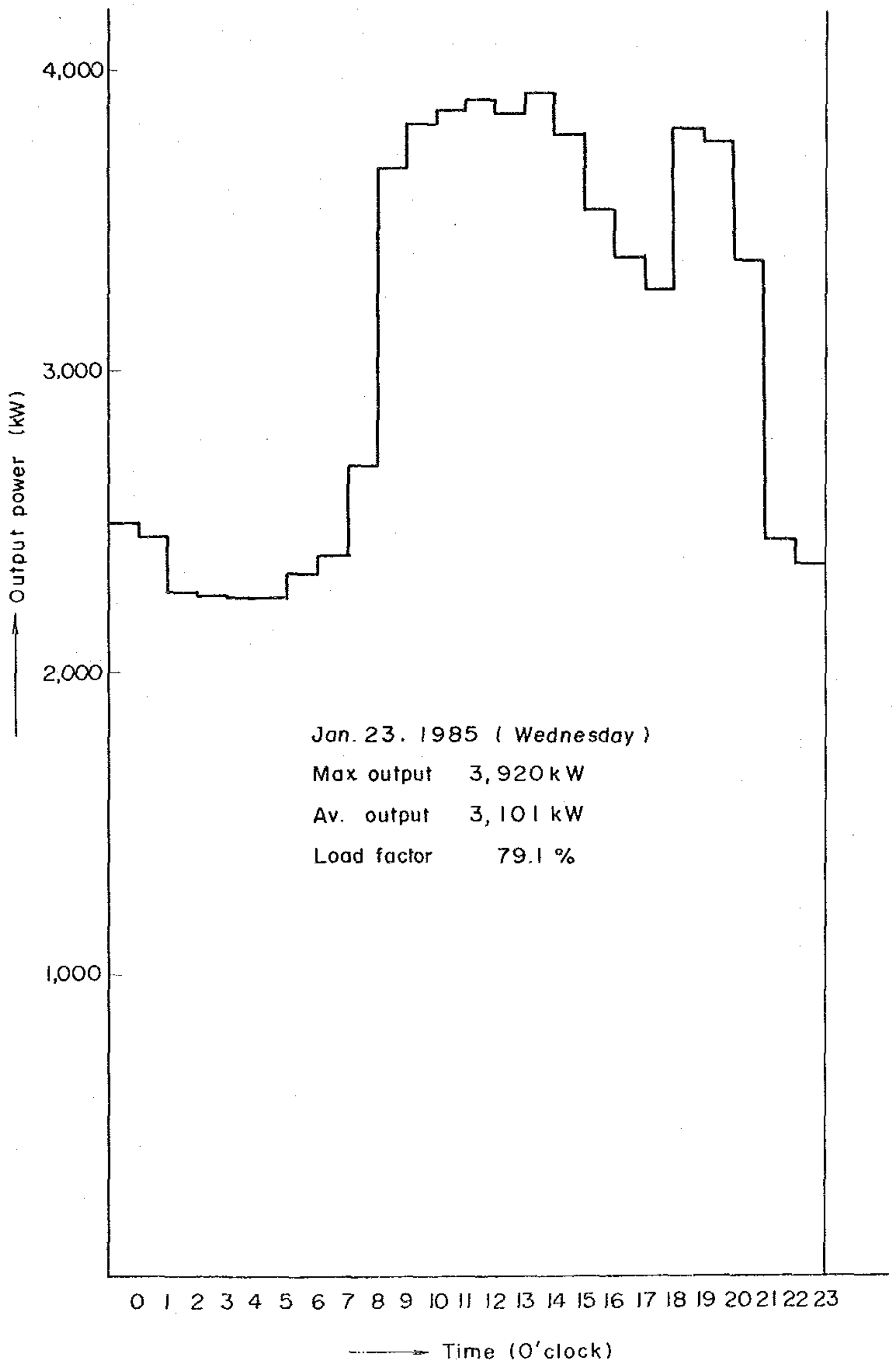


Fig. 4-5 Malakal Power Plant Daily Load Curve

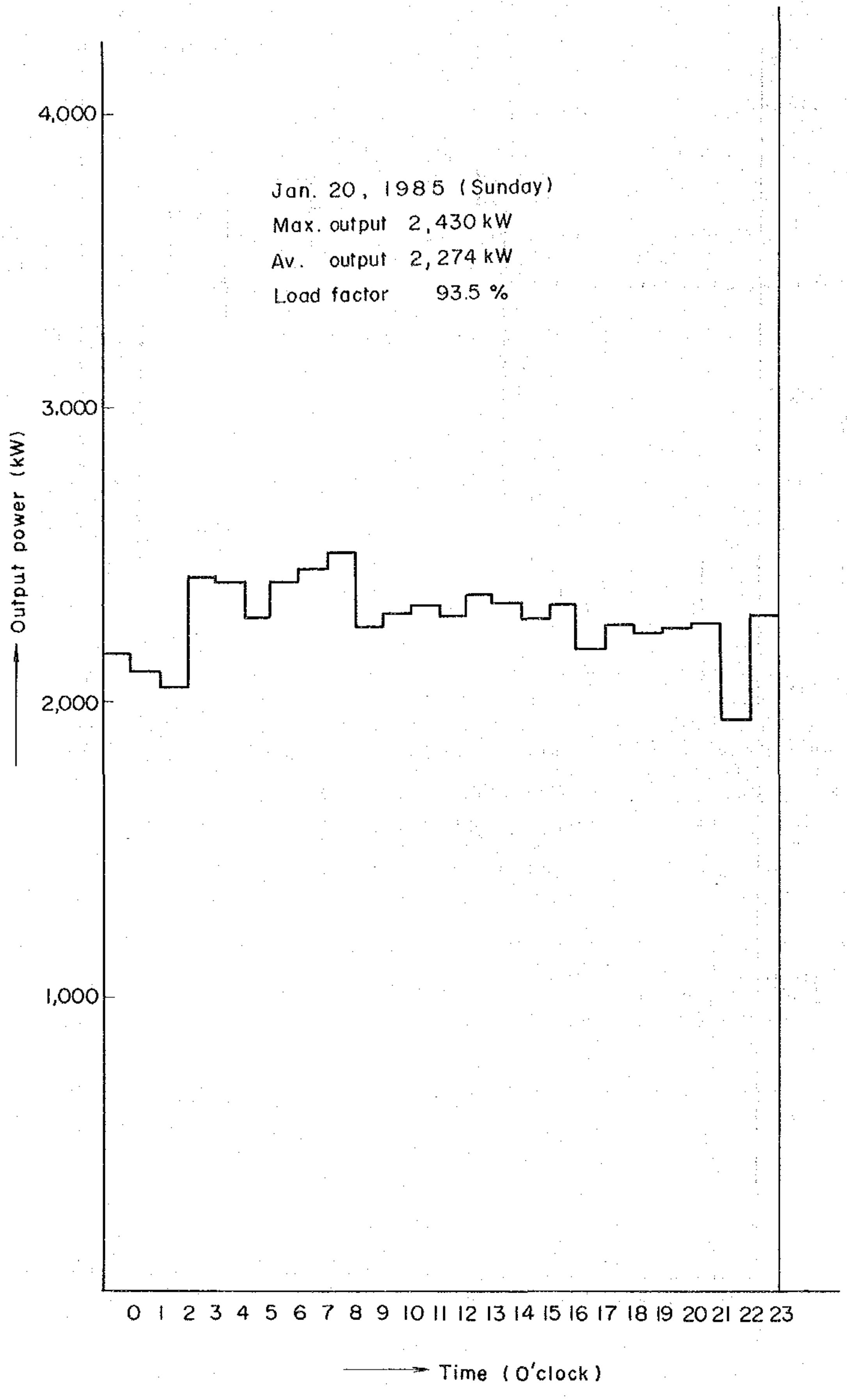
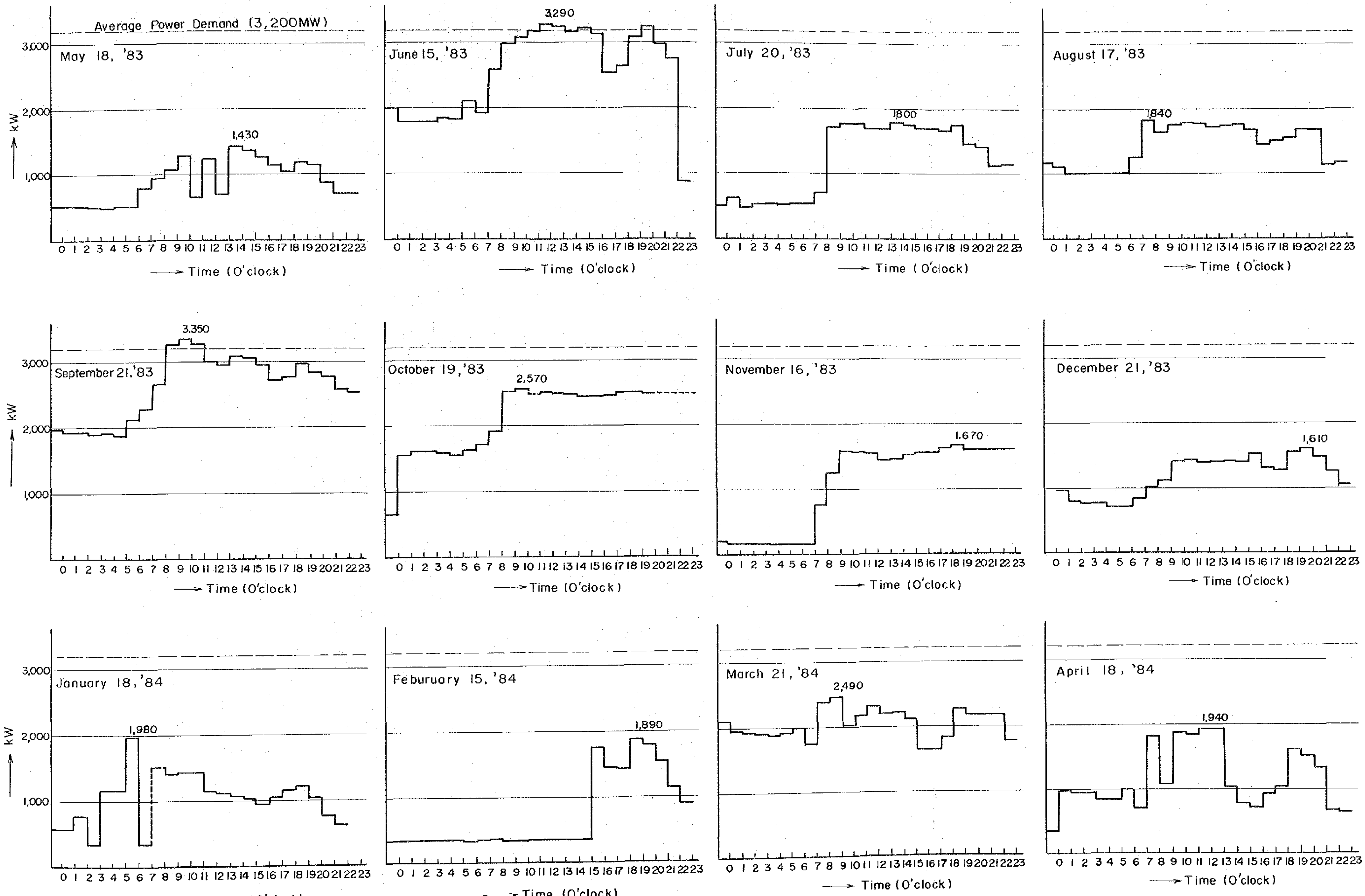


Fig. 4 − 6 Malakal Power Plant 3rd Wednesday Daily Load Curve (May. 1983~April. 1984)



4-8 Electric Rates

In the electric rate system of Palau, the rate for the consumer is the same irrespective of the type of the load. The present rate is 9 cents/kWH for a consumption up to 2,000 kWH per month, and 10 cents/kWH for the exceeding consumption. Also, a fixed charge of 45 dollars/month is levied on the consumers for which no WH meter is installed. The electricity consumed by the Government is totally free of charge, except for residences of officials such as the teachers, with no provision of WH meter. The total consumption by the Government is reported to be approximately 30% of the total generation, which is about 5,000 MWH per year from the record for 1984 (16,406 MWHx30%).

The changes in the electric rates since 1980 are as presented below.

Fiscal year	Electric rate structure	
	With meter	Without meter
1980	5 cents/kWH	$60/month
1981	6 cents/kWH	$30/month
1982	6 cents/kWH	$30/month
1983	9 c/kWH up to 2000 kWH 10 c/kWH for exceeding	$45/month
1984	Same as in 1983	$45/month

4-9 New Power Plant Project

(1) Background of Project

The Government of Palau is constructing a new power plant in Aimeliik State, the construction work contracted to IPSECO of Britain. The Government plans to shut down and dismantle the existing Malakal Power Plant when the Project, as well as the new power plant, is completed. The plant is based on the following considerations.

(a) Reason for Shutdown of Malakal Power Plant

i) As the existing facilities are aged, causing frequent failures, a stable supply of power to the load is getting more and more difficult.

ii) The repair expenses and the fuel cost are high with the existing facility.

iii) The equipment and the parts of the same model as the existing machines are no longer manufactured. Thus new orders have to be placed as equipment or parts are required for repair of the existing facilities, resulting in a long delivery time.

(b) Background for Selecting 16 MW Capacity (Five 3.2 MW Units) for New Power Plant

i) For supplying power of high reliability to the existing consumers. Stand-by generators are preferable for that purpose.

ii) To meet the new loads in the future, and to prepare the infrastructure for the economic and social development of the Babelthuap Island.

iii) As the manufacturers of equipment and machines are located in countries far away, difficult problems are encountered in procuring equipment and parts for repair in a plant failure. Thus it is necessary for Palau to have some margin of the facility.

iv) The 3 MW class generators have been considered as the optimum in terms of the economy. As there are facilities of similar capacity and IPSECO's construction on the Marshall Islands, the plant of the same standard design has been adopted.

(2) Outline of Power Plant

(a) General

Location : Imelsubech, Aimeliik State, Babelthuap Island

Plant total output : 16.35 MW

Unit output : 3,270 kW

Number of units : 5

Generator system : diesel engine generator

Date of start of construction : February, 1984

Date of completion : (schedule)

No. 1 Unit; February 22, 1985
No. 2 Unit; March 22, 1985
No. 3 Unit; April 19, 1985
No. 4 Unit; May 17, 1985
No. 5 Unit; June 28, 1985

Contractor of construction work : IPSECO International Power Systems, Ltd.(IPSECO) 103-105, Jermyn Street, London, England

Engine manufacturer: NEI-A.P.E., Ltd., Crossley Engines, Manchester, England

Manufacturer of electric equipment including generators and switch boards : Brush Electrical Machines, Ltd., Laiceslershire, Loughborough, England

(b) Equipment Specification

i) Diesel Engine

Model ; Crossley Pielstick turbo-charged 4 cycle diesel engine

Type ; 10 pczv. Mk2

Rated output ; 4,660 Hp.

Fuel ; BS2869, Class A or B, 3500 seconds Redwood, Wo.1 at 37.8°C

ii) Generator

Type ; Salient pole, brushless, self cooled

Capacity ; 4,087.5 kVA, at 0.8 power factor

Output ; 3,270 kW, at 450 r.p.m.

Voltage ; 13.8 kV, frequency; 60 Hz

iii) Neutral grounding of generator:

Generator neutrals are commonly grounded with 40 ohms.

Rated current; 200 A for 10 seconds

iv) Circuit Breaker

For generator; 13.8 kV, 400 A, rupturing current; 20.9 kA Bulk-oil CB, drawout type, 5 sets

For bus ; 1,200 A, 1 set, other specifications same as above.

For station service circuit ; 400 A, 2 sets, ditto

For fuel tank; 400 A, 2 sets, ditto

For switchyard; 13.8 kV, 800 A, rupturing current; 20.9 A
Bulk-oil CB, drawout type, 2 sets

v) Station service transformer:

1,500 kVA, 13.8 kV/440 V, delta-Y, 2 sets

(c) Operation

The Government of Palau will be contracted IPSECO to have the new power plant operated and maintained.

(d) Fuel (Bunker Oil)

The fuel for the new power plant is to be purchased from a fuel sales company which is a joint subsidiary of the Government of Palau and IPSECO.

(e) Main Circuit Connection Diagram

The connection diagram of the main circuits of the plant and the general plan are presented in Appendixes 4-1 and 4-2.

CHAPTER 5

PROJECTION OF ELECTRICITY DEMAND

Chapter 5 Projection of Electricity Demand

5-1 Method of Demand Projection

The Demand projections have been formulated for 10 years, which has been assumed as the period required for determining the size of the transmission and distribution system. The present peak demand has been assumed as 4,000 kW, as described in 4-7. Based on this assumption, the projections have been formulated based on the actual survey of the status of existing electric facilities and the consumers in the two different areas, that is:

(1) Electrified areas

(2) Electrification areas

5-2 Electricity Demand in Electrified Areas

(1) Existing Demand of Consumers other than Residence

It has been assumed that the demand of a residential load is 1 kW per residence (including the diversity factor), or that the total residential load has the demand of 1,420 kW for the total number of residence consumers of 1,420. The difference between the total demand of 4,000 kW, or 2,580 kW, has been assumed as the demand by the Government, commerce and industry.

(2) Demand of General Residential Consumers

The increase of the number of households in the next 10 years, due to the population increase, the new loads to be created in the area where the electrification is to be introduced, and the increase of the consumption per household, has been considered, based on the present demand of 1,420 kW. As the result, the total demand by residential loads has been estimated as 2,920 kW.

(Breakdown of Estimate)

(a) Increase of Demand by Population Increase

The standard case in the projection of the population increase presented by the *Office of Planning and Statistics of the* Government of Palau was selected as the basis. The projection assumes the population in 1995 at 12,725. The increase in the population from the present number (12,180), or 545 persons, was divided the average number of persons per household at present, or 5.4 persons. The increase in the number of household was thus assumed to be 110, of which the number in the area of the project was 75. 40 of this households were assumed to be in the Koror Island, and the remaining 35 in the area to be in the area with electrification. At present, there are 1,420 households in the Koror Island as described before, of which the number of households in the area with electrification was 95 according to the data obtained in the preliminary study.

(b) Growth of Load in Future

Assuming the growth of demand in each household in future, the future demand by household was estimated as 2 kW/household in the urban area, and 1 kW/household in the rural area, including the diversity factor.

(c) With the above estimates, the total demand by the household loads were calculated as below.

Urban area: (1,420 + 40) x 2 kW = 2,920 kW

(3) New Demands and Additional Demands

The new demands and additional demands by consumers other than households were estimated as 3,370 kW, as the total of loads in the following sectors.

(a) Potential consumers possessing the self-generating facilities, not relying on the public power supply (but withes to buy power from the public power system if its supply reliability is high): 1,550 kW

(b) Potential increase of demands by consumers who are now constructing or expanding new facilities, or who have definite plan for new facilities: 610 kW

(c) New demands and additional demands in future by industrial and economic development: 1,210 kW

The breakdown of the above demands are given in the Table below.

Items	Existing load	Existing self-generating facilities
Palau Pacific Resort (with 100 guest rooms)	350 kW	1,800 kW
Grace Hotel (with 60 guest rooms)	250 kW	520 kW
Van Camp Sea Food Company	500 kW	800 kW
Micronesian Industrial Corp. (MIC)	450 kW	900 kW
	Total: 1,550 kW	

Referring to the above table, Van Camp Foods Company and MIC are not operating at present. But they have been taken into account considering their high business opportunity and the prospect of the Government of Palau.

Airport Terminal (under construction)	300 kW
MacDonald Memorial Hospital (planning expansion)	200 kW
Sewage Base (under construction and planning)	110 kW
Total;	610 kW

The new demands and the additional demands created by the future industrial and economic development, together with the load growth by other factors, were assumed to be 1,210 kW in total.

(4) Demand Projection for Electrified Areas

The demands in 1995, in the areas where the electrification is already introduced, were thus estimated to be the total of (1) through (3) above, or 8,870 kW.

5-3 Demand Projection in Electrification Areas

The number of existing households in the area in Babelthuap, where the electrification is to be introduced, are 95 according to the data in the preliminary survey. The number of households that increases in future was estimated at 35. The total demand in this area was estimated at 130 kW, with the assumption that the demand of a household is 1 kW. The results of the survey of this area indicates, as shown in Appendix 5-1, that additional approximately 130 kW of demands are expected from the non residential consumers.

5-4 Electric Power Demand Projection

As described above, the electricity demand at the time of the implementation of the Project was estimated at 9,000 kW, of which the demand in the electrified area today is 8,870 kW, and than in the electrification area 130 kW. The system design of this Project is based on this projection. (Refer to the Minutes in Annex-I.)

CHAPTER 6

BASIC DESIGN

Chapter 6 Basic Design

6-1 Necessity of the Project

Based on the results of the preliminary study conducted in October 1984, and the basic planning study of the Team, it has been suggested that the return of the Project will be very large, and that the Project must be implemented, based on the following considerations.

(1) By constructing transmission line that connect the new power plant to the existing power system, a more stable supply of electricity can be assured. This will not only supply stable power to the existing load, but will have the effect of creating new demand for electricity, which will result both from the shift from the self-generating facilities and the development of new industrial demands. The increased demand thus created will reduce the generating cost of the system.

(2) The electricity can be supplied to the areas along and adjacent to the new transmission line where electrification has not been introduced, enhancing the welfare of the people and industrial development of these areas.

6-2 Design Policy

6-2-1 Design Criteria

The Project is to be designed by the following design criteria.

(1) Reliability of Facilities

The transmission and distribution system to be created under the Project will be a main power supply network in Palau. In view of this important role, the said system will be designed with a sufficient margin. The design will be made in order that high reliability of the transmission and distribution system can be maintained for ensuring the design of the power plant. Deliberate consideration will also be given to necessary spare parts not to cause long power outage (blackouts).

The distribution system is to be designed in good coordination with the existing distribution networks.

(2) Maintainability

The facilities are to be designed so that safety is assured with easy maintenance works. Due attentions are to be paid for preservation of environment, including the prevention of oil spilling, based on the conditions in the Project areas.

(3) Economical Design

Most economical design will be made with careful attention given to the conditions stated in (1) and (2) above. In designing the equipment, Japanese standards will be employed in principle.

(4) Unattended Facilities

The step-down substation will be unattended, and an alarm will be displayed at the supervising station when an abnormal condition is encountered.

(5) Limit on Voltage Regulation

In principle, the voltage regulation of the consumer at the line end will not exceed $\pm$10%.

(6) Standardization

Standard models are employed for equipment such as pole transformers, to reduce the equipment cost and to rationalize the inventory of spares for maintenance.

(7) Durability

Materials of high durability will be used, as the facilities are to be located under the adverse environment of salt deposition.

6-2-2 Design Conditions

(1) Altitude

No more than 1,000 meters.

(2) Meteorological Conditions

(a)	Temperature:	Maximum; 35°C Minimum; 20°C Average; 28°C
(b)	Relative humidity:	100% (max.)
(c)	Wind velocity:	10 minute average; 40 m/s (Maximum instantaneous; 52 m/s)
(d)	Precipitation:	Annual average; 4,100 mm
(e)	IKL:	37 days/year

(3) Salt Contamination

High reliability is required of the transmission and substation facilities which are to be built along the seashore. Accordingly, design will be made to enable them to fully withstand a rapid salt contamination of 0.5 mg/cm^2 (target value) under normal condition.

Design of the distribution facilities will be made in view of possible coordination with the designs currently used in Palau.

(4) Seismic Condition

Substation equipment; 0.4G horizontal, 0.25G vertical
Substation equipment foundation; 0.2G horizontal

6-2-3 Applicable Standards

In designing the equipment and facilities for the Project, the following Japanese standards will be used.

The Japanese Industrial Standard (JIS)

Standard of the Institute of Electrical Engineers of Japan (JEC)

Standard of Japan Electrical Manufacturers' Association (JEM)

Standard of the Japanese Electric Wire and Cable Makers' Association (JCS)

Technical Standard on Electric Facilities

However, if any particular specification is not made for item(s) of the said equipment and facilities in the above standard(s) or any one of these standards do not cover such item(s), internationally accepted standards, such as IEC standards(NOTE 1) will be used.

Despite the above-mentioned description, the American standards named REA(NOTE 2) and/or NESC(NOTE 3) will be used for the safety preservation related the maintenance work.

(NOTE 1): International Electrotechnical Commission
(NOTE 2): Rural Electrification Administration
(NOTE 3): National Electric Safety Code

6-2-4 Transmission and Distribution System

The electrical systems of the transmission and distribution lines must be determined based on consideration of the economy, technology available for maintenance and compatibility with the existing systems.

At present, the following electrical system is adopted to the distribution lines in the Koror Island.

(i) Nominal voltage; 13.8kV

(ii) Distribution system; 3 phase 4 wire

(iii) Frequency; 60 Hz

(iv) Neutral grounding; multigrounded

The electrical system for the transmission and distribution lines in this Project has been designed based on the following concept.

(a) Transmission Line System

In selecting the economical transmission voltage for a transmission line of modest size, the Still's formula is generally used.

If the Still's formula is directly applied, the economical voltage of for this Project would be 56 kV. Accordingly, two classes of standard voltages, 34.5 kV and 66 kV will be the conceivable.

Still's Formula; $V = 5.5 \times \sqrt{0.6 \times L + P/100}$

Where: V; transmission voltage in kV
L; length of line in km (=20 km)
P; transmission power in kW (=9,000 kW)

$$V = 5.5 \times \sqrt{0.6 \times 20 + 9000/100} = 56 \text{ kV}$$

An economic comparison study has been conducted for 34.5 kV and 66 kV. The result indicated that the cost of the 66 kV transmission line is more expensive than that of the 34.5 kV by approximately 1 million yen per kilometer in terms of the material costs only. In other words, or the 34.5 kV line is much more economical when all costs, including the installation/erection cost and equipment cost are taken into account.

The transmission voltage of 34.5 kV also has the following advantges if other factors are considered.

- The 34.5 kV is only one step higher than the maximum existing voltage of 13.8 kV. Although a little more sophisticated technology would be required for the operation and maintenance of the 34.5 kV system, it would be only the extension of the present technology which could be acquired by some technical training.

- Transmission line having voltage of the order of 34.5 kV can be constructed along roads, reducing the time required for the construction of lines.

The transmission voltage of 34.5 kV has been selected based on considerations on economy, maintenance and construction of the line.

The transmission system, the frequency, and the neutral grounding system have been selected considering the compatibility with the existing systems, as follows.

(i)	Nominal voltage;	34.5 kV (with maximum voltage of 36.5 kV)
(ii)	Transmission system;	3 phase 4 wire
(iii)	Frequency;	60 Hz
(iv)	Neutral grounding system;	Multigrounded

(b) Distribution Line System

The voltage of the distribution line has been chosen as the same as for the existing lines, considering the maintainablity and common use of spare parts.

(i)	Nominal voltage;	13.8 kV (with maximum voltage of 14.52 kV)
(ii)	Distribution system;	3 phase 4 wire
(iii)	Frequency;	60 Hz
(iv)	Grounding system;	multigrounded

(c) Low Voltage Distribution Line System

The electrical system of the low voltage distribution lines has been selected to be the same as that of the existing system.

(i)	Lighting load;	single phase 3 wire system, 120/240V
(ii)	Power load;	3 phase 4 wire, 208V (3 x 120V)

6-2-5 Transmission Line Route

Three alternatives of transmission line routes, A, B and C in Figure 6-1, have been considered. The economy, maintainablity, the easiness of construction work and the future expansion (the relation of the line to the electrification areas and the possibility of extending the line) have been studied for these three alternatives. The results of the comparison study are presented in Table 6-1. Route "B" has been selected as it was regarded to be the most appropriate.

6-2-6 Insulation Design

The insulation design has been worked out with the objective of protecting the equipment by coordinating the insulation levels of the lines and equipment in a whole range of voltages from the lightning strokes to the commercial frequency overvoltage. The basic concept of the insulation design is presented below.

- Protection against internal abnormal voltage (swhitching surges and overvoltage of a continuous nature) is ensured by the insulation characteristics of the equipment.

- Protection against external abnormal voltage (lightning stroke surges) is ensured by the lightning arresters. The neutral conductors may be used as the ground wires.

Fig. 6-1 Proposed Routes of Transmission Lines

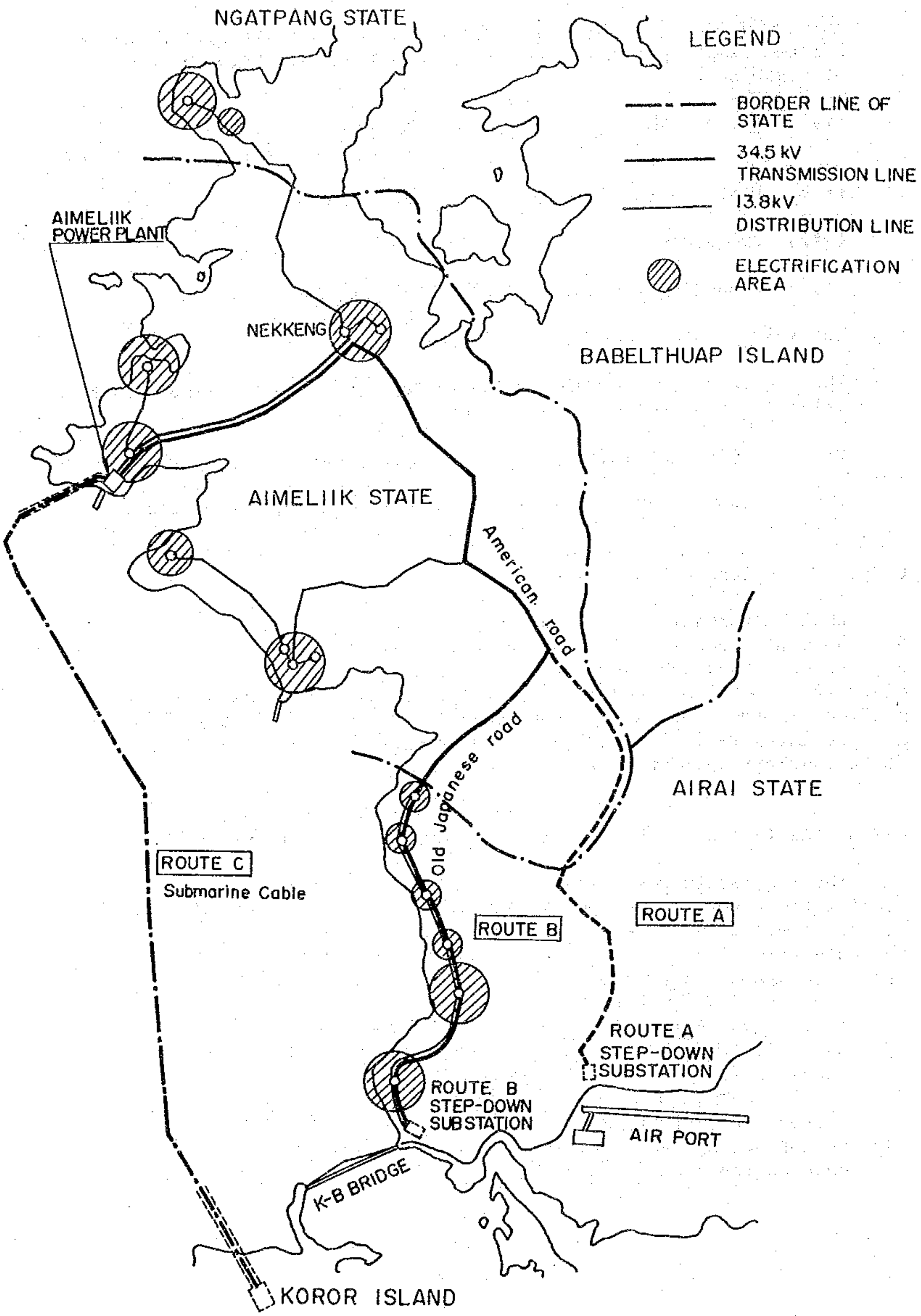
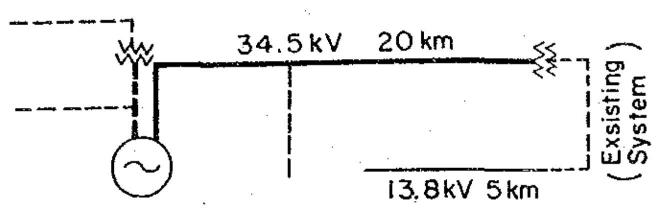
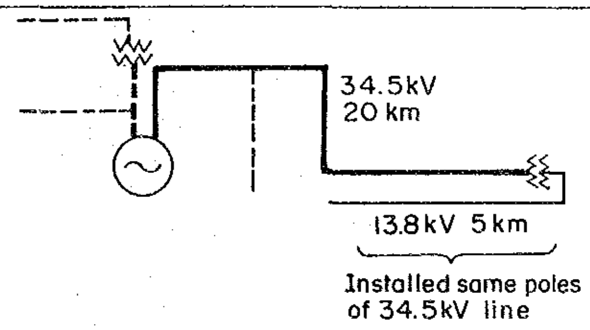
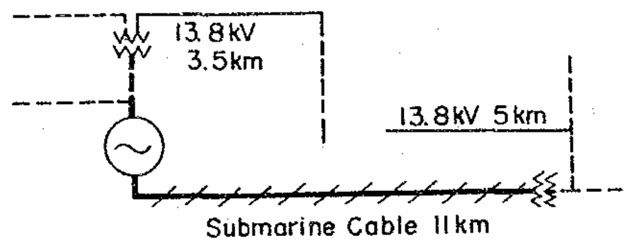


Table. 6 - 1 Comparison Table of Transmission Line Routes A, B and C

	A	B	C
Route	The Route Links the New Power Plant and Existing Power System via NEKKENG and American Road.	The Route Links the New Power Plant and Exsisting Power System via NEKKENG, American Road and Old Japanese Road.	The Route Links the New Power Plant and Exsisting Power System Using Submarine Cables.
Out Line of System			
Construction Cost	185.0 Million Yen	172.5 Million Yen	550 Million Yen
Maintenance Work	As the Transmission Line is to run Along the Road, Maintenance Work Will be Easy	Same as the Left Column	Maintenance Work Will be Done by Divers and Seems to be Relatively Difficult.
Repair Work	Not so Difficult	Same as the Left Column	Since Repair of Submarine Cables Has Rarely Been Made in the Past, Such Work Will involve High-level Techniques and be Difficult.
Construction Work	Ditto	Same as the Left Column	Special machinery for Civil Works to by Performed under Water Will be Needed in Laying out Cable Trenches.
Electrification Work	Independeut Distribution Line is Necessary for a Part of Electrification Areas.	As the Distribution Line can be String With the Same Poles of the Transmission Line, the Electrification Work Will be Easy	Isolated Distribution Line Will be Needed.
Expansion of Transmission Line	Easy	Same as the Left Column	This System Seems to be Rather Difficult in orden to Cope With the Later Development of Babelthuap Island.
Indgement *	2	1	3

* ◯ of "Judgement" Shows the Rating Orden of each Route.

(1) Basic Conditions

The basic conditions for the insulation design are presented in the table below.

Item	Unit	Circuit	
Nominal Voltage Uo	kV	34.5	13.8
Maximum Allowab Voltage Um	kV	36.50	14.52
Maximum Allowab Voltage to Ground Vm	kV	21.07	8.38
Switching Surge in Multiples of Maximum Voltage	—	2.8	2.8
Surge Between Phase in Multiples	—	4.5	4.5
Abnormal Voltage of Continu-ing Nature in Multiples	—	0.8	0.8

(2) Switching Surge Design

Based on the basic conditions stated above, the design against switching surges has been worked out as presented in the table 6-2.

(3) Commercial Frequency Voltge Design

The equipment is designed against the commercial frequency voltage so that the equipment to ground fault never occurs in the worst meteorological condition. The design parameters are presented in the table 6-3.

Table 6 - 2 Switching Surge Design

Nominal Voltage (kV)			34.5	13.8	
Maximum Allowable Voltage Um (kV)			36.5	14.52	
Peak Value of Voltage to Ground (kV)			29.80	11.27	$Um \times \frac{\sqrt{2}}{\sqrt{3}}$
Switching Surge in Multiples			2.8(4.5)	2.8(4.5)	(Phase)
Switching Surge Voltage (kV)			84(135)	34(54)	$Um \times \frac{\sqrt{2}}{\sqrt{3}} \times n$
Number of Insulators Required	Correction Factor		1.2	1.2	(Corrected for Altitude, etc.)
	Required Insulation Strength (kV)		101	41	
	Insulator	1 insulator 250ø S	75(0.74)	(1.83)	(Wet)
		2 〃	155(1.54)	(3.78)	(Withstand)
		3 〃	220(2.18)	——	(Allowance)
		4 〃	290(2.87)	——	
		LP Class 30	180(1.78)	——	
		〃 10	——	95 (2.31)	
Minimum Insulation Clearance	Correction Factor		1.10	1.10	(Corrected for Altitude)
	Required Insulation Strength (kV)		93	38	
	Required Clearance (cm)		16	7.5	
	Minimum Insulation Clearance (cm)		20	10	
Phase to Phase Insulation Clearance	Correction Factor		1.10	1.10	(Corrected for Altitude)
	Required Insulation Strength (kV)		149	60	
	Required Clearance (cm)		28	12	
	Insulation Clearance Phase to Phase (cm)		30	15	

Table. 6 - 3 Commercial Frequency Design

Nominal Voltage (kV)		34.5	13.8	
Maximum Allowable Voltage (kV)		36.5	14.52	
Maximum Voltage to Ground (kV)		21.1	8.4	
Insulation Clearance in Abnormal Condition	Correction Factor	1.1	1.1	(Corrected for Altitude)
	Voltage Withstand Required (kV)	24	10	
	Clearance for the Above (cm)	9	4	0.35V
	Insulation Clearance in Abnormal Condition (cm)	9	4	
Insulation Clearance Phase to Phase in Abnormal Condition	Correction Factor	1.1	1.1	(Corrected for Altitude)
	Voltage Withstand Required (kV)	41	16	
	Clearance for the Above (cm)	15	6	0.35V
	Insulation Clearance in Abnormal Condition Phase to Phase (cm)	15	6	

(4) Design against Contamination

The sites of this Project is within several kilometers from the sea shore. As there is wind with velocity of several meters per second in the transmission routes all the time, the contamination of insulators by the sea salt is quite feasible. On the other hand, no special consideration would be required for the cumulative contamination because the rainfall in these areas is more than 4,000 mm per annum. No symptom of cumulative contamination was observed in the survey for the basic design study. (Refer to Appendix 6-1). However, the rapid contamination must be taken into account as the typhoon occurs in the vicinity of Palau. Although no data on the rapid coutamination was available in the survey, it has been decided to take into account the rapid contamination in the contamination design for this project. The method employed for the contamination design is the standard practice in Japan, assuming the density of salt adhering the 250 mm suspension insulator to be 0.5 mg/cm^2. The insulators are to be designed to withstand the normal commercial frequency voltage under contamination.

The calculations for the design based on the above criteria are presented in the table 6-4.

Table. 6 - 4 Design Against Contamination

Nominal Voltage (kV)		34.5	13.8	
Maximum Allowable Voltage (kV)		36.5	14.52	
Maximum Voltage to Ground (kV)		21.1	8.4	
Salt Adhesion Equivalent Density (mg/cm^2)		0.5	0.5	(Lower surface of 250 mm)
Distance From Sea Shore (km)		0~5	0~5	
Withstand Voltage of Insulator	1 250mm (kV)	6.7(0.32)	6.7(0.80)	(Allowance)
	2 250mm (kV)	13.4(0.64)	13.4(1.60)	
	3 250mm (kV)	20.1(0.95)	—	
	4 250mm (kV)	26.8(1.27)	—	
	LP Class 10 (kV)	—	16.0(1.90)	Surface Leakage Distance ; 370mm
	LP Class 30 (kV)	29.8(1.41)	—	〃 840mm

(5) Design against Lightning Surge

Thunderstorms are observed in the areas under study throughout the year, the number of days being no less than 15 by the statistics. The existing facilities are designed for an IKL of 37. (Refer Minutes, Appendix-V)

Considering this status, the neutral line will be used as the ground wire, and the lightning arresters will be provided on the incoming lines of substations and the transformers to prevent the penetration of outside surges.

(6) Selection of BIL

In designing the BIL, the coordination with the existing facilities and the Japanese standards have been considered. The following BIL is selected.

13.8 kV, BIL; 110 kV
34.5 kV, BIL; 200 kV

(7) Insulators

The insulators selected by the above design conditions are presented in 6-3 and 6-4.

6-2-7 Protection System

Appropriate protective relay systems shall be provided that quickly and correctly detects a fault in the substation, or on the transmission line or distribution line, and prevents the damage on the equipment or cascading faults by automatically operating appropriate circuit breakers or by providing alarms.

(1) Main Transformer

The electrical fault shall be protected by the differential relay system, the equipment fault by the Buchholtz relay and the pressure relay, and the temperature rise detection relay.

(2) Transmission Line

(a) The line to line and the line to ground fault of the transmission line shall be removed quickly by the operations of overcurrent relays and overcurrent ground relays.

(b) When a section of a line is disconnected by the automatic operation of the circuit breakers in the faults mentioned above, the breakers shall be reclosed automatically after certain period of time (from 1 to 2 minutes) to activate the line. The transmission will be resumed if the fault is removed, or disconnected again if the fault stays.

(3) Protection in the Provisional Period

The protection system is essentially the same as described in Paragraph (2)-(b), but the automatic reclosing shall not be practiced as the provisional period is short.

6-3 Design for Transmission and Distribution Lines

(1) Type of Support Structures

As route of the transmission line of this Project is near the sea shore, as described before, the support structures must be protected from the corrosion caused by the salt.

Generally, the wooden poles, form steel structures, and concrete poles are used for the line. Regarding the corrosion resistance, the wooden poles (with creosote treatment) and steel structure have the life of approximately 25 years. The life of a concrete pole in an corrosive environment is quite long, being of the order of 50 years (or practically eternal).

It is assumed that the transmission line in this Project needs high reliability, considering the importance of the system, and the concrete poles have been selected for their high resistance against corrosion.

In erecting the concrete poles, however, the employment of the digger derrick is essential. Thus this support structure can be used only along the roads available.

In the detailed design, the use of the steel structure supports will be studied for the areas where the access by a vehicle is not possible.

(2) *Type of Conductor*

(a) Transmission Line

For this transmission line, which will be used to transmit a power of 9,000 kW (at power factor of 0.9) for the distance of 20 kilometers at a voltage of 34.5 kV, the options of the following conductors are available, with the premise that the voltage drop is within 10%.

Type	Size	Allow-able current	Trans-mission capacity	Voltge drop	Minimum tensile strength	Cost in %
ACSR (NOTE 1)	120 mm^2	338 A	20,900 kW	6.6%	5,550 kg	100
AAC (NOTE 2)	150 mm^2	431 A	23,200 kW	6.0%	2,270 kg	90
Cu (NOTE 3)	75 mm^2	347 A	18,700 kW	6.7%	2,910 kg	140

All of these conductors can meet the requirement in terms of the transmission capacity, tensile load and the electrical characteristics.

There remains some doubt on ACSR concerning the corrosion resistance, but AAC and Cu conductors have high resistance against corrosion.

Comparing AAC-150 mm^2 and Cu-75 mm^2, the AAC has a little less tensile strength, but is superior in the transmission capacity, voltage drop and economy.

Considering all these factors, AAC-150 mm^2 has been selected for the line.

The AAC-150 mm^2 conductor was also chosen for the transmission line from the new power plant to NEKKENG, although a smaller conductor could have been sufficient for the required transmission capacity, based on the following consideration.

(i) The growth of the electric demand in future, which will be caused by the developments in Babelthuap, must be taken into consideration.

(ii) It is desirable, from the point of view of maintenance, to reduce the types of conductor.

The size of the conductor for the neutral line was selected in such a way that it can stand the instantaneous current of the one line to ground fault. The magnitude of the fault current was assumed as below.

Assumed current; approximately 1,500 A
Duration of current; 1.0 second

Although several types of conductors can meet this requirement, AC 38 mm^2 (Note 4) (with instantaneous current capacity of 4,600 A) has been selected, because of its large tensile strength, superior mechanical characteristics and low cost. As this conductor is the same as the one for the 13.8 kV distribution lines, this choice reduces the kinds of conductor, facilitating the maintenance requirement.

(Note 1); ACSR: Aluminium Conductor Steel Reinforced
(Note 2); AAC : All Aluminium Conductor
(Note 3); CU : (Hard) Copper Conductor
(Note 4); AC : Aluminium Clad Steel Conductor

(b) Distribution Line

The choice of the conductors for the distribution lines was studied in the same manner as with the transmission line. As the transmission capacity required in the transmission lines is small in proportion to its voltage of 13.8 kV, the maximum being 150 kVA, the conductor was determined by its mechanical strength.

The conductor employed in the existing 13.8 kV line is #2 AWG gauge. The conductors in the table below have the equivalent characteristics as the existing conductor.

Type	Size	Allowable current	Maximum Transmission capacity	Voltage drop (NOTE 1)	Maximum tensile strength	Relative cost
Cu	38mm^2	220 A	4,733 kW	0.3%	1,480 kg	100%
ACSR	32mm^2	160 A	3,442 kW	0.4%	1,140 kg	65%
AC	38mm^2	195 A	4,195 kW	0.6%	2,340 kg	85%

(NOTE 1) Voltage drop is calculated at length of Distribution line is 6 km and load current is 6 Amps.

Among the 3 conductors above, ACSR was excluded because its resistance against corrosion was not quite clear. Of the remaining two types of conductors, AC is more economical. For this reason, the 38 mm^2 AC conductor was selected.

Although a smaller conductor could be chosen for the neutral line, the AC 38 mm^2 conductor, or the same conductor with the power line was selected considering the mechanical strength.

(c) Conductor Performance

The performance of the two conductors are presented in Table 6-5.

Table. 6 - 5 Performance of Conductor

Nominal Cross Section		150mm² AAC	38mm² AC
Composition (Strand/mm)	Aluminum	19/3.2	——
	AC	——	7/2.6
Calculated Cross Section (mm^2)	Aluminum	152.8	——
	AC	——	37.16
Tensile Strength (kg)		2270	2340
Outside Diameter (mm)		16.0	7.8
Weight (kg/m)		0.4187	0.1184

(3) Insulator

The LP insulators will be used for the suspension pole, and the combination of suspension insulator and LP insulators for the angled pole, realizing an economical design.

The type and number of insulators are selected as in the tabled below, based on the study in 6-2-6.

Insulators

Voltage	Pole	LP class 10	LP class 30	250 mm suspension
34.5 kV	Suspension	--	0	--
	Angled	--	0	4
13.5 kV	Suspension	0	--	--
	Angled	0	--	2

(4) Standard Span and Ground Clearance

(a) Standard Span

The line support structures in the Project are concrete poles. As the standard length of a concrete pole is from 10 to 15 meters, the standard span of the poles as determined by the tensile strength of the conductor, the sag and the height above the ground is generally from 20 to 120 meters. As the concrete poles are relatively expensive, an economic design can be attained by choosing the standard span as long as possible. In the Project, however, route of the line runs up and down, and along curves, making it necessary to select the positions of the poles on site according to the terrain. For this reason, the following standard spans are prepared for the Project, and the suitable spans will be selected in the construction work according to the conditions of the road and the actual terrain.

Transmission line; 60 m and 80 m
Distribution line; 40 m, 60 m and 80 m

(b) Ground Clearance of Transmission and Distribution Lines

(i) The ground clearance of the transmission and distribution lines was selected as in the table 6-6, according to the NESC standard.

Table. 6-6 Ground Clearance
(NESC Division 23, 232)

(Unit : m)

Conditon Below Wire and Conductor		Guy Wire	Ground Wire	Neutral Line	Drop Wire (Below 150W)	13.8kV 34.5kV
Crossing or Above Road	Road	5.5 (Note 1)	5.5	5.5 (Note 1)	5.5	6.1
	Road in Residential Area Without Traffic of Truck (Exceeding 2.5 meter in Height).	3.0	3.7	3.0	3.6	6.1
	Farmland, Ranch or Wood, With Vehicle Traffic.	5.5	5.5	5.5	5.5	6.1
	Road or Place With Pedestrian Only.	2.45	3.6	2.45	3.6	4.6
Line Along the Road	Urban or Town Road.	5.5	5.5	5.5	5.5	6.1
	Road Without Vehicle Traffic Under the Line	4.3	4.3	4.3	4.6	5.5

Note 1 4.9 meters at road end.

2 Add 30mm for every 3 meters of span when the span exceeds 75 meters, When the maximum opereting temperature of the conductor is less than 50°C, excluding the guy wire.

3 The values in the table is the sag at the maximum temperature of the conductor when its maximum operating temperature is more than 50°C.

(ii) The vertical distance from the charged part of the equipment on the support structure to the ground shall be according to the table 6-7.

Table. 6-7 Height of Equipment on Structure Above Ground

(Unit : m)

Condition Below Charged Part		Drop Wire (Below150V)	13.8kV Distribution Line	34.5kV Transmission Line
When Charged Part is Above Road	Road	4.9	5.5	5.8
	Road in Residential Area Without Traffic of Truck (Exceeding 2.5m in Height).	3.0	5.5	5.8
	Farm, Ranch or Wood	4.9	5.5	5.8
	Road or Place With Pedestrians Only	3.0	4.0	4.3
When Charged Part is Not Above Road	Urban or Town Road	4.9	5.5	5.8
	Road Without Vehicle Traffic	4.0	4.9	5.2

(5) Clearance

(i) The clearance of the transmission and distribution lines from objects shall be according to the table 6-8, based on the NESC standard.

Table. 6 - 8 Clearance

(Unit : m)

Clearance			Guy Wire, Ground Wire, Neutral Line	Drop Wire (Below 150V)	13.8 kV Distribution	34.5kV Transmission
Structure for Illumination, Traffic and Other Power Line	Horizontal ;		1.5	1.5	1.5	1.5
	Vertical:		1.2	1.2	1.2	1.43
Buildings	Horizontal		0.9	1.5	1.5	1.5
	Vertical	Roof or Projection Not Accessible by Pedestrian.	0.9	3.0	3.0	3.0
		Roof Accessible by Pedestrian	2.45	3.6	4.6	4.6
		Roof Accessible by Truck	5.5	5.5	6.1	6.1
		Roof Accessible by Vehicles	3.0	3.6	6.1	6.1
Other Objects	Horizontal :		0.9	1.5	1.5	1.8
	Vertical ;		0.9	1.5	2.45	2.45

Note 1. If the Clearance Can Not be Secured, the Power Line Must be Provided With Protective Measures.
2. To be no Less Than 3 meters When the Line Passes Over a Bridge.
3. The Increment for the Span Length and the Conductor Temperature Shall be Treated in the Similar Manner as With Ground Clearance.

(ii) The following distance shall be provided from the structure to the road, and the distance shall be such that the vehicle does not contact the structure.

From fire hydrant; 0.9 meters or more
From the road having edge stone; 150 mm or more

(iii) The clearance from the conductor on a different support structure shall be no less than 1.5 meters in the horizontal distance, and according to the table 6-9 in the vertical distance.

Table. 6-9 Vertical Distance for Clearance

(Unit : m)

Above / Below	Guy Wire, Neutral Line, Ground Wire	Drop Wire (Below 150V)	13.8kV Distribution 34.5kV Transmission
Guy Wire, Neutral Line, Ground Wire	0.6	0.6	1.2
Drop Wire	0.6	0.6	1.2
13.8 kV Distribution and 34.5 kV Transmission line	1.2	1.2	1.2

(6) Pole Assembly

The typical pole assembly is pesented in Appendix 6-2.

6-4 Electrification Plan

The power will be supplied based on the principles below to the areas where the electrification is to be introduced as described in 5-3.

(1) The distribution transformers will be located in order to correspond to geographical distribution of the ultimate power demand. The capacity of the transformers will be selected in such a manner that the neutral current caused by the unbalanced load current is limited, with balanced loads on the 3 phases of the line.

(2) In planning, the types of the transformers will be reduced as much as possible, so that the maintenance work is facilitated and the number of the spare transformers are reduced.

(3) The transformers connected to the 34.5 kV circuit will be provided with section switches, so that the distribution loads can be disconnected as required, in order to maintain a high reliability of the 34.5 kV transmission line.

(4) The transformers will be provided with lightning arresters.

(5) The low voltage circuit of the transformer will be provided with terminal blocks (with cases) which is connected through protective fuses, to facilitate the wiring works of the low voltage lines which will be constructed at the expense of Palau.

(6) The low voltage drop wires to the consumers will be made of DV wires, which size will be selected to have the voltage drop of not more than 10%. These wires will be supplied.

(7) The watt-hour meters for the consumers will be supplied.

The plan for installation of distribution transformers, which is based on the principles above, is illustrated in the one line diagram in Figure 6-2.

The equipment and materials required for this plan is presented in the table 6-10.

Fig. 6-2 SINGLE LINE DIAGRAM of Electrification Plan

State	Area	No.	Estimated Load (kVA)			Priority
			Houses	Others	Total	
Airai	Zone 1	1	13	—	13	3
〃	〃 2	2	6	—	6	3
〃	〃 3	3	13	—	13	3
〃	〃 4	4	13	—	13	3
〃	〃 5	5	4	—	4	1
〃	〃 6	6	3	—	3	1
Aimeliik	NEKKENG	7	4	25	29	1
〃	Imelsubech	8	14	13	27	1
〃	Medorm	9	16	4	20	1
〃	Imul	10	30	—	30	1
〃	Ngelkeai	11	10	43	53	1
〃	Elechui	12	6	4	10	2
Ngatpang	Housing area	13	38	—	38	3
〃	Ngatpang	14	14	50	64	1
	(Total)		184	139	323	

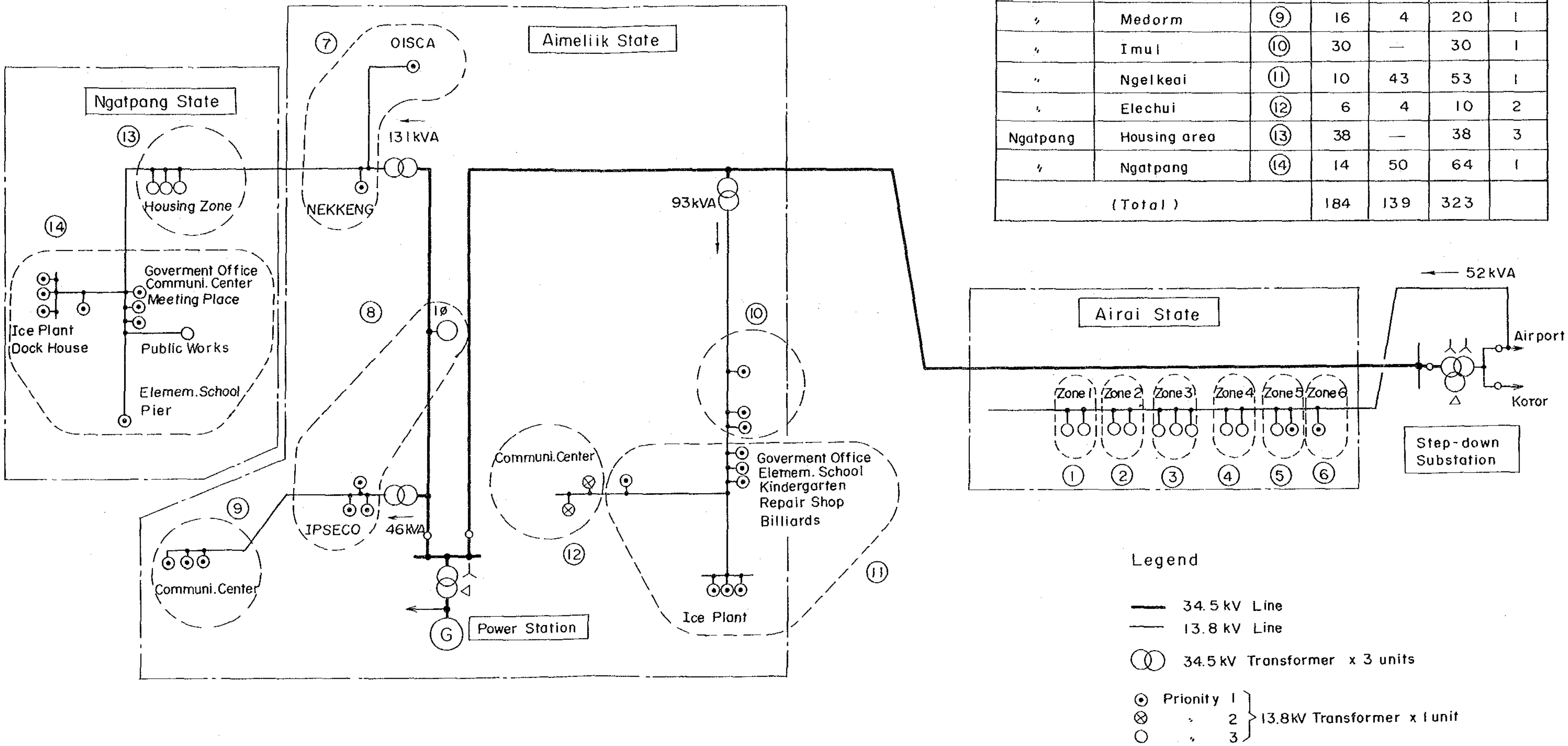


Table. 6-10 Equipment and Material Required for Electrification Plan

Item	Ratings, etc.	Number	Spare	Total	Remarks
Pole Transformer	34.5kV/13.8kV, 50kVA 1 ø	9	1	10	
"	34.5kV/240-120V, 20kVA 1 ø	1	1	2	
"	13.8kV/240-120V, 20kVA 1 ø	44	3	47	
Air Break Switch	34.5kV	4	1	5	
Arrester	34.5kV Circuit	10	2	12	
"	13.8kV Circuit	53	5	58	
Watt-hour Meter	120V, 30A, 1 ø	159	47	206	
"	120V, 120A, 1 ø	3	3	6	
"	240V, 120A, 3 ø	2	2	4	For ice plant
Low Voltage Drop Wire		Approx. 17,000m	—	17,000m	
Insulators and Others		1 Set		1 Set	

When priorities must be placed for the installation, it will be according to the following criteria.

Priority 1; Areas populated at present

Priority 2; Areas populated at present, but construction is difficult

Priority 3; Areas included in the future plan

Priority 4; Material for low voltage distribution

6-5 Substation Design

(1) Main Circuit

(a) The transmission line is designed as the 3 phase 4 conductor system with the neutral multigrounded, similar to the existing power system.

(b) The connection of the main transformers is as follows.

(i) Step-up substation;
delta-Y, neutral directly grounded

(ii) Step-down substation;
Y-Y-delta, neutral directly grounded

The delta winding in the three-winding transformer is the stabilizing winding, with not tap to the outside.

(c) The tap changers will be provided on the high voltage winding of the transformer, to maintain suitable transmission voltage.

(i) Step-up substation;
no-voltage tap changer with 4 taps,
36.5/34.5/32.8/31.0 kV

(ii) Step-down substation;
on-load tap changer with 19 taps, between 36.5 kV and 29.0 kV

(d) The one line diagrams and the general equipment layouts of the two substations are presented in Appendixes 6-3 through 6-6.

(e) Measures with Provisional Power System (Stage 1)

The system diagram and the one line diagram for this power system are presented in Appendixes 6-7 and 6-8.

With this sytem, the neutrals of the generators in the new power plant are grounded through resistors (40 ohms), while those of the existing system are directly grounded. To deal with the voltage rise of the ungrounded phases in a one line to ground fault, the neutral of the system is provided with the Temporary grounding circuit with pole transformers.

(2) Specifications Principal Equipment

The specifications for the principal equipment are presented below.

(a) Step-up Substation

(i) Transformers; 2 sets (1 in normal service, 1 standby) Rated capacity; 10 MVA, number of phase; 3, frequency; 60 Hz, Rated voltage; 13.8 kV/34.5 kV with no voltage tap changer (36.5/34.5/32.8/31.0 kV taps).

Connection; delta-Y

Cooling system; oil filled self cooled

(ii) Circuit breakers; 36 kV, rated current; 600 A, rated rupturing current; 12.5 kA

Rated breaking time; 5 cycles, insulation class; 30 A.

Rated closing and tripping voltage; DC 100 V (electromagnetic operation)

Type; oil filled

(iii) Line switches; 7 (with grounding switches on the line side)

Rated voltage; 36 kV, rated current; 600 A

Rated current of short duration; 12.5 kA

Operation; manual, simultaneous 3 phase operation

(iv) Arresters; 4

Rated voltage; 30 kV, rated frequency; 60 Hz

Rated discharge current; 10,000 A

(v) Bus conductors and insulators

Bus:

1) From the feeder circuit breakers of the new power plant to the primary of the transformer; CV cable; 1 circuit, 15 kV, 250 mm^2 per phase.

2) From the secondary of the transformer to the transmission line; H-Al 150 mm^2

Insulator:

Five 250 mm standard suspension insulators are used per string. The bushings and the supporting insulators are to have insulation coordination with the transmission line.

(vi) Control boards; 2 panels

The dimensions and the colors of the control boards will be selected to match the control boards of the new power plant.

(vii) Battery and battery charger; 1 set, installed in cubicle

Charger; 20 A, Battery; 100 AH/10 hours

The new DC 100V control power will be installed as the control power for the new power plant is DC 30V.

(viii) Grounding works:

Mesh method (with design grounding resistance of no more than 1 ohm).

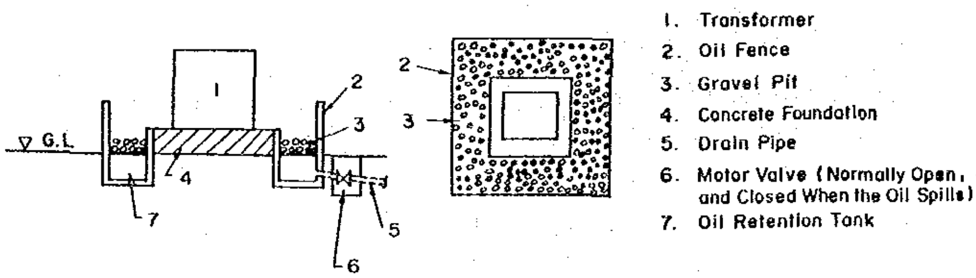
The mesh will be connected to the grounding line of the new power plant (having the grounding rod attached to the steel frame of the building).

(ix) Environmental and safety measures:

Fence: Fences, similar to those around the new power plant, will be installed around the substation.

Outdoor illumination: Outdoor illumination will be provided with lamps on the line structure of the station. Illumination for outdoor works will also be supplied.

Oil fence: The oil fence will be provided for the transformers, in a manner which concept drawing is given below.



A motor valve is installed on the drain pipe, which is normally open, and closes when the relays (differential relay and Buchholtz relay) are operated by the oil spill from the transformer, temporarily storing the oil in the retention tank.

(b) Step-down Substation

(i) Transformers; 1 set

Rated capacity; 10 MVA, number of phase; 3, frequency; 60 Hz, Rated voltage; 34.5 kV/13.8 kV with on-load tap changer (19 taps from 36.5 to 29.0 kV).

Connection; Y-Y-delta

Cooling system; oil filled self cooled, with hot-line oil purifier

(ii) Circuit breakers:

High voltage; 1. Same as in (2)-(a)-(ii).

Low voltage; 2. Cubicle type

Rated voltage; 24 kV, rated current; 600 A, rupturing current; 20 kA

Rated breaking time; 5 cycles, insulation class; 20 A

Rated closing and tripping voltage; DC 100 V

(iii) Line switches:

High voltage; 1. Same as in (2)-(a)-(iii)

Low voltage; 2.

Rated voltage; 24 kV, rated current; 600 A

Rated current of short duration; 20 kA

Operation; manual, simultaneous 3 phase operation.

(iv) Arresters:

High voltage; 1. Same as in (2)-(a)-(iv)

Low voltage; 1, cubile type

Rated voltage; 12 kV, rated frequency; 60 Hz

Rated discharge current; 10,000 A

(v) Bus conductors and insulators

Bus:

1) From the line to the primary of the transformers, H-Al 150 mm^2

Insulator:

High voltage; 5
Low voltage; 3

(vi) Battery and battery charger; 1 set, installed in cubicle. The same as in (2)-(a)-(vii)

(vii) Grounding works:

Mesh method (with design grounding resistance of no more than 1 ohm).

(viii) Environmental and safety measures:

The same as in (2)-(a)-(ix)

(c) Equipment with Provisional Power System (Stage 1)

The equipment below, used in the provisional period of the transmission system, will be utilized in principle when the system is completed in Stage 2.

(i) Circuit breaker:

1 in the step-up substation, with the same specification as in (2)-(a)-(ii).

(ii) Line switch:

1 in the step-up substation, with the same specification as in (2)-(a)-(iii).

(iii) Arresters:

1 in the step-up substation

1 in the step-down substation

(iv) Temporary grounding circuit

13.8 kV/120 V pole Transformer: 3 sets

(v) Load switch:

2 in step-down substation side, pole type, manual, anti salt contamination. Rated voltage; 24 kV, rated current; 300 A.

(d) Spares

Both substations shall be equipped with suitable number of spares.

(3) Operation

(3-1) Step-up Substation

(a) The substation is operated by the operators normally attending the power plant, who operates the circuit breakers and monitors the instruments from the control room of the substation which is located in the power plant.

(b) The line switches are operated manually at the locations.

(c) The new Aimeliik power Plant and the existing Malakal Power Plant are to be operated in a parallel operation, if necessary.

The synchronization of the plants in a parallel operation can be performed by the generator circuit breakers of the new and existing power plant. In addition, the line circuit breakers of the new power plant will be designed to have the synchronizing capability.

(d) The circuit breakers and line switches of the transmission line and transformers will be provided with interlock functions.

(3-2) Step-down Substation

(a) The monitoring and control of the step-down substation will be performed with the simple monitoring system, and no permanent attendant will be stationed. That is, the technical personnel will be dispatched to the substation as required to perform the monitoring, patrol in the station, and operation of equipment.

(b) Necessary information of faults and troubles will be transmitted to the nearby supervisory station and indications will be provided there.

(c) The equipment in the low voltage circuits will be housed in the outdoor cubicles.

(d) Interlocking functions will be provided on the circuit breakers and line switches as in (3-1)-(d).

(e) The synchronization of the new power system to the existing power system will not be performed at this substation.

(3-3) Provisional Power System (Stage 1)

(a) With the provisional power system, the 34.5 kV transmission line will be operated tentatively at 13.8 kV. That is, the main transformers will not be installed and the transmission line will be operated at the generator voltage.

(b) To meet the requirement that the voltage drop of the transmission line is kept within 10%, the transmission power from the new power plant will be imited to approximately 3,000 kW, and to restrain the abnormal voltage rise during faulty condition, the parallel operation of the new and existing power plant is required.

6-6 Design for Communication System

For the efficient operation of the power system of the Project, it is essential to have communication facilities for the verbal communication between the power plants and between power plant and locations on the transmission route, with which information for load dispatching and maintenance (including recovery of faults) can be exchanged.

As the area covered by the Project is relatively narrow, and as it is expected that the amount of daily communication required is limited, a 150 MHz band very high frequency radio system (one way) will be employed.

The following facilities will be provided.

Base station: The base stations will be established in Aimeliik Power Plant, Step-down Substation, Malakal Power Plant and the maintenance office. The facility in Malakal Power Plant will be used as the spare station in the future. The scope of work includes the construction.

Mobile station: On maintenance vehicles (2 cars)

Portable station: Line maintenance patrol personnels (2 stations)

1 spare holding each will be purchased for both mobile and portable stations.

6-7 Technical Aspects

The highest voltage to be employed for this Project will be 34.5 kV, which is higher than the highest voltage of 13.8 kV presently adopted for the existing facilities in Palau. Accordingly, it is deemed necessary that technical guidance in the operation and maintenance of the new facilities be given to Palauan personnel who are expected to be assigned to such work. The above-mentioned guidance will be rendered through on-the-job training in Palau. This will be done during the construction period and test operation (estimated period: three months) of the facilities following the completion of the Project. The technical Guidance to be provided by the Japan side will include the items enumerated hereunder.

(1) Technical training for daily operation and maintenance

(2) Measures in abnormal conditions, including Faults, and the method of recovery

(3) Management of facilities (including logging and paper works)

(4) Procedures for safety preservation for maintenance of equipment

6-8 Provision of Materials and Equipment

The following goods will be purchased for this project.

(1) Maintenance Vehicles

Out of the vehicles to be used for the construction works, the following goods will be transferred to Palau for the maintenance use.

(a) Patrol vehicle (4 wheel drive): 2
(b) Concrete pole digger derrick : 1

(2) Materials for Construction Works to be Conducted by the Government of Palau

Some parts of construction works for electrification, works related to low voltage distribution lines will be performed by the Palau side. The following goods for the works will be provided.

Drop wires for low voltage distribution (including accessories)	:	approximately 17,000 meters
Watt-hour meters	:	approximately 220
Fault indicator system for Step-down Substation	:	1 set (including cable, approximately 1,100 meters)

(3) Communication Facilities

Facilities for 3 mobile stations
Facilities for 3 patrol stations

(4) Spare parts and maintenance Tools

1 lot

6-9 Undertakings by Palau

The undertakings for the Government of Palau to perform are as described in the Minutes of Meetings (Refer to appendix-VI). The major items are as follows:

(1) Acquisition of real estates and rights of way for the construction works

(2) Reinforcement including construction and repair of the roads (including bridges), and cutting and removal of trees, as required by the Project

(3) Leveling work for the substations

(4) The construction work related to the low voltage distribution lines for electrification (goods except for wooden poles are to be supplied by Japan)

(5) Arrangement of existing transmission systems in the Koror Island

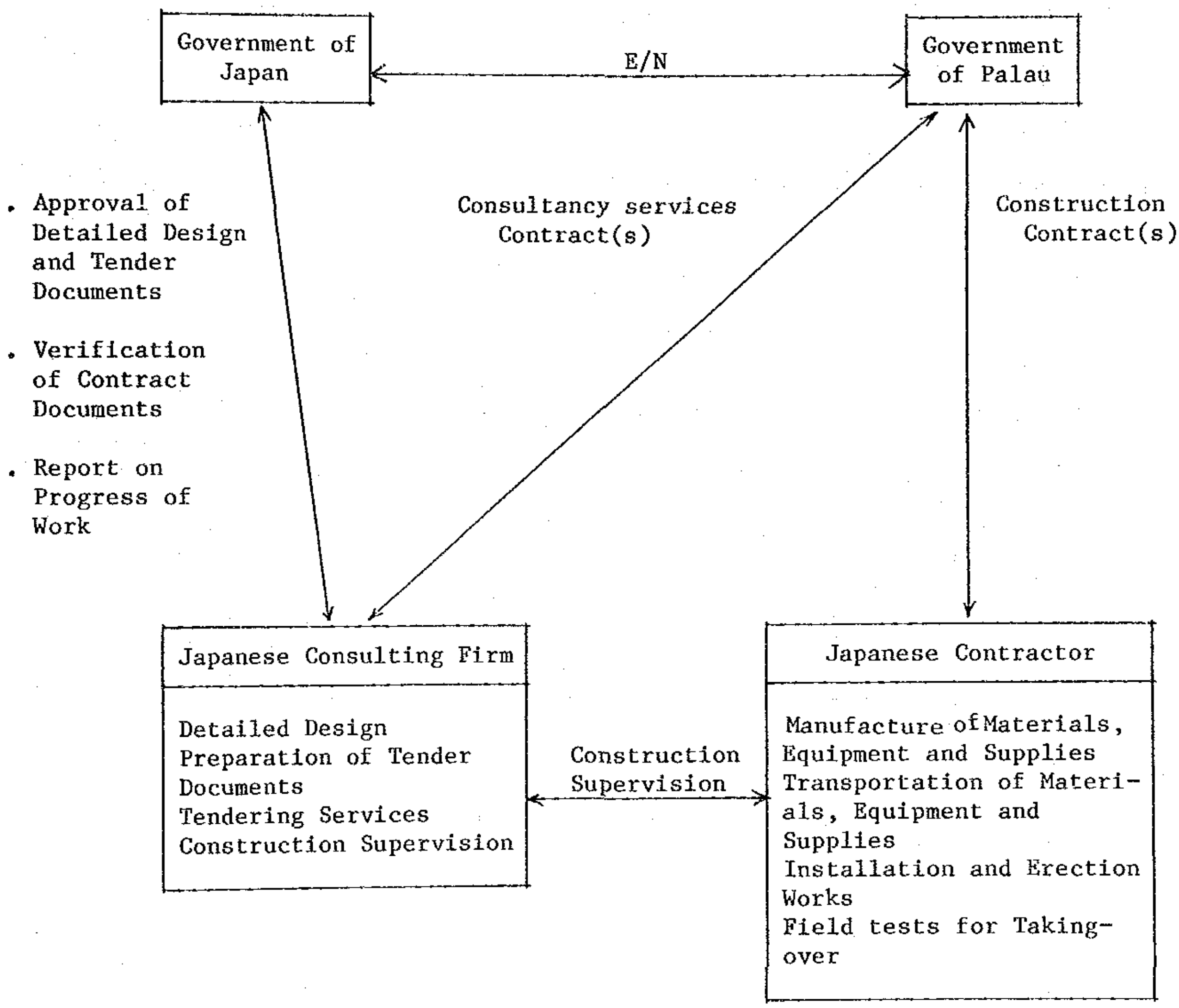
CHAPTER 7

IMPLEMENTATION

7-1 Implementing Body

(1) Implementing Organization

This Project is to be implemented by means of Japanese Grant Aid. The following table illustrates the relations among the parties concerned with the implementation of the Project.



(2) Implementing Organization of the Government of Palau

In implementing this Project, the Ministry of Administration of the Government of Palau will be responsible for liaison with the Government of Japan and taking the necessary procedures. The Ministry of

National Resources will be responsible for technical matters such as finalization of the detailed design and contract administration of construction works.

7-2 Implementation Schedule

This Project will be implemented in accordance with the terms and conditions of the Japanese Grant Aid System upon signing of the Exchange of Notes between the two Governments.

This project will be implemented as follows in two stages:

(1) Stage I

On the assumption that any and all work for Stage 1 is to be completed in or before March 1986, construction of the transmission line between the new Aimeliik Power Plant and K-B Bridge will be completed by the above-mentioned deadline. Power from the new power plant will be supplied directly to the existing power system without using a new substation.

In order to meet the requirements as stated above, the schedule enumerated hereunder should be followed.

(a) Detailed design will be started in April 1985 and contractor(s) will be selected before August of the same year after preparation of tender documents and tendering.

(b) Manufacture of the materials, equipment and supplies will be commenced in September, installation of equipment and relevant devices on the site will be started in December, and necessary construction works will be completed not later than the end of February 1986.

(c) Preparatory works including surveys of the transmission line route and reinforcement of construction road(s) should be started around November of 1985.

(2) Stage 2

Since the Exchange of Notes for Stage 2 is expected to be signed around June 1985, the work for this Stage will be implemented with some delay behind the schedule for Stage 1.

The work incorporated in Stage 2 is to construct two (2) substations at both ends of the transmission line, and distribution lines to be stretched from the transmission line.

(a) Detailed design will commence in June 1985 or thereabouts, and preparation of tender documents and tendering will be followed so that contractor(s) may be selected in November 1985.

(b) Manufacture of a transformer with a tap charger to be installed at the step-down substation will take six (6) months.

(c) The schedule for construction of the distribution lines is worked out so that the work can be performed successibly following the completion of the transmission line in Stage 1.

(d) Considering these factors, the facilities for stage 2 will commissioned at the end of August 1986.

(e) The training for maintenance and operation of the transmission/distribution lines and substations will be conducted during the period from September to November 1986.

(3) Implementation Schedule

The proposed implementation schedules for Stage 1 and Stage 2 are illustrated in Figure 7-1.

7-3 Implementation Plan

(1) Implementation mode

This Project will be executed on a turn-key basis under contract(s) to be concluded by and between the Government of Palau and contractor(s) of Japanese nationals.

Necessary procedures for this purpose will include tendering, evaluation of tender proposals, selection of the contractor(s) and so forth. Such contract(s) will come into force and effect upon verification by the Government of Japan thereof.

(2) Outline of Construction Work

(a) Transmission Line

(i) Stage 1

Before the start of the construction work, surveys will be conducted on the line route the position of each pole determined by the survey, and the poles will be erected according to the results of these surveys. As the time allocated to the construction work is limited, the work will be done by two shifts to shorten the time required. After the poles are erected, they will be finished by attaching arms and insulators, and then stringing work will be performed. The pole erection work will be performed from December 1985 through January 1986 while the rainy season changes to the dry season. Therefore, due considerations should be given to the weather conditions.

(ii) Stage 2

The construction of the distribution lines in Stage 2 will be immediately followed by construction of the transmission lines. The work procedures are similar to those of the transmission line, but there will be an extra work for installation of pole transformers.

Fig. 7 - 1 BABELTHUAP ELECTRICAL TRANSMISSION AND DISTRIBUTION LINES PROJECT

IMPLEMENTATION SCHEDULE