Palau Public Utilities Corporation
The Republic of Palau

No.

FINAL REPORT
ON
THE MASTER PLAN STUDY
FOR
THE UPGRADING OF ELECTRIC POWER SUPPLY
IN THE REPUBLIC OF PALAU

SUMMARY

JULY 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

THE CHUGOKU ELECTRIC POWER CO., INC.

IL
JR
08-018

PREFACE

In response to a request from the Republic of Palau, the Government of Japan decided to conduct the Master Plan Study for the Upgrading of Electric Power Supply and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Mitsuhisa Nishikawa of Yachiyo Engineering Co., LTD. (yec) and consists of yec and Chugoku Electric Power Co., INC. three times between January and June, 2008.

The team held discussions with the officials concerned of the Government of Palau and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Palau for their close cooperation extended to the study.

July 2008

Seiichi Nagatsuka
Vice President
Japan International Cooperation Agency

Mr. Seiichi Nagatsuka
Vice President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

July 2008

Dear Sir,

It is my great pleasure to submit herewith the Final Report of “The Master Plan Study for the Upgrading of Electric Power Supply in the Republic of Palau”.

The Study Team that consists of Yachiyo Engineering Co., Ltd. and Chugoku Electric Power Co., Inc. conducted field surveys in Palau over the period between January and June, 2008 according to the contract with the Japan International Cooperation Agency (JICA).

The Study Team compiled this report, which consists of the Master Plan Study for the Upgrading of Electric Power Supply, Pre-Feasibility Study on Prioritized Projects, Recommendations to Operational Improvement of Power Supply Equipment, etc. through close consultations with officials concerned of the Government of the Republic of Palau and other authorities concerned.

On behalf of the Study Team, I would like to express my sincere appreciation to officials concerned of the Government of Palau and other authorities concerned for their cooperation, assistance, and heartfelt hospitality extended to the Study Team.

We are also deeply grateful to the Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Economy, Trade and Industry, and the Embassy of Japan in Palau for their valuable suggestions and assistance during the course of the Study.

Yours faithfully,

Mitsuhisa Nishikawa
Team Leader
The Master Plan Study for the Upgrading
of Electric Power Supply in the Republic
of Palau

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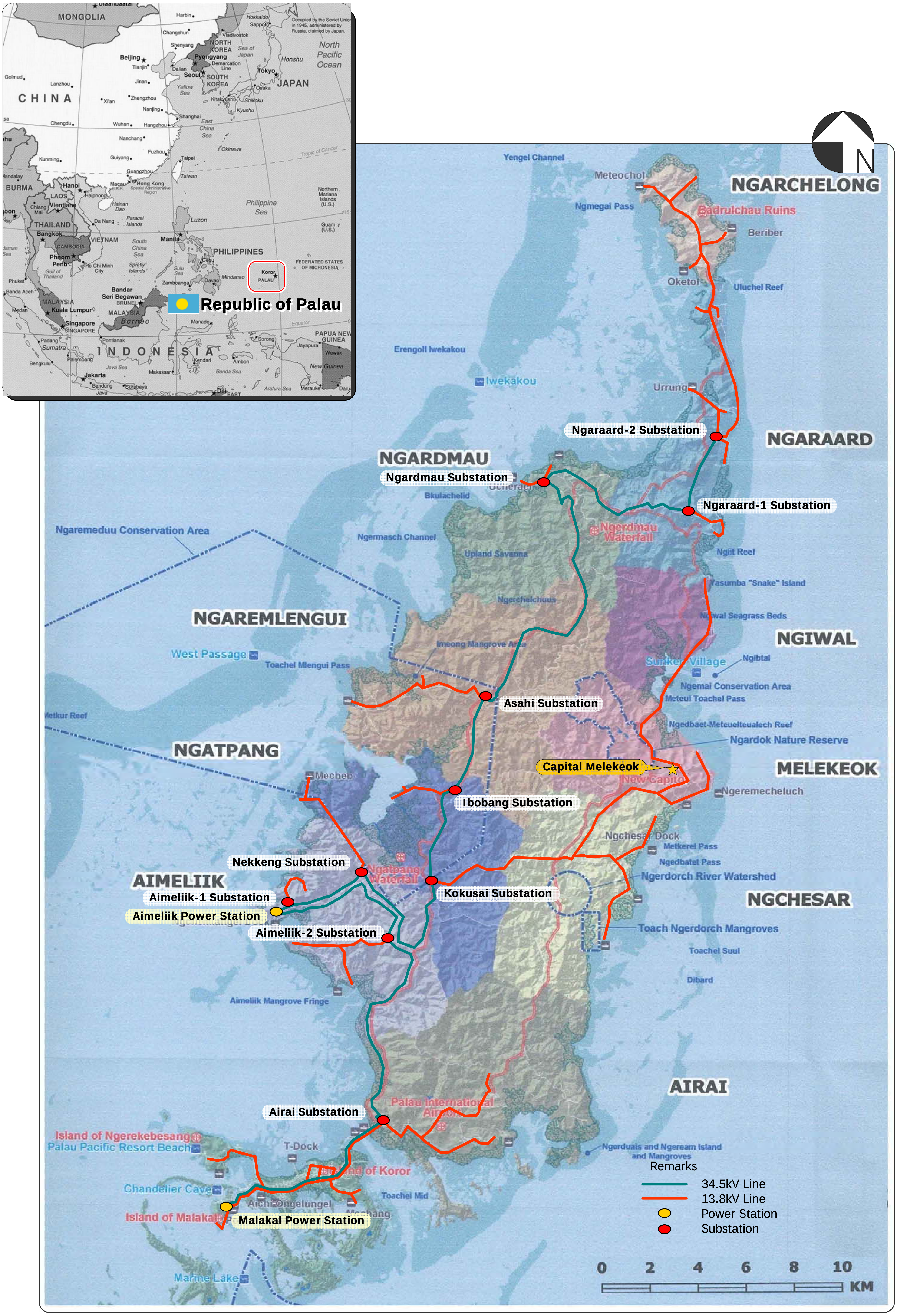

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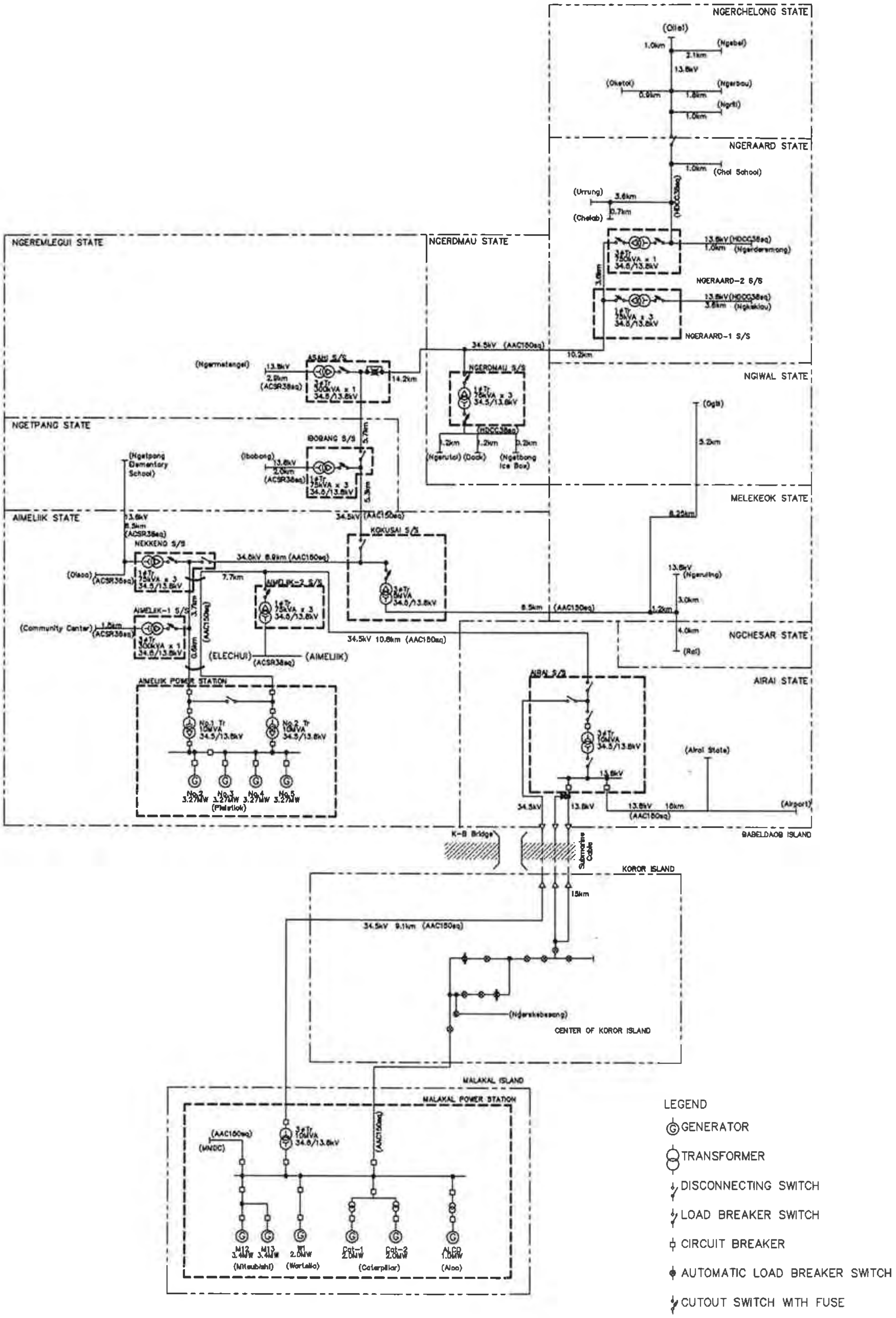

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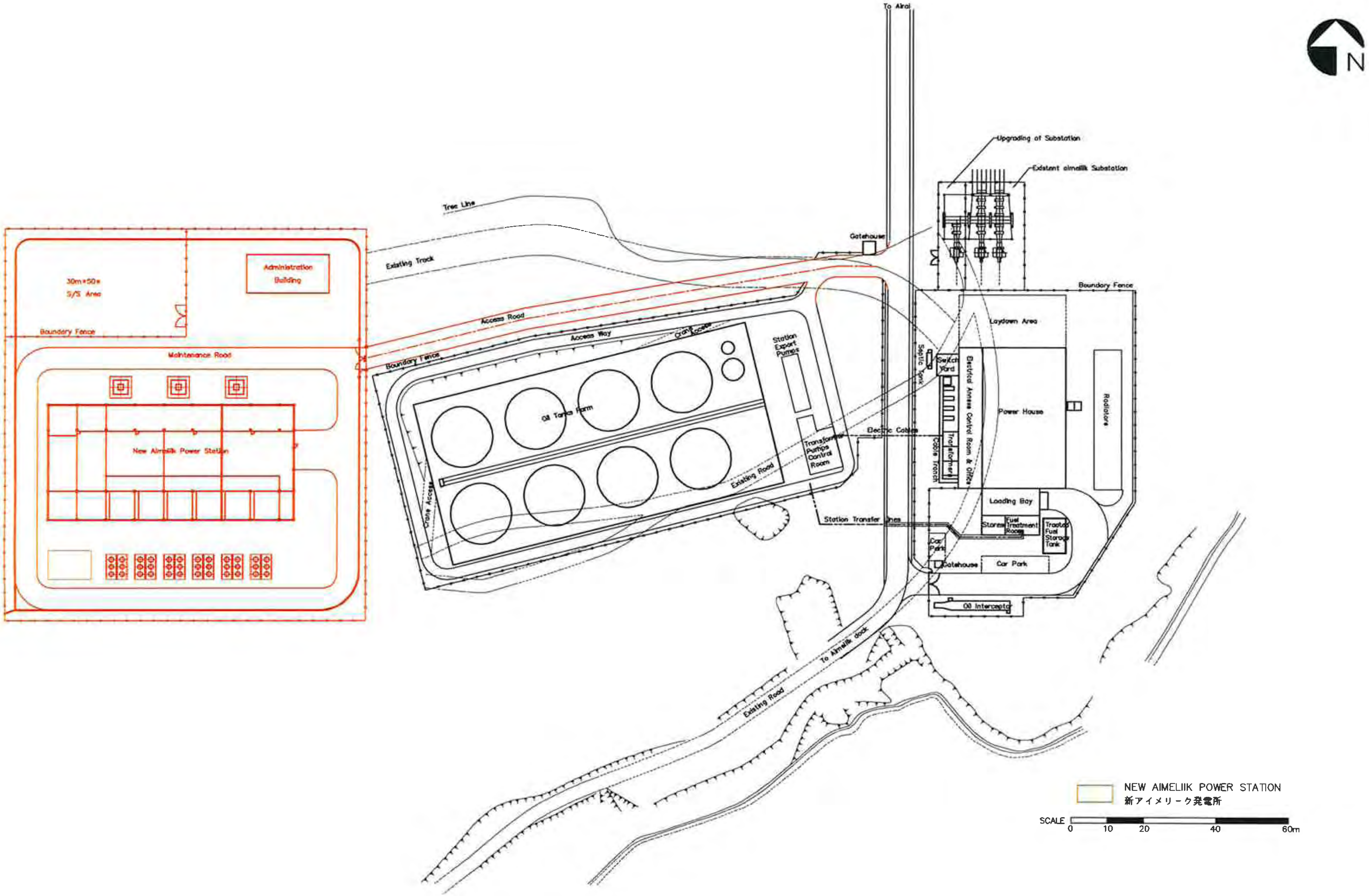

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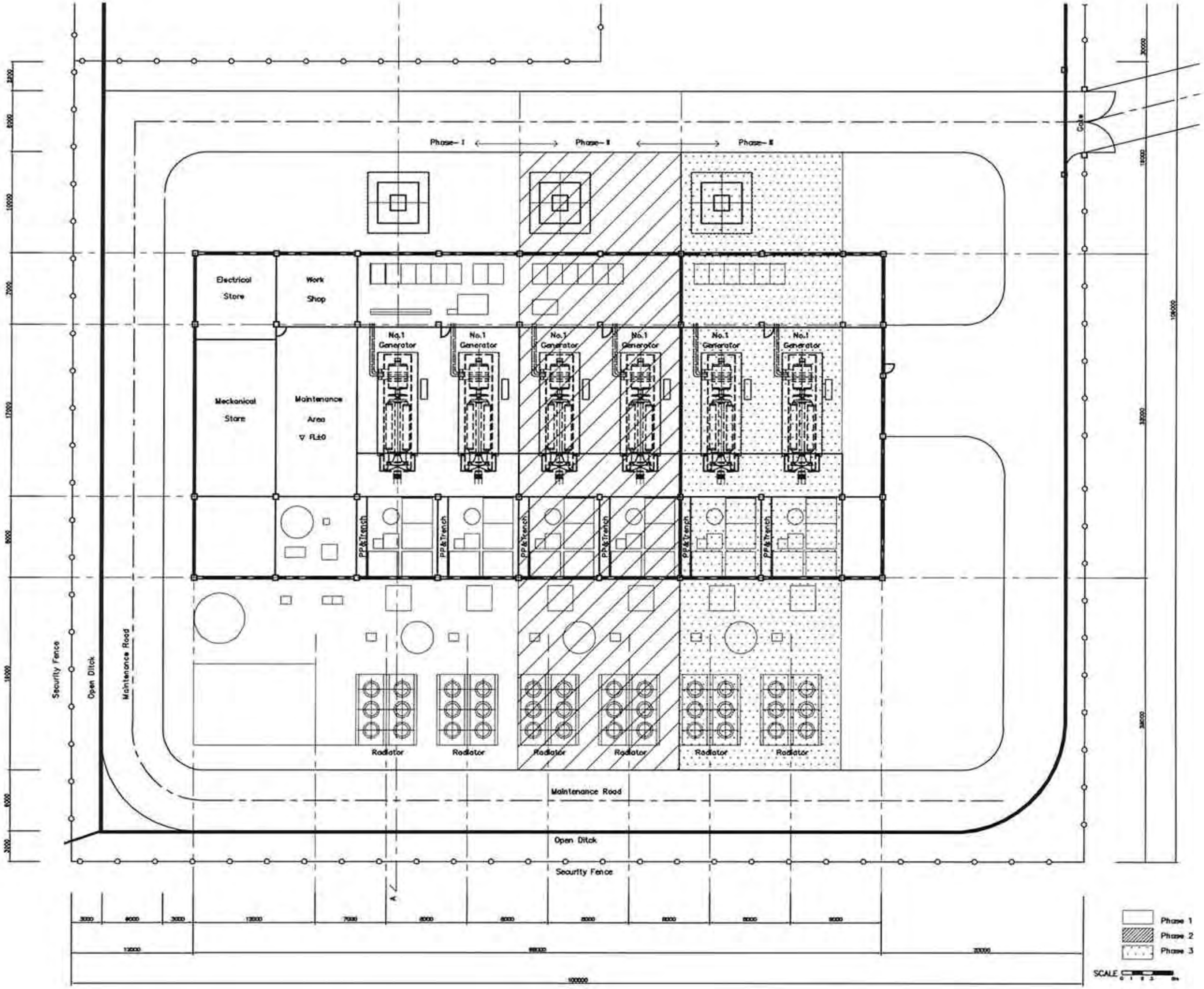

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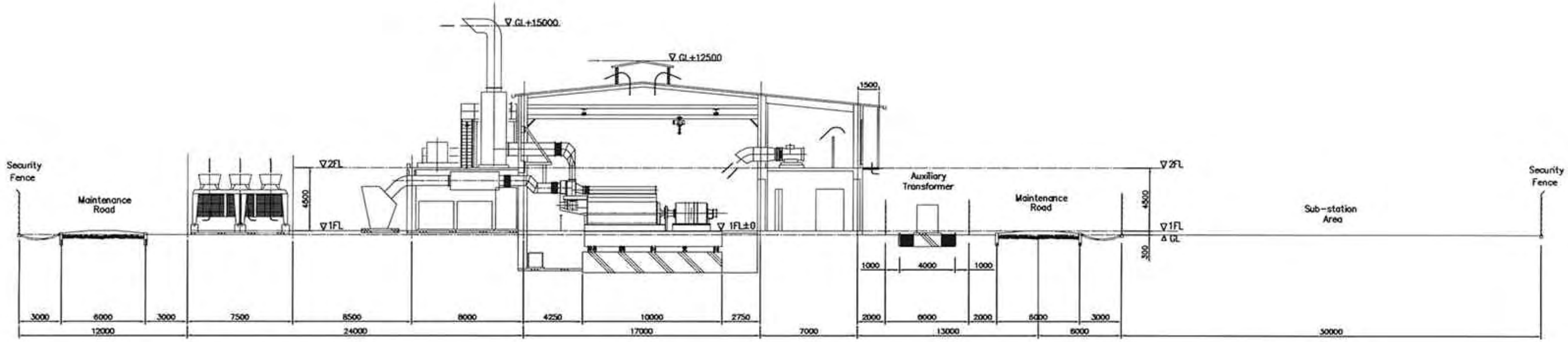

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Abbreviations

AAC	All Aluminum Conductor
AC	Aluminum Conductor
ACFA	Accelerated Co-Financing scheme with ADB
ADB	Asian Development Bank
ADF	Asian Development Fund
AFPAC	Automatic Fuel Price Adjustment Clause
ANSI	American National Standards Institute
AusAID	Australian Agency for International Development
CB	Circuit Breaker
CDM	Clean Development Mechanism
CEO	Chief Executive Officer
CFL	Compact fluorescent lamp
CFO	Chief Financial Officer
CTF	Compact Trust Fund
DS	Disconnecting Switch
DSM	Demand Side Management
EA	Environmental Assessment
EHC	Environmental Health Criteria Monograph No.238
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPC	Engineering, Procurement and Construction
EPDC	Electric Power Development Company
EQPB	Environmental Quality Protection Board
ETR	Electricity Tariff Rate
EU	European Union
FIRR	Financial Internal Rate of Return
FOB	Free On Board
FY	Fiscal year
F/S	Feasibility Study
GCB	Gas Circuit Breaker

GDP	Gross Domestic Product
GE	General Electric
GEF	Global Environment Facility
GIS	Geographic Information System
GM	General Manager
GNI	Gross National Income
GRT	Gross Receipt Tax
HDCC	Hard Drawn Copper stranded Conductor
HE	Heavy Equipment
HFO	Heavy Fuel Oil
IBRD	the International Bank for Reconstruction and Development
ICNIRP	International Commission on Non-Ionization Radiation Protection
IEE	Initial Environmental Examination
IEEE	Institute of Electrical and Electronic Engineers
IMF	International Monetary Fund
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature and Natural Resources
JAMSTEC	Japan Agency for Marine Earth Science and Technology
JBIC	Japan Bank For International Cooperation
JI	Joint Implementation
JICA	Japan International Cooperation Agency
LAN	Local Area Network
LDC	Least Developed Countries
LFT	Liquid Fuel Tax
LIBOR	London Inter-Bank Offered Rate
LP	Line Post
MCC	Motor Control Center
MCCB	Mold Case Circuit Breaker
MOPS	Mean of Platts Singapore
MRD	Ministry of Resources and Development
NASA	National Aeronautics and Space Administration
NEDO	New Energy and Industrial Technology Development Organization

NESC	National Electrical Safety Code
NOAA	National Oceanographic and Atmospheric Administration
NPV	Net Present Value
OCR	Ordinary Capital Resource
ODA	Official Development Assistance
OTEC	Ocean Thermal Energy Conversion
OGTF	Oil and Gas Task Force
OJT	On the Job Training
O&M	Operation and Maintenance
PICRC	Palau International Coral Reef Center
PNMDP	Palau 2020 National Master Development Plan
PPE	Palau Pacific Energy, inc
PPR	Palau Pacific Resort Hotel
PPUC	Palau Public Utilities Corporation
PSIP	Public Sector Investment Program
PT	Potential Transformer
SARS	Severe Acute Respiratory Syndrome
SCADA	Supervisory Control And Data Acquisition
SEL	Schweitzer Engineering Laboratories, Inc.
SID	Small Island Developing Countries
SVR	Step Voltage Regulator
TA	Technical Assistance
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Program
UNELCO	Union Electrique du Vanuatu
USAID	United States Agency for International Development
USGS	United States Geological Survey
WHO	World Health Organization

1. BACKGROUND AND HISTORY OF THE STUDY

1. Background and History of the Study

1.1 Background of the Study

The Republic of Palau (hereinafter referred to as "Palau") is located in the Pacific Ocean approximately 3,200 km south of Japan and is an island country consisting of some 340 islands with a total area and population of 488 km2 and 19,907 (2005 National Census) respectively. Political and economic activities in Palau are centred on Babeldaob Island, where the capital of Melekeok is located, and on Koror Island as some 93% of the total population live on these islands (2005 National Census). The power demand (peak load) on these islands recorded an average annual growth rate of 7.3% in the nine year period from 1997 to 2005 due to stable population growth of 2% a year, increased power consumption per capita and development of tourism, etc. Meanwhile, the power supply facilities of the Koror-Babeldaob power system can no longer provide a stable power supply due to their deterioration and insufficient maintenance and, following the breakdown of equipment in August 2006, planned outages of eight hours a day were introduced for one and a half months.

However, the planning capabilities of the Ministry of Resources and Development (MRD) and the operation and maintenance capabilities of the Palau Public Utilities Corporation (PPUC), which are responsible for power supply in Palau, are still insufficient while adequate discussions have not been conducted on the necessary measures to deal with a possible power crisis in the future.

Against this background, the Government of Palau has made a request to the Government of Japan for a development study for the formulation of a power supply improvement plan (hereinafter referred to as "the Study"). The suggested contents of the Study include the power demand forecast for Koror and Babeldaob Islands, formulation of a power facilities plan, Feasibility Study (F/S) on the power facilities required from the medium to long-term viewpoint, examination of possible funding sources, improvement of the business management of the PPUC, development of human resources at the PPUC and recommendations for the improvement of power facility operation.

1.2 Basic Policies of the Study

1.2.1 The regional power supply and demand in Palau is in the midst of a major transitional period because of the relocation of the capital in October 2006 and replacement work for the Aimeliik Power Station in recent years. In the Study, the optimal power development plan was formulated taking such changes of the power supply and demand situation in Palau into consideration.

1.2.2 For strengthening of the local capability to operate and maintain the power supply facilities, concrete and effective recommendations were made utilising the expert knowledge accumulated in the previous grant aid cooperation and follow-up study, the soft components of similar projects and the know-how of the power corporation, etc.

1.2.3 For business management improvement and funding, concrete as well as feasible plans were proposed to enable the PPUC to implement the priority projects targeted by the pre-F/S at an early date.

2. SOCIOECONOMIC CONDITIONS AND DEVELOPMENT PROGRAMMES IN PALAU

2. Socioeconomic Conditions and Development Programmes in Palau

2.1 Situation of Social Development

2.1.1 Population, History and Geography

The Republic of Palau (hereinafter referred to as “Palau”) is located between 6°53’N and 8°12’N and between 134°8’E and 134°44’E with a total land area of 488 km^2 and a population of 19,907 (2005 National Census). Although the capital was relocated from Koror State to Melekeok State in 2006, Koror State where 64% of the total population is concentrated is still the centre of Palau’s economic activities. Foreign nationals account for some 31% of the total population. The largest expatriate ethnic group is made up of Filipino settlers and workers, accounting for approximately 17% of the total population.

Palau became an independent country of Free Association with the US on 1st October, 1994 under the Compact of Free Association which guaranteed financial assistance by the US for a period of 15 years until 2009 while entrusting the US with the responsibility for the national defense and security of Palau. Based on this Compact, funding totalling US$ 700 million has been provided for Palau for the 15 year period and the annual payment of these funds has been an important source of income to support Palau’s economy.

2.1.2 Industrial Activities

The main industries of Palau are (i) the construction industry which relies on grant aid from the US and Taiwan, (ii) commerce based on the importation of foodstuffs and consumer goods, and (iii) tourism. However, sine it will be difficult for Palau to achieve economic autonomy by 2009 when financial support from the US under the Compact expires, the outcome of negotiations geared to extension of the Compact will greatly influence the Palau economy. Each industry is highly dependent on foreign labour which is primarily provided by Filipino workers. Tourism, which is one of the main industries in Palau, attracts more than 90,000 tourists a year, primarily from Taiwan, Japan, Korea and the US.

Palau is classified as a middle income country as its GDP per capita is US$ 7,267 (2005). However, of the government revenue of US$83.7 million in 2006, more than US$ 45 million, i.e. more than 50%, came from foreign aid, including funding under the Compact. Accordingly, the real GDP per capita is inferred to be around US$ 2,000 – 3,000.

The manufacturing, agricultural, fisheries and mining industries are not particularly extensive although in the fisheries industry, a foreign fishing company has obtained fishing rights for offshore Palau to export tuna to Japan, Korea and China. The local supply of food is heavily dependent on imports from the US even though taro and cassava are locally produced along with the catch of coastal fishery.

2.1.3 Situation of Public Services and Infrastructure Development

The Government of Palau in 1996 formulated the Palau 2020 National Master Development Plan (PNMDP) geared to achieving self-reliant development apart from the traditional reliance on US aid and to protecting the national culture. Separately from this Master Plan, the Palau Sector Investment Programme (PSIP) was formulated in April, 2003. The PSIP identified tourism, agriculture, fisheries, trade and light industry as priority sectors for economic development. The PSIP also classified concrete development projects in such fields as transport (roads, airports and harbours), water supply, sewerage, solid disposal, energy and communication into three categories (A, B and C) based on their priority. While some of these projects are in progress with the assistance of various donors, many remain on the desk because of a lack of funding. The Government of Palau is currently in the process of formulating a new PSIP compiling development projects for the next five years (2008 – 2012).

Table 2.1.3-1 shows the development state of public services (as of 2005). The water supply coverage and electrification rate, including rural areas, are as high as 94.6% and 98.9% respectively. Telephones and televisions are used by more than 85% of the total number of households.

Table 2.1.3-1 Development Situation of Public Services

No. of Households	Water Supply		Electricity Supply		Telephone		Television	
	Households	Ratio (%)	Households	Ratio (%)	Households	Ratio (%)	Households	Ratio (%)
4,707	4,452	94.6	4,656	98.9	4,056	86.2	4,076	86.6

Source: 2005 Census, Republic of Palau

In regard to the transport network which is an important infrastructure, the K-B Bridge constructed with Japanese grant aid to connect Koror Island to Babeldaob Island has been playing an important role in stimulating the economy on these two islands. Compact Road was constructed with grant aid of the US in 2005 as a circular road for Babeldaob Island, the economic development of which was lagging behind that on Koror State, partly because of the small size of its population. This new road not only provides access to the new capital but also allows islanders to quickly move around the island.

2.2 Economy and Fiscal Situation

2.2.1 Economic Growth and Structural Characteristics

(1) GDP

According to World Development Indicators 2007 by World Bank, the economy appears to have expanded at an average of around 2% per annum over the last 10-12 years on the real term basis.

The GDP of Palau is estimated to have reached US$ 170 million in 2007, according to the provisional estimate by the Office of Planning and Statistics. Per capita GDP is estimated to be US$ 7,267.

(2) GNI

Palau has the highest per capita GNI (US$7,630, 2005, World Bank) and Receives the most per capita aid (US$1,712 averaging over 1999-2002) of the Pacific Island countries.

Palau has received substantial assistance from the United States through the Compact of Free Association, totalling US$ 500 million over the period of 1994-2009. Assistance under this accounts for roughly 20% of annual GDP.

Under the Compact agreement with the United States, Palau has received direct financial assistance for the first 15 years, however, after that it is expected to achieve autonomous economic development while making use of the Compact Trust Fund (CTF) accumulated so far. However, Palau is hoping that the United States will continue its direct financial assistance beyond 2009.

(3) Structural Characteristics

The Palauan economy has been dominated by the public sector for decades. Employment in the public sector is currently estimated to account for 26-27 % of GDP, while public fiscal expenditure in FY2007 accounted for 60.4% of GDP. The economy of Palau is dependent on public finance and could not be sustained if overseas economic assistance was withdrawn.

Tourism has the highest growth potential of any industry in the private sector. Judging from the condition of natural resources and the history of Palau, no other industry has the potential to drive the economy other than tourism. The number of tourists visiting Palau reached 95,000 in 2004, however, in recent years it has been around 90,000.

The primary industry of agriculture, forestry and fishing occupies a small share of GDP, representing only 3.4% of GDP, on the basis of 2005 GDP data. The secondary sector does not occupy a big share as well, representing only 19.0%, more than half of which derives from construction. On the other hand, the tertiary sector (service sector) occupies by far the largest share - 77.6% - of GDP.

(4) Financial Sector

Palau uses the US$ as its national currency. Therefore, it does not have a central monetary authority and does not have to operate an independent monetary policy. There are currently seven commercial banks and the government-owned Palau Development Bank, and several small credit unions and insurance companies. The largest commercial bank is the Bank of Hawaii, which is most commonly used by citizens and businesses in Palau, holding 80% of all savings and conducting 60% of all lending. The PPUC deals with the Bank of Hawaii and the Guam Savings Bank. It has time savings of approximately US$600,000 with the Bank of Hawaii.

Due to the undeveloped state of the financial sector in Palau, the majority of Palauan citizens invest in financial commodities based in the US or other overseas countries. The PPUC too entrusts the management of most of its financial assets to an American investment bank (US$12 million).

(5) Prices

Consumer prices in Palau jumped by 5% in 2004 due to inflation in oil prices and increased taxes on cigarettes and alcohol, etc. Inflation has remained relatively high in the years since then (3.9% in 2005, 4.5% in 2006, and 2.9% in 2007).

2.2.2 Fiscal situation

(1) Budgetary Deficit

In 2002, the overall budgetary deficit accounted for US$ 34.2 million, which was equivalent to around 30% of GDP. Thereafter, the deficit has been reduced to less than 10%. However, government spending (expenditure) is very large accounting for more than 50% of the GDP, and it greatly outstrips government revenue every year. This shortfall is covered by grants under the Compact, and these grants amounted to US$53 million in 2006. Accordingly, there is no doubt that the economy of Palau would go insolvent without the financial assistance provided under the Compact. The Compact renewal negotiations planned for 2009 will have a vital impact on the future economy of Palau.

The largest expenditure item in the Government budget is wages and salaries, which accounts for a quarter of GDP, or around 40% of public expenditure. In general, public sector overwhelms private sector in terms of wages and salaries. As a result, many capable and trained people are employed by public sector. It seems to be difficult for private sector to attract capable workers.

(2) Balance of Payments

Since Palau is a very small country of only 20,000 people, it is very difficult to develop a competitive manufacturing sector when viewed in terms of international relative superiority. For this reason, Palau inevitably relies on imports and is faced with a trade deficit. All neighboring island nations in the Pacific face the same situation, and it is something that must be accepted. On the other hand, it is desirable for Palau to seek parity in its international balance of payments through developing tourism and related service industries based on utilizing the country’s natural resources.

When the Compact of Free Association commenced, the external debt outstanding was US$20 million, and external debt in 2006 stood at US$17.5 million. Palau recently borrowed US$20 million from Taiwan in order to fund construction of the new capital in Melekeok.

Concerning the future funding of national finances in Palau, the Compact Trust Fund, which started from an initial investment of US$ 70 million, had reached US$157 million as of the end of FY2007.

2.2.3 Compact Renewal and Economic Reform

(1) Negotiation of the Compact renewal scheduled in 2009

Under the Compact agreement, the US will provide direct financial assistance to Palau for the first 15 years (up to 2008), while in the 35 years after that (2009~2043), it is hoped that Palau can realize autonomous development utilizing the balance of the Compact Trust Fund (CTF).

As was mentioned in the last section, the CTF balance stood at US$ 157 million as of the end of FY2007. As stated in the Compact, the purpose of CTF is to provide a steady source of income that would replace the annual grants after the termination in 2009. However, according to study and analysis conducted by the IMF in 2004, it is predicted that the CTF will be exhausted before 2043. The IMF gave three scenarios, i.e. the optimistic case where the CTF lasts until 2031, the intermediate case where it lasts until 2023, and the pessimistic case where it runs out in 2019.

When this is considered, the Compact negotiations scheduled for 2009 take on paramount importance for Palau. Clearly there wouldn’t be a problem if Palau could self-sustainably manage and develop its economy without direct grant aid as was originally hoped, however, the fact is that the economy will become insolvent if American grant aid is finished.

(2) Structural Reform of the Palauan Economy and Development Policy

In order to realize future self-sustainable growth, great expectation is placed on growth of the private sector. Promotion of tourism should be the central factor in this, and it is hoped that a selective growth and development strategy that strategically incorporates a number of sectors is adopted. As the IMF and ADB point out, economic structural reforms in the following areas are required: ① formulation and execution of strategy geared to promoting high-end tourism that generates greater expenditure per tourist, ②complete overhaul investment regulations geared to attracting overseas investment, ③ review of the role of the Government and public sector in the economy, ④ tax reform, ⑤ land reform, ⑥ reform of financial systems and the financial sector, and ⑦ reform of the legal system for commercial activities.

2.3 Development Plans

Palau has several development plans, including the Palau 2020 National Master Development Plan (PNMDP), the Regional Development Promotion Plan for Palau (October, 2000, JICA) and the Public Sector Investment Program 2003 – 2007 (PSIP). As some time has passed since the formulation of these plans, the PNMDP of which the review has been in progress with the technical assistance of the Asian Development Bank is believed to indicate the latest development policies. This review began in August, 2007 by a team of Australian and New Zealand consultants and the draft report is compiled as of May, 2008. In the draft report, development priority is ranked by sector and project. The expansion of PPUC’s power generating facilities is ranked as the second highest.

3. CONDITIONS OF ELECTRICITY AND ENERGY SUPPLY IN PALAU

3. Conditions of Electricity and Energy Supply in Palau

3.1 Policies, System and Organization Relating to Electricity and Energy Supply

3.1.1 Electricity and Energy Policies

The Palau 2020 National Master Development Plan (PNMDP) was formulated in 1997, and development of the electricity sector has been advanced based on this with the policy of improving and expanding power supply facilities.

At present, work is in progress to revise the PNMDP with the technical assistance (TA) of the Asian Development Bank (ADB), however, it is unclear how the policies for the electricity and energy sector are treated in this revision process. As an individual policy regarding the electricity and energy sector, Executive Orders of the President No. 234 and No. 245 regarding a reduction of the energy consumption have been enforced. These orders clearly specify the obligation and targets for government organizations to reduce their energy consumption. In November, 2007, the Energy Efficiency Action Plan was formulated with EC assistance, indicating energy consumption reduction measures (wide use of small fluorescent lamp and a subsidy for the installation of solar water heaters, etc.) for both the public and private sectors.

3.1.2 Legal Framework for Electricity Business

RPPL No. 4-13 (PUC-Act) enforced on 16th February, 1994 provides the only legal framework for the electricity business in Palau. In accordance with the PUC-Act, the Palau Public Utility Corporation (PPUC) was established. The PUC-Act stipulates the authority and obligations of the PPUC, the transfer of assets from the government to the PPUC and the procedure for revision of the electricity tariff, etc.

3.1.3 Organizations Relating to Electricity and Energy Policies

Energy policies in Palau fall under the jurisdiction of the Ministry of Resources and Development (MRD). The MRD has four bureaus, i.e. Bureau of Agriculture, Bureau of Marine Resources, Bureau of Public Works and Bureau of Land and Surveys. The Office of Energy is within the Bureau of Public Works. This Office of Energy is mainly responsible for the promotion of the introduction of renewable energies as well as energy saving and there is no central organization in charge of electricity and energy policies. Fig. 2.1.3-1 shows the organizational set-up of the MRD.

3.2 Organizations Relating to Electricity Business

The electricity business in Palau is run by the PPUC. The management of the PPUC is under the direct supervision of the Board of Directors appointed by the President and is not under the supervision of the MRD.

The PPUC has six departments, i.e. Business Office, Accounting and Finance, Auxiliary Services, System Control, Power Distribution and Power Generation,-as shown in Fig. 2.2-1, and employs some 130 people.

The PPUC has office regulations which clearly specify the contents, obligations and required abilities, etc. for each type of job in the PPUC. While the technical staff of the Power

Generation Department and Power Distribution Department have sufficient technical expertise to conduct the routine operation and maintenance of the power supply facilities, both the manpower and capacity of the PPUC are insufficient to formulate medium to long-term facility improvement and maintenance plans. At the end of 2007, the PPUC newly recruited one mechanical engineer and one electrical engineer in its efforts to improve the technical level relating to power generation, transmission and distribution. However, these engineers were recruited from a neighbouring country and it is essential for the PPUC to train and upgrade its own engineers.

3.3 Power Supply and Demand Situation

3.3.1 Power Demand

(1) Nationwide Power Demand

Upon looking at annual changes in the power demand in Palau in the last seven years , by type of user, the commercial demand accounts for 40%, the residential demand accounts for between 32~35%, and the public sector demand of the central and state governments accounts for the remainder.

The total power demand has been just over 80 GWh since 2004, however, as Palau’s total power demand is not especially large, it can be easily affected by the opening of a large-scale commercial facility or hotel, the holding of a major event and/or outages caused by problems of the power facilities. Therefore, the annual figures do not necessarily represent the real power demand.

The power demand increased in 2007, suggesting the potential for a power demand increase due to an increase of the GDP and population, etc.

(2) Power Demand by State

In line with relocation of the capital from Koror State to Melekeok State on Babeldaob Island, the power demand in Melekeok State in the Koror-Babeldaob power system doubled from 2006 to 2007. Meanwhile, the power demand in Koror State, which accounts for 64% of Palau’s population, has levelled off although it still accounts for some 80% of the total power demand of this power system, illustrating the status of Koror State as a major power consumption area.

3.3.2 Power Supply Capacity

In Palau, the successive breaking down of four generating units, i.e. Wartsila-2, Wartsila-3, Mitsubishi-1 and Mitsubishi-2, at the Malakal Power Station in 2006 made it necessary to introduce planned outages for eight hours a day in August, 2006. This situation lasted until mid-September, gravely affecting the society and economy of Palau, however, repairs were completed and operation restarted in January 2007. As a result, the supply capacity as of May 2008, including that provided by the Aimeliik Power Station, stands at 19.6 MW. The highest ever output of 16.88 MW was recorded in November 2004 (FY 2005), indicating a reserve supply capacity of 13.8% at present.

Moreover, the PPUC is currently in negotiations to purchase one 5 MW class diesel engine generator. With this new unit, the total available capacity will increase to some 26 MW in

2009, however, the present reality is that many of the generating units are liable to break down at any time and all of the existing generating units face harsh operating conditions. Accordingly, the PPUC needs to continue implementing rehabilitation of its existing power generating equipment.

3.3.3 Load Characteristics of the Koror-Babeldaob Power System

Using demand data, power generation data and the maximum generating-end output in Palau from 1996 to 2007, as a result of calculating the power loss and load factor, the total power loss including the power station service load, transmission and distribution losses, streetlight load and non-technical loss, is approximately 20%. As the corresponding figure was some 25% around 10 years ago, a trend of improvement can be observed. The load factor is approximately 73 – 74%, however, since this is around 70% in Southeast Asian countries, the calculated load factor for Palau cannot be described as low, suggesting a relatively high level of facility utilisation. The peak load is observed in the evening, indicating that the type of power load in Palau is a typical civilian-led power load where the lighting load plays the central role. The load curve by day shows the beginning of a load increase at around 9 o'clock in the morning on weekdays and Saturdays, suggesting an increase of the load at offices and commercial premises, etc. On Sunday, the overall demand is some 10% lower than on other day of the week and the daytime load is relatively flat. As there is no major factory load in Palau, other load sources are inferred to be air-conditioning unit and refrigerators, etc. at homes, offices and commercial premises. More detailed examination results of the load configuration are described later.

3.4 Present Conditions of Power Generating Facilities and the Power Supply System

3.4.1 Conditions of Power Generating Facilities

The Koror-Babeldaob power system is served by two power stations, i.e. Malakal Power Station on Koror Island and Aimeliik Power Station on Babeldaob Island. Both power stations employ a diesel power generating system using diesel oil as the fuel. Table 3.4.1-1 outlines these two power stations. With deterioration due to age, as of May, 2008, the total available output of the two power stations is 19.6 MW which is approximately 64% of the total rated output. Table 3.4.1-2 shows the present conditions of the generating facilities at these two power stations.

Table 3.4.1-1 Generating Facilities of the PPUC
(for the Koror-Babeldaob Power System)

Power Station	Unit	Manufacturer	Rated Output (MW)	Available Output (MW)	No. of Cylinders	Engine Speed	Year of Installation
Aimeliik	Pielstick-2	Crossely Pielstick	3.27	2.0	10	450 rpm	1986
	Pielstick-3		3.27	2.0	10	450 rpm	1986
	Pielstick-4		3.27	2.0	10	450 rpm	1986
	Pielstick-5		3.27	2.0	10	450 rpm	1986
Sub-Total			13.08	8.0			
Malakal	Wartsila-1	Wartsila	2.00	1.7	12	1,200 rpm	1998
	Wartsila-2		2.00	(1.7)	12	1,200 rpm	1998
	Wartsila-3		2.00	(1.7)	12	1,200 rpm	1998
	Mitsubishi-12	Mitsubishi	3.40	3.2	12	720 rpm	1998
	Mitsubishi-13		3.40	3.0	12	720 rpm	1998
	Caterpillar-1	Caterpillar	1.825	1.6	16	1,800 rpm	2006
	Caterpillar-2		1,825	1.6	16	1,800 rpm	2006
	Alco-9	Alco	1.25	0.5	n/a	n/a	n/a
Sub-Total			17.70	11.6			
Total			30.78	19.6			

Source: PPUC

Table 3.4.1-2 Present Conditions of the PPUC's Generating Units
(for the Koror-Babeldaob Power System)

Power Station	Unit	Accumulated Operating Hours*	Operability	Present Conditions
Aimeliik	Pielstick-2	128,860	Operable	• Noticeable decline of the output and efficiency due to severe deterioration • Scheduled for rehabilitation in September 2008 (following rehabilitation of Unit No. 3)
	Pielstick-3	122,359	Operable	• Noticeable decline of the output and efficiency due to severe deterioration • Under rehabilitation as of May 2008
	Pielstick-4	134,584	Operable	• Noticeable decline of the output and efficiency due to severe deterioration • Scheduled for rehabilitation in 2009 or later (following rehabilitation of Unit No 2)
	Pielstick-5	132,149	Operable	• As above
Malakal	Wartsila-1	59,587	Operable	
	Wartsila-2	n/a	Inoperable	• Operation suspended due to burning of the crank shaft • Scheduled for repair of the crank shaft after completion of repairs to Unit No. 3
	Wartsila-3	n/a	Inoperable	• Repair of the crank shaft being implemented as of May 2008
	Mitsubishi-12	69,177	Operable	• Light burning of the crank shaft in August, 2006 and repair work to grind the crank shaft completed. Currently in operation
	Mitsubishi-13	63,386	Operable	• Heavy burning of the crank shaft in March, 2006 and repair work to grind the crank shaft completed
	Caterpillar-1	4,358	Operable	
	Caterpillar-2	4,379	Operable	
	Alco-9	35,207	Operable (stand-by)	• Noticeable decline of the output and efficiency due to severe deterioration

* As of the end of May, 2008
Source: PPUC

3.4.2 Conditions of Transmission and Distribution Facilities

(1) Transmission and Distribution Lines

1) Outline of Transmission and Distribution Lines

The transmission and distribution lines in Palau use 34.5 kV and 13.8 kV respectively with a three phase, four wire system, a frequency of 60 Hz and a multiple neutral grounding system. Table 2.4.2-1 outlines the transmission lines. The total length of transmission lines is 75.4 km, while the total length of distribution lines is 195.1 km.

2) Supports

Concrete poles are the main supports used by both the 34.5 kV transmission lines and 13.8 kV distribution lines. In the case of the 34.5 kV transmission lines, steel pipe poles are used in view of workability at sites where access was difficult at the time of installation due to poor road conditions. In comparison, many wooden poles are used for the 13.8 kV distribution lines.

Pole assembly comprises 34.5 kV double circuit lines (between the Aimeliik Power Plant and the Nekken Substation: one towards the Airai Substation and the other towards the Kokusai Substation), 34.5 kV or 13.8 kV single circuit lines, and 34.5 kV and 13.8 kV double circuit lines. In addition, there is little influence by the typhoon, so the accidents such as the support collapse have not occurred until now.

3) Conductors

AAC 150 mm^2 conductors are used for the 34.5 kV transmission lines. Connection between Babeldaob Island and Koror Island is provided by submarine cable but the absence of any design documents or installation records, etc. means that the type of this submarine cable is unclear. For the 13.8 kV distribution lines, AAC 150 mm^2 is used on some sections, however, AC 38 mm^2 and HDC 38 mm^2 are the main types.

4) Insulators

The types of insulators used are line post insulators for straight pull poles and a combination of line post insulator and suspension insulators for angle poles.

5) Standard Span, Ground Clearance and Phase-to-Phase Distance

The transmission and distribution lines in Palau have been constructed with a standard span of 50~70 m. The minimum ground clearance (6.4 m for transmission lines, 6.1 m for distribution lines) and phase-to-phase distance (1,190 mm for transmission lines, 825 mm for distribution lines) are based on the relevant specifications under the National Electrical Safety Code of the US.

6) Maintenance, Management and Work

① Maintenance

The early facilities were installed or constructed around 1985 and are now some 23 years old. Since periodic equipment inspections are not implemented, some insulators appear to be covered with dust while others have had their serial numbers erased by rainwater, etc. The PPUC is implementing inspections based on a list of equipment inspections it prepared in December 2007.

Once an accident occurs, PPUC staff members visit the site in response to a report by a local resident to deal with the situation (two members are designated to conduct emergency response).

② Management

Facility data is managed using the GIS (Geographic Information System). As the PPUC only possesses drawings, etc. prepared at the time of construction or installation, it is difficult to check the actual site condition based on the drawings which do not reflect the construction situation of Compact Road and the relocation of obstacles for the road.

③ Work

In principle, all transmission work and distribution work is directly conducted by the PPUC. For this reason, the PPUC owns four trucks mounted with an aerial work platform, two augers required for pole installation work and one crane, etc.

7) Other

The PPUC has its own training facilities in Malakal Power Station. In Koror Island, newly construction of the transmission or distribution lines appears to be difficult as the existing lines traverse roads. It is, therefore, advisable to introduce conduit lines for the installation of underground cables when road work is necessary

(2) Transforming Facilities

1) Outline of Transforming Facilities

There are 12 substations (including those on power plant premises) in the Project target area. Only the Aimeliik Substation and the Malakal Power Station have a circuit breaker for the transmission line, however, it is difficult to conduct planned outages due to problems in system configuration, while periodic inspections as recommended by the manufacturers are not conducted. It is planned to overhaul (replacement of the insulating oil and some parts) the transformers at the Airai Substation and Aimeliik Substation in June 2008 or thereafter.

2) Substation Configuration

The Aimeliik Substation which is one of the main power supply facilities is situated next to the Aimeliik Power Plant. This substation is the only substation with a configuration of two transmission lines and two transformer banks. An oil circuit breaker is installed on the primary side of both the transmission line and transformer.

The Malakal Power Station which is another power source consists of a transmission line and a transformer. For this reason, the circuit breaker for the transmission line also acts as the circuit breaker for the primary side of the transformer.

In the case of the Airai Substation, from which the distribution line extends to Koror Island, an oil circuit breaker is installed on the primary side of the transformer but the transmission line (linking the Aimeliik Substation to the Malakal Power Plant) passing through the substation premises only has disconnecting switches. These switches cannot interrupt fault current. From this point this substation does not have the ability to divide the transmission line.

At the other existing substations, the standard configuration is the connection of the transmission and distribution lines via a cut-out to a pole-mounted transformer.

3) Switching Devices (Air Insulation)

34.5 kV oil circuit breakers are used but their conditions are far from ideal as many traces of oil leakage are observed. At the Airai Substation, the height of the frame is dangerously low as evidenced by a serious accident involving the house-service transformer (protective fencing for the equipment is already installed). It is inferred that the existing disconnecting switches do not often experience common problems relating to the control system as they are manually operated with few occasions for outages for maintenance work.

4) Switchgear

The 13.8 kV switchgear at the Malakal Power Plant has a simple roof but the top side of the switchgear is rusted. Even though the leakage of rainwater through the roof cannot be ascertained as being responsible for this rust, two circuit breakers for the distribution lines have already been replaced because of breakdown. At present, work is in progress to enclose the switchgear. The switchgear at the Airai Substation is installed indoor and its condition is relatively good. However, it is installed so as to block the equipment delivery door, making any future use of this door impossible.

5) Transformer Winding

The standard connection types for the transformer winding are a Y-connection (direct neutral grounding) for the 34.5 kV lines at power stations, △-connection for the primary side of the distribution transformers and Y-connection (direct neutral grounding) for the secondary side of the distribution transformers. Of the two distribution lines drawn out of the Airai Substation, that heading towards Koror Island can be linked to the same Y-connection distribution line for the Malakal Power Plant. The other heading towards the airport cannot be linked live to the distribution lines from other substations on Babeldaob Island because of the different phase angle.

(3) SCADA

1) General

The Supervisory Control and Data Acquisition (SCADA) currently used by the PPUC was introduced in 2003 and is primarily used to monitor the power generation and transforming facilities, presumably because of the unfamiliarity of the system to its operators who have not received sufficient training. Electric Power Systems (EPS) Co., which supplied this SCADA system, is refusing to supply the terminal (portable PC) and password required to settle and change the relay setting. Consequently, it is necessary for the PPUC to place an order to EPS whenever a change of the protective relay setting is required and this situation makes the use of the system awkward.

2) Operation Records

Data cannot be accessed outside and new data is written over old data in sequence. For this reason, the available old data is in the form of a print-out and is not used for analysis (because of the difficulty of doing so).

3) Equipment Control

The power system is partially displayed on the pages featuring the two power plants, the Airai Substation, other 34.5 kV transmission lines and distribution lines. There is no single page displaying the entire system, making it difficult to quickly establish the operating status of the system. While it is possible to operate the substation circuit breakers from the Malakal Power Plant, the range of equipment which can be controlled in this manner is quite limited.

4) Recommendations

The existing SCADA system places a lot of dependence on EPS Co., and the PPUC cannot even freely settle and change protective relays. Accordingly, it is time to consider either expanding the current system based on outsourcing or upgrading the system to enable the PPUC to gauge and manage all aspects. The latter approach can be realized by renewing all existing SCADA terminals(excluding EPS Co.) or maintaining the current system upon officially purchasing the necessary information (terminal passwords, etc.) from EPS. In this case, since the system supplier would implement program repairs to the SCADA main unit, it is necessary to bind a contract at an appropriate cost.

3.5 Power Development Plans

Plans to improve or expand the power supply facilities have been formulated in Palau and the development of the power sector has been promoted under the development policy for the power sector set forth in the Palau 2020 National Development Plan (PNMDP) formulated in 1997. In October, 2003, a five year plan for the PPUC was prepared by Oceanic Companies (Marshalls), Inc., an American consultancy firm. This plan called the PPUC Strategic Plan 2003 – 2008 features a development plan for the power generation, transmission, distribution and substation facilities, calculation of the development cost, the necessary environmental and social considerations in the face of the planned development, a plan to revise the electricity tariff and other matters.

The PPUC Strategic Plan is considered to be the power development plan in Palau, and the principal goals and measures to achieve the goals of this plan are described below.

However, most of the proposed projects under the power generation, transmission, distribution and substation facilities development plan and the social and environmental consideration plan necessitated by the development and the plan to revise the electricity tariff, etc., all of which are proposed by the PPUC Strategic Plan 2003 – 2008, have not been implemented because of the lack of the necessary funding. In the case of the generating facilities, however, the installation of one 5 MW diesel engine generator at the Aimeliik Power Station is planned with a loan from Taiwan and negotiations with the Taiwanese company responsible for the procurement and installation of this generator are in progress.

Commencement of the operation of this generator is expected in 2010.

3.6 Potential of Primary and Renewable Energy in Palau

3.6.1 Endowment Situation of Primary Energies

The preliminary study report on oil and gas deposits in Palau compiled by the Oil and Gas Task Force (OGTF) in August 2007. According to this report, the Government of Palau, the Government of Kayangel State and TBMR/Sharp Drilling, Inc. (based in Texas, USA) concluded an exclusive oil drilling agreement for the Velasco Reef sea area. The agreement was subsequently inherited by Palau Pacific Energy, Inc. (PPE) in 1997. So far, even trial drilling has not been conducted because of the absence of reliable seismic survey (geological survey of the seabed using elastic waves) data.

Under this agreement, PPE was required to drill the first well within two years, however, because it failed to perform this, the Government of Palau abandoned the agreement with PPE in 2001 because of default. Meanwhile, the Government of Kayangel State concluded an agreement lasting until 2011 and submitted two applications to the EQPB for permission for trial drilling in the Velasco Reef sea area, citing PPE as the drilling company. However the drilling permits for these two applications have been on put on hold on the grounds that sufficient data has not been gathered to conduct an environmental impact assessment.

As the main industries in Palau, such as tourism and fisheries, rely on the rich marine resources, the Government of Palau has become more cautious in recent years regarding the development of oil. In February 2003, a study team financed by the World Bank was dispatched to Palau to examine the feasibility of oil development in the Velasco Reef sea area. This study team concluded that both the Government of Palau and the Government of Kayangel State lack (i) legal as well as technical knowledge concerning oil development and (ii) proper consideration of the environmental aspects and that Palau was, in fact, at a very early stage of oil development. The study team found the urgent establishment of legal, institutional and financial systems regarding the awarding of oil drilling rights and the oil business and also technical standards to be necessary. Accordingly, the study team recommended the postponement of the awarding of new oil drilling rights. It also recommended that a geological survey be entrusted to a professional survey organization to obtain information on the potential of oil reserves in the Velasco Reef sea area.

In conclusion, no oil or gas has so far been produced in Palau and the potential reserves have not been sufficiently confirmed. In view of the fact that such leading industries in Palau as tourism and fisheries are highly dependent on marine resources, any development of oil or gas businesses must be carefully conducted by studying the possible impacts, including trial drilling, on the environment in advance.

3.6.2 Potential of Renewable Energy in Palau

94% of Palau’s total population is connected to the distribution grid of the PPUC and a photovoltaic power generation system is principally used on islands which are distant from Koror Island or Babeldaob Island along with an independent diesel power generation system from the PPUC’s distribution grid.

In Palau, the Energy Office, which is directly controlled by the Ministry of Resources and

Development (MRD), is responsible for the planning of future renewable energy policies. As of May 2008, however, insufficient manpower (the Energy Office is run by its head and one staff member) means that the analysis of past study reports and the gathering of topographical and meteorological data for the purpose of developing renewable energies have not been sufficiently conducted, and no concrete policies have been formulated.

Palau participated in the Kyoto Protocol in December 1999 as a non-Annex I party and numerical targets for the reduction of greenhouse gas emissions have not been imposed. An increase of CO_2 and other greenhouse gas emissions in developing countries where further development is sought to improve the standard of living is almost unavoidable. Palau is classified in the category of small island developing countries (SID), which are believed to be the most liable to the effects of climate change as in the case of least developed countries (LDC), and it is important for Palau to clarify its own approach to the mitigation as well as adaptation to climate change to protect itself.

Moreover, the oil used in Palau as a source of primary energy is entirely imported and the economic structure of Palau has, therefore, been prone to direct impacts of oil price hikes in recent years. In consideration of this situation, it is necessary to examine feasible renewable energies while bearing in mind the need to reduce the emission of CO_2 and to alleviate the dependence on oil as a primary energy source through the introduction of renewable energies.

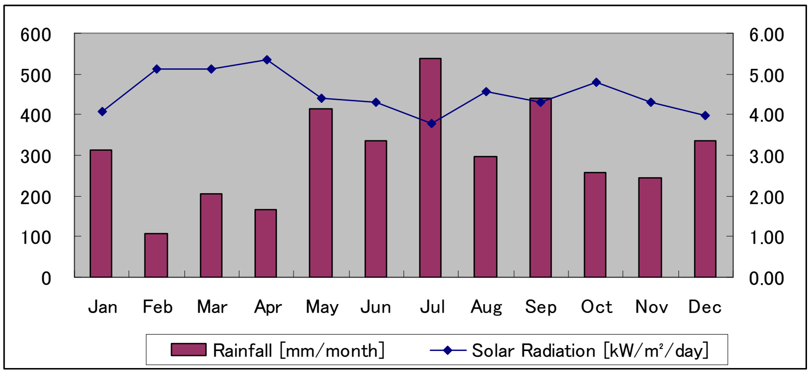
(1) Potential for Hydropower Generation

Palau is an island country and the number of rivers which can be used for hydropower generation are limited. As the highest altitudes on Babeldaob Island are around 100~150 m, the effective head for the purpose of hydropower generation is inferred to be around 60 m. Vergel3 Consult of the Philippines conducted a survey in November, 2005 on the hydropower generation potential in Palau and selected three river systems, i.e. Diongradid, Ngermeskang and Ngrikill, as potential river systems for hydropower generation from the viewpoints of the retained water available in the river system and the effective head. It concluded that an inflow type hydropower generation system would not produce a sufficient output at any of these river systems in view of the low river discharge and insufficient effective head even if the length of the intake channel is sufficiently stretched.

Moreover, in this report, based on the assumption of a micro hydropower system of around 1,000 kW capacity, it is deemed that these river systems cannot secure the effective head or generator water inflow unless reservoir systems are adopted. However, micro-hydropower generation with the range from 100 to 200 kW is highly possible in Palau because it has plenty of rainfall and a lot of small rivers and streams. Thus, possibility to introduce hydropower that is linked to other water resource development should be evaluated.

(2) Potential for Photovoltaic Power Generation

Data is available on the amount of solar radiation on the ground surface, which is calculated based on the amount of solar radiation and the duration of sunshine observed by a NASA satellite, while the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) established a meteorological data observation station at Aimeliik in 2003 and has since been gathering data on solar radiation on the ground surface. Fig. 3.6.2-1 shows the mean amount of solar radiation (measured at a level surface) and rainfall data for the last three years gathered by the JAMSTEC. While the amount of solar radiation tends to decrease during the rainy season from May to September (some reference materials consider the rainy season to last until October), the value is still higher than the mean amount of solar radiation measured at the optimal angle of inclination in Japan throughout the year, confirming the potential for photovoltaic power generation in Palau.



Source: JAMSTEC

Fig. 3.6.2-1 Amount of Solar Radiation and Rainfall in Palau (at Aimeliik)

(3) Potential for Wind Power Generation

The wind conditions in Palau are heavily dependent on the topography and considerably vary over a short distance of several kilometres. Accordingly, the wind velocity and wind direction data observed by meteorological stations and others is not very effective to assess the potential for wind power generation. At present, no anemovanes are installed in Palau for the purpose of assessing the wind power generation potential. The only available wind data is meteorological data gathered at the Koror Observation Station of the Palau Meteorological Centre, the JAMSTEC's Aimeliik Observation Station and the Ngardmau, Ngermlengui, Ngchesar, Aimeliik and Oikull Observation Stations of the Palau International Coral Reef Centre (PICRC). The data gathered by the PICRC's observation stations is not properly sorted and it is necessary to obtain and sort out the raw data.

Meanwhile, the guidelines of the New Energy and Industrial Technology Development Organization (NEDO) for the introduction of wind power generation stipulate that the target sites for wind power generation should have a mean annual wind velocity of at least 5 m/sec or 6 m/sec if possible. Based on the currently available wind velocity data for Palau, the potential for wind power generation in Palau is not very high.

Finally, in determining the wind power generation potential of Palau, it is necessary to project the scheduled site of wind power generation system installation and evaluate the feasibility of construction based on wind data obtained there.

(4) Others

There are other renewable energies, such as OTEC (ocean thermal energy conversion) and biomass energy, etc. In regard to OTEC, the MRD and Saga University of Japan have signed a cooperation agreement and research work is in progress at 10 sites, including the sea area near the capital of Melekeoku. However, equipment is still in the survey and experimental stage and no reports have yet been submitted to provide basic data for the planning of a concrete plan by the Energy Development Office for the introduction of an OTEC system. In the case of biomass energy, its potential in Palau which is a small island country is not very high because the quantities of agricultural waste, livestock dung and waste wood from sawing, etc. which can be used as biomass resources are very small to start with.

4. FINANCIAL AND MANAGERIAL ANALYSIS ON PPUC

4. Financial and Managerial Analysis on PPUC

4.1 Objectives of Financial and Managerial Analysis on PPUC

This chapter is to examine financial and managerial situation of PPUC. It is needed to support the investment project from its inception up to completion, and where necessary, through the project life. In addition, it is to help define the key areas and points for efficient and effective project implementation and necessary obligations by PPUC and the Republic of Palau. The general objective of analysis in this chapter is to ensure that PPUC is managerially and financially capable of implementing the proposed project and/or identify the problem areas to be improved.

4.2 Financial Structure and Management as the Executing Agency

4.2.1 Status of PPUC and Control of the Government

PPUC was established under law as a public corporation. In principle, PPUC is an autonomous body. PPUC can determine its financial policies, contract, sue and be sued in its own name. The National Government of Palau retains the right to a limited oversight role. Although the government has the right to review any documents or decisions made by PPUC, it cannot directly interfere in the business running of the PPUC except for decisions and revisions of electricity rates. According to hearings conducted at the PPUC, it seems that the Government tends to hold electricity rates down. This tendency will potentially hamper the sustainability of PPUC as an autonomous going-concern. In this context, it is hoped for the Government to review its relationship with PPUC and as well as to give consideration about how strictly the related parties are pursuing management principle of not causing operation net loss. Provided that the Government intention is to allow the deficit ridden character of operation loss, and to extend financial support to PPUC, the current situation may be kept on. If not, PPUC should be more autonomous and implement more strict management in its own responsibility.

4.2.2 Organizational Structure for Business Administration and Management

The following organizational chart delineates the vertical and horizontal accountability structure for PPUC’s business management and administration. The Board of Directors directs PPUC. The day-to-day management is directed by CEO. Under CEO, four managers work in the aspect of business administration and management. Four managers are horizontally equal. In the absence of CEO, however, CFO is charged with administrative responsibility, while Power Generation Manager is charged with technical and engineering responsibility.

- CFO (Accounting and Finance)
- Business Office manger
- Management Information System Manager
- Human Resource manager

The Business Office manager is currently charged with tariff collections. The Management Information System primarily provides technical support to the accounting division. He is assigned to the other technical needs of the other departments.

4.2.3 Corporate Planning and Budgeting

PPUC manages its own financial affairs and conducts corporate planning and budgeting in its own right. The Government has the right of oversight, but does not control any detail of the PPUC. All its affairs are overseen and its corporate power is exercised by the Board of Directors. However, even the present budget for fiscal 2008 has been approved and executed with a deficit, so rather than being a responsibly managed independent entity, the PPUC is failing to realize review of its charge system and improvement of operating revenue under government control. All members of the Board of Directors are politically appointed by the President, ensuring that government control and influence over the PPUC is maintained. In order to realize the autonomous operation of the PPUC in future, it will be necessary for these situations to be reviewed and improved.

4.2.4 Financial Management and Control

Financial reporting is prepared monthly, but submitted to the Board of Directors on requested basis. No internal audit activities are conducted by PPUC. PPUC relies on external audit. In view of efficiency and prompt improvement, JICA Study Team proposes that the management of PPUC adopt undertaking regular monitoring and review activities.

4.3 Cost Recovery and Tariff Structure

4.3.1 Existing Tariff Structure

The electricity tariff charging consists of the fixed rate and metered rate. The charged price by metered rate is calculated by multiplication of the consumption volume of electricity and the unit multiplying rate. The metered rate is comprised of the two rates, i.e. the basic multiplier rate and the AFPAC rate, as shown in the following table.

Table 4.3.1-1 Current Electricity Tariff Structure of PPUC

Unit: US$

Charge item			Residential	Commercial/ Government
Monthly Minimum Energy Charge			3.00	10.00
Cost per kWh	0-500	kWh	0.08	0.10
	501-2000	kWh	0.10	0.10
	2001above	kWh	0.12	0.12
AFPAC May 1, 2008～to date			0.17	0.17

Note: AFPAC (Automatic Fuel Price Adjustment Clause)

Note: Minimum energy charge for residential is US$3 in case of no consumption due to absence etc, and more than 150kWh.
In case of more than 1kWh up to 150kWh, a fixed price of US$ 8 is charged.

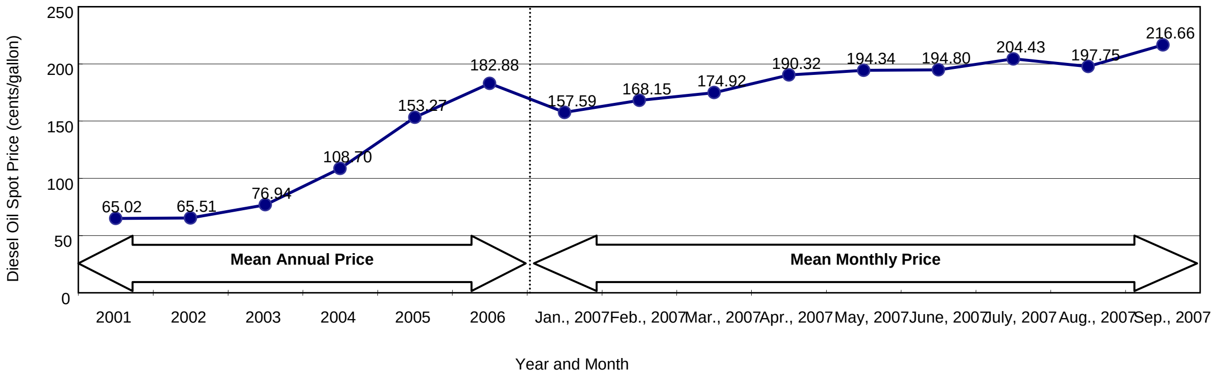
Source: PPUC

The electricity tariff of PPUC is subject to the automatic fuel price adjustment clause (AFPAC). The issues to be raised, however, are that this rate adjustment mechanism is to take effect quarterly (a review/ 3months). In case of such sharp hike of the oil price in a short term, the AFPAC response tends to be delayed and some shortfall of tariff revenue collection frequently takes place. The AFPAC rate has been constantly on a steep upsurge in recent years, as shown below. It actually rose from 2 cents to 17 cents from April 2004 to date. Since the adjustment function does not take effect every month, but only 4 times a year, it has resulted in delayed response in comparison with sharp oil price hike, and eventually in insufficient cost recovery.

With the reference to the basic rates, PPUC has not raised the basic electric rates since October 2001. AFPAC rates sharply rose from only 2 cents to 15 cents since 2001. Therefore the adjustment portion of the revenue by AFPAC is currently more than the revenue portion by the basic rates.

Taking a look at factors that function as to raise the basic rates, we can enumerate various factors such as inflation in general, needs of equipment renewal, labor cost increase etc. It means that the electricity rate change mechanism should include not only adjustment to oil price hike but also the response to those other factors.

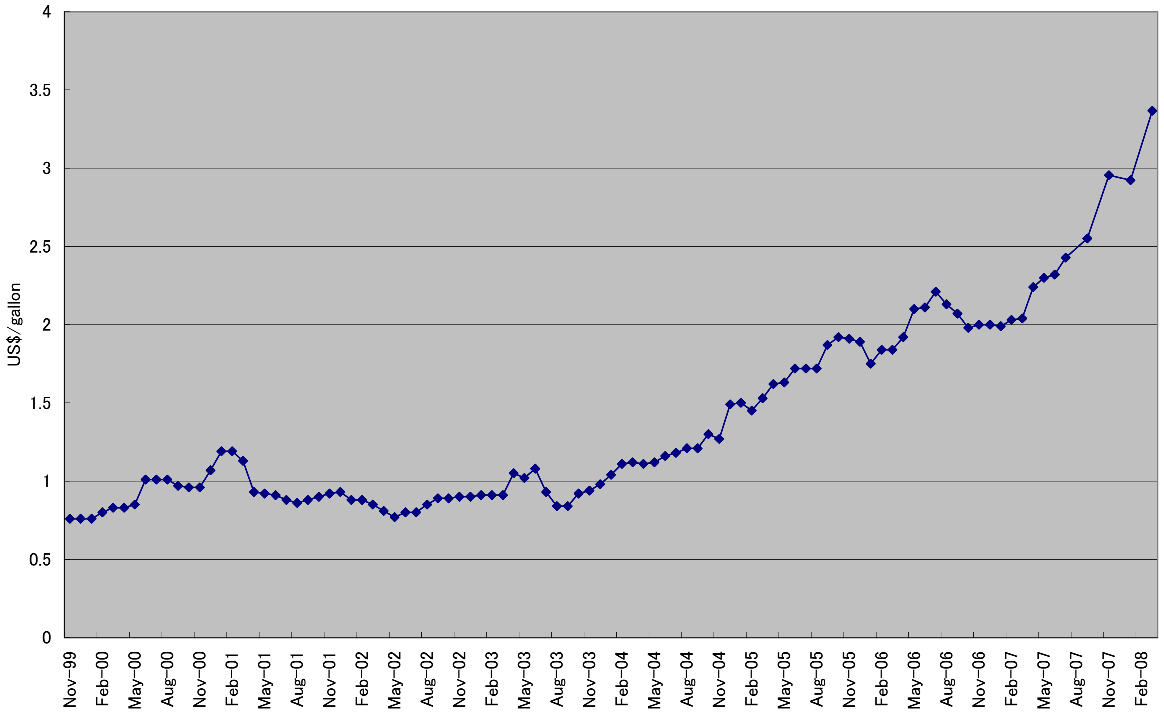
Currently the PPUC uses diesel oil as fuel. As shown in the following figure, the FOB price of diesel oil in Singapore rose by nearly three times in the period from 2001 to September 2007. As a result, the profit margin of the PPUC has been steadily deteriorating.



Source: US Department of Energy, EIA Home Page

Fig. 4.3.1-1 Recent Trend of the Diesel Oil Price (FOB) in Singapore

In addition, the following figure represents the PPUC's actual procurement price of diesel fuel oil since October 1999, on the monthly basis calculation.



Source: Calculated and Prepared by JICA Study Team, on the Basis of PPUC Data

Fig. 4.3.1-2 PPUC’s Procurement Price of Diesel Oil

4.3.2 Electricity Bill Collection

(1) Achievement Performance of Electricity Bill Collection

As for the last FY 2007, PPUC’s total amount of electricity bill accounted for US$ 20.18 million. On the other hand, the total amount of payments received for FY 2007 accounted for US$ 19.32 million. As a result, the achievement percentage of electricity bill collection was 96%. (It is calculated by US$19.32 million / US$ 20.18 million = 96%).

Let’s take a look at the performance by customer classification. The achievement rates of bill collection from commercial and residential customers were 100% and 96%, respectively. On the other hand, those from RoP and SG are regrettably 90% and 80%, respectively. Although the private sector must pay regularly by month, the national governments and state governments are usually several months behind in arrears with electricity bills. The overdue bills for RoP and SG for several months are finally paid by check, when the Government has enough cash to pay the accumulated bills. The time lag, however, causes necessity of short-term borrowings to PPUC. It is recommendable for the Governments to make payments regularly without delay.

For the first half of FY 2008 (Oct.2007～Mar.2008), the achievement ratio is stably the same as 96% as a whole. (The calculation is done as US$ 10.02 million / US$10.44 million = 96%)

(2) Methods of Electricity Bill Collection

The PPUC uses the following methods in order to collect electricity charges:

1) Customers visit PPUC’s office and pay the billed amount at the desk.
2) Automatic drawdown from customers’ bank account by credit card charge
3) Customers visit a bank and pay the billed amount to PPUC’s bank account of Bank Pacific or Bank of Hawaii
4) Deduction from salary
5) Payment by check (Government)
6) Pre-paid system

It is the most dominant way that customers visit PPUC’s office and pays the billed amount at the electricity payment desk. More than 90% of the customers pay in this way.

Automatic drawdown from the bank account is rarely used, a very few customers use this method.

The PPUC began to use a pre-paid system in order to prevent delayed bill collection from July 2007. At present, around 480 pre-paid meters are put into operation. Furthermore, PPUC intends to set up one thousand more pre-paid meters for the problem debtors.

Since the introduction of the pre-paid system was not until July 2007, the amount of electricity collection through pre-paid system accounts for only less than 2%. For the 1st half of FY 2008, the sum has accounted for approximately US$ 200,000. On the monthly average, the bill collection through pre-paid system is around US$ 33,000. The trend is upward.

With the reference to the steps taken for the delayed payments, PPUC firstly gives a reminding notice to the customers whose bills have not paid for more than 30days. Secondly, if the customer does not respond to pay off the balance, PPUC disconnects the electricity supply.

In case that the customer concerned cannot afford to clear off on the spot at one time, PPUC makes a negotiable contract with the customer. It includes a monthly payment schedule for a certain period (several moths or more than one year) in consultation with the customer. The interest rate is 1% per month.

4.3.3 Analysis on Structural Characteristics of Revenue and Expenditure

(1) Customer and Consumption

The total number of customers accounts for 6,799 as of September 2007. In terms of the account numbers, residential customer accounts occupy 77.4% (5,261), commercial 14.2% (967), RoP 4.3% (293) and SG 4.1% (278).

The total number of customer accounts has increased from 5,268 (Dec. 2001) to 6,799 (Sept. 2007) for 5.75 years. The total increase accounts for 1,531. The average yearly increase is 266 accounts per annum. The commercial accounts showed a higher increase rate (7.5% per annum) in comparison with the other user type classifications (Residential: 4.1%, RoP:4.5%, SG:3.9%). As a result, The commercial accounts share has been gaining ground very gradually from 12.1% to 14.2%, while the residential accounts has been losing its ground from 79.3% to 77.4%.

Concerning each customer classification type's share for FY 2007 (Oct. 2006 – Sept. 2007), currently the commercial customers consume 32.7 million kWh (39.4%), the residential consumer 27.3 million kWh (32.9%), RoP 18.8 million kWh (22.6%), and SG 4.2 million kWh (5.0%).

In recent years, the overall power consumption volume has not increased so much. The yearly consumption of Palau has been stayed around 80 million kWh in total. This fact can be attributed to several reasons. According to PPUC, public awareness of saving energy has well penetrated. On the other hand, this might be presumably because the power supply capacity has not grown in the past decade.

In terms of residential user, the monthly consumption volume per account decreased from the range of 500~550 kWh for the years of FY2002-FY2004 to around 430 kWh in FY2007. The average decrease rate is around 4.5% per annum. The commercial consumption per account has decreased more drastically from 4,213kWh/month (FY2002) to 2,821kWh/month (FY2007). The decrease rate is 7.7% per annum. On the other hand, the government sector has not decreased its consumption per month per account so much as shown below. The curve has been fluctuating, but not on a steady decreasing trend.

(2) Revenue and Expense

1) Operating Revenue

Irrespective of stagnant trend of consumption volume, the operating revenue of PPUC has climbed up from US$8,658,402 (FY2000) to US$20,050,833 (FY2007). Nominally, it substantially increased by 2.3 times larger. The increase rate is 15% per annum. These increases, however, were caused mainly by AFPAC and the cost recovery has not been sufficient as mentioned in the preceding sections. The fact is that PPUC have only managed to recover a substantial part of the fuel cost increase with the mechanism of AFPAC, but not completely, because of the delayed response of quarterly adjustment. In addition, AFPAC can cover only fuel cost increase, but it does not include the other factors such as general inflation and equipment renewal etc.

In terms of occupancy rate by user type, the commercial customers' share is largest (40%), followed by residential (30%) and government (30%).

The operating revenue of PPUC is generated mostly from electric power sales, but a very small portion is generated from non-electric power sales such as connection fees, late payment charges, pole attachment fees etc. In FY 2006, power sales generated 98% of operation revenue, and 97% in FY 2005. From FY 2007, PPUC started to collect revenue for electricity provision for street lights, which accounted for around US$151,000.

2) Operating Loss

The following table shows the recent situation of revenue and expenditure, based on the audited financial statements, FY2001-FY2006. The operation of PPUC has turned out to be constantly loss, and the annual amount of operating loss has been steadily increasing from US$ 735,673 (FY 2001) to US$ 4,686,601 (FY 2006).

Table 4.3.3-1 Recent Operating Loss, Non-Operating Revenue and Change in Net Assets

Item	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
Operatring Revenue						
Power	11,107,747	10,189,964	10,808,975	11,739,414	15,073,865	17,482,734
Other	419,747	231,545	302,522	242,266	414,559	321,351
Sub-Total	11,527,494	10,421,509	11,111,497	11,981,680	15,488,424	17,804,085
Bad Debts	0	0	0	0	288,788	-86,396
Net Operating Revenue	11,527,494	10,421,509	11,111,497	11,981,680	15,777,212	17,717,689
Opersating Expenses						
Generation-Fuel Cost	7,265,841	6,279,414	6,977,392	8,403,772	12,656,688	15,530,247
Generaton-Other Cost	1,091,123	1,277,842	1,217,513	1,631,389	2,444,890	2,355,184
Depreciation	2,248,848	2,234,400	2,236,790	2,239,607	2,356,631	2,506,465
Distribution and Transmission	809,893	1,046,461	1,044,065	1,561,029	1,165,961	1,059,226
Administration	814,595	826,033	771,060	691,437	838,435	786,834
Engineering Services	32,867	20,983	83,667	198,050	189,640	166,334
Sub-Total	12,263,167	11,685,133	12,330,487	14,725,284	19,652,245	22,404,290
Operating Loss	-735,673	-1,263,624	-1,218,990	-2,743,604	-3,875,033	-4,686,601
Non Operating Revenue	1,197,687	2,595,672	1,110,422	571,669	1,276,885	673,376
Net Income (1)	462,014	1,332,048	-108,568	-2,171,935	-2,598,148	-4,013,225
Net Income (2) : (1)+Depreciation	2,710,862	3,566,448	2,128,222	67,672	-241,517	-1,506,760

Source: Statements of Revenues, Expenses and Changes in Fund Equity, Audited by Deloitte, Touche Tohmatsu

Since depreciation does not represent actual cash outflow, when this is added back on, figures show a surplus up until fiscal 2004, however, from fiscal 2005 onwards, the figures show a deficit even when the depreciation is restored.

In spite of this burgeoning deficit in the electric utility balance, US financial support has not increased accordingly. Moreover, subsidies from the Government of Palau have not been provided at all from fiscal 2002 onwards. Accordingly, the PPUC has entrusted fund management to an American investment bank, however, not only have operating profits, which provided a steady return of around 10% per year, been written off, the operating balance is decreasing every year in order to offset the deficit. In view of these circumstances, in order for the PPUC to improve its financial condition, there is no other choice but for it to stringently pursue profitability of the power utility balance based on the spirit of self-help.

3) Operating Expense

In order to realize profitability in the power utility, PPUC will naturally have to take a course of actions: comprising: 1) increasing revenue, 2) decreasing expenses, or 3) combining both these approaches.

Definitely, fuel cost is overwhelmingly the most significant item. The total operating expense has increased from approximately 9 million (FY2000) to 20 million (FY2006). Particularly for these last 4 years, the operating expense has showed a steep rise.

In terms of money amount, the operating expenses budget in FY2008 accounts for US$ 25.1 million. Excluding the depreciation cost and bad debt expense, it is US$22.4 million, of which fuel expense accounts for US$17.2 million (approx. 77%). This projection of fuel expense is based on the average price of US$ 2.3/gallon, which is much lower than the current going rate. Therefore, although it is hoped that the fuel price depreciates closer to US$ 2.3/gallon, if the current market price remains high, the average procurement price this fiscal year is more likely to be nearer the mid-FY2008

(March 2008) price of US$ 3.4/gallon.

This financially means that the operating loss of PPUC may exceed US$ 10 million. The PPUC should have given more consideration to spiraling fuel prices when compiling its budget plan. In addition to revising its tariff system in a manner that improves profitability in terms of revenue, the PPUC will need to take steps geared to improving both revenue and expenditure.

4.3.4 Fundamental Direction for Cost Recovery Improvement

The PPUC‘s structure of expenditure has a striking characteristic in that fuel cost is by far the largest expense item. Even if PPUC may make efforts of cost recovery improvement in the other aspects, the result will be very trivial. It is urgent and far more important for PPUC to reduce fuel cost. However, unless new generators are installed, it will be very difficult to cut these fuel costs.

If it is impossible or very difficult to achieve this in the short term, the PPUC has to consider increasing revenue through revising tariffs. However, since customers will not consent to sudden tariff increases, it will be better to introduce phased increases over two or three years.

4.4 Main Steps to be Taken for Improvement of Financial Performance and Operation Efficiency of PPUC

4.4.1 Switch from Diesel Fuel Oil to Heavy Fuel Oil

Fuel cost is the main operation expense of PPUC accounting for 77% of total expenditure. The second large item is maintenance, which accounts for 10%. In order to improve PPUC’s operation, it is deemed as essential to reduce fuel cost. Palau currently uses diesel oil as fuel in power generation, however, profitability could be improved if this was changed to HFO. Generally speaking, the price of HFO is around 55-60% that of diesel oil.

Pacific countries are importing only diesel for the purpose of power generation. They are not importing HFO at present. Only Guam imports HFO. Therefore, if Palau can make an arrangement to procure HFO from a company that handles it in Guam, it will be able to reduce its fuel cost substantially. Since it has been confirmed that technical and environmental issues in importing can be cleared, actual procurement will depend on the outcome of business negotiations.

Assuming the current power consumption, it is highly likely that fuel costs could be reduced by between US$7~8 million through switching to HFO. Of course, in order to ensure operation and maintenance in the event where HFO is adopted, costs will arise in recruiting two additional operators, purchasing spare parts and paying higher depreciation costs arising from higher investment, however, since all these cost increases will amount to around US$400,000 per year, they are dwarfed by the fuel cost saving of US$10 million per annum.

Moreover, in the event where new operating equipment is installed, fuel efficiency levels will be higher than in the old equipment. This point is also included in this calculation. The energy efficiency of existing equipment using only diesel oil is 13.5kWh/gallon, however, the new generating plant using HFO will generate electric power with efficiency of 16.5 kWh/gallon, thereby enabling an energy efficiency improvement of approximately 20%.

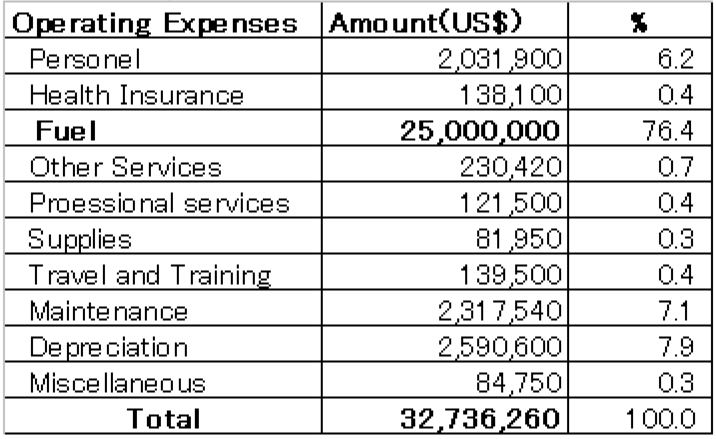
On the other hand, use of HFO will lead to an increase of power consumption within the power station of approximately 3~5%, however, overall a large cost reduction effect will be realized.

4.4.2 Revision of Electricity Tariff of PPUC

Major cost reduction like that described above can only be realized upon first replacing equipment at Aimeliik Power Plant. It will be near impossible to realize while still using the conventional equipment. Accordingly, the PPUC will need to continue using diesel oil and making do with the current high costs for the coming four or five years. However, the imbalance between revenue and expenditure caused by the current spiraling price of oil will further deteriorate the operating and financial condition of the PPUC. The best way to prevent this is thought to be to raise revenue through increasing electricity tariffs based on the revision of tariff rates.

When the fuel cost for FY2008 is adjusted by taking into account the present price of fuel (US$3.4/gallon) and reflecting the improvement effect of two generator units at Aimeliik, the resulting budget for FY2008 is as indicated in Table 4.4.2-1.

Table 4.4.2-1 Operating Expense for FY2008, Forecasted by JICA Study Team



Operating Expenses	Amount(US$)	%
Personel	2,031,900	6.2
Health Insurance	138,100	0.4
Fuel	**25,000,000**	76.4
Other Services	230,420	0.7
Proessional services	121,500	0.4
Supplies	81,950	0.3
Travel and Training	139,500	0.4
Maintenance	2,317,540	7.1
Depreciation	2,590,600	7.9
Miscellaneous	84,750	0.3
Total	**32,736,260**	100.0

Source: Prepared by JICA Study Team, on the basis of PPUC's budget for FY2008, with the modification done by JICA Study team

Note 1: Fuel expense projection is modified

Note 2: Bad debt expense is eliminated

Note 3: Depreciation remains as it is. Depreciation is not actual cash outflow. For preparation of future capital renewal, however, PPUC should accumulate a certain money reserve. Otherwise, it will have to depend on the Government or foreign assistance.

The self-sustainable and independent operation of the PPUC is also important from the perspective of the business management of Palau in general. Based on such a viewpoint, PPUC must achieve a balance of operation revenue and expenses. In order to prepare for future equipment replacement, it is desirable to seek a very small profit margin without excluding depreciation expense. The 2007 Electric Rate Study does not include depreciation expense in the corresponding money outflow forecast to be recovered by the operating revenue, however, the JICA Study Team's recommendation is that PPUC should seek profitability that includes future capital asset renewal as well. In other words, the power revenue will have to cover utility operating expenditure of approximately US$ 33 million.

Since the JICA Study Team estimates that the electricity consumption will account for approximately 84,000,000 kWh, it works out that the PPUC will need to charge around 39 cents per kWh in order to break even as is shown in table 4.4.2-2.

Table 4.4.2-2 Overall Electricity Rate for Cost Recovery to Ensure Sustainability of PPUC

FY 2008

Total Power Consumption Forecasted (FY2008)	**84,000,000kWh**
Total Revenue to be Collected for Cost Recovery (FY2008)	**US$ 33,000,000**
Overall electricity rate to be charged	**US$ 0.39**

Source: Calculated by JICA Study Team, on the basis of PPUC data

4.4.3 Strategy for Electricity Tariff Revision

(1) Points to bear in mind in tariff revision

In terms of revising and raising tariff rate, we should keep in mind about following things:

- Achieve full cost recovery in view of sustainability
- Don’t integrate the basic rate and AFPAC into one simple tariff structure. Please continue to have the system of AFPAC to ensure accountability to the public for price adjustment for fuel cost escalation
- Be prompt for fuel price hike (Adopt monthly review of AFPAC)
- AFPAC should be revised and developed from just adjustment item to a fully corresponding item to cover the whole fuel cost
- Complete consensus building within a few months, and adopt new electricity tariff, at latest from the beginning of FY 2009

(2) When should PPUC embark on the adoption and implementation of new electricity tariff?

It is urgent and paramount need to raise tariffs as soon as possible. Otherwise, the PPUC’s financial situation will be worsened rapidly. On the other hand, such revision and increase of tariffs must undergo a certain process prescribed by law, and it should secure the consensus of the people. In this connection, it will probably take several months will elapse until the adoption of a new tariff rate. At the latest, preparations will be completed by the end of FY2008 and the new tariffs will be implemented from the start of FY2009.

(3) What should be kept in mind for building a new tariff structure?

The PPUC must increase overall electricity rate by 40-50% in view of its current huge operating deficit. The tariff rate has not been revised since October 2001. The AFPAC, which is the fuel cost adjustment item, is far too low to cover the overall fuel cost. (The current AFPAC (17 cents/kWh) has been in effect since May 2008, however, 28 cents needs to be levied in order to cover fuel cost alone.

The Study Team proposes that the basic tariff structure be divided into 1) the AFPAC covering the fuel cost, and 2) the basic rate and customer charge covering other costs.

AFPAC	■ Recover fuel cost completely ■ Monthly revision , for prompt reflection of fuel price change
Basic rate / Customer Charge	■ Recover the other cost (except fuel cost) completely ■ Annual revision, to reflect the annual budgetary estimate and corporate planning ■ Keep the structure of customer charge as it is

This is like the essentially needed condition for PPUC to achieve full cost recovery. Taking a look at the adopted budgets of PPUC for the recent years, operating loss has been constantly forecasted and built-in in the budgets for these years at the time of adopting the budgets. This will indicate that neither Board of Directors nor the Management has been keen about importance of recovering all the operation expenses.

(4) Short-term Measures (FY2009-2012)

Since the new Aimeliik Power Station is not scheduled to start operation until fiscal 2013, the PPUC will have to continue using diesel oil until then.

Moreover, even if most of the funding required to carry out renewal of Aimeliik Power Station can be borrowed via a soft loan, the PPUC will still need to raise around 10% through its own funds.

It depends on whether the PPUC can put aside enough cash or the government can raise funds in place of the PPUC. From the viewpoint of realizing autonomous business operation, it is desirable for the PPUC to quickly raise electricity tariffs and balance revenues so that it is able to save the necessary funds.

Accordingly, the tariff and rate revisions recommended by the Study Team are based on the principle of balancing operating revenue with operating expenditure (approximately US$37 million) in FY2009. When revising tariffs, it is desirable to compile a system that gives consideration to general household users. If the following revision plan proposed by the JICA Study Team is implemented, the respective rates will work out as 31.6% for general households and 68.4% for enterprises and the government, meaning that the comparative burden placed on households is lessened somewhat.

Table 4.4.3-1 New Electric Tariff Rate to be proposed for the Target Year FY 2009

(Case 1: Even Burden Option)

Charge item			Residential	Commercial/ Government
Monthly Minimum Energy Charge			3.00	10.00
Cost per kWh	0-500	kWh	0.08	0.10
	501-2000	kWh	0.10	0.10
	2001above	kWh	0.12	0.12
AFPAC Oct. 2008- Sept. 2009			0.31	0.31

Source: Proposed by JICA Study Team in consideration of the aforementioned strategies and principles

Table 4.4.3-2 New Electric Tariff Rate to be proposed for the Target Year FY 2009

(Case 2: Residential Customer Preferential Option)

Charge item			Residential	Commercial/ Government
Monthly Minimum Energy Charge			3.00	10.00
Cost per kWh	0-500	kWh	0.08	0.10
	501-2000	kWh	0.10	0.10
	2001above	kWh	0.12	0.12
AFPAC Oct. 2008- Sept. 2009			0.26	0.33

Source: Proposed by JICA Study Team in consideration of the aforementioned strategies and principles

Provided that PPUC adopts the proposed tariff rate schedule in FY 2009, the following table shows the projected result of revenue for PPUC

1) Evenly-Imposing Option

Table 4.4.3-3 Projected Revenue from Residential Customers, the Target Year of FY2009

Projected Revenue from Residential Customers, under the Proposed New Tariff Structure, FY2009

Monthly use of Electric Power (kWh)	Number of billings	Customer Charge Rate (US$)	Revenue1 from Customer Charge (US$)	FY2009 Projected Sales (kWh)	Basic Rate (US$/kWh)	Revenue2 from Basic Rate Charge (US$)	AFPAC Rate (US$/ kWh)	Revenue3 from AFPAC (US$)	Total Revenue (US$)
0-500 kWh	45,296	3	135,888	10,044,754	0.08	803,580	0.31	3,113,873	4,053,341
501-2000 kWh	10,355	3	31,065	14,673,456	0.1	1,467,345	0.31	4,548,771	6,047,181
Over 2000kWh	8,607	3	25,821	3,823,052	0.12	458,766	0.31	1,185,146	1,669,733
Total	64,260		**192,774**	28,541,261		**2,729,691**		**8,847,790**	**11,770,255**

Source: calculated by JICA Study Team

Table 4.4.3-4 Projected Revenue from Commercial Customers, the Target Year of FY2009

Projected Revenue from Commercial Customers, and Government under the Proposed New Tariff Structure, FY2009

Classification of Customers	Number of billings	Customer Charge Rate (US$)	Revenue1 from Customer Charge (US$)	FY2009 Projected Sales (kWh)	Basic Rate (US$/ kWh)	Revenue2 from Basic Rate Charge (US$)	AFPAC Rate (US$/ kWh)	Revenue3 from AFPAC (US$)	Total Revenue (US$)
Commercial	11,808	10	118,080	37,511,511	0.10	3,751,151	0.31	11,628,568	15,497,799
RoP	3,576	10	35,760	19,691,727	0.10	1,969,172	0.31	6,104,435	8,109,367
SG	3,396	10	33,960	4,385,612	0.12	526,273	0.31	1,359,539	1,919,772
Total	0		**187,800**	66,559,221		**6,246,596**		**19,092,542**	**25,526,938**

Source: calculated by JICA Study Team

2) Option of Providing Preferential Rate for Residential Customers (Commercial/Government customers will pay more)

Table 4.4.3-5 Projected Revenue from Residential Customers, the Target Year of FY2009

Projected Revenue from Residential Customers, under the Proposed New Tariff Structure, FY2009

Monthly use of Electric Power (kWh)	Number of billings	Customer Charge Rate (US$)	Revenue1 from Customer Charge (US$)	FY2009 Projected Sales (kWh)	Basic Rate (US$/kWh)	Revenue2 from Basic Rate Charge (US$)	AFPAC Rate (US$/ kWh)	Revenue3 from AFPAC (US$)	Total Revenue (US$)
0-500 kWh	45,296	3	135,888	10,044,754	0.08	803,580	0.26	2,611,636	3,551,104
501-2000 kWh	10,355	3	31,065	14,673,456	0.10	1,467,345	0.26	3,815,098	5,313,508
Over 2000kWh	8,607	3	25,821	3,823,052	0.12	458,766	0.26	993,993	1,478,580
Total	64,260		**192,774**	28,541,261		**2,729,691**		**7,420,727**	**10,343,192**

Table 4.4.3-6 Projected Revenue from Residential Customers, the Target Year of FY2009

Projected Revenue from Commercial Customers, and Government under the Proposed New Tariff Structure, FY2009

Classification of Customers	Number of billings	Customer Charge Rate (US$)	Revenue1 from Customer Charge (US$)	FY2009 Projected Sales (kWh)	Basic Rate (US$/kWh)	Revenue2 from Basic Rate Charge (US$)	AFPAC Rate (US$/kWh)	Revenue3 from AFPAC (US$)	Total Revenue (US$)
Commercial	11,808	10	118,080	37,511,511	0.10	3,751,151	0.33	12,378,798	16,248,029
RoP	3,576	10	35,760	19,691,727	0.10	1,969,172	0.33	6,498,269	8,503,201
SG	3,396	10	33,960	4,385,612	0.12	526,273	0.33	1,447,252	2,007,485
Total	0		**187,800**	66,559,221		**6,246,596**		**20,324,319**	**26,758,715**

In total, the operation revenue of PPUC is expected to account for approximately US$37 million, almost equivalent to the projected operation expense.

However, this base case option will look as a substantial and drastic tariff hike from the viewpoint of consumers. Although it is urgent necessary for operation revenue to catch up with operation expense, it is better from the customer viewpoint to adopt phased increased over two or three years. Two options – the two-year pattern and the three-year pattern – are given below:

- ■ 2nd Option : It shall take two years to catch up and make both ends meet (FY2009-2010)
- ■ 3rd Option : It shall take three years to catch up and make both ends meet (FY2009-2011)

Although it is better to take time with tariff increases, the PPUC is not in a position to do this. Future oil inflation is also a factor, and if fuel prices continue to spiral, the government will need to subsidize the PPUC.

Raising tariffs over the long term is obviously more desirable for consumers, however, since existing tariffs are far too low, the PPUC deficit will only grow larger if even two or three years are taken to raise tariffs. In the two-year plan, deficit will increase by approximately US$6.5 million, while it will grow by US$11 million in the three-year plan. Since a deficit of US$10 million is already expected in FY2008, unless the government provides subsidies or some other form of financial assistance during this period, there is a risk that the PPUC will face serious financial distress.

(5) Long Term Measures (FY2013~: After the operation start of the new Aimeliik Power Plant)

From FY2013, the new Aimeliik Plant will start operation using only diesel or a combination of HFO 80% and diesel 20%. In order to determine which fuel PPUC will use, the following financial simulation is conducted:

1) Case of continuing to use diesel oil

The condition and assumptions will not change from the aforementioned in the short term measures. However, there is possibility that recent oil price hike may continue for the forthcoming 4~5 years. In the priority projects proposed in Chapter 6 of this report, assuming that operation will start from FY2013 and investment cost will be recovered in 20 years, the electricity tariff required to realize financial feasibility (FIIR of more than 10%) is examined below.

- Sub-case1: Fuel cost will be the same level as present (Diesel: US$ 3.6/gallon)

  Basically, PPUC must charge US$0.41/kWh.

- Sub-case2: Fuel (diesel) cost 20% up from now

  PPUC will have to raise overall rate of electricity tariff up to US$ 0.47/kWh.

- Sub-case3: Fuel (diesel) cost 30% up from now

  PPUC will have to raise overall rate of electricity tariff up to US$ 0.51/kWh.

- Sub-case4: Fuel (diesel) cost 40% up from now

  PPUC will have to raise overall rate of electricity tariff up to US$ 0.57/kWh.

2) Case of changing fuel from diesel to HFO

If fuel is changed from diesel to HFO, PPUC operating costs will be reduced a lot. There will be a large degree of capacity to absorb the shock of oil price hikes. Tariffs should be set so that the investment cost of the priority projects described in Chapter 6 can be recovered in 20 years of operation and financial feasibility can be secured.

- Sub-case 1: Fuel cost will be the same level as current

  Due to the benefit of big fuel cost reduction, PPUC can afford to make reduction of electricity tariff with the big margin to be generated. Overall electricity rate can be reduced by 6 cents and set at US$ 0.33/kWh.

- Sub-case2: Fuel cost 20% up from now

  The PPUC will not have to raise overall rate of electricity tariff. The rate can be reduced by 1 cent to US$0.38/kWh.

- Sub-case3: Fuel cost 30% up from now

  The PPUC only needs to raise the overall tariff by 1 cent to US$ 0.40/kWh.

- Sub-case4: Fuel cost 40% up from now

  PPUC will have to raise the overall tariff by 3 cents to US$ 0.42/kWh.

- Sub-case5: Fuel cost 50% up from now

  PPUC will have to raise the overall tariff by 5 cents to US$0.44/kWh.

4.5 The new actions currently taken by PPUC promptly response to the revision direction proposed by JICA Study Team

As said above, JICA Study Team has analyzed and pointed out the fundamental issues in the aspect of management and finance, and proposed the revision direction particularly concerned about the const recovery structure and the electricity tariff level and structure. Throughout the process of dialogue with PPUC Management, JICA Study Team has held intensive discussions and sincerely communicated with PPUC Management to lead to prompt actions for the improvement. PPUC has clearly understood necessity of securing sustainable operation and management to take prompt actions for the proposed directions essentialness of taking prompt actions for the proposed directions. As a result, PPUC has commenced to persuade the Palauan Government to understand the situation and held conferences with national people. On June 5, 2008, the prompt effort has resulted in the passage of the bill to revise PPUC's electricity tariff. The content is as follows:

- Commercial customers and Governments
  - Comprehensively the title charge shall be US$ 0.425/kWh
  - The basic rate shall be US$11
- Residential customers
  - By the range of electricity consumption rage, the title charge shall be:
    0~500 kWh : US$0.30/kWh
    500~2000kWh: US$0.38/kWh
    More than 2000kWh: US$0.425/kWh
  - The basic rate shall be US$3

As said above, the bill for the proposed revision is a very challenging content to raise the electricity rate up to one and a half times higher. As it were, it will be the almost equivalent content to fulfill the JICA Study Team's proposal at one time, although it does not include the proposal to keep the two streams of revenue source of AFPAC and basic rate and it does not take a gradual approach to increase step by step. (JICA Study Team has considered it essential to keep transparency of tariff fluctuation to be accompanied with fuel cost change.) If actually implemented, it will be a new and significant step to improve the const recovery structure. However, it is noteworthy that the increase portion is very large, considering that this is just one time rate-increase-opportunity. Taking a look at this challenge from the viewpoint of Palau national people, the rate change seemed to have taken place all of a sudden, and that the increase portion is incredibly large. Therefore, many happenings of turns and twists might occur before the rate increase is actually implemented and firmly established. It might be probable that the veto by the president will be used to turn down the bill. As things stand now, we should make preparations in view of firm establishment and actual implementation. Somehow, the utmost effort made by PPUC for these rate revisions should be appreciated very much.

5. EXAMINATION OF POWER DEVELOPMENT

5. Examination of Power Development

5.1 Power Demand Forecasts

5.1.1 Review of the Existing Power Demand Forecasts

Two power demand forecasts for the Koror-Babeldaob power system are available. One is based on the study conducted by the PPUC and Oceanic Companies of the US for the PPUC Strategic Plan 2003 – 2008, while the other is proposed under the ongoing review of the electricity charge (Electric Rate Study 2007) by economists.com Co. of the US.

Fig. 5.1.1-1 compares these two power demand projections in terms of the electric energy sold (power consumption), and it shows a large disparity between the two.

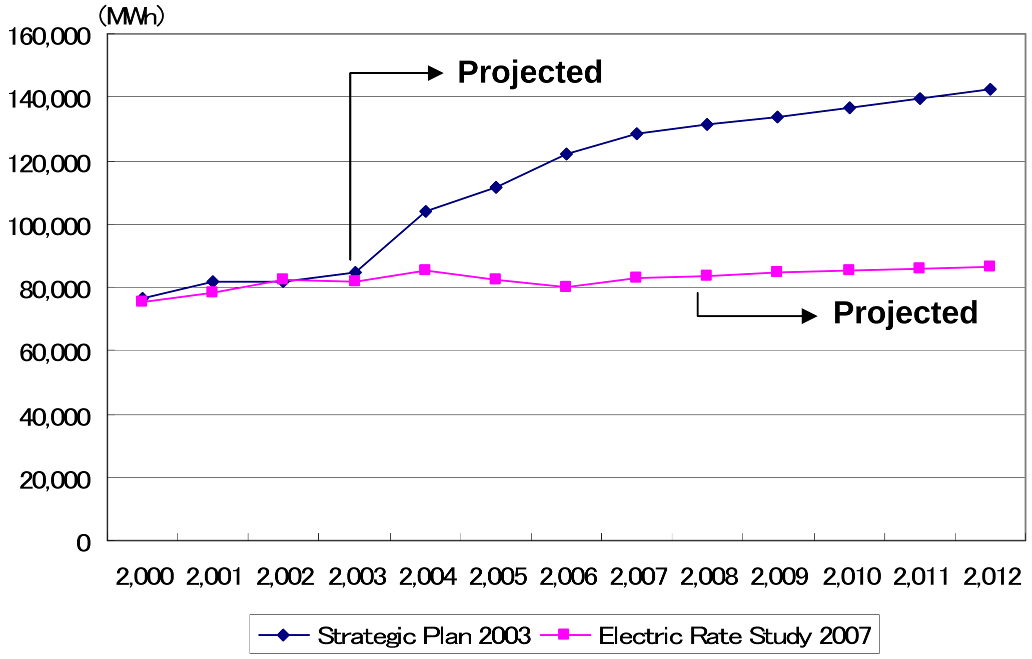


Fig. 5.1.1-1 Comparison of Projected Sale (Consumption) of Electric Energy Between the Strategic Plan 2003 – 2008 and the Electric Rate Study 2007

(1) Power Demand Forecast of the Strategic Plan

The demand projection of the Strategic Plan used the actual demand figures from 1997 to 2002 to project the peak load up to 2012. The peak load in this forecast exercise increases at an average annual rate of 5.7%, reaching some 27 MW in 2012. One noticeable feature is the projected annual growth rate of 22.6% in 2004 as a result of the accumulation of anticipated large-scale projects planned in and around that year.

(2) Power Demand Forecast of the Electric Rate Study

The actual figures for 2000 to 2007 were used in this power demand forecast to project the net system demand energy (sale of electric energy) up to 2033. An increase of 60 – 70 customers a year was basically assumed and the sale of electric energy was expected to increase at a rate of approximately 0.8% a year. As the provisional study report is designed to examine and propose a future electricity tariff based on the financial situation and expected income of the PPUC, its forecast of the growth of the power demand is on the conservative side. As the power demand in this report is a conservative forecast, the report calls for modification of the projection to reflect an increased demand in the period from 2000 to 2004 in the case of a subsequent power demand increase. In other words, the power demand forecast of this report reflects the stagnant growth of the power demand in the last several years.

5.1.2 Review of Economic Policies, Economic Growth Rate Forecast and Local Development Programme

10 years have passed since the announcement of the Palau National Master Development Plan (PNMDP) which is the current master plan for economic policies in Palau and the work to revise this plan is presently in progress with the technical assistance (TA) of the Asian Development Bank (ADB) for the purpose of formulating a road map for sustained economic development following the end of US assistance under the Compact agreement. While a draft report has been compiled, it is difficult to obtain this report because of its ongoing detailed checking by the Office of Planning and Statistics of the Bureau of Budget and planning. Other useful references for the present Study include such comparatively recent studies on the economic policy and local development programme as (1) the Study for the Local Development Plan in Palau (JICA, October, 2000), and (2) the Public Sector Investment Programme 2003 – 2007 (PSIP).

(1) Study for the Local Development Plan in Palau (JICA, October, 2000)

The report for this study proposes a long-term development strategy for each industrial sector up to 2020 and a medium to long-term development plan for each industrial sector up to 2009 to achieve private sector-led economic development to boost government revenue in addition to a structural adjustment programme featuring a reduction of the fiscal expenditure and an increase of government revenue in line with the development path adopted by the PNMDP 2020.

The growth scenario under this study indicates the future growth of the GDP, etc. as shown in Table 5.1.2-1. The nominal annual GDP rate is predicted to slowly increase from 4.3% in 2000 to 6.2% in 2020. The number of tourists visiting Palau is predicted to reach 90,000 in 2010 and 140,000 in 2020.

Table 5.1.2-1 Projected Changes of the GDP by the JICA Study

	1995	2000	2005	2010	2015	2020
Total Population	17,255	19,312	21,441	22,054	22,585	23,513
Employment Creation	8,368	9,211	10,426	11,602	12,252	13,454
Nominal GDP (US$ million)	105.21	134.83	172.24	212.70	298.56	404.07
Real GDP (US$ million) 1995 Base	105.21	116.14	122.17	129.25	143.98	160.83
Nominal GDP per Capita (US$)	6,108	6,982	8,033	9,645	13,219	17.185
Real GDP per Capita (US$)	6,108	6,014	5,698	5,861	6,375	6,840

(2) Public Sector Investment Programme 2003 – 2007 (PSIP)

The Government of Palau formulated the Public Sector Investment Programme (PSIP) in April, 2003 to review the planned development of the public sector and compiled the development projects to be implemented in the five year period from 2003 to 2007. The emphasis of economic development is placed on tourism, agriculture, fisheries, trade and light industry and the concrete projects to achieve the planned economic development in the transport (roads, airports and harbours), water supply, sewage treatment, waste disposal, energy and communication sectors are classified into three categories in terms of their priority: A (30 projects), B (20 projects) and C (16 projects). Although some of these projects are being implemented with the assistance of various donors, many have been shelved because of a lack of funding.

There is a population growth forecast up to 2025 based on the population statistics for 2000 as shown in Fig. 5.1.2-1. According to this forecast, the population of 19,129 in the 2000 census will increase to 22,813 in 2025, recording a population growth of 19.3% in 25 years. Meanwhile, the population growth rate will drop from 1.898%/year in 2000/01 to 0.305% in 2024/25. This data is useful for prediction of the power demand up to 2025.

For the economic growth of Palau, the IMF predicts the GDP growth rate based on three patterns (end, continuation and increase) of the Compact assistance after 2009 in its 2005 report entitled “Article IV Consultation Staff Report” (see Table 5.1.2-2).

Table 5.1.2-2 Prediction of the Future Annual GDP Growth Rate by the IMF

(Unit: %)

Status of Compact Assistance	Actual	Estimate	IMF Prediction					
	2004	2005	2006	2007	2008	2009	2010	2024
End	4.9	5.5	5.7	5.5	4.8	4.4	4.0	-2.0
Continuation			5.7	4.5	3.0	2.0	1.0	0.5
Increase			5.7	5.5	4.8	4.8	4.5	3.3

Source: International Monetary Fund, 2005 Article-IV Consultation Staff Report

Meanwhile, as is shown in table 5.1.2-3, the Office of Planning and Statistics of the Government of Palau forecasts the annual GDP growth rate up to 2010 to reflect the development plans/projects in the coming years. The forecast figures are somewhat higher than the IMF figures.

Table 5.1.2-3 Forecast of Future Annual GDP Growth Rate by the Government of Palau

(Unit: %)

FY	2005	2006	2007	2008	2009	2010
Annual GDP Growth Rate	8.4	8.8	8.2	7.8	7.4	7.1

Source: Office of Planning and Statistics, Bureau of Budget and Planning, Ministry of Finance

5.1.3 Examination of Demand Side Management

(1) Background of the Examination of Demand Side Management

The current electricity tariff employed by the PPUC has an escalated structure to encourage energy saving. However, the introduction of demand side management (DSM) aimed at reducing the generating cost, improving the operational efficiency, reducing the investment in equipment and reducing the environmental cost is feasible.

All electricity power companies throughout the world are now required to make active efforts to ensure the efficient use of energy against the background of rising international opinions demanding effective measures to deal with the sharp increase of the fuel cost due to the oil price hike in recent years and also to deal with global warming and other environmental issues.

(2) Examination Method of Introduction of DSM

1) Utilisation of the Guidebook

When considering the issue of demand side management (DSM), the Demand Side Management Best Practices Guidebook for Pacific Island Power Utilities (issued by the International Institute for Energy Conservation, UNDESA, in July 2007) provides particularly useful reference. The applicability of the programmes introduced in this guidebook to Palau is examined under the Study.

2) Examination Method

The examination of DSM will be conducted in accordance with the following procedure with a view to reviewing the future approach in the PPUC and predicting the power demand in the event where the DSM regime is introduced.

a. Load Survey

- Types, composition and load data of users
- Electricity tariff
- Load characteristics (daily load curve)
- Identification of user types affecting the daily load curve

b. Setting of Load Improvement Targets

Based on the load survey conducted in 1) above, feasible load improvement patterns (see Fig. 5.1.3-1) will be examined.

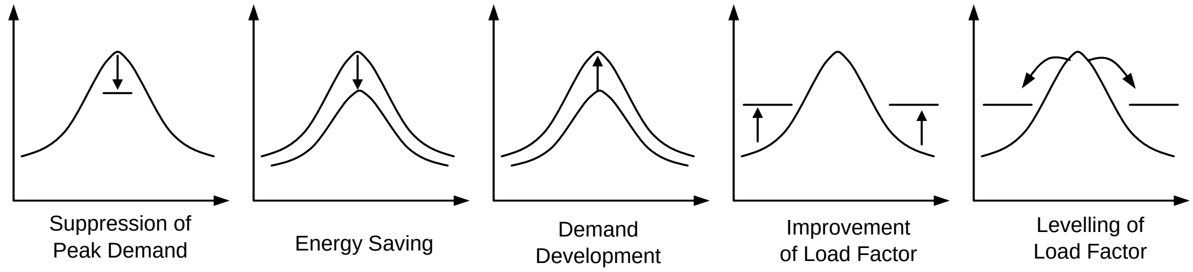


Fig. 5.1.3-1 Load Improvement Patterns

c. Examination of the Programme Implementation Method

The planned examination/analysis will include the identification of electrical appliances to suppress the peak demand and the cost-benefit of each programme for users and the PPUC, including the social and environmental benefits. In addition, a feasible DSM regime for the PPUC will be established to evaluate its impacts on the power demand o that the power demand prediction reflects such impacts.

(3) Examination of the Programme Implementation Method

The Government of Palau is currently in the midst of formulating the Energy Efficiency Action Plan with the intention of actively promoting energy saving activities in the coming years. The draft report compiled in November, 2007 proposes 14 programmes as listed in Table 5.1.3-1, and these programmes are expected to commence in the near future.

It is important to publicise the results and positive effects of government efforts in order to encourage similar efforts by commercial and residential electricity users.

Reduction of the power consumption by approximately 1.5% is currently believed to be possible by these programmes. While there are projects in which the reduction effect is difficult to quantify, further reduction of the power consumption is certainly possible the load for waterworks and sewerage system pumps, which currently account for 32% of government power consumption, can be reduced.

Table 5.1.3-1 Proposed Programmes in Energy Efficiency Action Plan

Programme Title	Description
1. Campaign to Distribute CFLs to Households	Joint distribution of two or three Energy Star-certified (certified by the US Department of Energy) CLFs to each household by the PPUC and electrical shops • Budget: US$ 15,000 – 20,000 • Energy saving effect: 820 MWh (US$ 180,000) Note: Interviews by the Study Team at four electrical shops found that some 90% of people already choose CFLs when purchasing lamps. Therefore, the energy saving effect of this programme is likely to be small.
2. Establishment of Fund to Promote the Introduction of a Hot Water Supply System Using Solar Heat	Facilitation of the introduction of a hot water supply system using solar heat as an alternative to en electric water heating system in homes and hotels, etc. to supper the energy consumption • Budget: US$ 20,000 • Energy saving effect: impossible to estimate (some 20% reduction of the energy consumption if an electric system is replaced by a solar system)
3. Application of Energy Saving Measures to the Bureau of Public Works Building and Campaign to Publicise Actual Examples	Replacement of fluorescent lamps using iron-core ballast with those using electronic ballast and repainting of the rooftop in white based on the findings of the energy diagnosis of the building conducted in August, 2007 • Budget: US$ 9,200 • Energy saving effect: US$ 340/month
4. Implementation of Findings of Energy Diagnosis Conducted at Buildings in the Capital	Appropriate setting of the air-conditioning temperature and control of the air-conditioning hours • Budget: US$ 20,000 • Energy saving effect: < US$ 117,000/year
5. Replacement of Lighting Fixtures at Government Buildings	Replacement of the incandescent lamps used in government buildings with CFLs and replacement of fluorescent lamps using iron-core ballast with those using electronic ballast • Budget: US$ 40,000 • Energy saving effect: US$ 20,000/year
6. Replacement of Rooftop of Government Buildings	Repainting of the rooftop of government buildings in white to improve the air-conditioning efficiency • Budget: US$ 50,000 • Energy saving effect: impossible to estimate
7. Improved Air-Tightness of Windows and Doors in Government Buildings	Improvement of the air-tightness of windows and doors through which cool air currently leaks in government buildings • Budget: US$ 7,000 • Energy saving effect: impossible to estimate
8. Survey on Pumps Used for Water Supply and Sewerage Systems in Koror and Airai States	Survey on pipeline leakage to reduce the pumping load of these systems which currently accounts for 32% of the government's electricity consumption; transition to a metered rate from the existing fixed tariff system and the installation of water meters • Budget: under examination • Energy saving effect: impossible to estimate

Programme Title	Description
9. Reduced Use of 2-Stroke Outboard Petrol Engines	Establishment of a fund to subsidize the replacement of 2-stroke outboard petrol engines by more fuel-efficient 4-stroke engines or diesel engines to cover the cost differential • Budget: US$ 10,000 • Energy saving effect: 25% saving of the fuel consumption compared to 2-stroke engines
10. Establishment of Fund to Promote the Purchase of Certified Low Energy Consumption Electrical Products	Partial refund of the purchase cost of certified (US standard or equivalent) low energy consumption electrical products using a fund with the cooperation of electrical stores and the PPUC; cooperation of the PPUC for monitoring of the power consumption before and after such purchase • Budget: US$ 30,000 • Energy saving effect: impossible to estimate
11. Campaign to Introduce the Effects of Energy Saving Programmes to Congressmen	Palau has few energy-related laws and the tax rate on fuel (US$ 0.05/gallon) has not been changed for a long time. Under this programme, congressmen will be provided with information for their examination of a law designed to reduce the energy consumption. • Budget: US$ 1,000 • Energy saving effect: impossible to estimate
12. Facilitation of the Recovery of Gas from Pig Farms	Establishment of a fund to provide a subsidy for the purchase of gas recovery equipment so that the gas produced from excreta at pig farms can be effectively used • Budget: US$ 10,000 • Energy saving effect: little
13. Energy Consumption Reduction Campaign on Remote Islands	Distribution of CFLs, repainting of rooftops in white and the offer of an energy diagnosis to suppress the energy consumption on remote islands because of the high generation cost on these islands • Budget: US$ 15,000 • Energy saving effect: 11,400 kWh (US$ 2,500)/year
14. Workshops on Efficient Energy Use and Energy Diagnosis of Ordinary Households	Local workshops to educate ordinary islanders on the need for energy saving and education in preparation for energy diagnosis • Budget: US$ 2,000 • Energy saving effect: impossible to estimate

5.1.4 Power Demand Forecast

(1) Basic Principles for Forecasting of the Power Demand

Forecasting of the power demand generally uses either the engineering method (build-up of individual demands) or the econometric method. Based on the results of comparative analysis, it was decided to use the econometric model for the power demand forecast in the Study. However, system capacity in Palau is relatively small at some 20 MW and the emergence of any large new consumers would greatly impact generating end output. Accordingly, while the Study will basically employ the econometric forecast method, the build-up method will also be used to produce a forecast which reflects an increase of the power demand by new large users by examining the existing development programmes of government and commercial facilities to ensure an accurate demand forecast.

(2) Examination of Power Demand Forecast Models

1) Historical Changes of the Electrification Rate

An increase of the electrification rate is believed to considerably affect an increase of the power demand and the electrification rate on Koror and Babeldaob Islands in 2005 was 99.5%, almost reaching the state of universal electrification.

As the oldest power demand data which can be obtained is data for 1996, the electrification rate does not affect the present forecasting of the power demand.

2) Historical Changes of the GDP

For forecasting of the GDP in the coming years, the forecast figures up to 2010 of the Bureau of Budget and Planning (BOBP) of the Ministry of Finance are used. For the period from 2010 to 2025, the GDP growth rate as of 2024 predicted by the IMF in its Article-IV Consultation Staff Report in 2005 is employed while assuming a linear decline of the GDP growth from 2010 to 2024. Based on this assumption, the forecast GDP growth rates in the future are shown in Table 5.1.4-1.

Table 5.1.4-1 Forecast GDP Growth Rates Used for Power Demand Forecast

(Unit: %)

		Actual	BOBP Forecast	IMF Forecast		
		2005	2010	2015	2020	2024
Low Case	End of Compact Assistance	8.4	7.1	3.9	0.6	-2.0
Base Case	Continuation of Compact Assistance			4.8	2.4	0.5
High Case	Increase of Compact Assistance			5.8	4.4	3.3

3) Changes of the Population

For changes of the population in the coming years, the forecast up to 2025 of the Centre for International Research (US Bureau of the Census) is used.

4) Power Demand in the Past

For the planned power demand up to 2025, power demand data for the last 20 years or so is required. However, only statistical data since 1996 is available in Palau and this data for the last 12 years is used. For the period from 1996 to 1999, data contained in the Statistical Year Book 2000 (Republic of Palau) is used. Data possessed by the PPUC is used for the period from 2000 to 2007.

5) Power Loss Factor

The power loss is defined here as the value achieved by subtracting the net system energy demand from the electric energy generated, and 20.8%, which is the average value for the last five years, is adopted here. This factor will be adopted and then the forecast will be revised upon forecasting future movements in the loss factor based on PPUC power system improvement plans as well as power station construction and transmission/distribution and transformer equipment expansion according to the master plan.

6) Load Factor

The load factor is calculated from the generating end maximum output and the gross generated energy. The load factor used for the present power demand forecast is 73.1%, which is the average load factor for the last five years for the PPUC.

7) Building of a Model

A forecasting model is built on Simple EE (ASIAM Research Institute, Japan) which is an economic forecasting simulation software used by Southeast Asian countries to forecast the power demand. This verification of the suitability of the power demand forecasting model for the Study has been conducted using the following indicators.

- Determination coefficient : 0.85 or higher is aimed at
- Durbin-Watson ratio : a value between 1.00 and 3.00 is aimed at
- Sign test of the coefficient : checking of the economic principles

With the forecasting model adopted for the Study, the power demand has been forecast for each user category using the following structural equations.

① Commercial

Power demand = f (GDP of the industrial sector; actual result for the previous year)

② Government

Power demand = f (GDP; actual result for the previous year)

③ Residential

Power demand = f (GDP/population; actual result for the previous year)

Based on the GDP growth rate forecast mentioned earlier, the power demand has been forecast for three cases of the GDP growth rate (high, base and low).

(3) Power Demand Forecast Results by Econometric Forecast Method

1) Forecast Results for Base Case (Continuation of Compact Assistance)

Table 5.1.4-2 shows the power demand and the peak demand forecast by the power demand forecast model for the base case.

Table 5.1.4-2 Forecast Power Demand and Peak Demand (Base Case)

	Unit	FY2007	FY2010	FY2015	FY2020	FY2025
Government	kWh	22,150,461	25,107,780	29,971,623	33,467,361	34,760,372
Residential	kWh	25,639,272	26,920,845	29,801,193	31,980,398	32,891,706
Commercial	kWh	32,639,230	40,468,171	48,902,179	55,068,712	57,343,296
Total	kWh	80,428,963	92,496,796	108,674,996	120,516,471	124,995,374
Growth Rate	%	3.8	5.1	2.9	1.5	0.3
Generated Energy	kWh	92,704,705	116,788,884	137,215,904	152,167,261	157,822,442
Peak Gen. Power	kW	15,581	18,238	21,428	23,763	24,646
Peak Demand	kW	13,518	14,445	16,971	18,820	19,520

Source: JICA Study Team

2) Forecast Results for Low Case (End of Compact Assistance)

Table 5.1.4-3 shows the power demand and peak demand forecast by the power demand forecast model for the low case.

Table 5.1.4-3 Forecast Power Demand and Peak Demand (Low Case)

	Unit	FY2007	FY2010	FY2015	FY2020	FY2025
Government	kWh	22,150,461	25,107,780	29,526,013	31,531,464	30,444,893
Residential	kWh	25,639,272	26,920,845	29,631,091	31,141,206	30,908,618
Commercial	kWh	32,639,230	40,468,171	48,074,283	51,488,761	49,409,885
Total	kWh	80,428,963	92,496,796	107,231,387	114,161,431	110,763,396
Growth Rate	%	3.8	5.1	2.4	0.5	-1.1
Generated Energy	kWh	92,704,705	116,788,884	135,393,165	144,143,221	139,852,772
Peak Gen. Power	kW	15,581	18,238	21,143	22,510	21,840
Peak Demand	kW	13,518	14,445	16,746	17,828	17,297

Source: JICA Study Team

3) Forecast Results for High Case (Increase of Compact Assistance)

Table 5.1.4-4 shows the power demand and peak demand forecast by the power demand forecast model for the high case.

Table 5.1.4-4 Forecast Power Demand and Peak Demand (High Case)

	Unit	FY2007	FY2010	FY2015	FY2020	FY2025
Government	kWh	22,150,461	25,107,780	30,479,298	35,807,172	40,518,065
Residential	kWh	25,639,272	26,920,845	29,994,400	32,975,602	35,411,015
Commercial	kWh	32,639,230	40,468,171	49,847,389	59,438,850	68,185,167
Total	kWh	80,428,963	92,496,796	110,321,086	128,221,623	144,114,247
Growth Rate	%	3.8	5.1	3.4	2.8	2.2
Generated Energy	kWh	92,704,705	116,788,884	139,294,301	161,895,989	181,962,433
Peak Gen. Power	kW	15,581	18,238	21,753	25,282	28,416
Peak Demand	kW	13,518	14,445	17,228	20,023	22,505

Source: JICA Study Team

4) Comparison of the Forecast for Each Case

Upon comparing changes in the forecast peak demand for the base, low and high cases, each case shows a similar pattern up to around 2013, however, the growth rate slows down thereafter for both the base case and the low case, reflecting the predicted decline of the GDP growth rate.

(4) Revision of Power Demand Forecast Results

In forecasting the power demand, survey and correction were carried out concerning the following items:

1) Accumulation of new large users such as hotels, etc.

2) Impacts of large users with a private power generation system

3) Accumulation due to development around the new capital (Melekeok State)

4) Effect on power demand reduction by introducing DSM

5) Effect on power demand reduction by introducing renewable energy

6) Estimation of future trend of power loss (based on future improvement plans)

Table 5.1.4-5 shows projected movements in the maximum power demand in each state based on the above conditions (base case), while Table 5.1.4-6 shows the results of the revised power demand forecast.

The revised power demand forecast of Base Case is used for all examinations in this Study, such as Power Station construction plans and transmission, distribution and substation expansion plan.

In case that new diesel generators that is planned to be installed in the Aimeliik Power Station adopts heavy fuel oil combustion engines, the power loss is much more than that of diesel oil combustion engines. However, utilization of heavy fuel oil has an advantage on fuel cost. The power demand forecast in case of heavy fuel oil combustion is used for this Study.

Upon comparing the power demand forecast result after revision in this Study with the latest power demand forecast of the PPUC, which was provided by Strategic Plan 2003, the forecast in Strategic Plan 2003 is found to excessively estimate and accumulate the power demand from individual projects. On the other hand, the JICA Study considers only highly feasible projects and is a more realistic forecast. Since it takes much time to actually go forward with projects in Palau and projects often end up being postponed or cancelled, it will be necessary to repeatedly revise power system expansion plans while counting only the most current and definite projects.

The future annual GDP growth rate used for the econometric forecast method was predicted by IMF in 2005. The Palauan economy is greatly influenced by negotiation result on continuation of grant aid based on the Compact with the US, which will become clear in 2009. At that time Palau will revise the future growth rate and then the PPUC also needs to revise the power demand forecast. From this point of view, the PPUC is recommended to record the actual power demand every year and check and review the disparity with the forecast as it revises the power system expansion plan.

Table 5.1.4-5 Power Demand Forecast by State (Base Case)

State	FY2007	FY2010	FY2015	FY2020	FY2025
Koror	10,111	11,743	13,280	14,586	15,080
Aimeliik	230	267	302	332	343
Ngatpang	68	78	89	98	101
Airai	2,109	2,449	2,770	3,042	3,145
Ngchesar	68	78	89	98	101
Melekeok	554	641	772	854	886
Ngaremlengui	108	126	142	156	161
Ngiwal	68	78	89	98	101
Ngardmau	41	47	53	59	60
Ngaraad	95	110	124	137	141
Ngarchelong	68	78	89	98	101

Table 5.1.4-6 Power Demand Forecast Data after Revision

Case	Kinds of Data	Unit	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
(In case of Heavy Fuel Combustion)																				
Base	Demand Energy	MWh	84,336	95,100	100,519	103,048	105,615	108,110	111,108	113,973	116,674	119,179	121,455	123,479	125,223	126,671	127,806	128,609	129,076	129,478
	Peak Demand	MW	13.17	14.85	15.70	16.09	16.49	16.88	17.35	17.80	18.22	18.61	18.97	19.28	19.56	19.78	19.96	20.08	20.16	20.22
	Generated Energy	MWh	104,247	113,350	121,253	123,944	127,040	130,830	135,767	137,648	142,401	145,431	148,134	151,721	153,813	155,547	156,948	157,878	158,466	158,574
	Peak Generated Power	MW	16.28	17.70	18.94	19.36	19.84	20.43	21.20	21.50	22.24	22.71	23.13	23.69	24.02	24.29	24.51	24.65	24.75	24.76
Low	Demand Energy	MWh	84,336	95,100	100,519	102,985	105,405	107,641	110,256	112,611	114,662	116,375	117,713	118,658	119,194	119,312	119,005	118,282	117,156	115,966
	Peak Demand	MW	13.17	14.85	15.70	16.08	16.46	16.81	17.22	17.59	17.91	18.17	18.38	18.53	18.61	18.63	18.58	18.47	18.30	18.11
	Generated Energy	MWh	104,247	113,350	121,253	123,868	126,788	130,264	134,737	136,000	139,969	142,039	143,609	145,870	146,497	146,618	146,267	145,345	144,001	142,216
	Peak Generated Power	MW	16.28	17.70	18.94	19.34	19.80	20.34	21.04	21.24	21.86	22.18	22.43	22.78	22.88	22.90	22.84	22.70	22.49	22.21
High	Demand Energy	MWh	84,336	95,100	100,519	103,119	105,852	108,640	112,072	115,527	118,990	122,442	125,860	129,231	132,533	135,752	138,871	141,867	144,727	147,631
	Peak Demand	MW	16.28	17.70	18.94	19.37	19.88	20.53	21.38	21.79	22.68	23.33	23.96	24.78	25.41	26.01	26.61	27.17	27.71	28.20
	Generated Energy	MWh	104,247	113,350	121,253	124,029	127,326	131,469	136,932	139,527	145,201	149,375	153,461	158,702	162,684	166,568	170,377	173,968	177,461	180,551
	Peak Generated Power	MW	13.17	14.85	15.70	16.10	16.53	16.97	17.50	18.04	18.58	19.12	19.65	20.18	20.70	21.20	21.69	22.15	22.60	23.05
(In case of Diesel Oil Combustion)																				
Base	Generated Energy	MWh	104,247	113,350	121,253	123,944	127,040	129,330	132,767	136,232	139,431	142,431	145,134	148,080	150,169	151,917	153,273	154,231	154,791	154,899
	Peak Generated Power	MW	16.28	17.70	18.94	19.36	19.84	20.20	20.73	21.27	21.77	22.24	22.66	23.12	23.45	23.72	23.94	24.09	24.17	24.19
Low	Generated Energy	MWh	104,247	113,350	121,253	123,868	126,788	128,764	131,737	134,584	136,999	139,039	140,609	142,229	142,853	142,988	142,592	141,698	140,326	138,541
	Peak Generated Power	MW	16.28	17.70	18.94	19.34	19.80	20.11	20.57	21.02	21.39	21.71	21.96	22.21	22.31	22.33	22.27	22.13	21.91	21.63
High	Generated Energy	MWh	104,247	113,350	121,253	124,029	127,326	129,969	133,932	138,111	142,231	146,375	150,461	155,061	159,041	162,938	166,702	170,321	173,786	176,876
	Peak Generated Power	MW	16.28	17.70	18.94	19.37	19.88	20.30	20.92	21.57	22.21	22.86	23.50	24.21	24.84	25.44	26.03	26.60	27.14	27.62

Source: JICA Study Team

5.2 Formulation of the Power Development Plan

5.2.1 Examination of the Power Station Construction Plan

(1) Power Generation Method

The electric power generated in Palau at present comes entirely from diesel power generating units. In general, the generating method is selected taking the required scale of power generation, operating mode (base, middle and peak), procurable fuel, site conditions and environmental impacts, etc. into consideration. Palau's continual employment of the diesel power generation method for future power stations is desirable in view of the facts that the peak demand in 2025 of around 25 MW will still be modest, that the construction of large-scale harbour facilities is difficult as the country is surrounded by coral reefs and that the staff members of the PPUC's power generation division are very familiar with the diesel power generation method.

(2) Fuel for Power Generation

The fuel currently used by the PPUC for power generation is a type of diesel oil (automotive diesel oil with a low sulphur content). Given the fact that the global oil price hike in recent years has been damaging the financial soundness of the PPUC, the use of heavy oil, which is cheaper than diesel oil, is proposed as the fuel for the generating units to be installed in the future.

Currently, diesel oil is supplied to Aimeliik and Malakal power stations by Shell and Mobil, respectively. The both companies transport diesel oil from Singapore to Palau by a tanker. The specifications of the tanker that Shell is using are as follows;

- Capacity : 7,850 DWT
- Total length : 110 m
- Total width : 41.6 m
- Draft : 7.1 m

According to Bunkerworld.com, who is a provider of market information for the marine fuels market and owned and operated by Petromedia Ltd (UK), seventy one companies that include five oil major companies such as BP, Chevron, ExxonMobil, Shell and TOTAL are registered to its web site as marine fuels (bunker fuel, a kind of heavy fuel oil used for vessels) supplier in Singapore.

The marine fuel handled by the above mentioned five oil major companies complies with ISO standards and is deemed compatible for use in diesel engines for power generation. In this Study, the specification of heavy fuel oil to be used for the new Aimeliik Power Station is assumed to be RME 180 (ISO grade) or equivalent. According to Shell's web site, the minimum order quantity of RME180 is 500 ton. In the event where two 5MW diesel generators start operation burning HFO in 2013, the estimated monthly consumption of HFO will be around 1,000 tons, which exceeds the minimum order quantity of Shell. Therefore, procurement will be possible.

(3) Single Unit Capacity

The single unit capacity of the generating units to be installed in the coming years is set at 5 MW per unit based on the relevant examination results explained later.

(4) Reserve Capacity

In general, reserve capacity is set at around 10% of the system capacity in industrialised countries and countries with a large system capacity. In the case of island countries such as Palau, however, since the ratio of the generating capacity of a single unit to the system capacity is fairly high, it is necessary to prepare reserve capacity assuming that a generator breaks down during the periodic inspection of another generator. Accordingly, it is proposed that reserve capacity equivalent to the capacity of the two largest generators be secured in the Koror-Babeldaob power system.

(5) Existing Generating Unit Decommissioning Plan

The Pielstick-2 through Pielstick-5 generating units at the Aimeliik Power Station are 22 years old, while rehabilitation work is planned in FY 2008 for the No. 2 and No. 3 units and in or after FY 2009 for the No. 4 and No. 5 units. The planned work comprises the replacement of major parts and can be classified as a measure to prolong the life of these units until the commencement of operation of the new units. Although the equipment manufacturers have recommended the periodic inspection of these units, such inspections have hardly been implemented at all during the 22 years of operation.

The Wartsila-2 and Wartsila-3 units at the Malakal Power Station are currently not working. The Mitsubishi-12 and Mitsubishi-13 units were recommissioned in October 2006 and January 2007 respectively following breakdowns, however, it is necessary to pay careful attention to the operation of these units so that the engine is not overloaded.

Based on the general characteristics of diesel generators and the operation and maintenance history of the generating units at the Aimeliik Power Station and Malakal Power Station, the decommissioning plan for the existing generating units shown in Table 5.2.1-1 has been formulated.

Table 5.2.1-1 Existing Generating Unit Decommissioning Plan

Power Station	Unit	Rated Output (MW)	Available Output (MW)	Total Operating Hours *1	Present Status	Decommissioning Plan
Aimeliik	Pielstick-2	3.27	2.0	128,860	Operable	Rehabilitation is scheduled to take place in FY 2008 as a measure to prolong the life until the introduction of the new units. Because of the significant decline of the output and efficiency due to severe deterioration, this will be one of the first units to be decommissioned with the commencement of the operation of the new units (to be decommissioned in 2013).
	Pielstick-3	3.27	2.0	122,359	Operable	Rehabilitation has been implemented since February, 2008 as a measure to prolong the life until the introduction of the new units. Because of the significant decline of the output and efficiency due to severe deterioration, this will be one of the first units to be decommissioned with the commencement of the operation of the new units (to be decommissioned in 2013).
	Pielstick-4	3.27	2.0	134,584	Operable	Rehabilitation is scheduled to take place in 2009 or thereafter as a measure to prolong the life until the introduction of the new units. Because of the significant decline of the output and efficiency due to severe deterioration, this will be one of the first units to be decommissioned with the commencement of the operation of the new units (to be decommissioned in 2014).
	Pielstick-5	3.27	2.0	132.149	Operable	As above
	Sub-Total	13.08	8.0			
Malakal	Wartsila-1	2.00	1.7	59,587	Operable	As this is a high speed machine (1,200 rpm), long life cannot be expected. It will be decommissioned after 20 years of operation (in 2019).
	Wartsila-2	2.00	(1.7)	n/a	Inoperable	Repair of crankshaft is scheduled after FY 2009.As this is a high speed machine (1,200 rpm), long life cannot be expected. It will be decommissioned after 20 years of operation (in 2019).
	Wartsila-3	2.00	(1.7)	n/a	Inoperable	Repair of crankshaft is scheduled in June, 2008. As this is a high speed machine (1,200 rpm), long life cannot be expected. It will be decommissioned after 20 years of operation (in 2019).
	Mitsubishi-12	3.40	3.2	69,177	Operable	Damage to the crankshaft is less severe than that of the No. 13 unit and its operation for load adjustment will continue.
	Mitsubishi-13	3.40	3.0	65,386	Operable	This unit will become a stand-by generator that is only in operation during unit 12 is shut down after 20 years of operation (in 2019).
	Caterpillar-1	1.825	1.6	4,379	Operable	As this is only used for a short period each time due to the high speed of 1,800 rpm, long life cannot be expected. This will be decommissioned after 10 years of operation (in 2016).
	Caterpillar-2	1.825	1.6	4,379	Operable	As above
	Alco-9	1.25	0.5	35,207	Operable (stand-by)	This will be decommissioned (in 2008) once the Wartsila-3 recommences operation.
Sub-Total		17.70	11.6			
Total		30.78	19.6			

[Remarks] *1: as of January, 2008

Since the PPUC currently has a reserve margin of only one unit’s capacity, it must maintain its existing generating units in good working conditions at any time and also ensure power supply capacity by elongating the life of its aged generators. It is strongly recommended that deteriorated generators at the Aimeliik Power Station must be rehabilitated and elongated their lives by replacing the worn-out major parts. Regarding the Malakal Power Station, periodical maintenance, check-up and replacement of major parts must be strictly conducted in conformity with manufacturer's operation and maintenance manual by stopping the generators in a timely manner.

(6) Power Station Expansion Plan

The plan to install the new generating units required up to 2025 has been formulated as shown in Table 5.2.1-2 based on the power demand forecast (base case) under the Study, taking the reserve capacity and generating unit decommissioning plan described earlier into consideration. According to this expansion plan, the new generating units will commence operation in three phases (Phase 1: 2 x 5 MW in FY 2013; Phase 2: 2 x 5 MW in 2014; Phase 3: 2 x 5 MW in 2019) and reserve capacity equivalent to the combined output of the two largest generating units will be continuously maintained. The year when the new generators commence operation in Phase-1 and Phase-2 is set as the earliest timing taking the procurement of fund and period of manufacturing into consideration. The delay of commercial operation for new HFO-fired diesel engine generators (Phase-1) will curtail fuel cost reduction by US$ 5.5 million/ year for one year delay and US$ 11million/year for two years delay. From the view point of power supply reliability and fuel economy, the operation of new HFO-fired generators should commence as soon as possible.

Fig. 5.2.1-1 shows the growth of power demand after 2008 and power development plan. The reserve margin of two largest generators is not secured in year 2008 and 2009 due to lack of long term power development planning and implementation in Palau for long periods. It is highly possible that the main power source in Palau will be still diesel generation for foreseeable future. Construction period of diesel power station requires around 24 months after concluding a contract with an equipment manufacturer and contractor. It will become longer if fund procurement period is considered. Thus, PPUC is strongly recommended to start power development planning and fund procurement planning for the period after year 2025 in or before 2020 at the latest and continue well-planned power development.

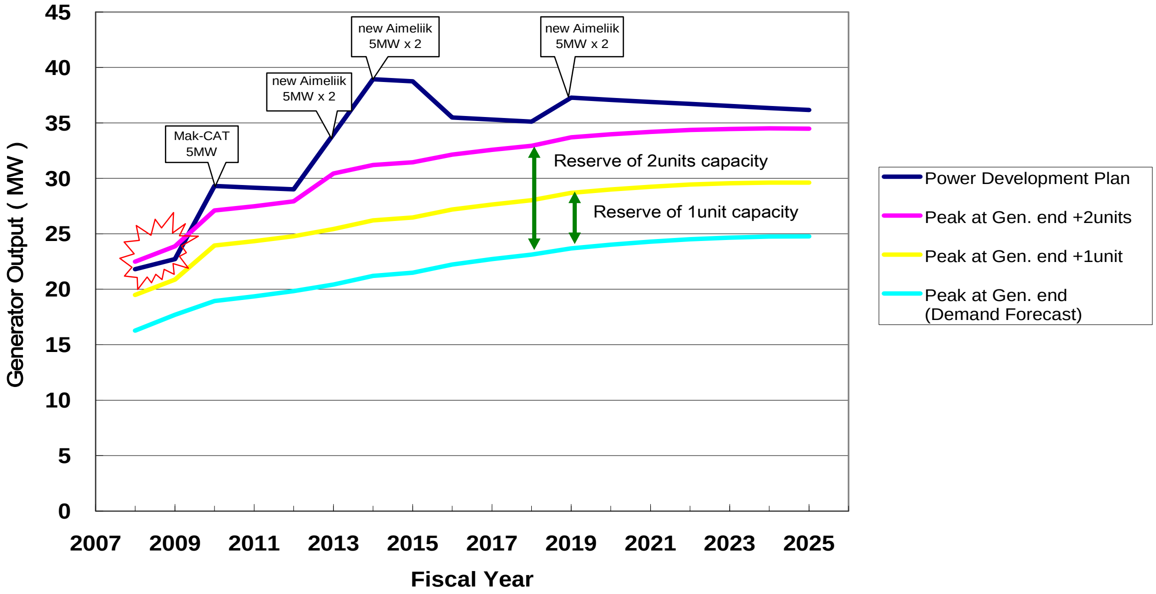


Fig. 5.2.1-1 Comparison of power demand forecast and power development

Table 5.2.1-2 Power Station Expansion Plan for the Koror-Babeldaob Power System

	Installed Year	**Capacity (MW)**	**Forecast (in Fiscal Year)**																	
			2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
1. Peak Demand（MW）			**16.28**	**17.70**	**18.94**	**19.36**	**19.84**	**20.43**	**21.20**	**21.50**	**22.24**	**22.71**	**23.13**	**23.69**	**24.02**	**24.29**	**24.51**	**24.65**	**24.75**	**24.76**
Growth Rate（%）				8.73%	6.97%	2.22%	2.50%	2.98%	3.77%	1.39%	3.45%	2.13%	1.86%	2.42%	1.38%	1.13%	0.90%	0.59%	0.37%	0.07%
2. Generating Capacity（MW）			**21.80**	**22.71**	**29.30**	**29.15**	**29.01**	**33.98**	**38.94**	**38.74**	**35.48**	**35.30**	**35.12**	**37.26**	**37.08**	**36.89**	**36.71**	**36.52**	**36.34**	**36.16**
2.1 Malakal P/S			**12.80**	**12.74**	**14.37**	**14.30**	**14.23**	**14.16**	**14.09**	**14.02**	**10.87**	**10.82**	**10.76**	**3.03**	**3.01**	**3.00**	**2.98**	**2.97**	**2.95**	**2.94**
(1) Wartsila-1	1998	2.00	1.70	1.69	1.68	1.67	1.67	1.66	1.65	1.64	1.63	1.63	1.62	**Retire**						
(2) Wartsila-2	1998	2.00	-	-	1.70	1.69	1.68	1.67	1.67	1.66	1.65	1.64	1.63	**Retire**						
(3) Wartsila-3	1998	2.00	1.70	1.69	1.68	1.67	1.67	1.66	1.65	1.64	1.63	1.63	1.62	**Retire**						
(4) Mitsubishi-12	1998	3.40	3.20	3.18	3.17	3.15	3.14	3.12	3.11	3.09	3.07	3.06	3.04	3.03	3.01	3.00	2.98	2.97	2.95	2.94
(5) Mitsubishi-13	1998	3.40	3.00	2.99	2.97	2.96	2.94	2.93	2.91	2.90	2.88	2.87	2.85	**Stand-by**	**Stand-by**	**Stand-by**	**Stand-by**	**Stand-by**	**Stand-by**	**Stand-by**
(6) Caterpillar-1（High Speed）	2006	1.88	1.60	1.59	1.58	1.58	1.57	1.56	1.55	1.54	**Retire**									
(7) Caterpillar-2（High Speed）	2006	1.88	1.60	1.59	1.58	1.58	1.57	1.56	1.55	1.54	**Retire**									
2.2 Aimeliik P/S			**9.00**	**9.98**	**14.93**	**14.85**	**14.78**	**19.83**	**24.85**	**24.73**	**24.60**	**24.48**	**24.36**	**34.24**	**34.06**	**33.89**	**33.72**	**33.56**	**33.39**	**33.22**
(1) Pielstick-2	1986	3.27	2.50	2.49	2.48	2.46	2.45	**Retire**												
(2) Pielstick-3	1986	3.27	2.50	2.49	2.48	2.46	2.45	**Retire**												
(3) Pielstick-4	1986	3.27	2.00	2.50	2.49	2.48	2.46	2.45	**Retire**											
(4) Pielstick-5	1986	3.27	2.00	2.50	2.49	2.48	2.46	2.45	**Retire**											
(5) Mak-CAT（Medium Speed）	2010	5.00			5.00	4.98	4.95	4.93	4.90	4.88	4.85	4.83	4.80	4.78	4.76	4.73	4.71	4.68	4.66	4.64
(6) New DG-1	2013	5.00						5.00	4.98	4.95	4.93	4.90	4.88	4.85	4.83	4.80	4.78	4.76	4.73	4.71
(7) New DG-2	2013	5.00						5.00	4.98	4.95	4.93	4.90	4.88	4.85	4.83	4.80	4.78	4.76	4.73	4.71
(8) New DG-3	2014	5.00							5.00	4.98	4.95	4.93	4.90	4.88	4.85	4.83	4.80	4.78	4.76	4.73
(9) New DG-4	2014	5.00							5.00	4.98	4.95	4.93	4.90	4.88	4.85	4.83	4.80	4.78	4.76	4.73
(10) New DG-5	2019	5.00												5.00	4.98	4.95	4.93	4.90	4.88	4.85
(11) New DG-6	2019	5.00												5.00	4.98	4.95	4.93	4.90	4.88	4.85
3. Power Balance(MW)（2.－1.）			**5.52**	**5.01**	**10.36**	**9.80**	**9.17**	**13.55**	**17.74**	**17.25**	**13.24**	**12.59**	**11.99**	**13.57**	**13.06**	**12.60**	**12.20**	**11.87**	**11.60**	**11.40**
4. Capacity of the largest generator（MW）			3.20	3.18	5.00	4.98	4.95	5.00	5.00	4.98	4.95	4.93	4.90	5.00	4.98	4.95	4.93	4.90	4.88	4.85
5. Firm capacity (MW) (2.－4.）			18.60	19.53	24.30	24.18	24.06	28.98	33.94	33.77	30.53	30.37	30.22	32.26	32.10	31.94	31.78	31.62	31.47	31.31
6. Reserve margin（MW）（5.－1.）			**2.32**	**1.83**	**5.36**	**4.82**	**4.22**	**8.55**	**12.74**	**12.27**	**8.29**	**7.66**	**7.09**	**8.57**	**8.08**	**7.65**	**7.27**	**6.97**	**6.72**	**6.54**
7. Capacity of second largest Generator（MW）			3.00	2.99	3.17	3.15	3.14	5.00	5.00	4.98	4.95	4.93	4.90	5.00	4.98	4.95	4.93	4.90	4.88	4.85
8. Safe reserve margin（MW）（6.－7.）			**(0.68)**	**(1.16)**	**2.19**	**1.67**	**1.08**	**3.55**	**7.74**	**7.30**	**3.34**	**2.74**	**2.19**	**3.57**	**3.11**	**2.70**	**2.35**	**2.07**	**1.84**	**1.69**

Source: Forecasted by JICA Study Team

Remarks： Decreasing factor for each engine is supposed to be 0.5 % per annum.

5.2.2 Examination of the Transmission, Distribution and Substation Facility Expansion Plan

(1) Planning Principles Under the Study

A transmission, distribution and substation facility expansion plan up to 2025 will be formulated under the Study based on comprehensive analysis of the efficiency, relevance and reliability, etc. of the relevant facilities. A realistic and optimal power system will be planned and special attention will be paid to the following points.

1) Plan contents which take the natural environment of Palau into consideration
2) Adequate establishment of the demand trend from the long-term viewpoint
3) Compatibility between the power generation facilities and transmission/distribution facilities
4) Effective utilisation of the existing facilities (in consideration of their efficiency)
5) Determination of the necessary timing to boost the facilities while allowing for the construction period
6) Cost reduction by means of the slimming down of the facilities and containment of the construction cost
7) Achievement of the required supply reliability and maintenance of adequate power quality
8) Compatibility with the existing facilities (common maintenance work and the sharing of spare parts)
9) Compatibility with existing development plans/programmes

(2) Evaluation of the Transmission/Distribution and Substation Facility Expansion Plan by Means of System Analysis

When compiling future plans for the power system, detailed examination will be conducted from the following perspectives:

1) Securing stable power supply
2) Rationalization of design
3) Evaluation of equipment and control and protection systems

Accordingly, the following system analysis was carried out in the Study:

- Confirmation of the secured installed supply capacity by means of power flow calculation
- Analysis of the static stability and transient stability of the system
- Confirmation of the maintenance of an adequate voltage and voltage stability
- Checking of any exceeding of the rated interrupting current of the circuit breaker by means of calculating the short-circuit current

(3) Review of the Development Plan of the PPUC

The latest plan of the PPUC for expansion of the transmission, distribution and substation facilities is the Strategic Plan for 2003 to 2008 formulated by a US consultancy firm (Oceanic Companies, Inc.) in August, 2003. One of its reports entitled “Financing Basis and Construction Plan for a New Power Station and Upgrading of Transmission and Distribution” points out the problems of the present power system and proposes a transmission, distribution and substation facilities upgrading plan. Table 5.2.2-1 shows the outline of this upgrading plan, its review results and the present situation.

Table 5.2.2-1 Review Results of the PPUC’s Upgrading Plan

Proposed Item	Outline	Present Situation and Evaluation
Construction of a new substation in Koror State	A new substation and transmission line are required as power supply to Koror State where the power demand in Palau is concentrated can become impossible if a problem occurs with the transformer at the Airai Substation or the transmission line between Airai and Aimeliik.	Koror State is responsible for 75% of the power demand in Palau. The construction of a new substation is required following the installation of the second transmission line between the Aimeliik Power Station and Koror State.
Construction of a new seabed transmission line (34.5 kV) between the Aimeliik Power Station and T Dock on Koror Island	A new seabed transmission line will be constructed to double the power supply lines from the Aimeliik Power Station to Koror State to rectify the fragile power supply system for Koror State to improve the power supply reliability.	The construction of an overhead line may be considered as an alternative because of cost and environmental considerations.
Overhead transmission line (34.5 kV) between T Dock and the Koror Substation	Following the construction of a new seabed transmission line as outlined above, a new transmission line will be required between the terminal section of this seabed line on the Koror side and the Koror Substation.	This new line will be required if a new seabed transmission line is constructed.
Increased voltage for the distribution line between the Kokusai Substation and Melekeok State (upgrading to a transmission line)	While power supply to Melekeok, the new capital, is currently provided from the Kokusai Substation via a 13.8 kV distribution line, upgrading of this line to a 34.5 kV transmission line is necessary in view of an expected demand increase in the coming years.	As the transformer capacity at the Kokusai Substation has been increased from 750 kVA to 5 MVA, any demand increase can be met for some time. The old HDCC 38 mm^2 wire has been replaced by AAC 150 mm^2 wire.
Construction of a new substation in the capital (Melekeok State)	The construction of a new substation is required to ensure a stable power supply for the new capital as explained above.	As above
Replacement of the wire of the Malakal distribution line	The capacity of the existing distribution wire (HDCC 38 mm^2) is insufficient for some feeder line and consideration of its replacement by AAC 150 mm^2 wire is necessary.	Already completed
Upgrading of the distribution lines on Koror Island	The distribution line on Koror Island uses wooden poles at some sections and their modernisation is necessary. Along with the modernisation work, replacement of the wire from HDCC 38 mm^2 to AAC 150 mm^2 should be considered to increase the distribution capacity.	Modernisation work is being conducted when found to be necessary.
Introduction of a SCADA system	The installation of a new seabed transmission line will enable loop operation between the Aimeliik Power Station and Koror State, an important load area, and both the reliability of the power supply and the flexibility of operation of the power facilities will improve. To achieve this, however, the introduction of a SCADA system is necessary so that the entire status of operation can be constantly monitored.	A SCADA system has already been introduced by a US consultancy firm (Electric Power Systems, Inc.) However, some improvements are required, including the introduction of a full range of equipment and the ability to download records.

(4) Transmission, Distribution and Substation Facility Expansion Plan

A transmission, distribution and substation facility expansion plan has been formulated based on the review results described in the previous section and the latest survey findings. Table 5.2.2-2 outlines the planned projects and their timing.

1) The new Koror Substation will be constructed as an important substation to supply power to Koror State, replacing the Airai Substation. A lead-in wire arrangement is adopted for the existing Airai-Malakal transmission line and two supply routes from the Aimeliik Power Station to the Koror Substation will be secured to enable continual power supply when one transmission line breaks down.

2) 3 MVA capacitors will be installed in the Malakal Power Station and the Koror Substation to compensate for a voltage drop of the system. Detailed examination will be required concerning the timing and method of capacitor installation.

3) In the event where the load and power factor improvements (installation of capacitors to distribution line) currently planned by the PPUC are implemented, it will be necessary to review the capacity of capacitors and the timing of installation.

4) The 2003 Strategic Plan recommends the construction of a new Aimeliik-Koror transmission line using submarine cable. However, as a result of comprehensive analysis of the cost and environmental implications of the new line, it has now been decided to double the Aimeliik-Koror transmission line by introducing a new overhead transmission line to improve the reliability of power supply on this route. The planned time for commissioning is FY 2013 in accordance with the plan to commission the new generating units at the Aimeliik Power Station.

5) In accordance with the installation of two new diesel generators at the Aimeliik Power Station scheduled to take place in 2013, the construction of the new Aimeliik Substation next to the power station is planned.

Table 5.2.2-2 Transmission, Distribution and Substation Facility Expansion Plan Up To FY 2025

FY	Project	Outline	Estimated Cost (MUSD)
2008	Relocation of transmission and distribution lines	Relocating parts of transmission and distribution lines along the Compact road	PPUC Planned
2008	Extension of distribution lines to unelectrified areas	Parts of Ngiwal and Airai States	PPUC Planned
2008	Capacitor installation in distribution lines	13.8kV, Total 4.4MVA	PPUC Planned
2009	SCADA improvement	Completion of repair by EPS and adding data store function	PPUC Planned
2010	Auto-Recloser installation in Babeldaob	13.8kV, 6 places (Aimeliik 1, Aimeliik 2, Nekken, Ibobang, Ngaraad 1, Ngaraad 2)	PPUC Planned
2012	Installation of a capacitor at the Malakal Power Station	34.5 kV; 3 MVA	0.3
2013	Construction of the Koror Substation	34.5 kV; 15 MVA; three transmission circuits; 3 MVA capacitor	3.0
	Construction of the new Aimeliik-Koror transmission line	34.5 kV; 19.3 km; AAC 150 mm^2	2.7
	Construction of the new Nekken-Kokusai transmission line	34.5 kV; 3.1 km; AAC 150 mm^2	0.3
	Improvement of the distribution grid in Koror State	Improvement of the distribution grid following the construction of the new Koror Substation	0.2
	Construction of the new Aimeliik Substation	34.5 kV; 15 MVA x 1 new transformer; relocation of two existing transformers; three transmission circuits	4.2
2013	Control Center and transmission line improvement in Northern area	Upgrading SCADA, Equipment for Control Center, 34.5 kV Auto-Reclosers in three places (Kokusai, Asahi and Ngerdmau)	0.5
2014 - 2019			
2020 - 2024	Rebuilding of the Airai Substation (to be conducted in correspondence with the situation of equipment deterioration)	34.5 kV; 15 MVA; three transmission circuits	2.5
2025	Construction of the new Airai-Melekeok transmission line	34.5 kV; 24.5 km; AAC 150 mm^2	2.5
	Construction of the new Melekeok Substation	34.5 kV; 10 MVA; three transmission circuits	2.3
	Increase of the voltage of the Kokusai-Melekeok distribution line	13.8 kV → 34.5 kV; 10.5 km	0.2
	Replacement of a transformer at the new Aimeliik Substation	34.5 kV; 10 MVA (one unit) → 15 MVA (one unit)	1.2

It is assumed that the new Koror Substation will cater for some 70% of the power load in Koror State after its commissioning. FY 2013 is planned as the year of commissioning in line with the completion of both the new transmission line and the new generating units at the Aimeliik Power Station.

(5) Improvement of the Distribution Grid in Koror State

As a result of the examination of the preferable distribution method for Koror State after the construction of the new Koror Substation, it is now planned to draw two feeder distribution lines from the Koror Substation for their connection to the existing distribution line between Airai and Koror and the distribution line in the Ngerchemai District respectively as shown in Fig. 5.2.2-1.

After the Koror Substation starts operation, load will be shared so that the Koror Substation will take about 70 % of the load in Koro State and the Malakal Power Station will take about 30 %.

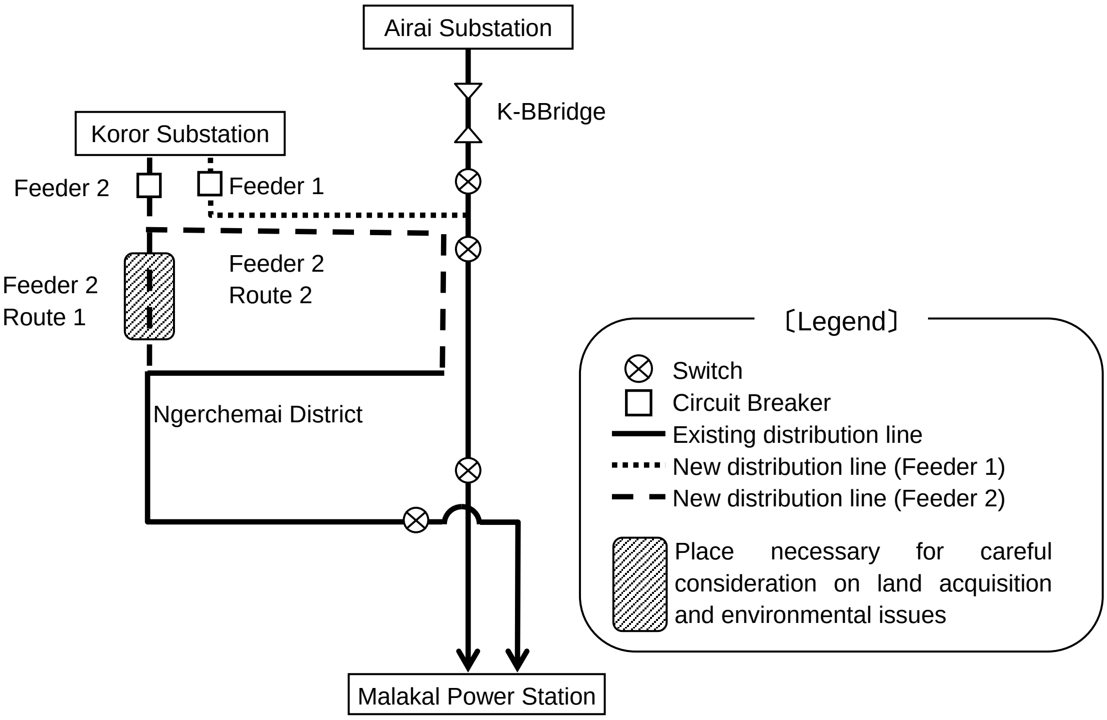


Fig. 5.2.2-1 Installation Method for Feeders from Koror Substation

(6) Rebuilding of the Arai Substation

Airai Substation is scheduled to undergo overhaul of the transformer in 2008 under the JICA follow-up assistance. While it is inferred that this substation will probably operate for another 10 years after this overhaul, rebuilding of the substation is likely to be necessary around 2020 to 2025. A π arrangement will be made for the lead-in cable of the Aimeliik-Airai transmission line at the time of this rebuilding work to allow for extension of the transmission line in the direction of Melekeok if required.

(7) Upgrading of the Voltage of the Kokusai-Melekeok Distribution Line (Upgrading to a Transmission Line)

Given the importance of ensuring the reliability of power supply for Melekeok State which includes the capital, the Strategic Plan calls for upgrading of the existing distribution line to a 34.5 kV transmission line.

However, the power demand in Melekeok State is still around 600 kW based on the results for 2007. Even if a high level of power demand in the near future is assumed, upgrading of the Kokusai-Melekeok distribution line to a 34.5 kV transmission line is not an urgent requirement from the viewpoint of the power demand. As the postponement of investment is a very effective way of improving the financial health of the PPUC, it is desirable to implement this project based on careful consideration of the demand growth trend and the development situation in and around the capital.

Two alternative routes to supply power to the capital are feasible: one entails construction of a new transmission line between Airai and Melekeok, and the other entails construction of a transmission line between Ngaragaard 1 substation and Melekeok. As both routes run along Compact Road, few problems are anticipated in regard to the construction and maintenance of the new transmission line. The construction of the Airai-Melekeok transmission line (alternative ①) is preferable for the future of the Koror-Babeldaob power system when it is considered that a new substation may be constructed in response to the growing power demand in Airai State.

(8) Measures to Compensate for Voltage Drop of 34.5 kV Transmission Line

From 2014 onwards, Malakal Power Station will become a reserve power station to deal with emergency situations. It will, therefore, constitute an end facility in the system. In this instance, a considerable voltage drop will occur in the 34.5 kV bus line of Malakal Power Station, necessitating installation of phase compensators at Malakal Power Station and Koror Substation.

(9) Measures to Compensate for Voltage Drop of 13.8 kV Distribution Lines

Power factor in Koror-Babeldaob system becomes 0.81 at peak demand. It is very small number for the power factor. It forces generators to operate with high voltage, burden auxiliary machinery in Power Stations and also causes the power loss increase in transmission and distribution. In order to improve the power factor, the PPUC is going to install capacitors (total 4.4 MVAR) in 13.8 kV distribution lines in 2008. It is very effective to improve the voltage drop and improve the transmission and distribution loss. It is, therefore, highly recommended.

(10) Extension of Distribution Lines to Unelectrified Areas

There are still unelectrified areas in parts of Ngiwal State and Airai State and the extension of a distribution line to these areas is necessary. Because of the high level of urgency and small budget requirement, the implementation of the necessary work disregarding the target period of the master plan (2010 – 2025) is preferable.

(11) Upgrading of SCADA and Control Center Establishment

It is urgently necessary to rehabilitate important functions for the operation of power equipment, for example, improvement of SCADA system troubles and enhancement of recording functions, etc. Moreover, since it will be necessary to install a control center in 2013 when transmission/distribution and transformer equipment will be rehabilitated, it will be necessary to upgrade the SCADA system in line with this.

(12) Installation of Auto-Reclosers in 34.5 kV Transmission Lines and 13.8 kV Distribution Lines

At present, no circuit breaker with proper protection system is installed and no function to measure voltage, current, power factor, etc. is provided on 13.8 kV feeders of six substations. To solve this problem, newly installation of auto-reclosers at the said six substations should be realized before 2010, so that operators can remotely control and supervise the feeders.

(13) Power System Analysis Results

System analysis was conducted for the present power system and future power system examined in the previous section and the problems were checked and verified. This system analysis was conducted using POPONAS (a power system stability analysis system developed by the Central Research Institute of Electric Power Industry) and ADAPOS (a power system analysis support system developed by Mitsubishi).

(14) Power Flow Calculation Results

Power flow calculation was conducted for those years (2012, 2013, 2024 and 2025) in which the system configuration will differ from the present configuration (2008). Based on the results of analysis, it was confirmed whether or not the transmission and substation facilities are within the tolerance of the installed capacity. In regard to the transformers, it was confirmed that no cross-section exceeds the tolerance as shown in Table 5.2.2-3. All of the transmission lines use or plan to use AAC 150 mm^2 wire, and it was also confirmed that no cross-section on any route exceeds the maximum transmission capacity of 23 MW.

Table 5.2.2-3 Comparison Between Power Flow Calculation Results and Transformer Capacities

Substation	Capacity (MVA)	2008	2012	2013	2024	2025
Ngeraard2	0.75	0.07	0.08	0.09	0.11	0.11
Ngeraard1	0.225	0.10	0.13	0.13	0.16	0.16
Ngerdmau	0.225	0.04	0.05	0.05	0.06	0.06
Asahi	0.3	0.12	0.15	0.15	0.18	0.18
Ibobang	0.225	0.03	0.04	0.04	0.04	0.05
Kokusai	5	0.73	0.92	0.94	1.13	-
Nekken	0.225	0.04	0.05	0.05	0.06	0.06
Aimelik-1	0.3	0.12	0.15	0.16	0.19	0.19
Aimelik-2	0.225	0.12	0.15	0.16	0.19	0.19
Airai	10	7.14	8.94	2.90	3.46	9.47
Malakal	10	0.81	2.17	1.61	2.55	2.55
Aimeliik	20	7.72	12.85	-	-	-
Koror	15	-	-	9.73	11.61	11.65
Melekeok	10	-	-	-	-	1.13
New Aimeliik	35	-	-	16.05	19.74	19.81

(15) Short-Circuit Current Calculation Results

It has been confirmed that the short-circuit current calculated based on the system analysis results is within the breaking capacity of each existing circuit breaker as shown in Table 5.2.2.-4 and Table 5.2.2-5. For each of the planned new circuit breakers, the rated breaking current will be selected based on the said analysis results.

Table 5.2.2-4 Short-Circuit Current Calculation Results and Rated Interrupting Current of Circuit Breakers (for the Power System in 2008)

	Short-Circuit Capacity (MVA)		Short-Circuit Current (kA)		Rated Interrupting Current of Circuit Breaker (kA)	
	34.5 kV side	13.8 kV side	34.5 kV side	13.8 kV side	34.5 kV side	34.5 kV side
Ngeraard2	39	1	0.7	0.04	-	-
Ngeraard1	45	10	0.8	0.42	-	-
Ngerdmau	53	1	0.9	0.04	-	-
Asahi	72	5	1.2	0.21	-	-
Ibobang	83	1	1.4	0.04	-	-
Kokusai	97	43	1.6	1.80	-	-
Nekken	135	1	2.3	0.04	-	-
Aimelik-1	160	5	2.7	0.21	-	-
Aimelik-2	133	1	2.2	0.04	-	-
Airai	133	76	2.2	3.18	12.5	18
Malakal	124	130	2.1	5.44	12.5	12.5
Aimeliik	165		2.8		12.5	

Table 5.2.2-5 Short-Circuit Current Calculation Results and Rated Interrupting Current of Circuit Breakers (for the Power System in 2013)

	Short-Circuit Capacity (MVA)		Short-Circuit Current (kA)		Rated Interrupting Current of Circuit Breaker (kA)	
	34.5 kV side	13.8 kV side	34.5 kV side	13.8 kV side	34.5 kV side	34.5 kV side
Ngeraard2	39	1	0.7	0.04	-	-
Ngeraard1	45	10	0.8	0.42	-	-
Ngerdmau	54	1	0.9	0.04	-	-
Asahi	72	5	1.2	0.21	-	-
Ibobang	83	1	1.4	0.04	-	-
Kokusai	97	43	1.6	1.80	-	-
Nekken	135	1	2.3	0.04	-	-
Aimelik-1	161	5	2.7	0.21	-	-
Aimelik-2	128	1	2.1	0.04	-	-
Airai	135	75	2.3	3.14	12.5	18
Malakal	114	95	1.9	3.97	12.5	12.5
Aimeliik	165	244	2.8	10.21	12.5	
Koror	130		2.2			

(16) Power System Stability Analysis

Concerning static stability in the Koror- Babeldaob power system, it was confirmed that all generators operate stable when there are no power system faults. As for transient stability, as a result of analyzing stability during breakdown of one transformer and one transmission line, it was confirmed that disturbances in the generators at Malakal and Aimeliik Power Stations are absorbed.

(17) Voltage Drop and Transmission Loss

From 2014 onwards, the four generators at Malakal Power Station will no longer need to operate at all times and this facility will become an end facility in the system. In this instance, a considerable voltage drop will occur. In order to examine the voltage drop in each annual cross section, the voltage drop was examined for two cases of the load power factor, i.e. 80% and 90%.

1) Measures to Improve Voltage Drop

① Conditions of Voltage Regulation in This Simulation

In the case where no generator at the Malakal Power Station is operated after 2014

In case of 90 % of power factor, if the tap of the step-up transformer at the new Aimeliik Substation is changed and the sending voltage is kept higher, the above criteria can be cleared.

In case of 80 % of power factor, countermeasures shown in Table 5.2.2-6 are necessary.

Table 5.2.2-6 Countermeasures necessary in case of 80% Power Factor

FY	Countermeasures against voltage drop
2014	- Change the tap of the step-up transformer at new Aimeliik Substation (5% up) - Install a 1 MVA compensator at Koror Substation and Malakal Power Station respectively
2015	- Increase the capacity by 0.5 MVA at Koror Substation and Malakal Power Station respectively
2017	- Increase the capacity by 0.5 MVA at Koror Substation and Malakal Power Station respectively
2019	- Increase the capacity by 0.5 MVA at Koror Substation and Malakal Power Station respectively
2020	- Increase the capacity by 0.5 MVA at Koror Substation and Malakal Power Station respectively (in consideration of loop-off)
2023	- Increase the capacity by 0.5 MVA at Koror Substation and Malakal Power Station respectively (in consideration of loop-off)

② In the case where at least one generator at the Malakal Power Station is operated after 2014

Voltage can be maintained at the rated level by operating just one generator (Mitsubishi-12), and operation of generators at this station is effective for improving the quality of electric power. Compared to the case of no generator operation at Malakal Power Station, since the disparity in voltage drop due to difference in the load factor is small, this is also significant.

2) Measures to Reduce Transmission Loss

Transmission loss is reduced when voltage improvements are implemented. Therefore, the abovementioned voltage drop countermeasures are also effective for reducing transmission losses. Accordingly, operation of generators at Malakal Power Station greatly contributes to maintaining the system voltage and reducing the transmission loss. The transmission loss reduction, in the case where one generator at the Malakal Power Station is constantly operated, amounts to an annual cost reduction of between US$ 0.5~1.0 million if it is converted using the generating cost in 2007 of 0.1904¢/kWh. (Refer to Table 5.2.2-7)

Table 5.2.2-7 Benefit of Generator Operation at Malakal Power Station

Case	Item	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Power Factor 80%	Improvement of transmission loss (%)	2.5%	2.7%	2.9%	3.0%	3.0%	3.2%	3.3%	3.4%	3.5%	3.6%	3.6%	2.7%
	Annual benefit (US$ Million)	0.6	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.1	1.1	0.8
Power Factor 90%	Improvement of transmission loss (%)	1.4%	1.5%	1.6%	1.7%	1.6%	1.7%	1.7%	1.8%	1.8%	1.8%	1.9%	1.5%
	Annual benefit (US$ Million)	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.4

In this Study, the new Aimeliik-Koror transmission line is to be operated in 2013. The transmission loss of a single-circuit transmission line will be more than twice of that of double-circuit transmission line. Accordingly the double-circuit transmission line is helpful to reduce the transmission loss. The transmission loss reduction, in the case where the transmission route from the new Aimeliik Substation to the Koror Substation is double- circuited, deserves annually around US$ 0.6 Million of financial benefit if it is converted using 0.1904¢/kWh of generating cost in 2007 (refer to Table 5.2.2-8).

Table 5.2.2-8 Benefit of Double Circuits of Transmission Line between Aimeliik and Koror

Case	Item	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Power Factor 80%	Improvement of transmission loss (%)	1.7%	1.7%	1.7%	1.8%	1.8%	2.0%	2.0%	2.1%	2.1%	2.1%	2.1%	2.1%
	Annual benefit (US$ Million)	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Power Factor 90%	Improvement of transmission loss (%)	1.6%	1.6%	1.6%	1.7%	1.7%	1.9%	2.0%	2.0%	2.0%	2.0%	2.1%	2.1%
	Annual benefit (US$ Million)	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6

* Calculation conditions: After voltage improvement by compensators installed at Malakal and Koror

As mentioned above, the transmission loss depends on the system conditions, such as voltage improvement by capacitors, loop-on or loop-off of double-circuit transmission line from Aimeliik to Koror. In every case, the transmission loss in case of Malakal generator operation is half of that in case of no Malakal generator operation.

3) Recommendations

As examined here, a high power factor will reduce the level of the current on the transmission line, reducing the transmission loss and realizing efficient use of transformers. It may be necessary to introduce a scheme to urge large users with a low power factor to improve their power factor by installing a compensator and so on. Since the PPUC plans to install capacitors to distribution lines, it will be necessary to review these installation plans while constantly monitoring the load factor following installation.

Environmental and Social Considerations at the Examination Stage of the Power Development Plan

5.2.3 Environmental and Social Considerations at the Examination Stage of the Power Development Plan

(1) Power Development Projects subject to Environmental and Social Considerations in the Master Plan Study

The present Study features the power development plan for a period of 15 years from 2010 to 2025 and the power supply facility construction projects under this plan are the subjects of "environmental and social considerations at the examination stage of the power development plan".

Table 5.2.3-1 Power Generation Projects Included in the Power Development Plan

FY	Project Title	Outline
2013	Replacement of Aimeliik Power Station (Phase 1)	• Procurement of two diesel generators (5 MW class) and auxiliary machinery • Remodelling of the fuel storage and supply facilities (in the case of heavy oil firing) • Construction of the power house (including those for the two generators in Phase 2) and an office building
2014	Replacement of Aimeliik Power Station (Phase 2)	• Procurement of two diesel generators (5 MW class) and auxiliary machinery
2019	Replacement of Aimeliik Power Station (Phase 3)	• Procurement of two diesel generators (5 MW class) and auxiliary machinery • Construction of additional power house (for the two new generators in Phase 3)

Note : Gray parts: Priority projects (target of the pre-F/S)

Table 5.2.3-2 Transmission and Distribution Projects Included in the Power Development Plan

FY	Project	Outline	Requirement for Social and Environmental Consideration
2012	Installation of a compensator at the Malakal Power Station	34.5 kV; 3 MVA	No
2013	Construction of the Koror Substation	34.5 kV; 15 MVA; three transmission circuits; 3 MVA compensator	Yes
	Construction of the new Aimeliik-Koror transmission line	34.5 kV; 20.7 km; AAC 150 mm^2	Yes
	Construction of the new Nekken-Kokusai transmission line	34.5 kV; 3.1 km; AAC 150 mm^2	Yes
	Improvement of the distribution grid in Koror State	Improvement of the distribution grid following the construction of the new Koror Substation	No (Installation of switch and replacement of cable)
	Construction of the new Aimeliik Substation	34.5 kV; 15 MVA x 1 new transformer; relocation of two existing transformers; three transmission circuits	To be included in the Aimeliik Power Station replacement project because of the involvement of the same site
2020 - 2024	Rebuilding of the Airai Substation (to be conducted in correspondence with the situation of equipment deterioration)	34.5 kV; 15 MVA; three transmission circuits	No (Rebuilding at the existing substation side)

FY	Project	Outline	Requirement for Social and Environmental Consideration
2025	Construction of the new Airai-Melekeok transmission line	34.5 kV; 24.5 km; AAC 150 mm^2	Yes
	Construction of the new Melekeok Substation	34.5 kV; 10 MVA; three transmission circuits	No (Site undecided)
	Increase of the voltage of the Kokusai-Melekeok distribution line	13.8 kV → 34.5 kV; 10.5 km	No (Reutilizing of the existing cable)
	Replacement of a transformer at the new Aimeliik Substation	34.5 kV; 10 MVA (one unit) → 15 MVA (one unit)	No (Renewal of the existing transformer)

Note : Gray parts: Priority projects (target of the pre-F/S)

Concerning the renewable energy introduction plan, which is a long-term target of the Study, environmental and social factors are considered regarding hydropower, wind power and solar power which are examined for feasibility in this report.

(2) Initial Environmental Examination (IEE) on the Master Plan Study

1) Current Situation of the Target Area

Palau designates 21 conservation areas that consist of marine reserves and mangrove reserves, etc. Especially, Lake Ngardok Nature Reserve was designated as an important wetland under the Ramsar Convention (2002). Moreover, Palau has rich historical and cultural heritage such as the stone monuments in northern Babeldaob as well as artifacts from World War II, etc.

2) Impact Assessment

General environmental and social impact assessment related to the construction projects of power supply facilities that are possible to be incorporated into the Power Development Plan is shown in the table below.

Table 5.2.3-3 Environmental and social impact assessment on the construction projects of power supply facilities

Environmental Factors		Hydropower			Wind Power	Solar Power	Diesel	T&D Line		Sub-station
		Dam type	Flow-in type	Micro hydro			Power	Over-head	Sub-marine	
Social Environment	Involuntary resettlement	A	B	C	B	C	B	B	C	C
	Local economy, such as employment and livelihood	A	B	C	C	C	B	B	B	C
	Land use and utilisation of local resources	A	B	B	B	B	B	B	C	B
	Social institutions, such as social infrastructure and local decision-making system	C	C	C	C	C	C	C	C	C
	Existing social infrastructure and services	C	C	C	C	C	C	B	C	C
	The poor, indigenous and ethnic people	C	C	C	C	C	C	C	C	C
	Erroneous communication of interests	C	C	C	C	C	C	C	C	C
	Cultural heritage	B	C	C	C	C	C	C	C	C
	Local conflict of interests	C	C	C	C	C	C	C	C	C
	Water usage or water rights and rights in common	A	B	B	C	C	C	C	C	C
	Public hygiene	C	C	C	C	C	C	C	C	C
	Infectious diseases	C	C	C	C	C	C	C	C	C
Natural Environment	Topography and geographical features	A	B	C	C	C	C	C	C	C
	Soil erosion	B	C	C	C	C	C	C	C	C
	Groundwater	C	C	C	C	C	C	C	C	C
	Hydrological conditions	A	B	C	C	C	C	C	C	C
	Coastal zone	C	C	C	C	C	C	C	B	C
	Flora, fauna and biodiversity	A	B	C	B	C	B	B	A	C
	Meteorology	C	C	C	C	C	C	C	C	C
	Landscape	A	B	C	B	B	B	B	C	C
	Global warming	C	C	C	C	C	B	C	C	C
Pollution	Air pollution	C	C	C	C	C	B	C	B	C
	Water pollution	A	B	C	C	C	B	C	C	C
	Soil contamination	C	C	C	C	C	C	C	C	C
	Waste	B	B	C	C	B	B	C	C	C
	Noise and vibration	B	B	C	B	C	B	C	C	C
	Ground subsidence	C	C	C	C	C	C	C	C	C
	Offensive odour	C	C	C	C	C	C	C	C	C
	Bottom sediment	A	B	C	C	C	C	C	B	C
	Accidents	A	B	C	C	C	C	B	C	B

Legend A : Serious impact is expected
B : Some impact is expected
C : No or minimal impact is expected

(3) Mitigation Measures and Items to be Considered in the Implementation Stage

1) Hydropower

Even though Palau has a lot of rainfall at 3,800mm/year, it is difficult to generate enough power by flow-in type hydropower as described previously because the elevation is not high enough even the top of the highest mountain Ngerchelchuus reaches 242 m. Thus, it is considered that dam-type and micro-hydro are the feasible types of hydro power generation.

In case of applying dam-type hydro, a construction site must be carefully selected in order to avoid the location of conservation areas and historical and cultural heritage as well as large scale resettlement. In addition, full scale EIA (Environmental Impact Assessment) and flow measurement of a target river should be implemented and the results of the assessment and the measurement should be taken into consideration in construction and site work planning in order to minimize the impact on the eco-system and the river basin.

2) Wind Power

As long as judging from the currently available wind monitoring data, Palau does not have high potential for wind power generation. It is recommended that impact on flying birds, noise and landscape should be carefully considered in implementing wind monitoring and site selection.

3) Solar Power

Generally speaking, solar power generation has less environmental impact. In case of grid-connection solar system, batteries are not necessary and battery disposal is not a problem. However, used-battery management system should be established for independent solar system because it requires periodical replacement of batteries.

4) Diesel Generation

Diesel generation may cause air pollution due to nitrogen oxides and sulfur oxides contained in exhaust gas and noise disturbance. Application of mitigation measures (i) to reduce ground concentration of air pollutant such as selecting low-NOx type engines and higher stacks and (ii) to reduce noise level at residences around the power station by utilizing the power house as a noise-prevention wall are necessary.

5) Transmission and Distribution Lines

Overhead lines may give impact on land utilization, flora and fauna and traffic during construction work. Transmission and distribution line routes should be carefully selected in order to avoid the location of conservation areas and historical and cultural heritage as well as involuntary resettlement. Impact on traffic during construction work should be mitigated by clearly indicating detour and “men at work” signs and enforcing traffic control.

6) Substation

Change of land utilization by the land acquisition and electric shock to ordinary people who enter the premise of the Substation is concerned. Since the land for electric pole or substation in Palau is often provided by the landowner free of charge as a local custom, there is no specific concern on the land acquisition. Electric shock to ordinary people should be prevented by installing a fence around the substation and locking the entrance.

5.3 Examination of Power Supply Options Including Renewable Energies

5.3.1 Current Condition and Assessment of Renewable Energies in Palau

(1) Photovoltaic Power Generation

Palau has high potential for photovoltaic power generation because it enjoys a high degree of solar radiation throughout the year. The Japan Agency for Marine Earth Science and Technology (JAMSTEC) established a meteorological data observation station at Aimeliik in 2003 and has since been gathering data on solar radiation on the ground surface. According to data gathered over the past three years, the mean annual amount of solar radiation is 4.51 kWh/m^2/day. Incidentally, data measured by NASA indicates a mean annual amount of solar radiation of 5.01 kWh/ m^2/day.

The Study examines the method of grid connection to the PPUC power system, i.e. linking power generated by photovoltaic cells during times of strong solar radiation to the grid side with a view to reducing PPUC diesel power generation, fuel consumption and CO_2 emissions.

Generally speaking, photovoltaic power generation takes up a vast amount of land space for the installation of photovoltaic cells, however, the forest coverage ratio of Palau is given as 87% and there are not a lot of open spaces suitable for the installation of photovoltaic cells. It makes little sense to cut down trees to make way for photovoltaic cells. Accordingly, examination in the Study is advanced based on the assumption that photovoltaic cells will be installed on the rooftops of large government buildings, universities, high schools, elementary schools, gymnasiums and hospitals, etc. that are numerously built in Koror.

Moreover, amid forecasts that the price of diesel fuel will continue to spiral from now on, it may be effective to install a photovoltaic system with output of between 100~200 kWp in Koror city center and use this to impress the need for energy saving and CO_2 emissions reduction to the citizens of Palau.

(2) Hydropower Generation

Palau has extremely high rainfall. Even though this fluctuates greatly from 520 mm during the rainy season in July to 100 mm during the dry season in February, the total amount of annual rainfall reaches 3,520 mm and, since there are numerous small rivers, there is thought to be high potential for the installation of micro hydropower systems. However, since it is necessary to conduct extended flow survey and overcome various environmental and social issues, the best candidate plan at present is thought to be to utilize overflow water from the waterworks reservoir that is currently being planned under support from the ADB.

Regarding the present public water supply in Koror and Airai State, water from the Ngerimal source in Airai State in the south of Babeldaob Island is currently supplied; however, during the dry season, since the water source dries up, this region is faced with critical water shortages. In response to this situation, the Government of Palau is advancing plans to construct a public water supply system on Babeldaob Island using ADB funds in order to secure a new source of water, and the new system is scheduled to be commissioned in 2011. It will be possible to realize hydropower generation potential of up to 200 kW through utilizing the overflow water from this new public water supply source.

(3) Solar Thermal Power Utilization

There are no statistics on the utilization of solar water heaters in Palau so the situation regarding dissemination is unclear, however, judging from conditions in Koror, no solar water heaters can be seen on building rooftops apart from one Taiwanese-owned hotel. Moreover, the Director of the Energy Office has said that electric water heaters are commonly used and that the spread of solar water heaters has so far been slow in Palau.

Within the Energy Efficiency Action Plan currently being compiled by the Government of Palau, one of the programs proposed for the reduction of energy consumption is the establishment of a fund for promoting the introduction of solar water heaters. According to this, agreements for the borrowing of new housing loans have come to include a clause requiring the installation of a solar water heater. Moreover, with the appearance of cheap Chinese-made solar water heaters in recent years, it is expected that such heaters will become more widespread from now on.

Solar water heaters are simple, relatively cheap and can certainly enable electricity tariff savings for power users. Since solar water heaters can lead to reduction of diesel power generation, fuel consumption and CO_2 emissions, they are a promising means of introducing renewable energy, and it is desirable that the Government of Palau continues to promote their dissemination.

(4) Wind Power Generation

There is not a lot of data on wind conditions in Palau available at present, however, wind velocity ranges between 1~6 m/sec throughout the year.

According to the NEDO guidebook on introducing wind power generation, since an annual mean wind velocity of between 5~6 m/sec is recommended for wind power generation, Palau may not be a suitable location for introduction.

The Energy Office of Palau plans to construct two or three data collecting towers (wind condition surveying towers) under EU support in 2008 and to implement a survey of wind conditions from the end of 2008. However, the data measurement sites have not yet been specifically decided.

Since the success of wind power generation absolutely depends on stable winds, the introduction of a wind power generation system should only be examined after conducting a survey of wind conditions and identifying suitable installation sites.

(5) Other Renewable Energies (Biomass Energy, Ocean Thermal Energy Conversion)

The type of biomass utilization thought to be possible in Palau is power generation from the combustion of solid waste. However, the total population of Palau is only less than 20,000, and even if 90,000 tourists per year are taken into account, the total figure is only around 110,000, meaning that little solid waste for fueling power generation is generated. Accordingly, there is deemed to be no prospect for the generation of power from solid waste before 2025.

Concerning ocean thermal energy conversion, experimental work is continuing in the United States and India, etc., however, since the equipment required for this is large and costly in relation to output, the technology has so far not been refined for practical use and there has been no instances of long-term power generation in connection with a power grid. There are also environmental concerns that the pumping of large quantities of ocean water will have an adverse impact on ecosystems. For these reasons, there is deemed to be no prospect for the practical implementation of ocean thermal energy conversion in Palau before 2025.

5.3.2 Effects of Introducing Renewable Energies

(1) Photovoltaic Power Generation

1) Examination of Photovoltaic Power Generation Capacity

If photovoltaic cells are installed on the rooftops of large government buildings, universities, high schools, elementary schools, gymnasiums and hospitals, etc. that are numerously built in Koror, it was found that cells with maximum total capacity of 3,000 kWp can be installed.

2) Calculation of the Generated Energy, Equipment Utilization Efficiency, Diesel Fuel Saving and Equipment Cost Redemption of Photovoltaic Power Generation

Here, based on the assumption that a standard photovoltaic cell system of 100 kWp capacity is installed and linked to the PPUC grid, calculation of the annual generated energy, equipment utilization efficiency, CO_2 emission reductions, reduction in fuel consumption for diesel power

generation, reduction in diesel fuel costs, and redemption of photovoltaic cell equipment costs is carried out. The results of calculation are given in Table 5.3.2-1.

Table 5.3.2-1 Calculation Results for Photovoltaic Power Generation Equipment

Item	Calculation Results	Unit
Capacity of photovoltaic power generation equipment	100	kWp
Photovoltaic power generation equipment cost	1,612,158	$
Annual generated energy of photovoltaic cells	115,230	kWh/year
Annual utilization efficiency of photovoltaic cells	13.1	%
CO_2 emissions reduction	21.7	ton -C/year
CO_2 reduction effect converted into forest area	22.3	ha
Annual reduction in diesel fuel	31.7	kl/year

(2) Hydropower Generation

1) Hydropower Generation Equipment Installation Method

With respect to hydropower generation, the Study Team proposes that a 200 kW hydropower Station utilizing overflow water from the reservoir of the new public water supply system being planned on Babeldaob Island under ADB funding be installed and connected to the power grid of the PPUC.

2) Calculation of the Generated Energy, Equipment Utilization Efficiency, Diesel Fuel Saving and Equipment Cost Redemption of Hydropower Generation

Here, based on the assumption that overflow water from a public water supply system reservoir is used as the water source for hydropower generation, calculation of the water source inflow, overflow, generator mean output, generator maximum output, generator minimum output, annual generated energy, reduction in fuel consumption for diesel power generation, mean equipment utilization efficiency, CO_2 emission reductions, and redemption of power generating equipment costs is carried out. The results of calculation are given in Table 5.3.2-2.

Table 5.3.2-2 Hydropower Generation Equipment Calculation Results

Item	Calculation Results	Unit
Capacity of hydropower generation equipment	200	kW
Hydropower generation equipment cost	5,000,000	$
Generator mean output	84.5	kW
Generator peak output	170.5	kW
Generator minimum output	17.3	kW
Annual hydropower generated energy	748,980	kWh
Mean equipment utilization efficiency	42.3	%
CO_2 emissions reduction	141.1	ton -C/year
CO_2 reduction effect converted into forest area	145.0	ha
Annual reduction in diesel fuel	206.0	kl/year

(3) Solar Thermal Power Utilization

1) Method of Solar Thermal Power Utilization

Palau is a tourist resort visited by approximately 90,000 tourists per year. These tourists consume a lot of bathwater and shower water; however, the hotels in Palau generally use electric water heaters to provide hot water. Electric water heaters are also widespread in general households, and these appliances account for 20% of electricity demand (according to the Energy Efficiency Action Plan Report).

Through switching the hot water appliances in tourist hotels and general households from electric water heaters to solar water heaters, it is proposed that power consumption be reduced while at the same time saving on power tariffs on the power demand side.

2) Estimation of Power Consumption and Electricity Tariff Savings through Introduction of Solar Water Heaters

Here, based on the assumption that solar water heaters are installed in hotels that accommodate tourists, calculation of the hot water usage, power consumption savings, electricity tariff savings, redemption period of solar water heater equipment, CO_2 emission reductions and reduction in fuel consumption for diesel power generation is carried out. The results of calculation are given in Table 5.3.2-3.

Table 5.3.2-3 Solar Water Heater Equipment Calculation Results

Item	Calculation Results	Unit
Capacity of solar water heater equipment (mean)	300	l/unit
Necessary quantity (over all Palau)	567	Units
Solar water heater equipment installation cost	2,268,000	$
Saving in power consumption due to solar water heaters (annual)	676,893	kWh/year
Electricity tariff saving for electricity consumer households	182,800	$/year
Equipment redemption period (based on electricity tariff savings)	12.4	Year
CO_2 emissions reduction	127.5	ton -C/year
CO_2 reduction effect converted into forest area	131.0	ha
Annual reduction in diesel fuel	186.1	kl/year

(4) Issues and Recommendations in Promoting Introduction of Renewable Energy

1) Photovoltaic Power Generation

① Issues

- Photovoltaic power generation equipment is costly in relation to output, the biggest issue concerns the raising of funds for installation. In the case where a photovoltaic power generation system of 100~200 kWp is introduced in order to enlighten people about and disseminate photovoltaic equipment, , the Government of Palau will need to raise between $1.5~3 million of funds.
- For now, it is proposed that photovoltaic cells be installed on the roofs of government office buildings in Koror, however, the securing of installation sites remains a major issue confronting the introduction of photovoltaic power generation.
- Through connecting photovoltaic power generation equipment to the PPUC grid, only a small percentage of diesel fuel consumption can be covered, while output will be influenced by the constantly fluctuating photovoltaic power generation. Accordingly, it will be necessary for the PPUC to limit output as required through constantly monitoring increases in the system voltage.
- When introducing photovoltaic power generation equipment here, it will be necessary to strengthen the technical capacity of managers, engineers and maintenance personnel in the PPUC generation and transmission/distribution departments and to take budget measures for the purchase of replacement parts, etc.

② Recommendations

- As a rule the Government of Palau should raise funds for the introduction of photovoltaic power generation based on a long-term plan for the introduction of renewable energy, although requesting international assistance is also an option. For example, will be necessary to request assistance from USAID, AUSAID, UNDF, GEF and JICA, etc.
- Concerning installation sites for photovoltaic cells, it is proposed that roofs of government office buildings and schools, etc. in Koror be targeted. In order to realize the introduction of photovoltaic power generation in future, it is proposed that the Government of Palau conduct further investigation with a view to securing installation sites for photovoltaic cells.

- Utilize photovoltaic power generation as a means of educating citizens about reducing CO_2 emissions. Towards this end, it is proposed that a 100~200 kWp photovoltaic power generation system be installed in central Koror, for example on the roof of Palau Community College or Palau High School, and used to demonstrate energy conservation and CO_2 reduction to the citizens of Palau.
- In order to ensure that introduction of photovoltaic cells does not reduce quality over the entire PPUC power system, it is necessary to gauge the actual state of existing power generation, transmission and distribution equipment and the distribution network on the PPUC side and to prepare for the introduction of photovoltaic cells while giving careful examination to grid linkage and grid protection.
- It is scheduled for five operating staff to receive training to coincide with the introduction of the 100 kW photovoltaic power generation system under EU assistance. Considering the future introduction of photovoltaic power generation, it will be necessary to further implement the planned and vigorous training of human resources through recruiting graduates of electric engineering universities and sending personnel to overseas training courses in order to develop them as expert engineers.

2) Hydropower Generation

① Issues

- Palau has high potential for the installation of hydropower generation systems, however, numerous issues need to be overcome regarding the complex and intertwined nature of land ownership issues, environmental and nature protection problems, and the huge amounts of funding that are needed.
- There are plans to construct a new public water supply system and water source on Babeldaob Island under ADB funding, however, the possibility of combining this with hydropower generation has so far not been considered. It is assumed that small scale hydropower generation which utilizes overflow water from the reservoir will not give significant impact on the environment.
- The PPUC has no past experience of hydropower generation. Moreover, it possesses no engineers endowed with the electric technical know-how or operation and maintenance capacity related to grid linkage.

② Recommendations

- It is proposed that concrete examination be advanced into utilizing overflow water for hydropower generation from the new water source that is planned for construction on Babeldaob Island under ADB funding.
- To ensure that introduction of hydropower generation doesn’t adversely affect quality of the overall PPUC power system, it is necessary to advance preparations upon gauging and carefully examining the actual state of existing power generation, transmission and distribution equipment and the distribution network on the PPUC side and giving careful examination to grid linkage and grid protection.
- It is necessary to secure engineers who can adjust the turbine output in line

with seasonal fluctuations in water flow and who can make technical judgments for grid linkage.

3) Solar Water Heaters

① Issues

- Electric water heaters are already widely used in Palau, and there is little likelihood that consumers will want to buy new solar water heaters.
- It is hard to imagine that citizens will want to switch to solar water heaters from electric water heaters, which are convenient for them and which they have grown accustomed to over many years.
- Since solar water heaters cannot heat water at nighttime and during rainy weather, there is doubt over whether they can secure the satisfaction of consumers.

② Recommendations

- It is proposed that the Government of Palau vigorously advertise the electricity conservation effect of solar water heaters.
- It is proposed that the Government of Palau further expand systems for promoting the dissemination of solar water heaters, for example, bank loans conditional on the installation of such heaters and the fund for promoting solar water heaters as indicated in the Energy Efficiency Action Plan.

(5) Organization and Functions for Introduction of Renewable Energies

1) Issues

Electric power and energy policies in Palau fall under the jurisdiction of the MRD Public Works Bureau Energy Office. However, since the Energy Office only has two staff members, who are too busy with attending routine liaison meetings, collecting information and processing clerical duties to compile energy policies, renewable energy introduction plans and energy saving plans, etc.

2) Recommendations

It is essential that energy policies, renewable energy introduction plans and energy saving plans, etc. are compiled and executed and that the activities of each department are coordinated. Accordingly, it is necessary to immediately strengthen the organization and technical capacity of the Energy Office.

6. PRE-FEASIBILITY STUDY

6. Pre-feasibility Study

6.1 Preliminary Design of the Preferential Project concerning Power Generation and Transmission and Distribution

6.1.1 Preliminary Design of the Power Generation Project

(1) Examination of the Unit Capacity and Number of Generators at the New Power Station

1) Preconditions

Based on the assumption that the new Aimeliik Power Station will eventually become the principal power station in Palau, the optimal unit capacity and number of generators are planned here based on the power demand forecast. In the case of an island nation power system, it is thought desirable for diesel generators to have a unit capacity equivalent to between 1/3~1/4 of the system capacity. Considering that the generating end maximum power demand in Palau in 2025 will be 24.76 MW, and taking into account the unit capacity of diesel generators widely available on international markets, generators with a unit capacity of 4.2 MW, 5.0 MW, 6.0 MW or 8.0 MW are selected for examination here.

The relationship between unit capacity and the number of generators is indicated below. Here it is assumed that the new Aimeliik Power Station will supply 17.18 MW that remains after subtracting the output potential of Malekal Power Station (2.94 MW) and the 5 MW Aimeliik Power Station receiving aid from Taiwan (4.64 MW) from 24.76 MW, i.e. the generating end maximum power demand in 2025. It is also assumed that spare capacity equivalent to the output of two generators is secured. The following table shows the relationship between unit capacity and the number of generators.

Table 6.1.1-1 Unit Capacity and Required Number of Generators

Unit Capacity	Required Number based on the Supply/Demand Balance	Number of Units Including Spare Capacity of 2 Units (Study Scenario)
4.2 MW	4.2 MW x 5 units = 21 MW	4.2 MW x 7 units = 29.4 MW
5.0 MW	5.0 MW x 4 units = 20 MW	5.0MW x 6 units = 30 MW
6.0 MW	6.0 MW x 3 units = 18 MW	6.0 MW x 5 units = 30 MW
8.0 MW	8.0 MW x 3 units = 24 MW	8.0 MW x 5 units = 40 MW

2) Overview of Evaluation Items

① Initial investment

Generally speaking, the larger the unit capacity of generators becomes, the construction cost per unit generating capacity (kW) tends to fall due to merits of scale. Assuming the same total generating capacity, installation costs are cheaper for a lower number of installed units.

② Firm capacity

In power systems, the capacity that can be supplied in the event where two peak capacity generators are idle is called the firm capacity and is an indicator of the supply stability. The required number of units based on the supply/demand balance indicates the supply capacity excluding two spare capacity units and shows the same value as the firm capacity.

③ Maintenance cost

Assuming that generators have the same capacity, the overall maintenance cost goes up as the number of installed units increases, and the maintenance cost per unit goes up as the unit capacity increases.

④ Fuel efficiency

Diesel engines are designed to display the highest efficiency when operated at 100% load. Therefore, fuel efficiency gradually declines as the engine load factor decreases. Here, based on the assumption that generating end maximum power demand is 24.76 MW in 2025 and the night time minimum output is 12.1 MW, the diesel engine load factor in the case where generators are operated in this range is evaluated as an indicator of fuel efficiency.

⑤ Total generating output

Evaluate the total generating output obtained through multiplying the unit capacity by the number of units.

3) Evaluation of Unit Capacity and Number of Units

General evaluation was carried out through giving scores of 0~4 points for each of the above evaluation items. Table 6.1.1-2 shows the evaluation results. According to these, it is preferable to install six diesel generators each with a unit capacity of 5 MW.

Table 6.1.1-2 Evaluation of Unit Capacity and Number of Generators

Case	Initial Investment	Firm Capacity	Maintenance Cost	Fuel Efficiency	Total Output	Total
4.2 MW x 7 units (29.4 MW)	2	3	1	4	1	11
5.0 MW x 6 units (30 MW)	3	2	3	4	2	14
6.0 MW x 5 units (30 MW)	4	1	4	1	2	12
8.0 MW x 5 units (40 MW)	0 (max)	4	2	1	4	11

Note : Concerning the scoring scale of 0~4, higher scores indicate better performance.

Since the new Aimeliik Power Station will carry the base load of Palau, diesel engines of the medium speed type (no more than 750 rpm), which enable long-term continuous operation, shall be adopted.

5 MW class diesel engine generators are manufactured by three Japanese companies (Daihatsu Diesel, Mitsubishi Heavy Industries and Niigata Power System) as well as one German company (Man Diesel), one Finnish company (Wartsila) and one US company (Caterpillar). Sufficient competitiveness can, therefore, be secured by a tender.

(2) Rough Specifications for New Aimeliik Power Station

The rough specifications (when adopting heavy fuel oil) for the new Aimeliik Power Station are shown in Table 6.1.1-3.

Table 6.1.1-3 Rough Specifications for the New Aimeliik Power Station

Work Category	Type of Work	Main Components of the Work and Equipment		
Facility construction	Civil work	Access road	:	approx. 6 m wide x 200 m long
		Site preparation	:	approx. 100 m x 100 m
		Exterior work	:	premise roads, water supply and drainage facilities and others
		Foundations for outdoor machinery, etc	:	radiator, water tank and others
		Fuel unloading jetty	:	for berthing of a 6,000 class oil tanker
	Building work	Construction of generator house	:	two story, steel frame with a total floor area of 3,332 m^2 (2,176 m^2 for the ground floor and 1,156 m^2 for the first floor)
		Ancillary systems	:	lighting, ventilation and overhead crane, etc.
		Building for auxiliary machinery	:	incineration furnace and others
Equipment procurement and installation	Engine	Normal mode of operation	:	continuous (base load; 8,000 hours/year)
		Rated output	:	generating end 5,000 kW or higher
		Speed	:	720 rpm or less (medium speed engine)
		Engine type	:	four stroke; compression ignition; internal combustion engine with reciprocal piston motion
		Supercharger	:	water-cooled V type engine
		Fuel oil	:	normal heavy fuel oil and diesel oil for starting up and stopping operation
		Cooling method	:	radiator
		Starting up method	:	compressed air (30 Mpa)
		Lubricating oil	:	local procurement
		Waste oil treatment system	:	suitable system to ensure no damage to the environment
		Installation method	:	common base with anti-vibration structure
	AC generator	Rated mode of operation	:	continuous (base load; 8,000 hours/year)
		Rated output	:	6,250 kVA (5,000 kW) or higher
		Rated power	:	13.8 kV; 60 Hz; three phase; three wire
		Power factor	:	0.8 (lagging current)
		Winding connection	:	Y connection; neutral leader line
		Insulation class	:	F class (JIS) or equivalent
	Mechanical systems	Fuel supply system	:	DFO service tank HFO buffer tank HFO service tank HFO purifier FO supply system heat trace
		Lubricating oil system	:	LO priming pump LO cooler LO purifier LO supply system
		Cooling water system	:	water tank water softener HT expansion tank LT expansion tank primary cooling water pump secondary cooling water pump
		Compressed air system	:	compressor air tank control system
		Air supply and exhaust system	:	air supply filter air supply silencer

Work Category	Type of Work	Main Components of the Work and Equipment		
		Waste oil treatment system	:	air supply cooler exhaust cooler exhaust stack duct, expansion joint oil separating tank oil separating system waste oil tank waste oil incinerator
		Black start-up	:	emergency generator (150 kW) with ancillary systems
	Electrical installations	Engine control panel	:	machine side control panel
		Generator control	:	desk control type
		Generator breaker panel	:	13.8 kV; VCB 630 A
		Transformer breaker panel	:	13.8 kV; DC
		Bass breaker panel	:	13.8 kV; VCB 630 A
		Transmission breaker panel	:	13.8 kV; VCB 630 A
		Neutral grounding panel	:	13.8 kV
		Protective relay panel	:	13.8 kV
		MCC	:	400 V; three phase; four wire
		DC power panel	:	battery; charger
		Low voltage distribution panel	:	L-1; M-1
	Type C fuel oil unloading system	Pipeline	:	jetty → tank yard; heat trace; heat insulation work
		Fuel tank remodelling work	:	suction heater; heat insulation work

(3) Locationing of the New Power Station

There are three candidate sites (A, B and C) as shown in Fig. 6.1.1-1 for the location of the planned new power station (including a new substation) under the plan in consideration of the re-use of the existing fuel storage facilities, fuel unloading facilities and transmission/distribution lines, etc. Judging from the project site evaluation in Table 6.1.1-4, it is deemed that Plan C is the optimum proposal.

Source: JICA Study Team

Fig. 6.1.1-1 Candidate Location for the New Power Station

Table 6.1.1-4 Evaluation of Candidate Project Sites

Conditions	Site A (North of Tank Yard; approx. 100 m x 100 m)	Site B (North of Site A; approx. 100 m x 100 m)	Site C (West of Tank Yard; approx. 100 m x 100 m)
Vegetation	Woodland Felling will have a negative impact.	Woodland and grassland The felling area will be smaller than that of Site A but there will still be an environmental impact.	Grassland Unlike Site A and Site B, the felling of trees will be unnecessary.
Topography	Land preparation work (cutting and banking) will be required to deal with the highly undulating land; generator installation on banked ground should be avoided.	Land preparation work (cutting and banking) will be required although the scale will be smaller than the similar work for Site A; generator installation on banked ground should be avoided; the cost is higher than that for Site A because of the steeper gradient.	The site forms a small hill and land preparation work may only consist of cutting. The cost will be the lowest among the alternatives.
Access Road	The length of the new access road will be short because of the proximity of the existing road but levelling work will be required to deal with the 3m height difference.	As left	The construction of a new access road for some 200 m will be required to modify the existing road.
Noise and Vibration	The distance to the nearest private house will be 250 m, possibly increasing the impacts on this and other houses because of the shorter distance than is currently the case.	The distance to the nearest private house of 200 m will be the shortest among the alternatives, causing concern in regard to noise pollution.	The distance to the nearest private house of 400 m will be the longest among the alternatives, improving the present situation.
Distance Between Old and New Power Stations	300 m (distance between the circuit breaker panels); connecting cable length: medium	350 m (distance between the circuit breaker panels); connecting cable length: short	400 m (distance between the circuit breaker panels); connecting cable length: long
Overall Evaluation	Δ (Fair)	X (Poor)	◎ (Best)

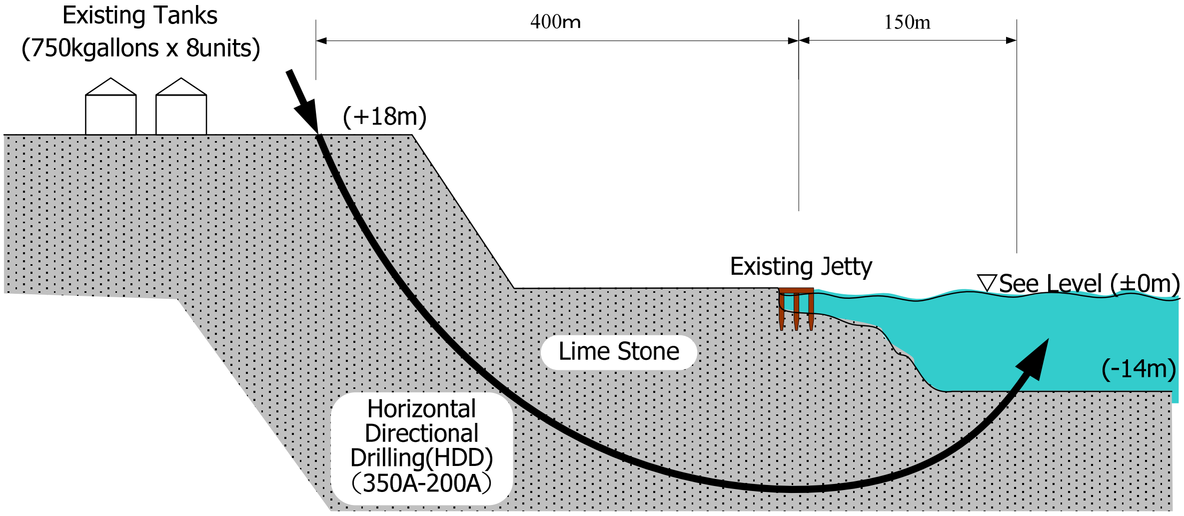
Source: JICA Study Team

(4) Planning Fuel Oil Loading Equipment

The existing fuel oil loading equipment at Aimeliik Power Station is designed for use with diesel oil. Tankers in the 7,850 ton class moor at a distance of around 50 m from the existing pier, and oil is transferred by a pressure-resistant hose housed in a drum on the pier. The pier is connected to the existing fuel oil tanks by a pipeline.

In the event where HFO-fired engine generators are installed, due to the high viscosity of the heavy fuel oil, the HFO temperature must be raised to 60°C or higher during the transfer. Accordingly, the existing fuel oil loading equipment cannot be used, and it is necessary to newly install specialized equipment for heavy fuel oil.

Upon examining the method of laying receiving pipes, the arc tunneling method was adopted for unloading HFO in consideration of environmental impact, landscape and price. Figure 6.1.1-2 gives a rough sketch of the arc tunneling method.



Source: JICA Study Team

Fig. 6.1.1-2 Arc Tunnelling Method

(5) Overall Work Schedule

In accordance with the contents of 5.2.1, the implementation schedule shown in Table 6.1.1-5 is planned. It will be necessary for the PPUC to commence fund raising and other preparatory work as soon as possible in view of the early commencement of the actual construction work to deal with the projected poor power supply and demand situation in FY 2012.

Table 6.1.1-5 Implementation Schedule (New Aimeliik Poser Station Construction Work)

	Item	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	Fund Raising	▭										
2	Consultant Selection	▭	▭									
3	Detailed Design											
	Phase-I		▭									
	Phase-II			▭								
	Phase-III								▭			
4	Tender											
	Phase-I		▭									
	Phase-II			▭								
	Phase-III								▭			
5	Work Supervision											
	Phase-I			▭	▭							
	Phase-II				▭	▭						
	Phase-III									▭	▭	
6	Facility Construction											
	Phase-I			▭	▭							
	Phase-III									▭	▭	
7	Equipment Procurement and Installation											
	Phase-I			▭	▭							
	Phase-II				▭	▭						
	Phase-III									▭	▭	

Source : JICA Study Team

(6) Power Station Construction Cost

Table 6.1.1-6 shows the estimated project cost for two cases, i.e. that with Type C HFO firing engine generators and that with diesel oil firing engine generators.

Table 6.1.1-6 Estimated Project Cost (New Aimeliik Power Station Construction Work)

(Unit: US$ million)

Item	Basic Plan Diesel Oil Conversion Engine					Alternative Plan Heavy Oil Conversion Engine				
	Phase－Ⅰ	Phase－Ⅱ	Urgent Project, (Phase－Ⅰ＋Ⅱ)	Phase－Ⅲ	Total	Phase－Ⅰ	Phase－Ⅱ	Urgent Project, (Phase－Ⅰ＋Ⅱ)	Phase－Ⅲ	Total
1. Land Acquisition	0.24	0.00	0.24	0.00	0.24	0.24	0.00	0.24	0.00	0.24
2. Construction Cost	5.22	0.00	5.22	1.56	6.78	8.22	0.00	8.22	1.56	9.78
3. Equipment Procurement and Installation Cost	10.40	9.60	20.00	9.60	29.60	12.60	10.00	22.60	10.00	32.60
4. Engineering Fee	1.59	0.96	2.55	1.12	3.67	2.11	1.00	3.11	1.16	4.27
5. Administration Cost	0.17	0.11	0.28	0.12	0.40	0.23	0.11	0.34	0.13	0.47
6. Contingency	1.76	1.07	2.83	1.24	4.07	2.34	1.11	3.45	1.28	4.73
Total	19.38	11.74	31.12	13.64	44.76	25.74	12.22	37.96	14.13	52.09

Source: JICA Study Team

6.1.2 Preliminary Design of the Transmission and Distribution Project

6.1.2.1 Submarine Cable Transmission Line Between Aimeliik Power Station and T Dock on Koror Island and Alternative

The preliminary design work has been conducted to compare the plan to lay a submarine cable between the Aimeliik Power Station and T Dock on Koror Island and the alternative plan to upgrade the existing transmission line as this issue is considered to be an issue to be dealt with in the short term. The following three options were compared and examined.

- Plan A : Installation of a underwater cable line
- Plan B : Upgrading of the existing transmission line (new line from the Nekken Substation to Compact Road)
- Plan C : Upgrading of the existing transmission line (new line from the Nekken Substation to the Kokusai Substation and the diverted use of the existing line from the Nekken Substation to Compact Road)

(1) Comparison of the Plan to lay Underwater cable Line and the Plan to Upgrade the Existing Transmission Line

As a result of the comparative examination, it was decided to adopt Plan C. Comparison of the plans is shown in Table 6.1.2-1

Table 6.1.2-1 Comparison of Alternative Plans

	Plan A	Plan B	Plan C
Configuration of the new line	Submarine cable: 11.6 km	Overhead line: 23.2 km Bridge section: 0.6 km	Overhead line: 21.8 km Bridge section: 0.6 km
Workability	The scale of the work will be large because of the involvement of a cable laying barge but no special problems are anticipated unless there are restrictions to the work.	• For those sections where the existing line will be diverted, each section must be worked on separately. • For the section from KB Bridge to the substation, the existing poles will require remodelling or replacement. • For the section between the Nekken Substation and Compact Road, it will be difficult to secure the necessary work space because of the existing double lines along the road.	• As left • As left • No work will be required between the Nekken Substation and Compact Road as the existing line will be converted.
Construction period (site work)	3 months	9 months	8 months
Reliability	As the cable will be protected against anchors and rock, no problems are anticipated in regard to reliability.	The cable at the bridge section will require some management at the openings of the bridge. The reliability of the overhead line is the same as that of other similar line.	As left. The section along Compact Road which will be made redundant may be used to quickly restore the power supply at the time of power failure incidents.
Environmental impacts	There is concern in regard to a possible negative impact on the confirmed coral communities.	Careful attention will be required for the route selection at those sites where mangrove grows at the roadside.	As left
Maintenance	Routine maintenance will not be required but any accident will mean a prolonged power cut.	The maintenance requirements are the same as those of the existing lines. The cable in the bridge section is less likely to be damaged because of its position inside the bridge structure.	As left
Estimated project cost (US$ million)	Land acquisition : 0.00 Construction : 0.00 Equipment procurement and installation : 10.94 Consultant : 1.09 Management (PPUC) : 0.12 Contingency : 1.22 Total : 13.37	Land acquisition : 0.00 Construction : 0.00 Equipment procurement and installation : 2.51 Consultant : 0.25 Management (PPUC) : 0.03 Contingency : 0.28 Total : 3.07	Land acquisition : 0.00 Construction : 0.00 Equipment procurement and installation : 2.45 Consultant : 0.25 Management (PPUC) : 0.03 Contingency : 0.27 Total : 3.00
Transmission loss	0.4-0.5% reduction in comparison with plan B,C	0.4-0.5% increase in comparison with plan A	As left
Overall evaluation	The total cost including project cost and transmission loss is by far the highest and there is in concern in regard to a negative impact on marine creature. This plan has been rejected.	While the total cost including project cost and transmission loss is small, there is a possibility of a problem in regard to workability. This plan has been rejected.	While further examination is required in regard to workability, the total cost including project cost and transmission loss is the lowest. This plan has been selected.

(2) Implementation Schedule

The implementation schedule for Plan C is shown in Table 6.1.2-2.

Table 6.1.2-2 Implementation Schedule

(Work to Construct New 34.5 kV Transmission Line Between the Aimeliik Power Station and the Koror Substation)

Item		2009	2010	2011	2012	2013
1	Fund Raising	▭				
2	Selection of Consultant			▭		
3	Detailed Design				▭	
4	On-Site Supervision				▭	▭
5	Equipment Procurement and Installation				▭	▭

6.1.2.2 Preliminary Design of Koror Substation

(1) Selection of Substation Site Location

In planning the installation of double circuit line between Aimeliik and Koror, confirmation was carried out with the PPUC concerning landowners and development plans for a number of substation sites along the 34.5 kV transmission line. As a result, Site A, located adjacent to the transmission line as shown in Fig. 6.1.2-1, is chosen considering that small earth works are expected. However, because Site A is private land, Site B owned by Koror State shall be the alternative.

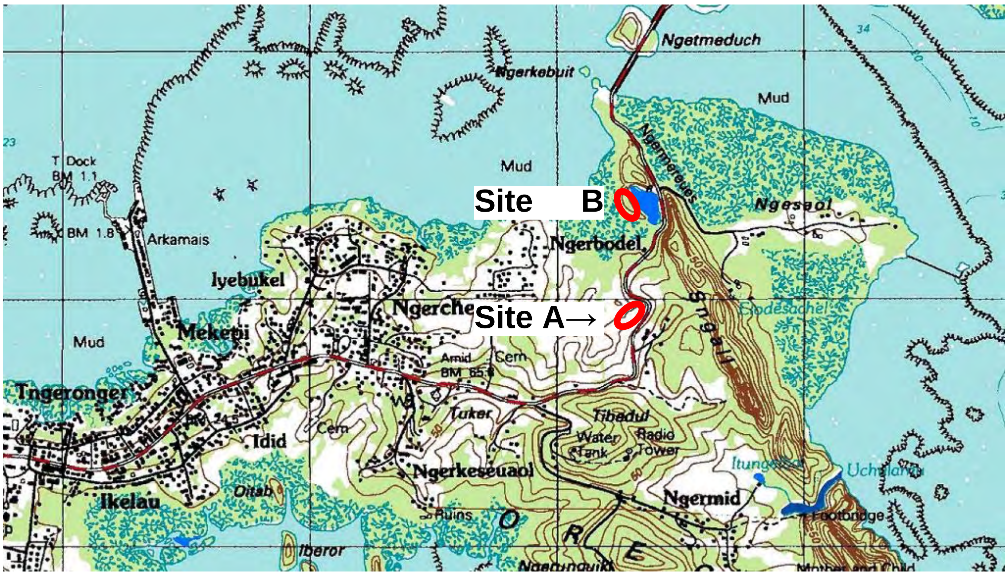


Fig. 6.1.2-1 Koror Substation Site Location

(2) Site Size

In view of the fact that the shape of the site and direction for the extension of the transmission and distribution lines have not yet been decided, a type site size of 736 m^2 (23 m x 32 m) is assumed. This size may, therefore, be changed when the new substation site is finalised.

(3) Scale of Facilities

The scale of facilities at Koror Substation shall be as follows:

① Three 34.5 kV transmission lines
② Two 13.8 kV distribution lines
③ One 15 MVA transformer
④ The single bus bar method will be used because of the small configuration of three transmission lines and one transformer bank.

(4) Equipment Ratings

The ratings of main equipment shall be as follows:

① Transformer: Rated capacity : 15 MVA, Winding: Y-Y (-Δ)

② Transmission line circuit breaker : Rated voltage: 36 kV
  Rated current : 600 A
  Rated interrupting current : 12.5 kA

③ Distribution line circuit breaker : Rated voltage : 24 kV
  Rated current : 600 A
  Rated interrupting current : 12.5 kA

④ Compensator : Based on the system analysis results, a 3 MVA capacitor bank shall be installed to counteract voltage drop.

⑤ 34.5 kV Power Cable : Triplex cable (250 mm2) will be laid in a conduit line.

⑥ 13.8 kV Power Cable : Triplex cable (250 mm2) will be laid in a conduit line.

⑦ Substation Transformer : The capacity will be 20 KVA and it will be installed inside the 13.8 kV switchgear.

⑧ DC Power Unit : Nominal voltage: 100V, Rectifier output: 30 A, Capacity of Battery: 90 Ah

(5) Estimated Project Cost

① Land cost : Donation is assumed because of the public nature of the project.

② Construction cost : US$ 2.45 million

③ Consultant fee : US$ 0.245 million

④ Management cost (PPUC) : US$ 0.027 million

⑤ Reserve : US$ 0.278 million

⑥ Total : US$ 3.0 million

(6) Implementation Schedule

Table 6.1.2-3 Implementation Schedule (Work to construct the Koror Substation)

	2009	2010	2011	2012	2013
Fund Raising	▨				
Selection of Consultant			▨		
Detailed Design				▨	
On-Site Supervision				▨	▨
Equipment Procurement and Installation				▨	▨

6.1.2.3 Preliminary Design of the New Aimeliik Substation

(1) Selection of Substation Site Location

This new substation will be located on the premises of the Aimeliik Power Plant.

(2) Site Size

The land preparation work (30 m x 50 m) will be carried out in concert with the new Aimeliik Power Station construction plan.

(3) Scale of Facilities

① Three 34.5 kV transmission lines

② Three 15 MVA transformers

(4) Bus Bar Connection Method

The single bus bar method will be adopted and a circuit breaker will be installed for each transmission line and transformer.

(5) Main Equipment Ratings

① Transformer: Rated capacity : 15 MVA, Winding : Y-Y (-Δ) (standard)

② Transmission line circuit breaker :
Rated voltage : 36 kV
Rated current : 600 A
Rated interrupting current : 12.5 kA

③ Substation Transformer:
The capacity will be 20 KVA and it will be installed inside the 13.8 kV switchgear (because of the importance of this substation, two units shall be installed for their switching over by an AC power panel)

④ DC Power Unit: Rectifier output: 30 A, Capacity of battery: 90 Ah
(Assuming continual 5 kW for the switchgear (20 A instantaneous), 10 A continuous for communications equipment, and 6 hours outage time)

(6) Estimated Project Cost

①	Land cost	:	(This will be part of the land preparation cost for the new power station)
②	Construction cost	:	US$ 3.5 million
③	Consultant fee	:	US$ 0.35 million
④	Management cost (PPUC)	:	US$ 0.038 million
⑤	Reserve	:	US$ 0.312 million
⑥	Total	:	US$ 4.2 million

(7) Implementation Schedule

Table 6.1.2-4 Implementation Schedule (Work to construct the New Aimeliik Substation)

	2009	2010	2011	2012	2013
Fund Raising	▨				
Selection of Consultant			▨		
Detailed Design				▨	
On-Site Supervision				▨	▨
Equipment Procurement and Installation				▨	▨

6.2 Environmental and Social Considerations Regarding Priority Projects

6.2.1 Environmental and Social Consideration System in Palau

(1) Legal Framework for Social and Environmental Considerations

It is necessary to obtain an environmental permit from the Environmental Quality Protection Board (EQPB) in accordance with the Environmental Protection Act of Palau (24 PNCA) when any of the following activities are planned.

1) Civil engineering work
(excavation, banking, levelling, dredging and stone crushing, etc.)
2) Drainage to the ocean or a river
(discharge of sewage and harmful substances to a water area)
3) Construction and operation of waste treatment facilities
4) Installation of toilets and foul water treatment facilities
5) Use of agrochemicals
6) Construction and operation of a water supply or sewerage system
7) Construction and operation of a fixed emission source of air pollutants
8) Burning of fields

(2) Projects Subject to EA and EIS

Concerning projects for which an EA or EIS must be prepared, the conducts assessment based solely on the perceived scale of environmental impacts (whether or not pollutant emissions will increase, whether or not the emission/discharge level is within the accepted limit, whether or not the technology to be used is a new technology, whether or not the planned development is to be conducted on public land, whether or not land reclamation is required and whether or not any cultural heritage is involved).

Any activity which falls under any of the items below is judged to cause “a significant impact on the environment” and the submission of an EIS is required.

1) Activity which causes the irrevocable loss or damage to a natural or cultural resource
2) Activity which restricts the beneficial use of the environment
3) Activity which infringes a long-term environmental policy or target, the Environmental Protection Act or guidelines indicated by various regulations or judicial precedents based on this Act
4) Activity which causes a severe impact on the economy and/or social welfare of communities
5) Activity which causes a severe impact on public health
6) Activity which causes a serious secondary impact on demographic changes, public facilities and infrastructure, etc.
7) Activity which causes the serious deterioration of the quality of the environment
8) Activity of which the individual impacts are limited but which causes a serious impact or becomes a large-scale activity through the accumulation of individual impacts
9) Activity which causes a severe impact on an endangered species or its habitat
10) Activity which causes negative impacts in terms of air quality, water quality and environmental noise
11) Activity which causes a severe impact on such environmentally fragile areas as a flood plain, area prone to erosion, geographically dangerous land, river mouth, lagoon, reef, mangrove swamp, freshwater area and coastal waters

(3) Status of the Present Study from the Viewpoint of the Environmental Impact Assessment Act

The Environmental Impact Assessment Act of Palau (Chapter 2401-61) stipulates that feasibility studies and planning studies are excluded from the list of projects/activities using central or state government funds which require an EA. Because of this, it is unnecessary for the present Study to obtain an environmental permit.

However, there are individual projects planned by the Study which fall under such activities listed which do require an environmental permit as ① civil engineering work (excavation, banking, levelling, dredging and crushing of stone, etc.), ② drainage to the sea or a river, ④ installation of toilets or sewage treatment facilities and ⑦ construction and operation of a fixed source of air pollutants. An environmental permit will, therefore, be required for the construction of the new Aimeliik Power Station, the new Koror Substation, and construction of transmission and distribution lines. As the implementation body for the Master Plan, the PPUC must accordingly swiftly prepare the application for an environmental permit after the finalisation of the Study and submit it to the EQPB together with a letter of confirmation that no important historical, cultural or archaeological objects are involved (issued by the

Historical Preservation Office), the title deed for the land and a building permit issued by the state government.

PPUC needs to prepare Environmental Assessment Report based on the results of Initial Environmental Examination (IEE) conducted by the Study Team and the IEE report and to submit four copies of the document to EQPB if it requires to do so as a result of the examination for the application.

6.2.2 Target Projects subject to Pre-Feasibility Study

Among power supply facilities construction projects included in the Power Development Plan, projects that have high urgency and should be implemented in recent years are categorized as "priority projects" and subject to pre-feasibility study. In this Environmental and Social Considerations on priority project, the following three projects, namely, replacement of Aimeliik Power Station (Phase-1 and Phase-2), construction of Koror Substation and construction of transmission line between Aimeliik Power Station and Koror are examined.

6.2.3 Initial Environmental Impact Assessment on Priority Project

6.2.3.1 Replacement of Aimeliik Power Station

(1) Outline of the Project

Outline of the replacement of Aimeliik power station (Phase-1 and Phase-2) are shown in the table below. The location of the new power station and the arrangement of equipment is shown in the attached drawings in front pages.

Table 6.2.3-1 Outline of the Replacement of Aimeliik Power Station

FY	Project Title	Outline
2013	Replacement of Aimeliik Power Station (Phase 1)	• Procurement of two diesel generators (5 MW class) and auxiliary machinery • Remodelling of the fuel storage and supply facilities (in the case of HFO firing) • Construction of the power house (including those for the two generators in Phase 2) and an office building
2014	Replacement of Aimeliik Power Station (Phase 2)	• Procurement of two diesel generators (5 MW class) and auxiliary machinery

(2) Evaluation of Environmental and Social Factors

Table 6.2.3-2 shows evaluation results of environmental and social factors for the replacement of the Aimeliik Power Station.

Table 6.2.3-2 Evaluation Results of Environmental and Social Factors for the Replacement of the Aimeliik Power Station

Environmental Factor		Overall Rating	During Construction Work	During Operation	Remarks
Social Environment	Involuntary resettlement	C	C	C	
	Local economy, such as employment, livelihood and others	C	C	C	
	Land use and utilisation of local resources	B	B	C	The site for replacement must be purchased (currently not owned by the PPUC).
	Social institutions, such as social infrastructure and local decision-making system	C	C	C	
	Existing social infrastructure and services	C	C	C	
	The poor, indigenous and ethnic people	C	C	C	
	Erroneous communication of interests	C	C	C	
	Cultural heritage	C	C	C	
	Local conflict of interests	B	B	B	Complaints have been made about noise by residents living near the existing Aimeliik Power Station and there is concern regarding their objection to the expansion of this power station.
	Water usage or water rights and rights in common	C	C	C	
	Public hygiene	C	C	C	
	Infectious diseases	C	C	C	
Natural Environment	Topography and geographical features	C	C	C	
	Soil erosion	B	B	C	Concern regarding soil erosion at the time of site preparation.
	Groundwater	C	C	C	
	Hydrological conditions	C	C	C	
	Coastal zone	C	C	C	
	Flora, fauna and biodiversity	B	B	B	Concern regarding negative impacts on rare flora and fauna
	Meteorology	C	C	C	
	Landscape	C	C	C	
	Global warming	B	C	B	Increased CO_2 emission
Pollution	Air pollution	B	C	B	Concern regarding negative impacts of NOx and SOx emission
	Water pollution	B	B	B	Concern regarding water pollution due to household waste water and waste water containing oil
	Soil contamination	C	C	C	
	Waste	B	C	B	Increased amount of waste oil
	Noise and vibration	B	C	B	Concern regarding negative impacts of noise
	Ground subsidence	C	C	C	
	Offensive odour	C	C	C	
	Bottom sediment	B	B	C	Concern regarding disturbance of bottom sediment during installation of HFO unloading pipeline
	Accidents	C	C	C	

Rating

A: Serious impact is expected

B: Some impact is expected

C: No or minimal impact is expected

(3) Initial Environmental Impact Assessment

1) Social Environment

① Land Use and Utilization of Local Resources

The planned site to be used for the replacement of the Aimeliik Power Station is owned by private and land acquisition is necessary. The site is currently covered by trees and grass and is not used. Therefore, no special problems are anticipated in regard to the acquisition of this site for the replacement of the Aimeliik Power Station. There is no land expropriation law and procedure for national project in Palau. The only protocol to be taken is prescribed in the Constitution of Palau which requires “to pay appropriate compensation for land expropriation”. After the completion of the Study, PPUC shall acquire the land through the process of disclosure, explanation and agreement with the Governor, local residents and land owners.

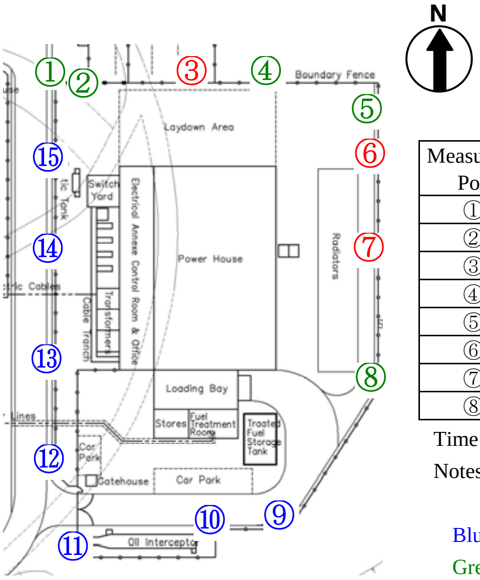
② Local Conflict of Interests

(a) Predicted Impacts

Complaints have been made by residents living near the Aimeliik Power Station about the noise and vibration caused by the power station and these residents may object to the replacement plan. The direct distance between the existing Aimeliik Power Station and the nearest private house is slightly less than 300 m and there is currently nothing which blocks the loud noise from the Power Station.

(b) Present Situation of Noise and Vibration

Fig. 6.2.3-1 shows the noise level measurement results for the boundary of the existing Aimeliik Power Station premises. Upon measuring noise near a house located to the northeast of the power station, noise was found to be 52.1 dB (A). This was lower than the permissible value (daytime noise in residential areas: 55 dB (A) or lower) suggested by the noise guidelines of the World Bank. No vibration could be felt.



Measuring Point	Noise Level	Measuring Point	Noise Level
①	75.1dB(A)	⑨	67.8 dB(A)
②	76.9dB(A)	⑩	62.3 dB(A)
③	81.7dB(A)	⑪	63.1 dB(A)
④	78.0 dB(A)	⑫	66.2 dB(A)
⑤	79.2 dB(A)	⑬	63.1 dB(A)
⑥	84.9 dB(A)	⑭	62.2 dB(A)
⑦	85.5 dB(A)	⑮	67.3 dB(A)
⑧	78.2 dB(A)		

Time of measurement: 26th January, 2008, 10:30 – 11:00

Notes: The colours used to classify the measuring points have the following meanings.

Blue: noise level < 70 dB (A)

Green: noise level < 80 dB (A)

Red: noise level ≧ 80 dB (A)

Fig. 6.2.3-1 Noise Level at Boundary of the Existing Aimeliik Power Station Premises

(c) Analysis over the debate on noise and vibration generated by the power station

During an interview with a local resident (70 year old woman) living near the power station, the following complaints were made.

a) The noise from the power station intensified 6 – 7 years ago.
b) The vibration is strong enough to make her jump out of bed at night.

During the visit to Aimeliik State on 24th January, 2008, complaints similar to those above were made about the noise and vibration.

The PPUC admits that the following complaints about noise and other matters have been made.

a) The first complaint about noise was made more than 10 years ago.
b) Complaints have been made that the catch of fish and shellfish has declined because of contamination of the sea by diesel oil.
c) However, no complaint has been made in the form of an official document.

(d) Impact Assessment

As mentioned later, noise level that will be observed at the nearest houses around the power station after the replacement of the Aimeliik power station is acceptable if it is compared with the World Bank's ambient noise standard. However, it is considered to be unavoidable that the residents around the power station may object to the replacement plan if the current complaints about the noise from the power station are taken into consideration.

(e) Impact Avoidance or Mitigation Measures

As part of the project to replace the Aimeliik Power Station, the following measures will be implemented to reduce the noise which travels to nearby private houses and the understanding of these measures on the part of local residents will be secured.

a) Phased decommissioning of the existing Aimeliik Power Station with the commissioning of the new generating units
b) Locationing of the new generating units as far as possible from private houses (attenuation of noise by distance)
c) Locationing of such noisy machinery as the radiator and air intake silencer as far as possible from private houses and locationing of the power house, etc. so as to allow them to function as a sound barrier (attenuation of noise by a sound barrier)

2) Natural Environment

① Soil Erosion

(a) Predicted Impacts

There is concern in regard to subsequent soil erosion by rain during land preparation work.

(b) Impact Assessment

The Candidate Replacement Site has a gentle slope and the felling of many trees will be unnecessary. Moreover, by preparing the ground on two levels, it will be possible to reduce the scale of the excavation work and the impact of soil erosion seems to be minimal.

② Flora, Fauna and Biodiversity

(a) Predicted Impacts

The felling of trees to prepare land at the Candidate Replacement Site may have a negative impact on the flora, fauna and biodiversity.

(b) Impact Assessment

The vegetation at Candidate Replacement Site C predominantly consists of ferns and the felling of trees as part of the land preparation work will be unnecessary. While a community of Nepenthes mirabilis, an insectivorous plant, is observed at Candidate Replacement Site C, this species is not listed on the IUCN’s Red List as an endangered species. Thus, the impacts of the land preparation work on the flora, fauna and biodiversity will become minimal.

③ Global Warming

(a) Predicted Impacts

The number of generating units will increase as a result of the replacement of the Aimeliik Power Station, resulting in an increase of the emission of CO_2.

(b) Impact Examination

With the growth of the power demand, the electric energy generated in FY 2025 will have increased by 59% from the FY 2006 level while the rate of increase of CO_2 emission is expected to be 38%. Although an increase of the emission of CO_2 following an increase of the generated electric energy is unavoidable, the improved thermal efficiency of the generating units by the replacement of the Aimeliik Power Station will reduce the CO_2 emission by unit electric energy generated. In addition, due to the reduction of transmission and distribution losses by the expansion of the transmission and distribution systems, the growth of generated energy will be less than the growth of electricity demand.

Table 6.2.3-3 Estimation of CO_2 Emission

FY	Power demand (GWh)	Electric Energy Generated (GWh)	Fuel Consumption	CO_2 Emission (t-CO_2)	T& D losses (including parasitic power)	Thermal Efficiency (%)
2006	77.5	99.5	Diesel oil: 27.1 x 10^6 ℓ	68,902	22.1%	36.0%
2025	129.5	158.6	Heavy oil: 29.0 x 10^6 ℓ Diesel oil: 6.6 x 10^6 ℓ	95,245	18.3%	42.6%
Rate of Increase	+67%	+59%	-	+38%	-17% (relative ratio)	+18% (relative ratio)

Sources: PPUC for FY 2006 operating data and the Study Team for estimated FY 2025 operating data. The CO_2 emission factor is cited from the "GHG Emission Calculation and Reporting Manual Ver. 2.1" (June, 2007 of the Ministry of the Environment and the METI).

3) Pollution

① Air Pollution

The ground surface concentrations of nitrogen oxides and sulphur oxides that are emitted from the power station were calculated utilizing Bosanquet and Sutton's formula. The preconditions of the calculation were as follows;

- Capacity and number of diesel engines in operation: 5MW class X 7 unit (including a 5MW class diesel engine to be installed utilizing Taiwanese loan)
- Quantity of exhaust gas : 31,600Nm^3/h · unit
- Exhaust gas temperature : 365℃
- Concentration of NOx in exhaust gas : 950ppm
- Concentration of SOx in exhaust gas : 1,125ppm (in case of 4.5% sulfur heavy fuel oil)
- Height of stack : 20m
- Diameter of stack (exhaust port) : 0.85m

As shown in the following table, calculated maximum ground surface concentrations of nitrogen oxides and sulphur oxides are lower than Palauan Air Quality Standards. Even though monitoring data of NOx and SOx in the ambient air are not available in Palau, ground surface concentrations of NOx and SOx that are emitted from Aimeliik Power Station may be compared with the Palauan Air Quality Standards because there is no major pollutant sources other than the Aimeliik Power Station.

Table 6.2.3-4 Calculated Maximum Ground Surface Concentration of Pollutants and Palauan Air Quality Standards (annual arithmetic mean)

	Palauan Air Quality standards	Calculated Maximum Concentration	Remarks
Nitrogen Oxides	0.05 ppm	0.01565 ppm	-
Sulfur Oxides	0.02 ppm	0.01618 ppm	In case of 4.5% Sulfur HFO

② Water Pollution

(a) Predicted Impacts

There is concern in regard to water pollution as a result of the seepage of fuel oil, lubricating oil and waste oil, etc. into the discharged water.

(b) Impact Assessment

In the preliminary design of the Study, a waste oil treatment system and oil water separator that mees Palauan waste water quality standards are incorporated into the design and impacts of water pollution will be minimal.

③ Waste

(a) Predicted Impacts

The increased generating output following the replacement of the Aimeliik Power Station will increase the amount of waste oil for disposal. If heavy oil (Type C fuel oil) is used as the fuel for the new generating units, the amount of sludge produced will increase compared to the diesel oil currently used.

(b) Impact Assessment

In the preliminary design of the Study, a waste oil incinerator shall be installed to burn off waste oil from the power station. Thus, the impacts of waste oil will be minimal.

④ Noise

(a) Predicted Impacts and Assessment

Noise reduction by diffusion, distance and prevention wall was calculated by simplified equations and noise level at the nearest residences to the Aimeliik Power Station was estimated.

Table 6.2.3-5 shows the results of noise level prediction. Since current load curve of Koror-Babeldaob power system indicates that load in night time is almost 70% of the day time load, number of generators in operation after the replacement of Aimeliik Power Station is assumed to be seven in day time and five in night time. Based on this assumption, noise level at the nearest residences to the power station is calculated. In the evaluation of noise level, the World Bank’s ambient noise guidelines area applied as reference because there is no Palauan noise guideline. The calculation results indicates that the estimated noise level at the nearest residence-1 and 2 is lower than the maximum allowable level of the World Bank’s ambient noise guidelines in residential category. In addition, noise level at residence-1 after the replacement of the Aimeliik Power Station will become lower than the current noise level that measures around 52dB (A). Thus, the impact of noise is minimal.

Table 6.2.3-5 Results of Noise Level Prediction

Receptor	World Bank's Ambient Noise Guidelines		Noise Prediction Results (dB(A))			
	One Hour L_{Aeq} (dB(A))		Residence-1		Residence-2	
	Day time (07:00-22:00)	Night time (22:00-07:00)	Day time	Night time	Day time	Night time
Residential; Institutional; Educational	55	45	51.5	41.2	49.2	32.2
Industrial; Commercial	70	70	-	-	-	-

⑤ Bottom sediment

(a) Predicted Impacts

During the construction of heavy oil unloading pipeline off the shore of existing jetty, disturbance of bottom sediment and impacts on sea bottom fauna is concerned.

(b) Impact Assessment

It was observed that the sea bottom soil is fine and white mud as a result of underwater survey. Neither coral nor fish was observed around the surveyed sea area. Horizontal Directional Drilling (HDD) method shall be adopted as the installation method of heavy oil unloading pipeline. A pipe is thrust into the ground tracing arch-shape by the HDD method and the edge of the pipe pops out from the bottom of the sea at the targeted point. Since large-scale marine construction work is not required by HDD, impacts on sea bottom fauna is minimal, only a little sediment might be blown up.

(c) Impact Avoidance and Mitigation Measures

Silt fence will cover around the point where the pipe pops up to prevent the disturbance of bottom sediment.

(4) Comparison with zero-option

Compared with the planned diesel generating method, "zero-option" in which the Project is not implemented will give much less negative impact to the environment. However, since it is impossible to meet growing power demand and to supply reliable and enough power, considerable negative social impact is unavoidable if the zero-option is adopted. Therefore, the Project should be implemented with careful environmental mitigation measures (emission, noise and waste) are incorporated into it.

6.2.3.2 Installation of New Transmission Line between Aimeliik Power Station and Koror

(1) Outline of the Project

Since overhead wiring method will be adopted for the double circuit transmission line between Aimeliik Power Station and Koror Island, pole length for single and double circuit will be 13m and 16m respectively. Concrete poles will be installed on the shoulder of the existing road.

(2) Evaluation of Environmental and Social Factors

Table 6.2.3-6 shows evaluation results of environmental and social factors for the Installation of New Transmission Line between Aimeliik Power Station and Koror.

Table 6.2.3-6 Evaluation Results of Environmental and Social Factors for the Installation of New Transmission Line between Aimeliik Power Station and Koror

Environmental Factor		Overall Rating	During Construction Work	During Operation	Remarks
Social Environment	Involuntary resettlement	C	C	C	
	Local economy, such as employment and livelihood	C	C	C	
	Land use and utilization of local resources	C	C	C	
	Social institutions, such as social infrastructure and local decision-making system	C	C	C	
	Existing social infrastructure and services	C	C	C	
	The poor, indigenous and ethnic people	C	C	C	
	Erroneous communication of interests	C	C	C	
	Cultural heritage	C	C	C	
	Local conflict of interests	C	C	C	
	Water usage or water rights and rights in common	C	C	C	
	Public hygiene	C	C	C	
	Infectious diseases	C	C	C	
Natural Environment	Topography and geographical features	C	C	C	
	Soil erosion	C	C	C	
	Groundwater	C	C	C	
	Hydrological conditions	C	C	C	
	Coastal zone	C	C	C	
	Flora, fauna and biodiversity	C	C	C	
	Meteorology	C	C	C	
	Landscape	C	C	C	
	Global warming	C	C	C	
Pollution	Air pollution	C	C	C	
	Water pollution	C	C	C	
	Soil contamination	C	C	C	
	Waste	C	C	C	
	Noise and vibration	C	C	C	
	Ground subsidence	C	C	C	
	Offensive odour	C	C	C	
	Bottom sediment	C	C	C	
	Accidents	C	C	C	
	Electro magnetic field	C	C	C	

Rating

A: Serious impact is expected

B: Some impact is expected

C: No or minimal impact is expected

(3) Initial Environmental Examination

1) Social environment

① Land Use and Utilisation of Local Resources

(a) Predicted Impacts

The installation of electric poles restricts the land use around them.

(b) Impact Assessment

Even though electric poles are designed to be installed in a span of 50 to 70 meters, the span can be adjusted depending on the land situation. Thus, the installation of electric poles will not restrict the land use.

2) Natural Environment

① Flora, Fauna and Biodiversity

(a) Predicted Impacts

There is a concern that the installation of electricity poles may give negative impacts on flora and fauna along the transmission line route.

(b) Evaluation of Impacts

The transmission line will be constructed along the existing gravel covered roads and asphalt paved Compact Road with the pole interval of 50 to 70 meters. The line mainly goes through forests, savanna and grass fields avoiding swamp and mangrove forests.

② Landscape

(a) Predicted Impact

The Landscape will change when the transmission line is constructed.

(b) Evaluation of the Impact

There is no conservation area along the transmission line route, nor scenic areas. Since only a few people travel along the transmission line and recognize, no impact on landscape is concerned.

3) Pollution

① Magnetic Field

(a) Predicted Impacts

The EQPB of Palau has pointed out that the magnetic field created around overhead transmission lines could affect public health and has requested that the Study Team include the possible impacts of such magnetic fields in the IEE.

(b) Evaluation of the Impact

The WHO has concluded that there are no substantive health issues related to ELF electric fields at the levels generally encountered by members of the public in its Fact Sheet 322 – Electromagnetic Fields and Public Health and the Environmental Health Criteria Monograph No. 238 regarding electromagnetic fields.

For the present Study, the strength of a magnetic field occurring along the transmission line under the conditions assumed for the project has been calculated in the following manner. The strength of the magnetic field produced by the planned transmission line is far below the threshold indicated in the Guidelines of the International Commission on Non-Ionization Radiation Protection (ICNIRP) and it is judged that there will be no harmful effects to humans.

Table 6.2.3-7 Electromagnetic Field Strength Calculation Results

Case (Current, Height)	Current Value	Cable Height Above Ground	Max. Magnetic Field Value (mG)	Max. Magnetic Field Value (μT)*	ICNIRP Guidelines	Evaluation Result
1 (I-1, H-1)	430 A	9.37 m	19.85	1.9846	83 μT (60 Hz)	< 83 μT
2 (I-1, H-2)	430 A	7.47 m	30.93	3.0928		As above
3 (I-2, H-1)	340 A	9.37 m	15.69	1.5692		As above
4 (I-2, H-2)	340 A	7.47 m	24.46	2.4455		As above
5 (I-3, H-1)	251 A	9.37 m	11.58	1.1584		As above
6 (I-3, H-2)	251 A	7.47 m	18.05	1.8053		As above

* 1G = 100 μT

(4) Comparison with zero-option

Compared with the planned overhead transmission line method, “zero-option” in which the Project is not implemented will give much less negative impact to land utilization and landscape. However, since it is impossible to meet growing power demand and to supply reliable and enough power, considerable negative social impact is unavoidable if the zero-option is adopted. Therefore, the Project should be implemented with careful environmental and social mitigation measures are incorporated into it.

6.2.3.3 Construction of Koror Substation

(1) Outline of the Project

The scope of the new Koror Substation consists of a 34.5/13.8 kV step down transformer, three circuits of incoming transmission lines (34.5kV) and two circuits of outgoing distribution feeders (13.8kV). The land area of the substation is approximately 23m×32m (736m^2).

(2) Evaluation of Environmental and Social Factors

Table 6.2.3-8 shows evaluation results of environmental and social factors for the construction of Koror Substation.

Table 6.2.3-8 Evaluation results of Environmental and Social Factors for the Construction of Koror Substation

Environmental Factor		Overall Rating	During Construction Work	During Operation	Remarks
Social Environment	Involuntary resettlement	C	C	C	
	Local economy, such as employment and livelihood	C	C	C	
	Land use and utilisation of local resources	B	B	C	Currently the candidate site is a private land and impact caused by land acquisition is concerned.
	Social institutions, such as social infrastructure and local decision-making system	C	C	C	
	Existing social infrastructure and services	C	C	C	
	The poor, indigenous and ethnic people	C	C	C	
	Erroneous communication of interests	C	C	C	
	Cultural heritage	C	C	C	
	Local conflict of interests	C	C	C	
	Water usage or water rights and rights in common	C	C	C	
	Public hygiene	C	C	C	
	Infectious diseases	C	C	C	
Natural Environment	Topography and geographical features	C	C	C	
	Soil erosion	C	C	C	
	Groundwater	C	C	C	
	Hydrological conditions	C	C	C	
	Coastal zone	C	C	C	
	Flora, fauna and biodiversity	C	C	C	
	Meteorology	C	C	C	
	Landscape	C	C	C	
	Global warming	C	C	C	
Pollution	Air pollution	C	C	C	
	Water pollution	C	C	C	
	Soil contamination	C	C	C	
	Waste	C	C	C	
	Noise and vibration	C	C	C	
	Ground subsidence	C	C	C	
	Offensive odour	C	C	C	
	Bottom sediment	C	C	C	
	Accidents	C	C	C	
	Electro magnetic field	C	C	C	

Rating
A: Serious impact is expected
B: Some impact is expected
C: No or minimal impact is expected

(3) Initial Environmental Impact Assessment

1) Social environment

① Land Use and Utilization of Local Resources

(a) Predicted Impacts

As a result of field survey, it turned out that the candidate of the new Koror substation is privately owned and it will be necessary for the PPUC to purchase it. Since available land in Koror is limited because it is densely populated, the negotiation of land acquisition with the land owner may be difficult.

(b) Impact Assessment

Since the land is vacant and not used for any purpose at the moment, the change of land use status will not be a problem. The land for electric pole or substation in Palau is often provided by the landowner free of charge as a local custom. There is no land expropriation law and procedure for national project in Palau. The only protocol to be taken is prescribed in the Constitution of Palau which requires "to pay appropriate compensation for land expropriation". When necessary, the PPUC pays a reasonable price to acquire the necessary land. Since 10% contingency is already included in the cost estimation, land compensation expense will be appropriated from the contingency, if necessary. As the land owner was identified during the field survey, PPUC considers that the negotiation of land acquisition will be tough.

(c) Impact Avoidance or Mitigation Measures

From the viewpoint of reduction of distribution loss, above mentioned site is the most appropriate. However, alternative land that is owned by the Koror state government (currently used for stock yard of gravel) will be examined as a candidate site if the land acquisition is difficult.

2) Natural environment

① Flora, Fauna and Biodiversity

(a) Predicted Impacts

The construction of the new substation will threaten the survival of plants and animals traditionally inhabiting the site.

(b) Impact Assessment

As shown in the above photograph, the planned construction site for the new Koror Substation has already been prepared and the grass and trees have been cleared. It is, therefore, judged that the construction of the new substation at this site will not have any impact on local flora and fauna.

(4) Comparison with zero-option

Compared with the planned construction of new substation, "zero-option" in which the Project is not implemented will give much less negative impact to land utilization and landscape. However, since it is impossible to meet growing power demand and to supply reliable and enough power, considerable negative social impact is unavoidable if the zero-option is adopted. Therefore, the Project should be implemented with careful environmental and social mitigation measures are incorporated into it.

6.2.4 Recommendations concerning the Environmental Management Organization of the PPUC

The PPUC currently has no specially appointed personnel in charge of environmental and social consideration matters and no engineers who possess expert know-how on environmental impact assessment. It is necessary to obtain an environmental permit for the priority projects formulated in the Study, i.e. the replacement of Aimeliik Power Station, installation of transmission line between Aimeliik Power Station and Koror, and installation of Koror Power Station. The PPUC will need to make an environmental permit application to the EQPB based on the findings of the Study and the initial environmental impact assessment report prepared by the Study Team.

Regarding environmental management, the PPUC does not currently monitor air pollution and noise, however, complaints regarding noise have been made by residents living around the existing Aimeliik Power Station. In order to secure the understanding of local residents for the replacement of Aimeliik Power Station, it will be necessary for the PPUC to conduct periodic noise measurements and to plan and implement countermeasures.

Taking into account the above points, in order to smoothly execute the priority projects, it is necessary for the PPUC to as quickly as possible recruit an environmental engineer to take charge of the environmental permit application, environmental impact assessment and environmental monitoring.

6.3 Financial Analysis and Fund Procurement for the Projects Proposed

6.3.1 Necessary Fund and Lending Institutions for Concessional Loan

The Study Team conducted the following examination and planning with respect to the power generation, transmission and distribution equipment planned for construction by 2025 in the Master Plan.

1) Power generation projects (Aimeliik Power Station replacement and expansion),
2) Transmission and distribution improvement project in line with the above.

According to the JICA Study Team’s cost estimate for these projects indicated in the previous section, the total investment cost for realizing this power supply master plan is as follows.

Table 6.3.1-1 Necessary Fund to be Procured for the Master Plan implementation

Unit: Million USD

		Diesel Oil Case	HFO Case
Power Generation Projects	Phase 1	19.38	25.73
	Phase 2	11.73	12.22
	Phase 3	13.64	14.13
	Total	**44.75**	**52.08**
Transmission & Distribution Projects	Phase 1/2	11.20	11.20
	Phase 3	8.70	8.70
	Total	**19.90**	**19.90**
Grand Total		**64.65**	**71.98**

Source: JICA Study Team

The following table shows the necessary fund for the Priority Projects (Phase 1 and Phase 2).

Table 6.3.1-2 Necessary Fund for the Priority Projects (Phase 1 and Phase 2)

	HFO Case	Diesel Oil Case
Power Generation Project	US$31.1 million	US$38.0 million
Transmission and Distribution project	US$11.2million	US$11.2 million
Total	US$42.3 million	US$49.2 million

Source: JICA Study Team

In terms of domestic procurement in Palau, National Development Bank of Palau will not be able to extend such a large amount of loan for the long term repayment such as 20-25 years, and the interest rate is fairly high: 5.5-6%. Palau has CTF, but such a big amount will not be possibly withdrawn for only one sector. PPUC should seek for foreign assistance. Considering about the fact that the per capita GNI of Palau has already reached US$ 7,267 (2006) and that the necessary amount for the projects is fairly high, Palau had better not expect grant assistance to cover such a big amount for the whole scope. PPUC will have to seek for concessional loan. There will be four possible sources for soft loan lending institutions:

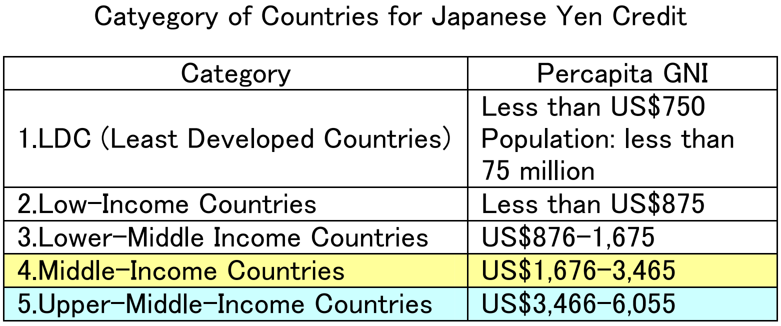
- ✓ JBIC (Japan Bank for International Cooperation)
- ✓ ADB (Asian Development Bank)
- ✓ World Bank
- ✓ Taiwan ODA

■ JBIC

Japan has not extended Japanese yen credit to Palau so far, but provided technical assistance and grant assistance under JICA, probably because of the existence of the US direct financial support under the Compact. However, the situation will be gradually changed as the direct financial support will be terminated in 2009. Japanese Yen Credit will be one option for PPUC to seek necessary fund.

The following table shows the classification category of countries for JBIC lending.

Table 6.3.1-3 JBIC's General Classification of Recipient Countries for Japanese Yen Credit



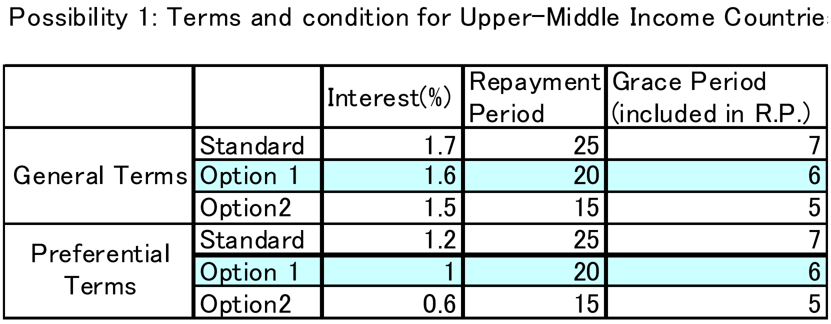
Catyegory of Countries for Japanese Yen Credit

Category	Percapita GNI
1.LDC (Least Developed Countries)	Less than US$750 Population: less than 75 million
2.Low-Income Countries	Less than US$875
3.Lower-Middle Income Countries	US$876-1,675
4.Middle-Income Countries	US$1,676-3,465
5.Upper-Middle-Income Countries	US$3,466-6,055

Source: JBIC

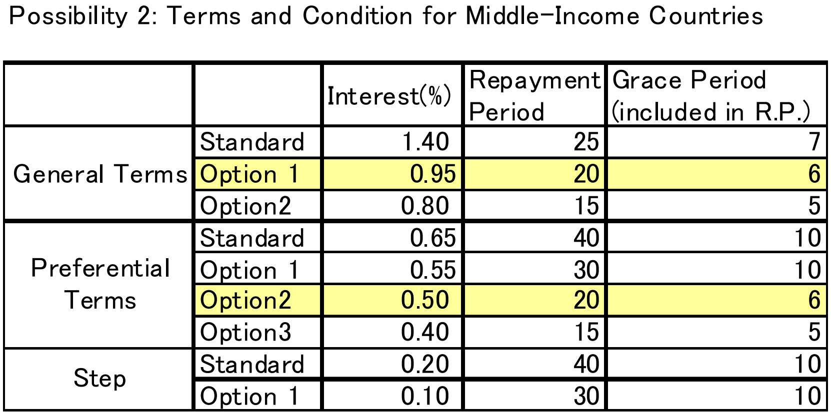
Since Palau's per capita GNI is over US$ 7,000, Palau is already beyond even the category No. 5 (Upper-Middle-Income Countries). Anyhow, the decision-making on the terms and conditions of Japanese Yen credit for Palau is up to JBIC and Ministry of Foreign Affairs, Japan. The following table will show the term and condition in case of Category 4 and 5 for reference.

Table 6.3.1-4 Terms and Condition of Japanese Yen Credit to be assumingly applied to “Upper middle income countries” and “Middle-income countries”



Possibility 1: Terms and condition for Upper-Middle Income Countrie

		Interest(%)	Repayment Period	Grace Period (included in R.P.)
General Terms	Standard	1.7	25	7
	Option 1	1.6	20	6
	Option2	1.5	15	5
Preferential Terms	Standard	1.2	25	7
	Option 1	1	20	6
	Option2	0.6	15	5



Possibility 2: Terms and Condition for Middle-Income Countries

		Interest(%)	Repayment Period	Grace Period (included in R.P.)
General Terms	Standard	1.40	25	7
	Option 1	0.95	20	6
	Option2	0.80	15	5
Preferential Terms	Standard	0.65	40	10
	Option 1	0.55	30	10
	Option2	0.50	20	6
	Option3	0.40	15	5
Step	Standard	0.20	40	10
	Option 1	0.10	30	10

Source: Prepared by JICA study Team

With the reference to Japanese Yen Credit, around 90% of the total amount shall be provided to the recipient country. The rest of the amount (about 10%) has to be provided from the recipient country’s self-effort.

One more condition to be reminded is that Japanese yen credit is a sovereign loan. JBIC needs the guarantee by the Government of Palau for the loan repayment.

■ ADB

With the reference to ADB, Palau became the 63rd member country of ADB at the end of 2003. Thereafter the development status and the debt service capacity of Palau were assessed by ADB. It was determined in December 2005 that Palau would be a Group B country. In case of a Group B Country, it is up to negotiation with donor countries. In some cases, OCR may be used. In other cases, ADF and OCR may be blended. ADB has cooperated in the aspect of policy advice and analytical support as in the same manner as WB. However, ADB is now changing its attitude and strengthening support for not only Palau but also other Pacific island countries, in the face of the gradually changing situation of the Compact.

In reference to the corresponding criteria of ADB to classify developing member countries into three groups (A, B and C), ADB does not show such statistical criteria table as shown above as JBIC. ADB intentionally avoid indicating the clear-cut criteria table in terms of per capita GNI, because there will be various socio-economic circumstances to take into considerations. In this connection, ADB classifies Palau as Country Group B.

The following table shows a general term and condition of financial assistance of ADB for a Group B Country. The term and conditions largely differ, depending on whether the financing source is ADF or OCR.

Table 6.3.1-5 Term and condition of fiancial assistance from ADB

	ADF	OCR
Repayment Period	32 years	Economic life of the project concerend
Grace Period	8 years	Implementation period of the project concerned
Interest rate	1% (Grace period) 1.5% (Repayment period)	LIBOR + Commission charge

Note 1: In case of OCR, the repayment period and the implementation period
are determined individually by each project

Note 2: In case of ADF, the repayment priod and the grace period are universally 32 years and 8 years respectively.

Note 3: Floating interest rate, to be changed by every 6 months, in consideration of the past 6-month performance

Note 4: LIBOR : London inter-bank offered rate

Source: Prepared by JICA Study Team on the basis of ADB's information and data

In case of OCR, the interest rate is determined by LIBOR (London Inter-bank Offered Rate) + Commission Charge. That is to say, the interest rate is a floating ratio and not so concessional.

In case of ADF, the interest rate is almost same level as the case of Japanese yen credit for the upper-middle income countries. In terms of the repayment period, ADF loan offers more generous term as 40 years of the total repayment period including grace period. When it comes to Japanese yen credit for middle income countries, Japanese yen credit's interest rate is softer than ADF.

With the reference to government guarantee for repayment, all the ADF projects need the government guarantee. On the other hand, OCR loan projects do not always need government guarantee. Depending on institutional viability and management capacity as well as project financial viability, ADB shall determine about whether the guarantee of the Government is necessary or not.

- World Bank

Palau is an IBRD-eligible country. World Bank's current stance to Palau, however, is clear. WB is to focus on the provision of the targeted policy advice and analytical support in a few key areas to leverage donor resources and build local capacity. WB's stance is shaped by the recognition of the substantial support from the Compact as well as Taiwan's aid and JICA's assistance as well as the high position of per capita GNI.

- Taiwan ODA

Although Taiwan's aid might be a possible fund source, the issue is the size of the necessary fund amount and interest rate. In December 2007, PPUC determined to procure a 5MW generator with the assistance from Taiwan. The loan agreement was reached. The interest rate is 3.5%, and the money borrowed is US$ 7million. Taiwan ODA will be one option to be taken by Palau. For Palau, the term and condition will not be so generous than the soft loan to be extended from international aid financial agencies. In addition, the necessary money size is by far bigger than last year's loan agreement amount.

- Co-financing by JBIC and ADB

When it comes to con-financing, ADB and JBIC, last year made a co-financing loan agreement for the power sector development to Samoa, together with Australian AID. JBIC's portion is around 38%, ADB's portion is around 42%. Another 8% comes from AusAID and 12% from Samoa, it self. As shown in the case of Samoa, another possibility for Palau is this sort of co-financing between JBIC and ADB. Besides, the scheme of ACFA (Accelerated co-financing with ADB) was recently developed by JBIC and ADB in order to promote co-financing.

6.3.2 Underlying assumptions for financial analysis of priority projects

(1) Project life

The main component of the projects is the replacement of old generators in Aimellik Power Station. In the Study, planning and design were carried out with a view to replacing four 5MW generators in two phases. Since the economic life of generators is 20 years, the Project life shall also be 20 years. The start of commercial operation of the Phase 1 generating equipment I scheduled for FY2013, so the Project lie will last until FY2032. The construction period lasts from 2011 to 2012.

(2) Technical design and plan

The financial calculation conducted for this financial analysis is based on the technical study and design conducted by JICA Study Team.

(3) Computing incremental cash flows

The project's net cash flows shall be forecast over the project life. In this case, since the project's main part will be the replacement of deteriorated power generating equipment, the net revenue obtained from selling power generated with the new equipment will be the incremental part in cash flow. Meanwhile, in the case of the transmission and distribution improvement project, the improvement work of transmission efficiency will reduce transmission losses and improve efficiency, thereby generating surplus revenue from power sales. .

- Power generation: sales of electric power to be generated from the newly installed equipments
- Transmission and distribution: improvement of transmission loss

(4) Current price terms

As in the custom of ADB, JBIC and World Bank, this financial analysis projection is prepared in current price terms. It does not count any inflation elements.

(5) Fuel expense and price

It is clear that future movements in oil price will significantly affect the financial performance of the project. That is, it is possible that changes in the price of oil will greatly impact the financial standing of the PPUC, although it is hard to say how fuel prices will change in the future. The proposed scheme of AFPAC is to thoroughly improve the tariff system and to fully cover the fuel cost as well as conducting revision every three months. Moreover, it will be necessary to strive for monthly review and revisions. Provided that the PPUC thoroughly improves its system, it is possible that the oil price hikes will be sufficiently absorbed by the tariff system.

The current price of diesel oil procurement for PPUC is US$ 3.67/gallon as of May 2008. For this study, this current price is used as a constant price for financial projection analysis. Meanwhile, the price of HFO is counted by assuming the current market price of RME 180 on the Singapore market (MOPS), the same price of ocean freight of diesel, the same amount for handling fee, secondary transport, LFT and GRT. This is US$ 2.6/gallon. Since the gap is fairly large at US$ 1/gallon, and fuel cost accounts for a major share of the power generating cost in Palau, this will impart a major disparity in the projected financial returns of the project.

6.3.3 FIRR and NPV

(1) The Priority Projects

In the aspect of operation expense, fuel cost is a decisive factor. On the other hand, in the aspect of operation revenue, the financial result of operation will differ, depending on electricity tariff.

The following table and figure distinctly shows the difference between the HFO use operation and the conventional operation of using only diesel oil. The financial rate of return and the net present value are calculated as below:

Table 6.3.3-1 FIRR and NPV analysis with the variable of Electricity Tariff Rate

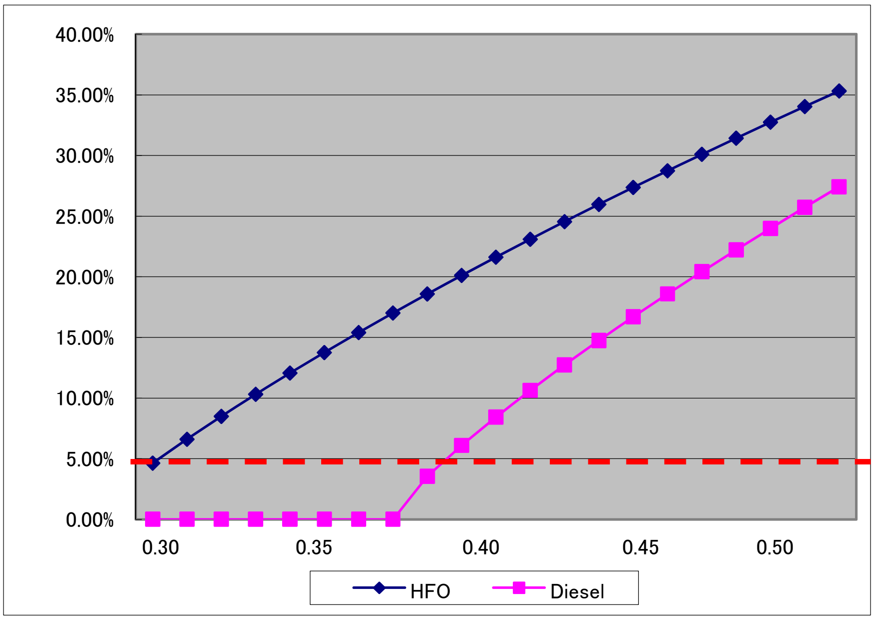
HFO use

ETR	FIRR	NPV at 5%
US$/kWh	%	US$
US$0.31	6.60%	6,576,292
US$0.32	8.49%	14,649,472
US$0.33	10.31%	22,722,650
US$0.34	12.06%	30,795,830
US$0.35	13.75%	38,869,011
US$0.36	15.40%	46,942,189
US$0.37	17.01%	55,015,370
US$0.38	18.58%	63,088,548
US$0.39	20.11%	71,161,727
US$0.40	21.61%	79,234,908
US$0.41	23.09%	87,308,087
US$0.42	24.54%	95,381,265
US$0.43	25.96%	103,454,445

Diesel

ETR	FIRR	NPV at 5%
US$/kWh	%	US$
US$0.40	8.43%	12,131,285
US$0.41	10.63%	20,555,580
US$0.42	12.73%	28,979,880
US$0.43	14.74%	37,404,180
US$0.44	16.69%	45,828,478
US$0.45	18.58%	54,252,775
US$0.46	20.42%	62,677,072
US$0.47	22.22%	71,101,372
US$0.48	23.99%	79,525,670
US$0.49	25.72%	87,949,968
US$0.50	27.42%	96,374,269

FIRR (%)



Source: Prepared by JICA Study Team

Fig. 6.3.3-1 Comparison between Two Scenarios (HFO use or Diesel Oil Use)

In case of continuing to use diesel oil, PPUC has to keep on charging US$ 0.39/kWh. If the price goes up, PPUC will have to raise the tariff furthermore in order to continue the service.

On the other hand, provided that PPUC successfully introduces HFO use, PPUC will be able to decrease the rate to around US$0.31/kWh, simultaneously keeping the reasonable return.

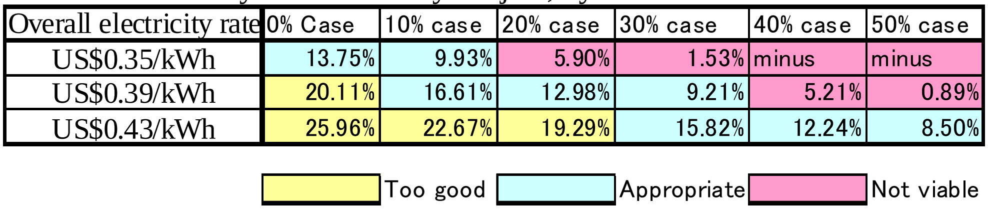
The improvement of power transmission and distribution is essentially important to keep the service efficiently as well as to prevent disconnection. Although the direct benefit of the project will not be as large as that of power generation, the function of transmission and distribution is indispensable. Without the stable and efficient operation of transmission and distribution, the electricity company will not be able to sustainably manage the operation as a whole.

The benefit is, herein, calculated as improvement of transmission. Without these investment activities, the risk of operation will be getting larger. For this time, JICA Study Team has not calculated the benefit of avoiding such risk by using meticulous approach of calculation, because the benefit will be sufficient by integrating both PG and TD into one comprehensive project.

(2) Sensitivity Analysis

Fuel cost is the largest risk factor in this project. By setting forth several scenarios of fuel cost, the sensitivity on FIRR for the power generating project in case of HFO use is calculated and analyzed. The impact on FIRR in fuel price hike scenarios and various scenarios of electricity tariff is examined. The following table shows the sensitivity on FIRR change for the Priority Project of HFO use case.

Table 6.3.3-2 Sensitivity on the Priority Project, by several scenario of fuel cost increase



Overall electricity rate	0% Case	10% case	20% case	30% case	40% case	50% case
US$0.35/kWh	13.75%	9.93%	5.90%	1.53%	minus	minus
US$0.39/kWh	20.11%	16.61%	12.98%	9.21%	5.21%	0.89%
US$0.43/kWh	25.96%	22.67%	19.29%	15.82%	12.24%	8.50%

🟨 Too good 🟦 Appropriate 🟥 Not viable

6.3.4 Time-schedule from the confirmation of fund procurement up to the operation commencement

This study is to prepare the medium-long term master plan for PPUC, and it includes this pre-FS. Provided that this fund procurement is done as Japanese Yen Credit, SAPROF study shall be done as a follow-up effort after this pre-FS in order to firm up the details, and both countries of Japan and Palau will reach the loan agreement.

In terms of time-schedule, the SAPROF shall be implemented during the latter half of 2008. After adjustment and confirmation, the loan agreement shall be made around February or March 2009. Thereafter, PPUC shall retain the consultant with due process in accordance with Japanese yen credit procedure. It shall need around 6~9 months. After that, the detail design study shall be implemented by the Consultant during the former half of 2010. The bidding for the construction work (PQ, Bidding, Bidding evaluation, and contract negotiation) shall be done in the latter half of 2010. Machinery procurement work shall start 6~8 months later around 2011, and the installment work shall be done in 2012. Finally the Phase 1 construction and installment shall be finished during FY 2012 (September 2012).

Table 6.3.4-1 Time-Schedule from Fund procurement to Plant Operation Commencement

	Year 2008												Year 2009												Year 2010												Year 2011												Year 2012											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
JICA MP andPre-FS	■	■	■	■	■	■																																																						
Follow-up actions for land acquisition, fund procurement etc.							■	■	■	■	■	■																																																
Loan agreement													■	■	■																																													
Retaining of consultant																■	■	■	■	■	■	■	■																																					
Detai design																								■	■	■	■	■	■	■																														
Bidding of phase 1 construction																															P ■	■	Bid ■	■	Bid Evaluation ■	■	Contract Negotiation ■	■																						
Phase 1 construction work																																							═	═	═	═	═	═	═	═														
Bidding of phase 1 machinery																																					PQ ■	■	Bid ■	■	■	Bid Evaluation ■	■	■	Contract Negotiation ■	■														
Phase 1 machinery Procurement																																															═	═	═	═	═	═	═	═	═	═	═			
Operation																																																										═	═	═

7. EXAMINATION FOR OPERATIONAL IMPROVEMENT OF POWER SUPPLY EQUIPMENT

7. Examination for Operational Improvement of Power Supply Equipment

7.1 Operational Improvement of Power Generation Equipment

7.1.1 Current Operation and Maintenance Conditions of Power Generation Equipment

As of May 2008, the PPUC has made a start on introducing the recommendations made in the "Power station Performance Audit" by the American consulting firm Electric Power Systems Inc., and the operation and maintenance situation is being improved. However, supply continues to be impeded by breakdowns and stoppages in the generating equipment, and further improvements need to be made. The following sections indicate the current conditions regarding operation and maintenance in the Power Generation Department.

(1) Organizational Setup

Fig. 7.1.1-1 and Fig. 7.1.1-2 show the organizational setup of the PPUC Power Generation Department.

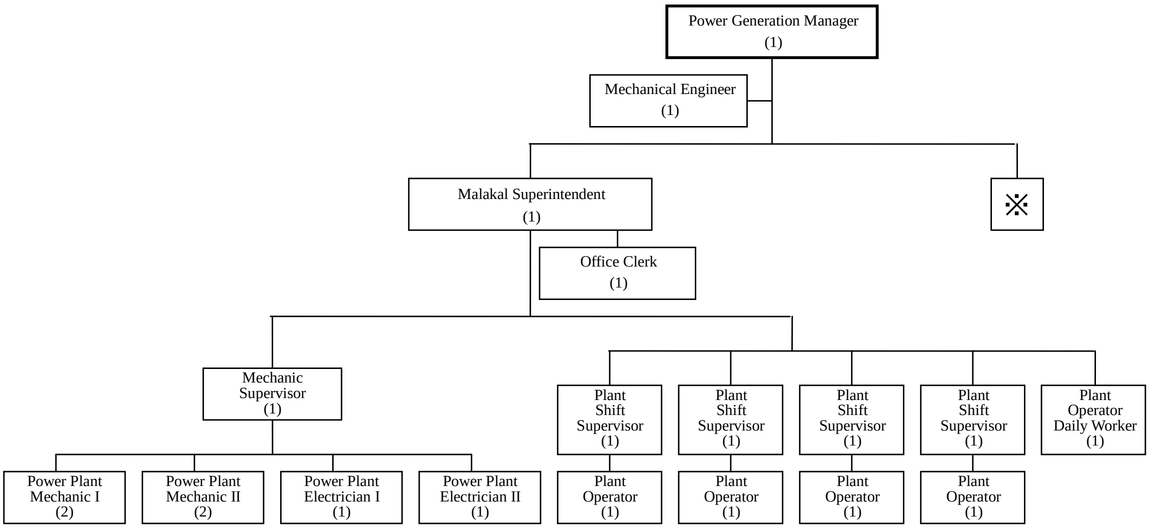


Fig. 7.1.1-1 Organization Chart of Malakal Power Station

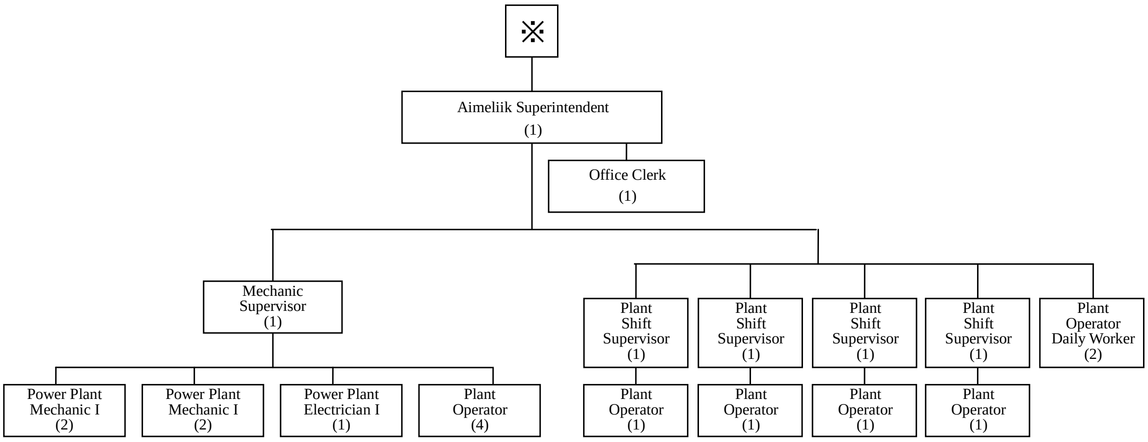


Fig. 7.1.1-2 Organization Chart of Aimeliik Power Station

Operation is carried out based on the shift system indicated. Four teams comprising two members each work three shifts. Maintenance is supervised by the machine equipment manager, however, concerning operation management, there is no operating manager to analyze and assess the operating data.

Regarding actual maintenance work such as periodic inspections and maintenance, etc., rather than outsourcing this to the equipment makers, a team of roughly 10 members under the mechanical equipment manager directly handles the work at both power stations. However, in accordance with recommendations given in the Power Station Performance Audit, in an effort to improve operation and maintenance, the PPUC has bound a contract to recruit a mechanical engineer from a nearby country to implement the following work for two years from November 2007.

- Add up remaining operating times and compile future maintenance plans for each item of equipment.
- Implement and supervise periodic inspections and maintenance from an expert viewpoint.

The recruited mechanical engineer has experienced the supervision of diesel power generating equipment at a company in the Philippines, which also conducted its own maintenance without outsourcing to the makers. He also has experience of providing guidance as a maintenance instructor and is confirmed to be the ideal person for passing on the above work to the PPUC. This mechanical engineer has helped formulate the following maintenance plans:

1) Operating plans giving a breakdown of daily operating plans for generators at Malakal and Aimeliik Power Stations (2008-2010)
2) Formulation of periodic inspection and maintenance schedules for each equipment based on the operating plans
3) Examination of inspection and maintenance items in each generator and periodic inspection
4) Preparation of the list of spare parts required in each generator and periodic inspection
5) Preparation of the spare parts ordering schedule based on the periodic inspection and maintenance schedule
6) Preparation of the ordering standard and inventory list for emergency spare parts

Although the mechanical engineer prepares maintenance plans, little progress is being made in transferring technology to local personnel regarding planning techniques, basic technologies of generating equipment, implementation and supervision of maintenance and so on.

(2) Legal Systems and Statutory Technical Standards concerning Operation and Maintenance

Palau currently has no legal systems or statutory technical standards for power generating equipment. It will need to establish such legislation and standards based on a long-term viewpoint in future. Concerning existing power generating equipment, each supplier has designed and installed equipment based on the technical standards in each country. In particular, since safety technical standards are important from the operation and maintenance viewpoint, it is necessary to establish these from a long-term perspective, however, the training of engineers to perform such work is the most pressing issue at present.

(3) Safety Regulations and Emergency Communications Networks

The PPUC does not have a document (safety regulations) specifying its policy regarding safety matters. However, the mechanical engineers at the PPUC have compiled an "Emergency Preparedness Plan" providing guidelines on how to respond to major accidents and other emergency situations in the Power Generation Department. As for the emergency communications setup, persons who discover problems are required to notify the plant manager, however, concrete standards for this and the network for notifying other personnel haven't been confirmed.

(4) Budget Measures

Looking at the maintenance budgets and actually incurred expenses concerning engines and generators over the past five years, a start has been made on managing maintenance expenses for each generator unit since 2007. However, there are major disparities between budgeted amounts and actual maintenance costs, due to the fact that adequate maintenance plans were not compiled in the past and periodic repairs were not implemented because of the need to satisfy power demand.

Since the mechanical engineer has started to prepare maintenance plans from fiscal 2007, it is expected that budget and actual cost performance will be improved from now on.

(5) Operation of Power Generating Equipment

Daily operating plans are compiled by the mechanical engineer based on daily load curves from the same period the previous year. However, since Pielstick-3 at Aimeliik Power Station is currently undergoing rehabilitation work, there are no such plans and, except for the stoppage of high-speed low-capacity generators at times of low demand (nighttime, etc.), all the generating equipment is kept operating.

Basic data on operation is collected by means of log sheets, handover ledgers, trouble reports, trip reports and emergency record sheets in the case of Malakal Power Station, and by means of log sheets, handover ledgers and trouble ledgers in the case of Aimeliik Power Station. Although records are made, they are not effectively utilized because there is no system for analyzing and assessing them, while storage procedures are not specified. Moreover, some log sheets were found to contain no data because of troubles with measuring instruments. The accuracy of measuring instruments is not checked.

(6) Maintenance of Engines

Although equipment makers recommend that power generating units undergo periodic inspections every 1,000 hours, 3,000 hours, 6,000 hours, 12,000 hours and 24,000 hours, due to inadequate maintenance plans and budget measures, only the 1,000-hour and 24,000-hour inspections are implemented at Aimeliik Power Station. Meccron Co., which performs the rehabilitation work for Unit No. 3, plans to compile periodic inspection and maintenance plans based on internal conditions in future. As for Malakal Power Station, ever since the aforementioned mechanical engineer has been recruited, periodic inspection and maintenance plans have been compiled and implemented according to the operation and maintenance manuals of the equipment manufacturers.

(7) Maintenance of Systems

In order to keep engines operating with good efficiency, it is necessary to compile maintenance plans and conduct maintenance on lubrication systems and cooling water systems too. Currently, concerning the periodic inspection and maintenance of engines and generators, maintenance plans are being finalized and budget items are finely compartmentalized, however, this progress has so far not been reflected in other systems. It will be necessary for the mechanical engineer to clarify heat exchanger cleaning intervals and filter replacement intervals, etc. for other systems and to compile maintenance plans for entire plants.

(8) Lubricating Oil and Cooling Water Management

At Aimeliik Power Station, lubricating oil is sampled every 1,000 hours. At Malakal Power Station, it is sampled every month. The sampled lubricating oil is sent to the petroleum company for analysis, and the results of analysis are used to determine whether or not to replace the lubricating oil.

Concerning cooling water, the generating units made by Mitsubishi are equipped with water softeners, while other units use city water for cooling purposes (anti-corrosive is not applied). Periodic analysis of cooling water properties is not implemented.

(9) Spare Parts

The storage situation regarding emergency spare parts is good with lists of inventory quantities and locations maintained and renewed every month. Regarding Aimeliik Power Station, the clerical worker who was recruited in May 2008 conducts the inventory management of these spare parts. Concerning gaskets and other expendable items, more than the quantities required for a single overhaul are kept on hand. However, concerning relatively large and expensive spare parts, stocks of spare parts are insufficient. .

(10) Maintenance Tools

Similar to the spare parts, storage conditions are also good for maintenance tools. Standard tools such as spanners and wrenches are managed by each machine technician, whereas special tools used for disassembling and assembling engines are kept in the machining rooms of power stations. The power stations also possess cutting and processing machines such as lathes and milling cutters, etc. and they are able to manufacture emergency parts. Welding machines were observed, however, welding technicians possessing the necessary expertise were not confirmed.

(11) Work Guidelines and Inspection Record Formats

Work contents, preliminary and follow-up measures and divisions of roles are clarified based on work guidelines, and through securing the advance approval of managers and providing education to work operators, they help secure the safe and sound implementation of work. Such work guidelines are currently not prepared in the Power Generation Department of the PPUC. In future, it will be necessary to prepare such guidelines according to the actual work conducted in each workplace.

(12) Human Resources Development

Human resources development in the Power Generation Department is based on OJT. Even when new employees are recruited, concentrated training entailing dispatches to equipment makers, etc. for imparting technical know-how is not conducted. Only five employees have experienced operation and maintenance training at equipment makers, i.e. the plant manager, two mechanical engineers and one electrical engineer at Malakal Power Station, and the machine equipment manager at Aimeliik Power Station.

Furthermore, staff members do not possess the apparatus to conduct deskwork and they also lack basic computer skills. Thus, another important issue is that each employee acquires the basic skills required to operate personal computers.

It is necessary to thoroughly respond to these specific issues and criteria by incorporating steps into personnel evaluations and so on. Employees currently undergo evaluation once every year, however, since evaluations only comprise giving marks for general written items, it is impossible to discern how skills are being honed with respect to specific issues.

(13) Current Conditions of Power Generating Equipment

Since Wartsila-2 and Wartsila-3 units at Malakal Power Station have not been used as power sources ever since they experienced crankshaft burning in 2006, there is a lack of supply reserve capacity at the plant. Repair parts for both units have already been delivered and work is currently being advanced on Wartsilla-3 ahead of Wartsilla-2. Fig. 6.1.1-5 shows the repair situation regarding Wartsilla-3. It appears that Wartsilla-3 will be ready for recommissioning around July 2008, while Wartsilla-2 should be operational again by the middle of 2009 or the start of 2010 at latest. Concerning switchgear in Wartsila-2 and Wartsila-3 units, the two Caterpillar generator switchgear sets that were hurriedly introduced and switched to when frequent crankshaft burning occurred in 2006 are still in use today.

Concerning the power generating equipment at Aimeliik Power Station, the PPUC concluded a contract for the rehabilitation of Peilstick-3 with Meccron Co., which conducts consulting for the Philippine plant equipment and industrial equipment, and this rehabilitation work was commenced from the end of February 2008 over a 60-day schedule. Following confirmation of operating conditions in Pielstick-3, where work has finished, it is planned to bind similar contracts with the same company for the rehabilitation of the three remaining units. In fiscal 2008 (October 2007 to September 2009), budget has been appropriated for the rehabilitation work of Pielstick-3 and Pielstick-2. However, upon implementing internal inspection of Pielstick-3, since damage that cannot be repaired on site (for example, cracking at the bottom of the cooling water jacket, etc.) was confirmed, related parts will be transported to Meccron Co. for repairs there.

Meanwhile, as of May 2008, the Mitsubishi-13 unit at Malakal Power Station is due for its 7,500-hour periodic inspection. As was mentioned above, since there is currently not enough reserve supply capacity available, it will be necessary to delay the periodic inspections of other units in the event where an unexpected problem occurs. Such delays in periodic inspections lead to the occurrence of further problems, and such a vicious cycle prevents the planned implementation of preventive maintenance.

7.1.2 Recommendations for Operational Improvement of Power Generation Equipment

(1) Problems and Recommendations concerning Routine Operation

1) Operating Setup

As was mentioned above, both power stations have two operators at work at all times, and four teams of operators share the workload over three shifts (morning, evening and night). One of the teams provides cover for day shifts and personnel who take leave. At times of routine operation, operating personnel manage equipment load, frequency, voltage, power factor, current and electric energy, and they decide when to turn generators on and off in line with daily load fluctuations based on their own experience. However, the mechanical engineer should compile clear procedures and implement periodic OJT so that operating disparities according to individual operator differences are eliminated. In the event of emergencies, communication setups are established and enable pertinent instructions to be given.

2) Operating Records

Log sheets are divided into those for engine generators, transmitted energy and fuel oil. Performance records are not kept and there are also missing entries due to broken or missing instruments. In addition, some areas have been neglected for an extended period and the partial absence of data impedes the appropriate gauging of current conditions and forecasting of risks.

Operators record the operating values of each engine generator hourly in record sheets. Generator unit-related items such as generated electric energy, exhaust gas temperature, fuel rack, cooling water pressure and temperature, lubricating oil pressure and temperature and so on as well as instrument readings from the generator control panel are covered and provide adequate operating records.

3) Analysis of Operating Records

The above operating records are only sent to plant engineers and stored inside the plants, however, they are not utilized for conducting the technical assessment (determining current status, forecasting future condition and predicting risks) of engine generators. The PPUC does not have sufficient skilled engineers who are capable of making technical assessments from operating records for engine generators and power generating systems, however, it is important to report such technical assessments to the PPUC headquarters so that they can be fed back to operators and maintenance staff and shared through all the PPUC. Such sharing of information makes it possible to conduct the operation and maintenance of sound power generating equipment.

Operators keep notes of everyday occurrences and these notes sometimes contain important hints, which engineers should be able to decipher and, where necessary, translate into detailed investigations, identification of causes and compilation of steps and measures. All alarm situations should be recorded and dealt with according to the above procedure.

Statistics of breakdown records are not currently maintained. Monthly and annual statistics of operating time, routine stoppage time, breakdown stoppage time and generated electric energy for each generating unit give a numerical indication of the reliability of power generating equipment and provide indices of sound operation and maintenance.

4) Maintenance of Instruments

In addition to implementing education via OJT and so on and thoroughly ensuring that operators report instrument breakdowns and problems, it is necessary to build a setup for predicting breakdowns and problems in instruments from operating records. It is important for both the reporting side and the side receiving and making judgments based on reports, to have common awareness that instrument failures and deficiencies are abnormal. Furthermore, it is strongly recommended that instruments are periodically calibrated and that broken instruments are replaced with new products.

5) Recommendations

- Formulation of the start and stop procedure for power generating equipment
- Calibration, maintenance and replacement of instruments
- Analysis, assessment, countermeasures and reporting of operating records and incident records
- Preparation and reporting of breakdown report statistics

(2) Problems and Recommendations in Periodic Inspections

Engines and so forth should periodically undergo maintenance. The operation and maintenance manuals that are supplied by equipment makers give detailed descriptions of the work items that need to be performed after different operating periods.

However, inspections are currently not implemented at periodic intervals due to the pressing demand for electricity and shortages of replacement parts resulting from the inadequate budget. As a result, maintenance inspections are postponed and massive repair costs are incurred when major breakdowns are allowed to occur and render operation impossible for extended periods.

Furthermore, other problems are found during maintenance inspections and stoppage times are prolonged due to the need to procure parts. When this happens, the demand for power becomes more pressing and subsequent maintenance inspections end up being postponed again. This kind of vicious cycle is repeated over and over.

The PPUC recruited a Philippine engineer last year and assigned him to Malakal Power Station with a view to breaking free of this negative cycle. A periodic inspection schedule and so on is compiled, however, it is important that periodic inspections be compiled in a manner that takes actual conditions into account and fully utilizes the skill and experience of the Philippine engineer. A broad outline of periodic inspections is given below.

1) Formulation and implementation of short-term and long-term plans for maintenance inspections of engine generators

Detailed schedules should be compiled for 2 years in the short term and 10 years in the long term.

2) Procurement and storage of emergency spare parts for engine generators

Concerning large parts kept permanently on hand in case of sudden accidents, make sure that stores can be checked at any time. It is desirable to build an internal network so that information concerning spare part inventories can be shared.

3) Procurement and storage of replacement parts for engine generators

Conduct management so that the replacement parts required in 1) can be procured and inventories can be checked at any time.

4) Formulation and implementation of long-term and short-term plans for auxiliary equipment maintenance inspections

Periodic inspections for pumps and motors, and periodic inspections of filters

5) Procurement and storage of emergency spare parts and replacement parts for auxiliary equipment

Conduct management so that the replacement parts required in 4) can be procured and inventories can be checked at any time.

6) Formulation and implementation of long-term and short-term plans for control panel and circuit breaker panel, etc. maintenance inspections

Calibrate meters during stoppages for engine generator maintenance inspections. Moreover, implement protective relay calibration every two years.

7) Quality control of fuel oil

Have fuel suppliers submit constituent tables and performance tables with every lot purchased, and make sure that values satisfy the standards prescribed by the engine makers.–

8) Quality control of lubricating oil

Have lubricating oil suppliers submit constituent tables and performance tables with every lot purchased, and make sure that values satisfy the standards prescribed by the engine makers.

9) Quality control of cooling water

Cooling water systems for power generating equipment in Palau are the circulatory type using radiators and city water. Generally it is required that radiator circulation water has hardness of no more than 40 ppm.

10) Request for dispatch of maintenance instructors (SV) from equipment makers during overhauls

The PPUC currently implements overhauls by itself since SV dispatch costs from makers are too expensive. However, as may be gathered from rehabilitation case studies at Ameliik Power station, because the wear and tear of major regions has been left neglected for extended periods, it had become necessary to implement large-scale repairs by the time problems were discovered by external engineers, and the PPUC incurred massive costs (in terms of both finance and repair time) as a result. Accordingly, it is considered necessary to request the dispatch of SVs from equipment makers when conducting overhauls and to periodically assess the integrity of equipment from an expert point of view.

11) Maintenance budget

In order to establish the appropriate maintenance setup, the annual maintenance budget should continue to be appropriated from now on. Since the cost of maintenance is generally 2.0 cents/kWh and total electric energy in fiscal 2009 is forecast as 113,350 GWh, it will be necessary to raise a maintenance budget of approximately US$ 2.27 million for fiscal 2009.

(3) Problems and Recommendations in the Power Generating Equipment Organization

1) Assignment of a Planning Engineer

Assign a Planning Engineer (1) to be responsible for the following tasks in Ameliik and Malakal Power Stations.

- i) Formulation of periodic inspection plans for the power stations
- ii) Formulation of annual budgets for operation and maintenance
- iii) Control and procurement of the spare parts and expendables required for periodic inspections and everyday maintenance
- iv) Generator performance management (output and thermal efficiency)
- v) Fuel consumption management and fuel ordering
- vi) Control of operating records and inspection and maintenance records

All the above tasks are currently handled by the mechanical engineer, however, it is necessary to carry out transfer of technology in order to enable the Palau personnel to conduct planned maintenance and performance management, etc. of generating equipment by themselves. For this reason, a planning engineer shall be assigned to work full-time on the above tasks.

2) Recruitment of a System Planning Manager to Manager Long-Term Demand Forecasting and Power Development Plans

Currently, external consultants are depended on to compile long-term power development plans, etc., however, in order to rapidly respond to changes in the environment surrounding the electric power utility, it is necessary to train PPUC personnel to independently compile long-term plans and financing plans. Through planning and promoting systematic power source plans and securing appropriate reserve supply capacity, it will become possible to periodically stop generating equipment and conduct planned maintenance (preventive maintenance), thereby contributing to smoother supply.

3) Appointment of an Officer in Charge of Environmental and Social Measures The PPUC needs to appoint an officer to be in charge of environmental measures and social measures that may arise in the construction, operation and maintenance of power

stations and transmission and distribution lines.

7.2 Operational Improvement of Transmission and Distribution Equipment

7.2.1 Current Operation and Maintenance Conditions of Transmission and Distribution Equipment

(1) Organizational Setup

The transmission/distribution and transforming branch of PPUC is composed of the System Control Department and Power Distribution Department, and the composition and mandates of each department are as indicated below.

1) The System Control Department, which comprises seven members led by the manager, mainly conducts equipment maintenance planning, equipment data and breakdown data management, site survey of power receiving applications, works planning, testing and management of watt meters and so forth. The department headquarters is located in the offices of Malakal Power Station.

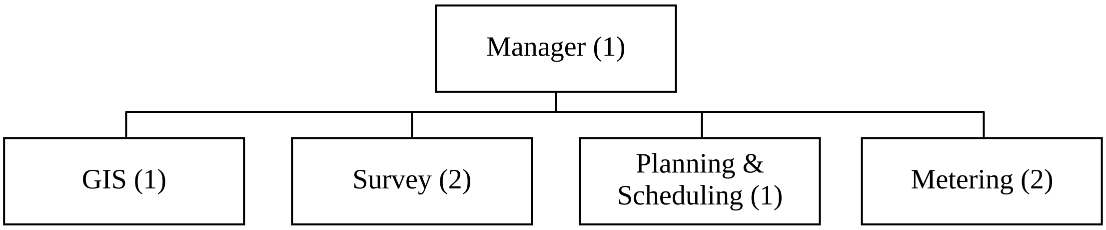


Fig. 7.2.1-1 Organization Chart of the System Control Department

2) The Power Distribution Department, which comprises 22 members led by the manager, is responsible for conducting all maintenance and works on the PPUC transmission, distribution and transforming facilities. The department headquarters is located in the offices of Malakal Power Station.

The department has two work teams (each comprising 1 supervisor, 4 workers, and 1 heavy equipment operator) that implement transmission and distribution line works. In addition, there is one tree trimming crew (1 supervisor and 3 workers).

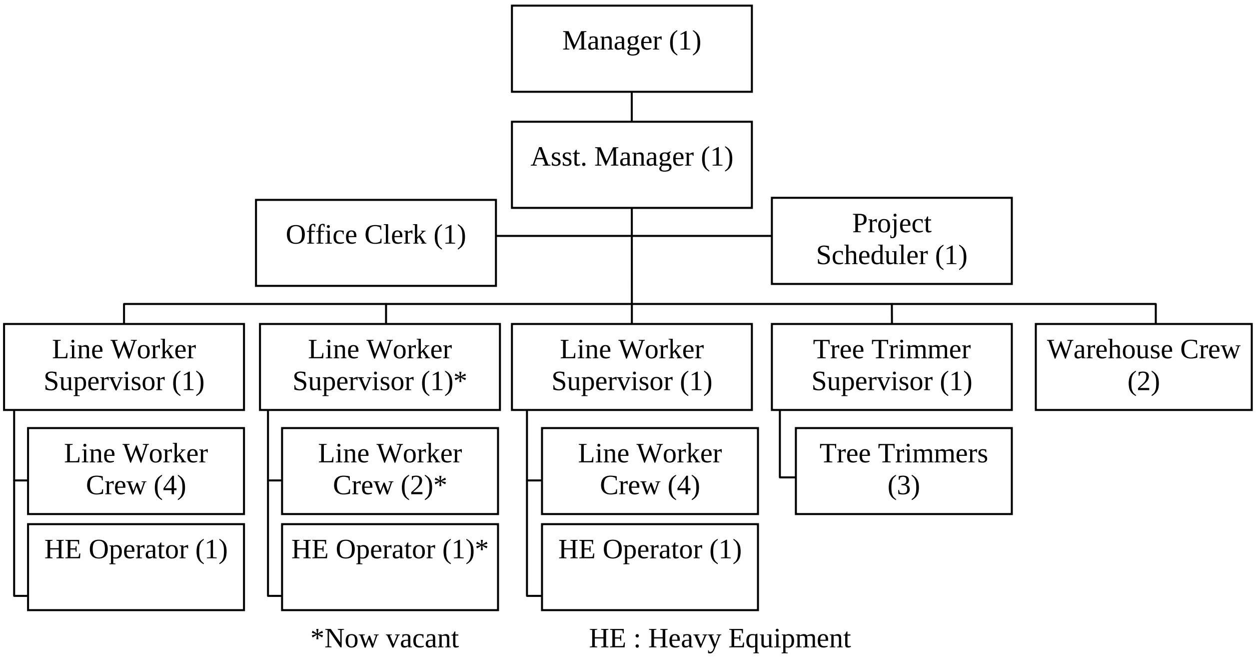


Fig. 7.2.1-2 Organization Chart of the Power Distribution Department

(2) Legislation and Standards

Palau does not have any original legislation or standards pertaining to electric power, however, in light of its historical links with the United States, the American electricity technical standard NESC is applied. Moreover, linemen attend Pacific Lineman Training courses hosted by the United States, and American rules are incorporated regarding technology and skills.

The PPUC has enacted the Electrical Service Regulations stipulating its power supply rules. According to these, power supply voltage is managed according to the C84.1 Standard of the American National Standards Institute (ANSI). Concerning work safety too, a safety manual was enacted on July 11, 1995 to provide internal rules.

(3) Operation of the Power System

SCADA was introduced in 2003 and the monitoring and control of the power system can be carried out from both Aimeliik Power Station and Malakal Power Station. However, actual control work is almost all carried out at Malakal Power Station. The SCADA monitors are installed in the power station control rooms, and plant operators also conduct system operation. Concerning generators, only a minor amount of information can be monitored from SCADA, while control cannot be exercised. When alarms are raised in SCADA, operators simply notify the Power Distribution Department or System Control Department, but they do not implement any autonomous recovery operations.

(4) Voltage Management and Load Management of Distribution Lines

The transformers (13.8kV/240V/120V) mounted on distribution line poles have taps for switching the voltage ratio over five stages, however, voltage management is not carried out to an adequate extent because voltage adjustment using these is not even carried out in areas where voltage drop is a problem.

Moreover, transformers with far larger capacity than power demand (load) can be seen in numerous cases.

(5) Daily and Periodic Inspections

Inspections and maintenance of transmission and distribution equipment are conducted according to the System Preventive Maintenance Schedule from January 2008. This System Preventive Maintenance Schedule was compiled by the System Control Department and approved by the General Manager (GM) on December 5, 2007, and inspections of all transmission and distribution lines and transformer substations are carried out according to it. Moreover, the same check sheet is used from the confirmation through to the resolution of troubles.

There are 10 items on the check sheet concerning transmission and distribution equipment and these include proximity to trees, supports, state of insulators and so on. Inspections are implemented by a minimum of three linemen who belong to the Power Distribution Department. The linemen usually travel by car when making inspections, however, they also conduct foot patrols and inspections around once every one or two months.

Transformer equipment inspections are conducted under the responsibility of the Power Distribution Department, however, assistance is provided by two members from the Power Generation Department, while measurement engineers from the System Control Department implement watt meter operations. The results of inspections are shared among members in meetings of the Power Distribution Department, and the manager enters the contents in the said check sheet. When abnormalities are discovered, the Power Distribution Department manager compiles a repair plan (need for outages, preparation of materials, work plan, etc.) and reports to the GM. Moreover, the Power Distribution Department manager reports on operating performance to the GM once every month. Moreover, thoughts and improvement proposals from the System Control Department are reported to the GM every week.

Concerning tree trimming, a schedule for implementing this over all Babeldaob Island is prepared separately from the System Preventive Maintenance Schedule every six months (the same thing is scheduled for Koror Island too), and the work is conducted by four tree trimmers. The scope of tree trimming underneath transmission lines is prescribed as a width of 50 feet (approximately 15 m).

(6) Spare Parts

Spare parts are stored according to different item headings in the materials store of the Power Distribution Department, and a store manager prepares and manages a list of items in stock. ~~S~~ Stored quantities are determined according to past frequency of use, and the store is managed so as to maintain the said quantities.

(7) Troubleshooting

Whenever accidents occur, the manager of the Power Distribution Department receives notification either from the customer center that is contacted by the consumer or by the power station operator that takes the SCADA alarm; procedures (power outage, preparation of materials, compilation of work plan) are taken by the Power Distribution Department Manager and System Control Department Manager, and the restoration work is implemented.

(8) Utilization of Manuals

The linemen use the texts provided in Pacific Lineman Training as their working manuals. Plenty of written materials such as the user manuals provided by equipment suppliers and maintenance manuals are available, however, these are not adequately utilized.

(9) Human Resources Training and Owned Technology and Skills

The PPUC autonomously builds concrete poles and so far it has not experienced any injurious accidents and so on in the course of this work. All linemen have attended Pacific Lineman Training and they possess expert know-how.

7.2.2 Recommendations concerning Operational Improvement of Transmission and Distribution Equipment

(1) Power System Operation

When troubles occur in the power system, the system operators need to promptly implement primary treatment. Operators also need to analyze and assess operating records in order to secure power quality, and this work requires a high level of technology and skill. SCADA does not automatically operate power systems; rather its function is to assist operators in rapidly collecting accurate information and definitely transmitting control commands.

Installing control posts, is a rational measure for avoiding personnel increases. Currently, due to problems on the equipment side (SCADA, power equipment), the amount of work that can be implemented is limited, and it is necessary to overcome this problem first. Moreover, since power system operating technology is not something that can be easily acquired, it is recommended that specialist operators for power systems be recruited and trained on a planned basis in readiness for the future rehabilitation of equipment and installation of control posts. Concerning training, since opportunities for training and plant observation are limited in Palau, it is more effective to take part in overseas training courses and equipment observation.

(2) Distribution Line Voltage Control and Load Control

When complaints arise over voltage drop, it is necessary to definitely conduct voltage measurement and confirmation of the transformer tap position onsite. It is preferable to confirm voltage during the peak period when voltage drop is at its largest, however, since there are occasions when short-term voltage drop becomes problematic due to load characteristics, it is recommended that an oscilloscope which is capable of continuously measuring voltage be installed. Since the oscilloscope can simultaneously measure and record voltage, current, frequency and power factor, etc., it can also be utilized for measuring the load power factor of consumers.

The PPUC supply voltage is set according to ANSI C84.1, so if rated voltage is 240 V, supply voltage must be maintained at between 228~252 V. Since it is the duty of the PPUC to supply electricity at appropriate voltage and voltage control is an important aspect of its work, it is recommended that the existing GIS be used to control the installation locations of transformers, tap locations and voltage measurement results.

Moreover, since the loss factor increases when transformers are used at low load, it is necessary to install transformers that have variable capacity according to load. In future it is desirable that transformers commensurate to the power demand (load) be installed and planned as an efficient equipment configuration.

(3) Daily and Periodic Maintenance

1) Transmission and distribution lines

In the System Preventive Maintenance Schedule, in cases where troubles are discovered in the patrols, since it takes time to conduct repairs, subsequent patrol work is delayed. Therefore, rather than confirming all items of equipment in a short span such as a month, it is more efficient to separate inspection items into those requiring monthly inspection (caution points close to trees and so on) and those requiring inspection every two or three months (external appearance of equipment, etc.). By doing this, it would be possible to handle the necessary work based on the existing lineman staff (13 linemen). The results of inspections should be recorded and archived so that they can be utilized in compiling equipment rehabilitation and repair plans.

In order to facilitate the future maintenance of transmission and distribution lines, each line should be given a name (for example, the Aimeliik-Koror line, etc.). Concerning patrol records and inspection records too, through prescribing line names and numbers, it will become easier to gauge the state of each piece of equipment and to compile upgrading plans.

2) Transformer equipment

Concerning transformer equipment, periodic inspections basically consist of external appearance inspections. When abnormalities are discovered in these, power outages and repairs are scheduled. Accordingly, internal inspections are not implemented so long as the external appearance of equipment is good, and internal problems are left unattended until a breakdown occurs. Due to the configuration of systems, it is not so easy to conduct power outages because they impede the supply of power, however, considering that equipment breakages lead to even longer power outages and higher repair costs, it is desirable that the internal inspections (usually conducted every few years) recommended by equipment makers are carried out in major transformer substations.

Moreover, although the values obtained in inspections are used to determine equipment status, no examination is carried out regarding changes following previous inspections. For the purpose of preventive maintenance, it is necessary to spot signs of trouble as early as possible, so it is recommended that control of trends be introduced with respect to the gas pressure of gas circuit breakers and the oil level of transformers. Moreover, concerning transformers, it is recommended that sampling analysis of insulation oil be periodically implemented.

(4) Spare Parts

The spare parts list does not include the date of purchase or maker guarantee period of parts, however, these items need to be recorded for the sake of quality control. In particular, since electroscopes, grounding tools and insulation instruments such as measuring poles carry a risk of electric shock if insulation performance declines, it is absolutely necessary to conduct periodic inspections on them.

(5) Troubleshooting

It is important to prevent troubles from occurring in advance through investigating the cause of accidents and examining and executing reoccurrence prevention measures. It would be effective to add and utilize a column for reoccurrence prevention measures to the accident reports that are prepared by the PPUC.

(6) Improvement in Equipment Maintenance Capacity

The System Preventive Maintenance Schedule was prepared based upon analysis of current equipment and organizational capacity levels by the manager of the System Control Department who possesses ample experience of working in overseas power companies. The System Preventive Maintenance Schedule has only just gone into use in the PPUC. For the immediate future, it is deemed appropriate to implement continuous maintenance work based on the System Preventive Maintenance Schedule and, when the need arises, to carry out review of it upon referring to existing manuals.

(7) Training and Securing of Human Resources

Since Palau does not have many education agencies that can offer expert technology, it is difficult to secure engineers who possess the necessary technology and skills. Recruiting foreign engineers is a short-term solution, however, it is necessary for the PPUC to internally train local engineers who can support the company in the long term. In order to continue to secure highly capable Palauan personnel in the future, it is desirable to offer scholarships geared to giving promising human resources the opportunity to acquire expert education overseas.

1) Power Transmission, Distribution and Transformation

The Power Distribution Department directly conducts all work regarding installation of concrete poles and overhead lines and it possesses ample experience and capacity of actual work. Equipment rehabilitation plans are largely compiled by the System Control Department. It is necessary to develop human resources who are able to compile rehabilitation plans from patrol and inspection records within the Power Distribution Department which is responsible for the actual management of equipment.

The Power Distribution Department does not currently possess any power transformation engineers, however, it compiles transformation equipment inspection schedules and monitors degradation trends. Accordingly, it is necessary to immediately assign at least one power transformation engineer to compile the inspection schedule and conduct guidance for the other personnel.

2) Power System Operation

Since there are no SCADA or Communications Department engineers, it is difficult to implement maintenance or expansion of power systems. In the current situation, since there is a risk that appropriate systems cannot be constructed even if SCADA is replaced, it is recommended that engineers be assigned.

The Master Plan proposes installation of a control center to centrally monitor and control equipment. Accordingly, it will be necessary to assign at least four control post operators in 2011 and to train them in operation methods utilizing the existing SCADA so that they can be rapidly deployed to the control center.

If installation of electric power equipment is not accompanied by higher operating capacity, not only will it be impossible to conduct the efficient operation of power equipment, but also there will be risk of disasters affecting the public. Therefore, it will be necessary to implement planned training from two or three years before the commissioning of the control center.

Possible approaches towards achieving this would be to implement OJT by experienced personnel, to conduct a human resources training project (for example, a technical cooperation project of the type implemented by international donors) or to receive experts.

7.2.3 SCADA Improvement Plan

The present SCADA is faced with the following problems:

- Some devices are incomplete (monitors, generator information, etc.)
- Operating records cannot be downloaded.
- Passwords necessary for changing equipment settings have not been conferred.
- Display and control of instruments installed following the commissioning of SCADA have not been incorporated.

The current problems could have been avoided if the PPUC had sufficient technical capability. However, since upgrading in line with equipment installations and revisions needs to be carried out irrespective of what SCAD maker is adopted, it is necessary to select a supplier that can provide follow-up services into the long term.

The following three scenarios can be considered as the future SCADA expansion plan:

1) Bind a contract with the existing SCADA supplier covering the repair of problems and incorporation of newly added instruments.

2) In addition to binding a contract with the existing SCADA supplier covering the repair of problems and incorporation of newly added instruments, purchase the necessary information (passwords and maintenance tools) required to lower the level of dependence on the supplier.

3) Abandon upgrading by the existing supplier, and carry out full-scale renewal.

In order for the PPUC to appropriately implement maintenance and renewal work in future, it is recommended that SCADA engineers are assigned to train human resources on the job. In the event where the existing supplier rejects such a contract (option 2) above), it will be necessary to select option 3), however, even in this case, it will be necessary to recruit SCADA engineers, training operators and make other advance preparations on the PPUC side.

8. CONCLUSIONS AND RECOMMENDATIONS

8. Conclusions and Recommendations

8.1 Power Station Construction Plans and Transmission, Distribution and Substation Expansion Plans

The Study Team recommends the Republic of Palau to implement the following projects as the power development plan of Koror-Babeldaob power system from year 2010 to 2025. The Team also recommends Palau to utilize heavy fuel oil as fuel for the new Aimeliik Power Station.

Table 8.1-1 Power Station Construction Plans

FY	Project Title	Outline	Estimated Cost (million USD)	
			HFO Firing	Diesel Oil firing
2013	Replacement of Aimeliik Power Station (Phase 1)	• Procurement of two diesel generators (5 MW class) and auxiliary machinery • Remodelling of the fuel storage and supply facilities (in the case of heavy oil firing) • Construction of the power house (including those for the two generators in Phase 2) and an office building	25.73	19.38
2014	Replacement of Aimeliik Power Station (Phase 2)	• Procurement of two diesel generators (5 MW class) and auxiliary machinery	12.22	11.73
2019	Replacement of Aimeliik Power Station (Phase 3)	• Procurement of two diesel generators (5 MW class) and auxiliary machinery • Construction of additional power house (for the two new generators in Phase 3)	14.13	13.64
Total			52.08	44.75

[Remarks] ▨ Priority Projects

Table 8.1-2 Transmission, Distribution and Substation Expansion Plans

FY	Project	Outline	Estimated Cost (Million USD)
2008	Relocation of transmission and distribution lines	Relocating parts of transmission and distribution lines along the Compact road	PPUC Planned
2008	Extension of distribution lines to unelectrified areas	Parts of Ngiwal and Airai States	PPUC Planned
2008	Capacitor installation in distribution lines	13.8kV, Total 4.4MVA	PPUC Planned
2009	SCADA improvement	Completion of repair by EPS and adding data store function	PPUC Planned
2010	Auto-Recloser installation in Babeldaob	13.8kV, 6 places (Aimeliik 1, Aimeliik 2, Nekken, Ibobang, Ngaraad 1, Ngaraad 2)	PPUC Planned
2012	Installation of a capacitor at the Malakal Power Station	34.5 kV; 3 MVA	0.3
2013	Construction of the Koror Substation	34.5 kV; 15 MVA; three transmission circuits; 3 MVA capacitor	3.0
	Construction of the new Aimeliik-Koror transmission line	34.5 kV; 19.3 km; AAC 150 mm^2	2.7
	Construction of the new Nekken-Kokusai transmission line	34.5 kV; 3.1 km; AAC 150 mm^2	0.3
	Improvement of the distribution grid in Koror State	Improvement of the distribution grid following the construction of the new Koror Substation	0.2
	Construction of the new Aimeliik Substation	34.5 kV; 15 MVA x 1 new transformer; relocation of two existing transformers; three transmission circuits	4.2
2013	Control Center and transmission line improvement in Northern area	Upgrading SCADA, Equipment for Control Center, 34.5 kV Auto-Reclosers in three places (Kokusai, Asahi and Ngerdmau)	0.5
2014-2019			

FY	Project	Outline	Estimated Cost (Million USD)
2020 - 2024	Rebuilding of the Airai Substation (to be conducted in correspondence with the situation of equipment deterioration)	34.5 kV; 15 MVA; three transmission circuits	2.5
2025	Construction of the new Airai-Melekeok transmission line	34.5 kV; 24.5 km; AAC 150 mm^2	2.5
	Construction of the new Melekeok Substation	34.5 kV; 10 MVA; three transmission circuits	2.3
	Increase of the voltage of the Kokusai-Melekeok distribution line	13.8 kV → 34.5 kV; 10.5 km	0.2
	Replacement of a transformer at the new Aimeliik Substation	34.5 kV; 10 MVA (one unit) → 15 MVA (one unit)	1.2
Total			19.9

[Remarks] ▨ Priority Projects

Financial internal rate of return will be affected by electricity tariff rate and fuel price. The following table shows the sensitivity analysis results of FIRR on priority projects in case of HFO usage.

Table 8.1-3 Sensitivity analysis results of FIRR with the variation of fuel price and electricity tariff rate

Overall electricity rate	0% Case	10% case	20% case	30% case	40% case	50% case
US$0.35/kWh	13.75%	9.93%	5.90%	1.53%	minus	minus
US$0.39/kWh	20.11%	16.61%	12.98%	9.21%	5.21%	0.89%
US$0.43/kWh	25.96%	22.67%	19.29%	15.82%	12.24%	8.50%

🟨 Too good 🟦 Appropriate 🟥 Not viable

Source: JICA Study Team's analysis

8.2 Renewable Energy Introduction Plan

8.2.1 Photovoltaic Power Generation

It is recommended to install additional photovoltaic power generation equipment with capacity of 100 to 200 kWp by 2025. Concerning the specific approach, photovoltaic cells will be installed on the rooftops of government office buildings and connected to the PPUC power grid.

8.2.2 Hydropower Generation

Hydropower generation system with capacity of 200kW which utilizes overflow water from a planned water reservoir to be constructed under ADB's assistance should be incorporated into the public water supply plan.

8.2.3 Solar Thermal Energy Utilization

Introduction and dissemination of solar water heaters should be promoted. The dissemination promotion efforts such as the establishment of new housing loans which have a clause requiring the installation of a solar water heater, the establishment of a fund for promoting the introduction of solar water heaters as described in the Energy Efficiency Action Plan, etc. should be expanded by the government of Palau in addition to the aggressive advertisement on an electricity bill saving effect by a solar water heater.

8.3 Improvement Plans for PPUC's Business Management

The following electricity tariff revisions are strongly recommended by the Study Team in order to improve PPUC's business management.

(1) Short Term Measures (2009-2013)

- **1st Option: Electricity tariff shall be revised in FY 2009**

Table 8.3-1 New Electric Tariff Rate to be proposed for the Target Year FY 2009
(Case 1: Even Imposing Option)

Unit: US$

Charge item		Residential	Commercial/ Government
Monthly Minimum Energy Charge		3	10
Cost per kWh	0-500 kWh	0.08	0.10
	501-2,000kWh	0.10	0.10
	2,001kWh above	0.12	0.12
AFPAC Oct. 2008-Sep.2009		0.31	0.31

Note: AFPAC (Automatic Fuel Price Adjustment Clause)
Source: Calculated by JICA Study Team

Table 8.3-2 New Electric Tariff Rate to be proposed for the Target Year FY 2009
(Case 2: Residential Customer Preferential Option)

Unit: US$

Charge item		Residential	Commercial/ Government
Monthly Minimum Energy Charge		3	10
Cost per kWh	0-500 kWh	0.08	0.10
	501-2,000kWh	0.10	0.10
	2,001kWh above	0.12	0.12
AFPAC Oct. 2008-Sep.2009		0.26	0.33

Note: AFPAC (Automatic Fuel Price Adjustment Clause)
Source: Calculated by JICA Study Team

- **2nd Option:** It shall take **two years** to catch up and make both ends meet (FY2009-2010)

Alternative Option 2 2-Year Step Up Option

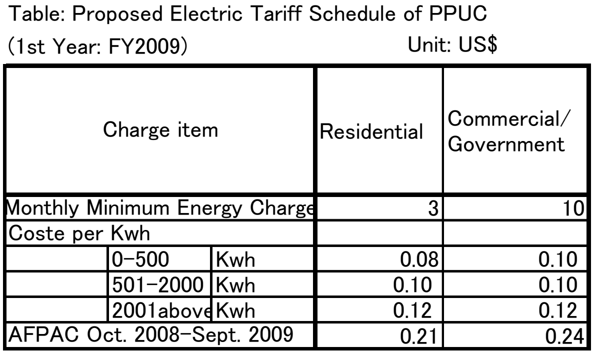


Table: Proposed Electric Tariff Schedule of PPUC
(1st Year: FY2009) Unit: US$

Charge item			Residential	Commercial/ Government
Monthly Minimum Energy Charge			3	10
Coste per Kwh				
	0-500	Kwh	0.08	0.10
	501-2000	Kwh	0.10	0.10
	2001above	Kwh	0.12	0.12
AFPAC Oct. 2008-Sept. 2009			0.21	0.24

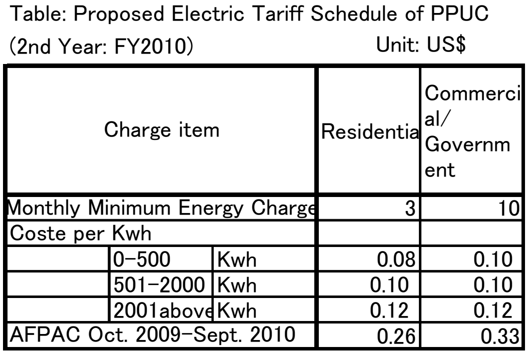


Table: Proposed Electric Tariff Schedule of PPUC
(2nd Year: FY2010) Unit: US$

Charge item			Residentia	Commercial/ Government
Monthly Minimum Energy Charge			3	10
Coste per Kwh				
	0-500	Kwh	0.08	0.10
	501-2000	Kwh	0.10	0.10
	2001above	Kwh	0.12	0.12
AFPAC Oct. 2009-Sept. 2010			0.26	0.33

- **3rd Option:** It shall take **three years** to catch up and make both ends meet (FY2009-2011)

Alternative Option 3   3-Year Step Up Option

Table: Proposed Electric Tariff Schedule of PPUC
(1st Year: FY2009)   Unit: US$

Charge item			Residential	Commercial / Government
Monthly Minimum Energy Charg			3	10
Cost per Kwh				
	0-500	Kwh	0.08	0.10
	501-2000	Kwh	0.10	0.10
	2001abov	Kwh	0.12	0.12
AFPAC Oct. 2008-Sept. 2009			0.2	0.23

Table: Proposed Electric Tariff Schedule of PPUC
(2nd Year: FY2010)   Unit: US$

Charge item			Residentia	Commercial / Government
Monthly Minimum Energy Charg			3	10
Cost per Kwh				
	0-500	Kwh	0.08	0.10
	501-2000	Kwh	0.10	0.10
	2001abov	Kwh	0.12	0.12
AFPAC Oct. 2009-Sept. 2010			0.23	0.28

Table: Proposed Electric Tariff Schedule of PPUC
(3rd Year: FY2011)   Unit: US$

Charge item			Residential	Commercial / Government
Monthly Minimum Energy Charg			3	10
Cost per Kwh				
	0-500	Kwh	0.08	0.10
	501-2000	Kwh	0.10	0.10
	2001abov	Kwh	0.12	0.12
AFPAC Oct. 2010-Sept. 2011			0.26	0.33

(2) Long Term Measures (FY2013~:After the commencement of operation at new Aimeliik Power Station)

1) Case of Diesel Oil utilization at new Aimeliik Power Station

- Sub-case1: Fuel cost will be the same level as current (Diesel: US$ 3.6/gallon)
  Basically, PPUC shall charge US$0.41/kWh: Overall electricity rate shall rise by 2 cents from US$39/kWh.
- Sub-case2: Fuel cost 20% up from now
  PPUC will have to raise overall rate of electricity tariff up to US$ 0.47/kWh.
- Sub-case3: Fuel cost 30% up from now
  PPUC will have to raise overall rate of electricity tariff up to US$ 0.51/kWh.
- Sub-case4: Fuel cost 40% up from now
  PPUC will have to raise overall rate of electricity tariff up to US$ 0.57/kWh.

2) Case of Heavy Fuel Oil utilization at new Aimeliik Power Station

- Sub-case 1: Fuel cost will be the same level as current
  Due to the benefit of big fuel cost reduction, PPUC can afford to make reduction of electricity tariff with the big margin to be generated. Overall electricity rate shall fall down to the level of probably around US$ 0.33/kWh from US$0.39/kWh..
- Sub-case2: Fuel cost 20% up from now
  Still, PPUC will not have to raise overall rate of electricity tariff. The rate shall stay on almost the same level, and get down to US$0.38/kWh by only 1 cent.
- Sub-case3: Fuel cost 30% up from now
  PPUC will still not have to raise overall rate of electricity tariff so largely: only 1

cent up to US$ 0.40/kWh.

- Sub-case4: Fuel cost 40% up from now
  PPUC will have to raise overall rate of electricity tariff , but only 3 cents up to US$ 0.42/kWh.
- Sub-case5: Fuel cost 50% up from now
  PPUC will have to raise overall rate of electricity tariff up to US$0.44/kWh by 5 cents.

(3) The new actions currently taken by PPUC promptly response to the revision direction proposed by JICA Study Team

On June 5, 2008, the prompt effort has resulted in the passage of the bill to revise PPUC's electricity tariff. The PPUC's immediate action in response to the recommendations to solve the raised problems is highly appreciated. The content is as follows:

- Commercial customers and Governments
  - Comprehensively the title charge shall be US$ 0.425/kWh
  - The basic rate shall be US$11
- Residential customers
  - By the range of electricity consumption rage, the title charge shall be:
    0~500 kWh : US$0.30/kWh
    500~2000kWh: US$0.38/kWh
    More than 2000kWh: US$0.425/kWh
  - The basic rate shall be US$3

8.4 Recommendations for Operational Improvement of Power Supply Facilities

8.4.1 Power Generation Facilities

(1) Recommendations to Improve Daily Operation

① Formulation of the start and stop procedure for power generating equipment

② Calibration, maintenance and replacement of instruments

③ Analysis, assessment, countermeasures and reporting of operating records (log sheet) and incident records

④ Preparation and reporting of breakdown report statistics

(2) Recommendations to Improve Periodical Maintenance

① Formulation and implementation of short-term and long-term plans for maintenance inspections of engine generators

② Procurement and storage of emergency spare parts for engine generators

③ Procurement and storage of replacement parts for engine generators

④ Formulation and implementation of long-term and short-term plans for auxiliary equipment maintenance inspections

⑤ Procurement and storage of emergency spare parts and replacement parts for auxiliary equipment

⑥ Formulation and implementation of long-term and short-term plans for control panel and circuit breaker panel, etc. maintenance inspections

⑦ Quality control of fuel oil

⑧ Quality control of lubricating oil

⑨ Quality control of cooling water

⑩ Request for dispatch of maintenance instructors (SV) from equipment makers during overhauls

⑪ Securing enough maintenance budget

(3) Recommendations to the Organizational Structure of Power Generation Division

① Assignment of a Planning Engineer

② Recruitment of a System Planning Manager to Manage Long-Term Demand Forecasting and Power Development Plans

8.4.2 Transmission, Distribution and Substation Equipment

(1) Recommendations to Improve Power System Operation

It is recommended that specialist operators for power systems be recruited and trained on a planned basis in readiness for the future rehabilitation of equipment and installation of control posts.

(2) Recommendations to Improve Distribution Line Voltage Control and Load Control

It is recommended that an oscilloscope which is capable of continuously measuring voltage be installed. It is also recommended that the existing GIS be used to control the installation locations of transformers, tap locations and voltage measurement results.

(3) Recommendations to Improve Daily and Periodic Maintenance

It is more efficient to separate inspection items into those requiring monthly inspection (caution points close to trees and so on) and those requiring inspection every two or three months (external appearance of equipment, etc.). Each line should be given a name (for example, the Aimeliik-Koror line, etc.). It is desirable that the internal inspections (usually conducted every few years) recommended by equipment makers are carried out in major transformer substations. It is recommended that control of trends be introduced with respect to the gas pressure of gas circuit breakers and the oil level of transformers. Moreover, concerning transformers, it is recommended that sampling analysis of insulation oil be periodically implemented.

(4) Recommendations to Spare Parts and Maintenance Tools

The spare parts list does not include the date of purchase or maker guarantee period of parts, however, these items need to be recorded for the sake of quality control. In particular, since electroscopes, grounding tools and insulation instruments such as measuring poles carry a risk of electric shock if insulation performance declines, it is absolutely necessary to conduct periodic inspections on them.

(5) Recommendations to Improve Troubleshooting

It would be effective to add a column for entering reoccurrence prevention measures to the accident reports that are prepared by the PPUC.

(6) Improvement in Equipment Maintenance Capacity

For the immediate future, it is deemed appropriate to implement continuous maintenance work based on the System Preventive Maintenance Schedule and, when the need arises, to carry out review of it upon referring to existing manuals.

(7) Training and Securing of Human Resources

1) Power Transmission, Distribution and Substation

It is necessary to immediately assign at least one substation engineer to compile the inspection schedule and conduct guidance for the other personnel.

2) Power System Operation

It is recommended that SCADA engineers be assigned. It is necessary to assign at least four control post operators in 2011 and to train them in operation methods utilizing the existing SCADA so that they can be rapidly deployed to the control posts.