**Republic of Nauru**
**Republic of Kiribati**
**Independent State of Papua New Guinea**
**Solomon Islands**
**Independent State of Samoa**

No.

# Preparatory Survey on the Programme for Climate Change in the Pacific Islands (Renewable Energy)

## Final Report

**June 2009**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

**Tokyo Electric Power Company, Inc. (TEPCO)**

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## Abbreviations

| Abbreviation | Words |
|---|---|
| ADB | Asian Development Bank |
| AFPA | Automatic Fuel Price Adjustment |
| APACE | Australian Appropriate Technology for Community and Environment |
| AUD | Australian Dollars |
| AU | Australia / Australian |
| CDM | Clean Development Mechanism |
| CISRO | Commonwealth Industrial and Scientific Research Organization |
| DNA | Designated National Agency |
| DOE | Department of Energy |
| DPE | Department of Petroleum and Energy |
| EIA | Environmental Impact Assessment |
| EIB | European Investment Bank |
| ENSO | El Nino Southern Oscillation phenomenon |
| EPC | Electric Power Corporation |
| EU | European Union |
| GDP | Gross Domestic Product |
| GEF | Global Environmental Fund |
| GHG | Green House Gas(es) |
| GREA | Guadalcanal Rural Electrification Agency |
| ICCC | Independent Consumer and Competition Commission |
| IEA | International Energy Agency |
| IPBC | Independent Public Business Corporation |
| IPP | Independent Power Producers |
| JICA | Japan International Cooperation Agency |
| JPY | Japanese Yen |
| KNEP | Kiribati National Energy Policy |
| kWh | kilo watt hour |
| L | Litres |
| MMERE | Ministry of Mines, Energy & Rural Electrification |
| MNRE | Ministry of Natural Resources and Environment |
| MPWU | Ministry of Public Works and Utilities |
| NGO | Non Governmental Organization |
| OCCCT | Office of Climate Change and Carbon Trade |
| ODA | Official Development Assistance |
| OTML | Ok Tedi Mine Ltd |
| PDP | Power Development Plan |
| PIEPSAP | Pacific Islands Energy Policies and Strategic Action Planning (Project) |
| PIGGAREP | Pacific Islands Greenhouse Gas Abatement (through) Renewable Energy |
| PNG | Papua New Guinea |
| PNGSDP | PNG Sustainable Development Programme |

| | |
|---|---|
| PNGSEL | PNG Sustainable Energy Ltd |
| PPL | PNG Power Ltd |
| PREA | Pacific Region Energy Assessment |
| PV | Photovoltaic |
| RAMSI | Regional Assistance Mission to Solomon Islands |
| REP5 | EU-ACP Renewable Energy Project (for 5 EU-ACP Counties) |
| SE | South-East (Trade Winds) |
| SELF | Solar Electric Fund |
| SHS | Solar Home System |
| SIEA | Solomon Islands Electricity Authority |
| SIREA | Solomon Islands Rural Electrification Agency |
| SIVEC | Solomon Islands Village Electrification |
| SMEC | Snowy Mountain Engineering Corporation |
| SOPAC | Pacific Islands Applied Geoscience Commission |
| SPREP | South Pacific Regional Environment Programme |
| STP | Solomon Islands Tropical Products Limited |
| TA | Technical Assistance |
| TEPCO | Tokyo Electric Power Company |
| UNDP | United Nations Development Programme |
| USD | US Dollars |
| VFEP | Village First Electrification Programme |
| WB | World Bank |

# Chapter 1. Introduction

## 1.1 Background and Objective of the Study

### 1.1.1 Background

The Pacific Islands are vulnerable to the recent global climate change, and urgently require strategic counter measures. However, in the power sector of the Pacific Islands, electricity supply still remains mainly depend on diesel generation, which emits green house gases (GHG).
As one measure, Japan established a new financial mechanism, Cool Earth Partnership, in the scale of US$10 billion. Through this, Japan will cooperate actively with developing countries' efforts to reduce emissions, such as the development of renewable energy project and efforts to increase awareness and enhance efforts in energy efficiency and energy conservation. Assistance will be provided to developing countries that are making efforts to reduce GHG emissions and achieve economic growth in a compatible way, on the basis of policy consultations between Japan and those countries. Through the Cool Earth Partnership, Japan Government set up the following assistance policy.

**1. Assistance for adaptation to climate change and improved access to clean energy: up to US$ 2 billion (JPYen 250 billion)**

- Grant aid, technical assistance and aid through international organizations will be provided to address the needs in developing countries. A new scheme of grant aid, "Program Grant Aid for Environment and Climate Change", will be created as a component of this package.
- In the context of improved access to clean energy, feasibility study on rural electrification projects with geothermal energy and "co-benefit" projects that address climate change will be conducted.

**2. Assistance for mitigation of climate change: up to US$ 8 billion (JPYen 1 trillion)**

- "Climate Change Japanese ODA Loan" with preferential interest will be created to provide loans amounting to JPYen 500 billion for the purpose of implementing programs to address global warming in developing countries.

Through capital contribution and guarantee by JBIC (JBIC Asia and Environment Facility), trade and investment insurance by NEXI, and government support (projects to be implemented through NEDO), together with private funds, up to JPYen 500 billion will be provided for projects to reduce GHGs emission in developing countries. In this context Asian Clean Energy Fund (at ADB) will also be utilized to promote energy conservation in the Asian-Pacific region.

(Source: MOFA Website)

Currently the following countries and areasin the Pacific Islands are registered in the membership.

- Republic of Palau
- Federated States of Micronesia
- Republic of the Marshall Islands
- Nauru
- Kiribati
- Papua New Guinea
- Vanuatu
- Tuvalu

- Samoa
- Tonga
- Niue
- Cook Islands

Out of the above partnership countries, Kiribati, Vanuatu, Tuvalu and Samoa have developed a comprehensive strategic paper for adaptation to climate change, "National Adaptation Programme of Action (NAPA)". In line with the policy of Japanese Government, JICA is aiming at strengthening cooperation for adaptation and mitigation against climate change effects in the Pacific Islands.

### 1.1.2 Objective

The survey is designed to better understand development needs in renewable energy in the target countries and propose possible cooperation fields for adaptation and mitigation as counter measures to be supported by the Cool Earth Partnership.

### 1.1.3 Surveyed Countries

Nauru, Kiribati, Papua New Guinea, Solomon Islands, and Samoa

### 1.1.4 Main Agencies to be Visited

- Ministry or Department in charge of Renewable Energy
- Ministry or Department in charge of Budget/Planning
- Power Utilities
- Donor's Offices

## 1.2 Methodology of the Works

The survey consists of a domestic survey and a local survey. The domestic survey is primarily aimed at collecting data and information from existing and available data sources. The local survey will aim to identify and collect additional data and information by interview and site visit survey where there is deemed to be insufficient obtained from the domestic survey.

## 1.3 Schedule

### 1.3.1 Duration

The survey starts at the end of March 2009 and will continue through to the end of May. The overall schedule is shown below.

**Table 1-1 Overall Schedule of the Survey**

| | **March** | **April** | **May** |
|---|---|---|---|
| Data and Information Collection (Domestic) | | | |
| Interview and Site Visits (Local) | | | |
| Making Report (Domestic) | | | |

### 1.3.2 Local Survey Schedule

The local survey was conduced by 2 teams, Team A, headed by Mr. Masaharu Yogo (TEPCO), who visited Nauru, Samoa and Kiribati and Team B, headed by Mr. Yasushi Kawano (TEPCO), who visited Papua New Guinea (PNG) and Solomon Islands. The local survey schedule was as follows.

**Table 1-2 Local Survey Schedule**

| Apr | Team A | Apr | Team B |
|---|---|---|---|
| 14 | | 14 | PNG (Kick-off Meeting) |
| 15 | Nauru (Kick-off Meeting) | 15 | PNG (Meeting and Site Visit) |
| 16 | Nauru (Site Visit and Wrap-up Meeting) | 16 | PNG (Meeting) |
| 17 | Move to Fiji | 17 | PNG (Wrap-up Meeting) |
| 18 | Weekend | 18 | Weekend |
| 19 | Move to Samoa | 19 | Move to Solomon |
| 20 | Samoa (Kick-off Meeting and Site Visit) | 20 | Solomon (Kick-off Meeting) |
| 21 | Move to Fiji | 21 | Solomon (Site Visit) |
| 22 | From Fiji to Kiribati | 22 | Solomon (Site Visit) |
| 23 | Kiribati (Kick-off Meeting) | 23 | Solomon (Site Visit) |
| 24 | Kiribati (Site Visit) | 24 | Solomon (Wrap-up Meeting) |
| 25 | Weekend | 25 | Weekend |
| 26 | Weekend | 26 | |
| 27 | Kiribati (Wrap-up Meeting) | 27 | |

# Chapter 2. Republic of Nauru

## 2.1 Profile of the Country

### 2.1.1 General Information

(1) General Information

Nauru consists of a single island located 4,800km from Tokyo, 4,000km from Sydney and 4,200km from Honolulu. The closest nearby island is 300km from Nauru. The elevation of Nauru is 65 metres at the highest point. Nauru in terms of size is quite small with a total land area of 21 square kilometers, which is home to some 10,000 people (8,777 estimated as in 2006-2007).

The Nauru economy has been mostly driven by the mining of phosphate which has generated most of the revenue for the government. The GDP of Nauru in 2006 recorded at 36.881 million AUD and its GDP per capita was 3,742 AUD.

In 1968, Nauru republic became independent from the UN trust territory which had been governed by Australia, New Zealand and UK. At that time, her GDP per capita was the largest one in the World due to the revenues from the export of phosphate. However now that phosphate reserves are very low and facing depletion new alternate mining techniques are being investigated so as to enable secondary mining to proceed.

The national phosphate company was restructured in late 2005 into three key business areas Mining (RONPHOS), the Ports Authority and Utilities. An Australian company in 2005 entered into an agreement intended to exploit remaining supplies. The rehabilitation of mined land and the replacement of income from phosphate remain a serious long-term problems.

In anticipation of the exhaustion of Nauru's phosphate deposits, substantial amounts of phosphate income were invested in trust funds to help the transition and provide for Nauru's economic future. As a result of heavy spending from the trust funds, the government faces virtual bankruptcy. To cut costs the government has frozen wages of public service departments, hospitals and other capital plant is deteriorating.


**Figure 2-1 Map of Nauru**

(2) Economy

(a) Main Industry

Mining (phosphate) (Source: Website of MOFA of Japan)

(b) Gross National Income (GNI)

N/A

(c) GNI per Capita

7,842 US$ (2006) (Source: Website of MOFA of Japan)

(d) Economic Growth

6.3% (2006) (Source: Website of MOFA of Japan)

(e) Inflation Rate
N/A

(f) Trading Amount
Export: N/A
Import: N/A

(g) Trading Item (2004)
Export: Rock phosphate, Fish
Import: Machinery, Vehicle, Building materials, Miscellaneous Goods, Food
(Source: Website of MOFA of Japan)

(h) Trading Countries
Export: Japan, India, China
Import: Australia
(Source: Website of MOFA of Japan)

(i) Currency
Australian Dollars, 1 AUD = 69.177 JPY (2009/4/29, http:www.oanda.com)

(3) Japan's Cooperation
Record of Japan's cooperation to Nauru is shown below, which are ODA loans, Grant Aid and Technical Cooperation.

**Table 2-1 Record of Japan's Cooperation**

| | 2007 | Accumulated Amount by 2007 |
|---|---|---|
| ODA Loan | 0 | 0 |
| Grant Aid | 120 million Yen | 1.003 billion Yen |
| Technical Cooperation | 8 million Yen | 0.191 billion Yen |

(Source: MOFA of Japan, accessed in April 2009)

## 2.2 Outline of the Power Sector

### 2.2.1 Legal Framework of the Power Sector

The supply of power on Nauru was formerly the responsibility of the Nauru Phosphate Corporation (NPC). In 2005 this was mandated to the newly created Nauru Utilities Authority (NUA). The NUA inherited 15 MW of installed generation capacity from the Nauru Phosphate Corporation. However, most of this plant was not operational or severely de-rated. NUA is also responsible for water supply and managing the import and distribution of petroleum fuels.

### 2.2.2 Institutional Framework of the Power Sector

(1) Structure of the Power Sector
NUA is the sole electricity provider which operates a single power house on the island. NUA is also responsible for the importation and distribution of petroleum fuels. However, determining the price of petroleum fuels is the responsibility of the Ministry of Finance. Prior to the NUA, the Nauru Phosphate Corporation (NPC) was responsible for electricity generation, waste disposal, water distribution and the importation of petroleum fuels, until it went bankrupt.

(2) Organizations in Charge of Renewable Energy
There is no government office responsible for renewable energy and departments interested in renewable energy have usually operated independently or on an ad hoc basis. Such departments are the Ministry of Finance, NUA and the Aid Management Unit. Although NUA has a newly appointed officer whose duties include renewable energy and energy efficiency.

### 2.2.3 Laws and Regulation regarding the Renewable Energy

Currently, no regulations with regards to renewable energy are in place. However the Nauru Energy Policy (NEP) is being drafted with the emphasis being on the use of renewable energy to supply 10% of Nauru's energy demand by 2020.

### 2.2.4 Power Demand and Supply Status

(1) Past Records and Current Annual Power Consumption (kW, kWh)

Nauru is fully electrified with all the 2,000 households connected to the grid. The phosphate mining company RONPHOS is the major electricity consumer and receives power continuously when possible. Past annual electricity consumptions in Nauru were recorded as shown in the next table. The annual electricity consumption per capita was recorded around 2.0 MWh in 2004 that was about 10 times of Kiribati.

**Table 2-2 Past Annual Electricity Consumption in Nauru**

| | Year | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|
| Annual Energy | Million kWh | 15.13 | 13.98 | 17.76 | 20.5 | 21 |
| Averaged | MW | 1.7 | 1.6 | 2.0 | 2.3 | 2.4 |
| Population | thousand | 10.0 | 10.1 | 10.1 | 10.1 | 10.0 |
| Annual Electricity Consumption per Capita | MWh per Capita | 1.51 | 1.38 | 1.76 | 2.03 | 2.10 |

(Source: Key Indicators for Asia and the Pacific, 2008, ADB)

In year 2000/1, electricity consumption in Nauru was 915 kWh/month per household, however, in 2004/2005 it was 725 kWh/month per household due to large power shortages (Source: Reform of Nauru's Basic Infrastructure Services). Due to the power shortage, electricity is rationed, with only half the island with power at intervals of 4 hours. Peak demand in 2008 was estimated approximately 7-8 MW, however the power supply ability is only around 5 MW due to poor operational condition of the generators.

(2) Past Records and Current Annual Power Generation

Nauru used to have eight power generators, however, none of the eight generators was operational in 2006. Instead, Nauru has been reliant over the past three years on five rented 0.8MW power generators for its entire power needs, where these now are used for backing up the supply from the generators in the main powerhouse. The cause of deterioration of the diesel generators in the main powerhouse could be attributed to poor water-proof installation, insufficient maintenance or lack of periodical inspection.

Power is now provided by the Nauru Utilities Authority (NAU) through main powerhouse which houses five diesel generators. At the time of visit only three units were in operation, one was undergoing overhaul while the other was a newer machine waiting to be commissioned. Total power supply available is 4-5 MW and peak demand is at 7-8 MW. The next table shows the generators as installed in Nauru in April 2009.

**Table 2-3 Generators in Nauru in April 2009**

| Unit No. | Power output | Status |
|---|---|---|
| Unit 1 | 1.8 MW | Operated |
| Unit 4 | N/A | Being repaired |
| Unit 5 | 0.8 MW | Operated |
| Unit 6 | 1.6 MW | Operated |
| Unit 7 | 2.3 MW | Being repaired |

(Rental generators from Australia are not included in the above table.)

Unit 1 was manufactured in 1980's, Unit 4, 5 and 6 are manufactured in 1970's and Unit 7 was manufactured in 1990's. All the generators rotating at 750 rpm at nominal rate are equipped with the machine governors. Units 4 and 7 now being repaired under the supervision of the Utilities Manager dispatched from Australia and are supposed to be commissioned in June and August this year respectively. Besides the five generators in the powerhouse three of the rental generators still remain in service and are used as backup power in the event there is a breakdown in the powerhouse.

(3) Information about Power Network System

The powerstation of Nauru is located in the Southwest of the island with diesel generating units as described in the above section. The medium voltage distribution lines extend from the power station both in North and South directions around the island.

(4) Cost of Power Generation

According to the interview survey, the cost of generation and distribution was estimated at around AU 30 cents per kWh with the long-run marginal cost of supply estimated to be closer to AU 38 cents per kWh.

### 2.2.5 Power Development Plan

In spite of apparent power shortage and insufficient power supply capacity, there were no obvious power development plans for Nauru. The power sector of Nauru is now under reform especially in regard to the tariff structure and tariff collection system where this includes the installation of prepaid meters. The future electric power consumption will be uncertain, including that of the major electric consumer, the Mining Company (RONPHOS). Due to these uncertainties it now is difficult to make an accurate power demand forecast for Nauru.

### 2.2.6 Tariff and Collection

The residential consumers have been required to pay a nominal cash amount of AUD 5.00 per month for electricity, regardless of total consumption. It has not provided any incentives for households to conserve and reduce their electricity consumption. The current electricity tariffs in Nauru are well below cost recovery rates. Domestic customers were charged at rate of AU 9 cents per kWh on the average much lower than the cost of supply currently around AU 30 cents per kWh and the future long run marginal cost of AU 35 cents per kWh.
Current tariff will have risen to AUD 25.00 per month. From May 2009, installation of prepaid meters will start by assistance of EU.

## 2.3 Current Situations of Renewable Energy and a Course of Action

### 2.3.1 Potential

(1) Solar

Pacific Region Energy Assessment 2004 (PREA 2004), funded by Global Environmental Facility (GEF), UNDP, Secretariat of the Pacific Regional Environment Programme (SPREP) and Pacific Islands, stated the potential for solar energy technologies applied for Nauru as follows.
"As an equatorial country, Nauru has a very good solar resource. Measurements show an average of about 5.8 kWhr/m$^2$/day with only small seasonal variation. Solar PV offers electricity generation that can supplement the existing diesel generation. However, unless very expensive electrical storage systems are included, the penetration of solar power into the grid is limited to around 15%-20% of noon time demand. This still represents more than 1MWp of solar PV and would be a large investment even without storage."

The grid connected solar power systems have potential as demonstrated by REP5 project and mentioned in PIGGAREP. However, the limitation of the grid-connected capacity should be carefully considered. *

* To secure controlling ability of the electric demand-supply balance and system frequency of power systems, the limitation of the installed capacity of solar power systems may be around 10 % of the total system. However, it depends on the existing system generators, load characteristics and the allowable frequency variations on the system.

The following solar power projects have been carried out in Nauru.

- REP5 (by European Commission)
  The REP 5 project installed a 40kW solar capacity on the roof of Nauru College which powers the entire school and its surplus electricity is fed into the power grid. The project includes the installation of another grid-connected solar panel in the school being under construction and installation of prepaid meters for all the 2,000 households.

- Renewable Energy Technologies/Renewable Lamps (by Taiwan)
  Taiwanese Government has supported the installation of small off-grid solar panels in 14 districts. A set of solar powered systems at each district consists of three solar panels with batteries. A capacity of each unit is estimated around 200 Watts.

According to the officer responsible for the REP5 Project they basically deal with renewable energy through the Renewable Energy Department of NUA, and noted that although there used to be a plan for installing large solar power generation connected to the power grid, the plan has not yet been realized due to, may be, land acquisition problems.

(2) Wind

PREA 2004 stated the potential for wind energy technologies applied for Nauru as follows.
"The wind resource is poorly known though probably not economically useful. A resource assessment for topside would be worth carrying out to determine the appropriateness of further development."
Some small wind turbines are installed on the top of the power poles carrying the around island distribution lines which are used for boosting the wireless Internet signals.
The following wind power assessment project is planned for Nauru:

- Nauru Wind Power Feasibility Study (PIGGAREP)
  From May 2009, PIGGAREP install a wind anemometer to measurement the wind resource at the site located in Ijuw District that is in the East side of the island. So far, the expected output from wind anemometers are unknown.

(3) Biomass

PREA 2004 stated the potential for biomass energy technologies applied for Nauru as follows.
"With little or no biomass present topside, there are insufficient biomass resources for either combustion or significant production of biofuels. Rehabilitation efforts may result in topside biofuel plantations but certainly no production will be seen within the next decade."

(4) Ocean/ Wave Energy>

PREA 2004 stated the potential for ocean wave and ocean energy technologies applied for Nauru as follows.
"Wave energy in the equatorial region is low with around 10-15 kW/m estimated from satellite observations. Even if wave conversion systems become commercially available, the low resource will make it difficult to economically develop wave power in Nauru. With the very rapid drop off that occurs beyond the reef, there is opportunity for OTEC energy development once engineering

and commercial trials are completed elsewhere. Within the next 10 years, it does not appear likely that OTEC can be a part of the Nauru energy economy."

Wave energy may also be a potential renewable energy option, as there are many large waves that can be seen crashing on the reef which is between 20-30 meters from the shoreline.

In the 1980's an Ocean Thermal Energy Conversion (OTEC) plant was tested in Nauru but was destroyed by the strong waves.

### 2.3.2 Needs Collected from the Interview

This project conducted an interview survey with relevant agencies. From the interview survey the current situation and needs in the power sector are summarized as follows.

- There is not an authorized demand forecast and power development plan.
- There are 5 diesel generators, that are main power facilities. However, 2 generators, out of those, are under maintenance. Instead of that, rental generators from Australia are prepared as temporary facilities. Currently, electric power can be supplied in 4 hours per day in half of the island by turns. Power shortage is very serious.
- Diesel generators should be installed to supply enough power. Before that, incremental installed capacity should be examined by current data analysis and elaborate demand
- As for off-grid renewable energy, Taiwan has assisted community based solar (total 10 kW) and small wind power for wireless internet installed on distribution poles.
- EU has assisted 40 kW grid connected solar power installed on a roof of a school. The another site is also under construction.

### 2.3.3 Consideration on Cooperation Fields

The most critical issue is installation of stable power supply. As for renewable energy with such stable power, a central grid-connected solar generator with the capacity of several tens or a hundred kW can be considered. However, the specification of the plants should be made with the precise data or information known about the power demand forecast, land acquisition, existing generators and solar radiation. Especially, the suitable place for solar power generators has to be examined due to the lack of available land on Nauru. As well to provide support for plan/design for the installation of PV and connection to the grid, as it is essential to provide training on how to manage the power system where renewable energy such as solar PVs are connected.

Training programme can be provided through two (2) ways, namely dispatching expert and invitation to Japan. Training programme for renewable energy targeting at engineers and energy efficiency targeting at policy makers can be held in Japan. Training programme in Japan would offer the following agenda. The above programmes in the recipient country and Japan can be conducted through a regional assistance programme.

- Site visits to assess each renewable energy technology
- Lecture for planning and design of large scale grid-connected solar power
- Lecture for design and site visit of solar home system (captured and reverse flow)
- Lecture for planning and design of wind power
- Lecture for energy conservation programmes
- Site visits of each energy efficiency technology
- Lecture for maintenance of solar power
- Factory tour for solar power

## 2.4 Current Situations of Energy Conservation and a Course of Action

### 2.4.1 Current Situation

(1) Energy Consumption in Demand Side

During the high phosphate production years, industrial use dominated the Nauru energy economy. However, it has diminished and the domestic sector is now the dominant user. Electricity consumption has decreased since 2000/01. For example, electricity consumption per household in

Nauru was 915 kWh per month in year 2000/01 and due largely to worsening supply shortages, household consumption dropped to around 725 kWh per month. A survey 2005 of a sample of Nauru households indicated an average consumption of 586 kWh per month.(Reform of Nauru's Basic Infrastructure Services).

PREA 2004 assessed that the 2000/01 electricity consumption per household in Nauru was more than double that of Palau, the second highest household electricity use in the Pacific. It was more than 30 times greater than household consumption in urban Kiribati (Reform of Nauru's Basic Infrastructure Services).

Nauru is 100% electrified and, due to past economic affluence, appliance ownership is very high. Most households own one or more air conditioners, fans, electric stoves and TV sets. PIREP reports that the tariff system, where residential consumers are required to pay a nominal cash amount of AUD5 per month for electricity, regardless of total consumption, does not provide any incentives for households to conserve and reduce electricity consumption. Current tariff has risen to AUD25 per month. The regime change is under review as of April 2009, to charge households the total amount of electricity consumption through installing prepaid metres. A commercial usage is for ice making for fish storage, for the two hotels, for the three larger stores and for the numerous

Chinese restaurants on the island. The RONPHOS / NPC phosphate production facilities represent the only industrial use of electricity in Nauru.

(2) Energy Efficiency

(a) Overall efficiency

A factor to indicate energy efficiency could be electricity consumption per GDP is shown in the next table along with the electricity consumption per capita that gives an indication of the countries state of the economy.

In making this assumption a country in a development stage would ideally have lower consumption, however as it develops the GDP will increase as will the ability to spend, hence consumption increases and efficiency decreases.

Therefore the figures indicate that in Nauru energy consumption is very high and there are very low levels of efficiency.

**Table 2-4 Overall Energy Efficiency**

| | Electricity consumption per capita (kWh/year) | Electricity consumption per GDP (Wh/GDP (USD)) |
|---|---|---|
| Nauru | 2,843 | 569 |
| Samoa | 534 | 114 |
| Kiribati | 101 | 31 |
| PNG | 432 | 206 |
| Solomon | 132 | 83 |

(Source: CIA World Fact Book: Samoa, Kiribati, PNG and Solomon: 2006, Nauru: 2005)

The figures show that electricity consumption per capita is quite high (2,843 kWh/year) and the efficiency is quite low (569 kWh/GDP). The former is more than 20 times of that of Kiribati and the latter is one eighth, indicating significantly greater levels of inefficiency.

(b) Supply side efficiency

The efficiencies of electricity generators in the powerhouse are not known. A few of the electricity generators are not in operation due to mechanical breakdown and therefore a number of the containerized (standby) generators are used. The power system is currently under reconstruction supported by Australia.

(3) Energy Efficiency Policy, Measures and Programmes

Reform of Nauru's Basic Infrastructure Services states promoting energy efficiency as an important measure.

One target is tariff system reformation to provide a price signal for consumers. The government has also placed high priority for a public communication strategy that includes dissemination through the local media and schools on power and water conservation. Technical assistance to undertake this is already a part of EU's package of assistance to Nauru.

(4) Donors' Programmes

A programme for promoting efficient lighting is under consideration by GEF/UNDP.

### 2.4.2 Potential and Needs

(1) Potential

The energy efficiency in Nauru is quite low. Therefore there is a huge potential for energy efficiency in each sector, governmental, industrial and domestic sector. Efficiency improvement of electricity supply side has been conducted with Australian support.

PREA 2004 estimates that "electricity generation can be cut by as much as 50% through supply side efficiency improvements, the elimination of unnecessary loads, improved efficiency of appliances and the switching off of appliances when not actually in use."

(2) Needs from the Recipient Country

The only industry in Nauru, the mining Company, owned by the Government, expressed its strong interest in support for energy efficiency, since the electricity cost is a burden with 6.5 million AUD out of the total cost of 50 million AUD.

(3) Summary of Requirements

Nauru has great potential for the introduction of energy efficiency in each sector. One of the main obstacles, i.e. no price signals to consumers, will be amended by the reform of tariff system supported by Australia. Public awareness campaign will be conducted by the government (GEF/UNDP) and the mining company showed its strong interest in support for energy efficiency.

### 2.4.3 Consideration of Cooperation Fields

Energy audits and improvement planning for the mining company in conjunction with training might be a possible project for Nauru. Similar projects to the above at the governmental buildings and hotels may also be possible.

# Chapter 3. Republic of Kiribati

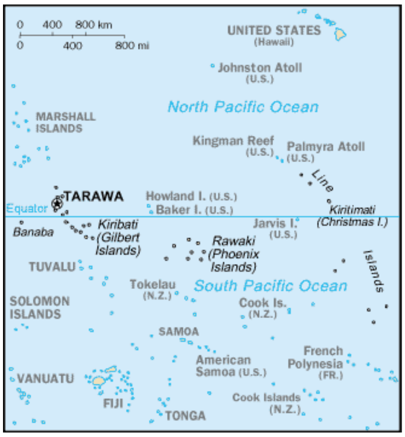



**Figure 3-1 Map of Kiribati**

## 3.1 Profile of the Country

### 3.1.1 General Information

(1) General Information

Kiribati, officially the Republic of Kiribati, is an island nation located in the central tropical Pacific Ocean. It is composed of 32 atolls and one raised coral island, dispersed over 3,500,000 square kilometers, straddling the equator, and bordering the International Date Line to the East.

(2) Economy

Kiribati has few natural resources. Commercially viable phosphate deposits were exhausted at the time of independence (1979). Copra and fish now represent the bulk of production and exports. Tourism provides more than one-fifth of GDP.

Foreign financial aid, largely from the United Kingdom and Japan, is a critical supplement, equal in recent years to 25% to 50% of GDP. Agriculture accounts for 12.4% of GDP; industry 0.9%, and trade 18.5%. The main export and import countries are Australia, Japan, and Korea.

(a) Main Industry

Copra, fish and tourism (Source: Website of MOFA of Japan)

(b) Gross National Income (GNI)

120 million US$ (2007) (Source: Website of MOFA of Japan)

(c) GNI per Capita

1,170 US$ (2007) (Source: Website of MOFA of Japan)

(d) Economic Growth

2.5% (2007) (Source: Website of MOFA of Japan)

(e) Inflation Rate

0.2％ (2007) (Source: Website of MOFA of Japan)

(f) Trading Amount

Export: 6.32 million AU$.
Import: 91.59 million AU$.
(Source: Website of MOFA of Japan)

(g) Trading Item (2004)

Export: Copra, Fish (decorative), Seaweed.
Import: Food, Machinery.
(Source: Website of MOFA of Japan)

(h) Trading Countries

Export: Japan, Korea, and Australia.
Import: Australia, Fiji, and Singapore.
(Source: Website of MOFA of Japan)

(i) Currency

Australian Dollars, 1 AUD = 69.177 JPY (2009/4/29, http:www.oanda.com).

(3) Japan's Cooperation

Record of Japan's cooperation to Kiribati is shown in the next table, composing of ODA loans, Grant Aid and Technical Cooperation.

**Table 3-1 Record of Japan's Cooperation**

| | 2007 | Accumulated Amount by 2007 |
|---|---|---|
| ODA Loan | 0 | 0 |
| Grant Aid | 228 million Yen | 16.8 billion Yen |
| Technical Cooperation | 33 million Yen | 3.6 billion Yen |

(Source: MOFA of Japan, accessed in April 2009)

### 3.1.2 Geography and Weather

(1) Geography

Kiribati consists of about 32 atolls and one raised island (Banaba), with at least three located in each hemisphere. The groups of islands are:

- Banaba: an isolated island between Nauru and the Gilbert Islands
- Gilbert Islands: 16 atolls located some 930 miles (1,500 km) North of Fiji
- Phoenix Islands: 8 atolls and coral islands located some 1,100 miles (1,800 km) Southeast of the Gilberts
- Line Islands: 8 atolls and one reef, located about 2,050 miles (3,300 km) East of the Gilberts

Banaba (or Ocean Island) is a raised-coral island which was once a rich source of phosphates, but it was mostly mined out before independence. The rest of the land in Kiribati consists of the sand and leaf rock islets of atolls or coral islands which rise but a few meters above sea level. The soil is thin and calcareous, making agriculture very difficult. Kiritimati (Christmas Island) in the Line Islands is the world's largest atoll. Based on a 1995 realignment of the International Date Line, Kiribati is now the easternmost country in the world, and was the first country to enter into the year 2000 at Caroline Island, which, not coincidentally, has been renamed Millennium Island.

(2) Weather

The whole country is in a tropical monsoon area and has little changes monthly and daily in temperature. Rainfall even exceeds 3,000 mm in some areas. The average temperature and rainfall of Tarawa are shown in the next tables.

**Table 3-2 24 Hours Average Temperature (Tarawa)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| °C | 27.9 | 27.8 | 27.8 | 27.9 | 28.1 | 28.0 | 27.8 | 27.9 | 28.1 | 28.2 | 28.1 | 28.0 | 28.0 |

(Source: World Climate Website, 1951-1990, Station at about 1.35°N 172.90°E. Height about 2m / 6 feet above sea level.)

**Table 3-3 Monthly Average Rainfall (Tarawa)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 277.3 | 198.8 | 189.9 | 173.5 | 157.3 | 136.9 | 160.1 | 117.4 | 87.3 | 87.0 | 134.9 | 194.3 | 1914.4 |

(Source: World Climate Website, 1951-1990, Station at about 1.35°N 172.90°E. Height about 2m / 6 feet above sea level.)

## 3.2 Outline of the Power Sector

### 3.2.1 Legal Framework of the Power Sector

The Public Utilities Ordinance (CAP 83) contains the legislative basis for establishment and management of the Public Utilities Board (PUB). The Ordinance provides for the Minister of Public Works and Utilities (MPWU) to declare electricity supply and/or water supply areas to which the

PUB has the exclusive right within such area to provide electricity supply and water supply services.

Amendments were made to the ordinance in 2000, to give the PUB Board of Directors more independence and autonomy to set its tariff and to hire and dismiss staff. In the past the tariffs had to be approved by the Minister and the hiring and dismissal of staff was acted upon by the Public Service Commission (PSC). Since 2001, the PUB has its own condition of service.

With regard to tariffs, the Board of Directors is legally accountable to customers directly and indirectly through the MPWU. However, in practice, the Board of Directors is still responsible to Cabinet through the MPWU on matters of public interest, principally the setting of tariffs. In cases where the tariffs proposed by Cabinet will result in financial losses, government may consider providing subsidy or alternatively provide guaranteed loan from financial institution to assist PUB.

The PUB is headed by the Chief Executive Officer (CEO) who is appointed by the Board of Directors on a three year contract and is renewable on mutual agreement depending on performance. The CEO reports directly to the Board of Directors on the daily operations of the PUB. The CEO directs and coordinates responsibilities for running PUB's four main Divisions.

1. Power Generation and Distribution
2. Water Supply and Sewerage
3. Accounting and Finance
4. Administration and Personnel

There are also other acts, regulations and polices that effect the power sector and the main ones are listed below:

- The Prices Ordinance (CAP 75 of 1976; revised 1981) enables regulations regulating retail prices of prescribed commodities. Currently the only petroleum fuels under retail price control are benzene / petrol and kerosene.
- Petroleum Act (CAP 69) provides for the customs involvement in the inspection of petroleum products clearance and distribution safety, rationing and storage regulations.

### 3.2.2 Institutional Framework of the Power Sector

#### (1) Structure of the Power Sector

The Ministry of Public Works and Utilities (MPWU) is responsible for the planning, management and coordination of the energy sector. In addition, other specific energy sector responsibilities have been delegated to the respective entities as follows:

- The Energy Planning Unit (EPU) is responsible for coordinating the implementation of energy policies and providing necessary advice and assistance on all energy activities and energy related matters.
- The Public Utilities Board (PUB) is a statutory authority responsible for provision of power, water supply and sewage services for South Tarawa and the provision, operation and maintenance of all assets associated with service delivery.
- The Kiribati Solar Energy Company (KSEC) is an incorporated company majority owned by the government which provides electrical services for rural areas through the sale or lease of solar photovoltaic systems.
- The Kiribati Oil Company (KOIL) is an incorporated company involved in the distribution of petroleum products with the Kiribati government holding a majority share in the company.
- Ministry of Lines and Phoenix which is responsible for all the government services including development of power, electrification, transmissions on the outer islands including Christmas Island.

#### (2) Organizations in Charge of Renewable Energy

Currently there is no single organization which is in charge of renewable energy however the Energy Planning Unit plays a pivotal role in implementing and coordinating renewable energy activities. The KSEC deals with solar energy and was established in 1984. To date it has electrified some 2,000 households in the outer islands amounting to a total sum of 285.5kW in installed solar

PV systems with 6.4kW for communication, 7.5kW for street lights, 47.6kW for community buildings and 224kW for residential households. A typical residential installation would include a 100 Watt panel and a 100 Ah battery which is rented out for a monthly maintenance fee.
The current shareholders of the KSEC consist of the:

- Minister of Public Works and Utilities who holds 99% of shares
- Secretary of Public Works and Utilities
- Secretary of Home Affairs
- Manager, Bank of Kiribati
- Manger, PUB
- Secretary for Finance

(3) KSEC

(a) Regulations and Incentives

Currently there is no incentive with regard to payment of the monthly tariff. However, the only financial burden is the payment of the monthly maintenance fee.
The objectives for which the company (KSEC) was incorporated for are unrestricted but its initial function was to:

a) Purchase solar energy systems and components;
b) Resell the products mentioned in (a) to the government and private sector;
c) Assist the government in achieving it’s energy goals by contributing to the fulfillment of stated government energy and development policy objectives; and
d) Carry on any other business connected with or incidental to the foregoing objectives.

(b) Tariff and Collection

Tariff for the rental of solar PV systems provided by the KSEC is currently at AUD$9 a month, however judging from the financials, it is not adequate to break even. The KSEC has hopes that the tariff can be raised to AUD$15. Tariff is collected by solar technicians who are based on each island and is sent to the KSEC headquarters in Betio, Tarawa by telegraphic transfer were the customers’ accounts are updated.
A contract agreement is signed between the KSEC and the customer where by the KSEC provides maintenance as long as the monthly maintenance fee is paid. In instances where the fee is not paid the system is disconnected and a fee is charged for reconnection. For subsequent months of non-payment of the maintenance fee would then result in the removal of the solar PV system from the customers’ site.

(c) Solar Energy for Outer Islands Project

Under the European Union’s (EU) "Solar Energy for Outer Islands" project, a commitment of 4 million Euros was made to KSEC. The initial implementation period of the programme was to end in March of 2005, but was extended until 31 December 2007.
This budget is proposed to be distributed as follows:

- Equipment: €2,744,000
- Training, Installation and Storage, and Technical Assistance: €950,000
- Mid-term review & end-of-project evaluation: €160,000
- Contingencies (6%): €246,000

The €2,744,000 for equipment could be distributed as follows:

- Additional 800 to 1,000 Small Household Systems of 100Wp: €1,200,000
- Between 200 and 250 larger PV systems (300 Wp): €600,000
- Between 20 and 40 community halls: €90,000
- Electrifying 4 secondary schools and one island council with micro-grids and offering computer labs to the schools: €600,000
- Setting up service centre in Kiritimati Island with related services: €94,000
- Equipment for grid connected solar array: €100,000

### 3.2.3 Laws and Regulation regarding Renewable Energy

The Kiribati National Energy Policy (KNEP) (2009) was just recently passed by the Kiribati Cabinet states:
"Increased use of applicable renewable energy technologies is seen as the most appropriate long term alternative to conventional systems, however there are a number of barriers to its widespread use which will be addressed through these policies.

- Promote sustainable renewable energy development.
- Ensure that the limited biomass (inclusive of biofuels) resources are used in an economical, environment and culturally sustainable manner.
- Strengthen collaboration with development partners for the advancement of renewable energy programmes.
- Promote and encourage the use of appropriate renewable energy technologies
- Expedite the replication of successful solar programmes.
- Introduce appropriate incentive packages including taxes, duties and tariffs to encourage use of renewable technologies."

However, under the current PUB Act, any area declared by the Minister for electrification becomes exclusive to PUB. Therefore for grid connected renewable energy projects, permission is first needed from PUB to enable connection to the grid.

### 3.2.4 Power Demand and Supply Status

(1) Past Records and Current Annual Power Consumption (kW, kWh)

Past annual electricity consumption has been recorded as shown in the next table, where electricity consumption per capita in Kiribati has been around 0.2 MWh/annum.

**Table 3-4 Past Annual Electricity Consumptions in Kiribati**

| | Year | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|
| Annual Energy | Million kWh | 14.9 | 13.7 | 17.7 | 20.4 | 19.7 |
| Averaged | MW | 1.7 | 1.6 | 2.0 | 2.3 | 2.2 |
| Population | Thousand | 87.4 | 88.8 | 90.4 | 92.5 | 94.2 |
| Annual Electricity Consumption per Capita | MWh per capita | 0.17 | 0.15 | 0.20 | 0.22 | 0.21 |

(Source: Key Indicators for Asia and the Pacific, 2008, ADB)

In 2008, the electric generation and power consumption in Tarawa which is solely supplied by connection to the main grid is recorded as shown in the next table. Annual generated power in 2008 was 22.45 MWh, where the maximum power consumption / demand was 4.73 MW in July 2008.

**Table 3-5 Electric Generation and Power Consumption in Tarawa Grid - 2008**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Units Generated (million kWh) | 1.92 | 1.81 | 1.84 | 1.88 | 1.90 | 1.77 | 1.96 | 1.96 | 1.88 | 1.91 | 1.76 | 1.87 | 22.45 |
| Station Consumption (million kWh) | 0.09 | 0.10 | 0.10 | 0.10 | 0.10 | 0.09 | 0.10 | 0.10 | 0.10 | 0.09 | 0.09 | 0.10 | 1.18 |
| Units Sent Out (million Wh) | 1.83 | 1.71 | 1.74 | 1.77 | 1.79 | 1.68 | 1.86 | 1.85 | 1.79 | 1.82 | 1.66 | 1.77 | 21.27 |
| Maximum Demand (MW) | 4.5 | 3.93 | 4.48 | 3.68 | 4.65 | 4.67 | 4.73 | 4.53 | 4.02 | 3.98 | 4.13 | 3.96 | |
| Fuel Used (kilo-litres) | 497 | 466 | 481 | 494 | 497 | 463 | 514 | 515 | 496 | 516 | 465 | 477 | 5882 |

(Source: Data from PUB)

(2) Past Records and Current Annual Power Generation

The four diesel generators in Betio and Bikenibeu Power Stations supply almost all the electric power in Kiribati through the main grid. In regard to the planning arrangement, Betio has one diesel generator, Daihatsu 1.25MW installed in 2004. Bikenibeu has three Daihatsu diesel generators, each rated at 1.4MW. Two of these diesel generators were installed in 2002 and the third in 2005. All engines generate at 11kV. Past records of peak power demand and available generating units are summarised in the next table.

**Table 3-6 Power Balance in Kiribati**

| Description | Installed Capacity | | | Recorded | | |
|---|---|---|---|---|---|---|
| | [kW] | 2004 | 2005 | 2006 | 2007 | 2008 |
| Peak Demand | | 3800 | 3990 | 5250 | 5050 | 4730 |
| Generating Output | | | | | | |
| Betio Power Station | | | | | | |
| No.1 Daihatsu (2004) | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 |
| Bikenibeu Power Station | | | | | | |
| No.3 Daihatsu (2002) | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 |
| No.4 Daihatsu (2002) | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 |
| No.5 Daihatsu (2005) | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 |
| Total Available Capacity [kW] | | 5450 | 5450 | 5450 | 5450 | 5450 |

(3) Information about the power network system (kinds of network diagrams or maps)

A single main 11kV power grid supplies electricity on the main Island of Tarawa. A simplified system diagrams is provided in Figure 3-2, where this has omitted the medium voltage to low voltage transformers, switching gear and circuit breakers.

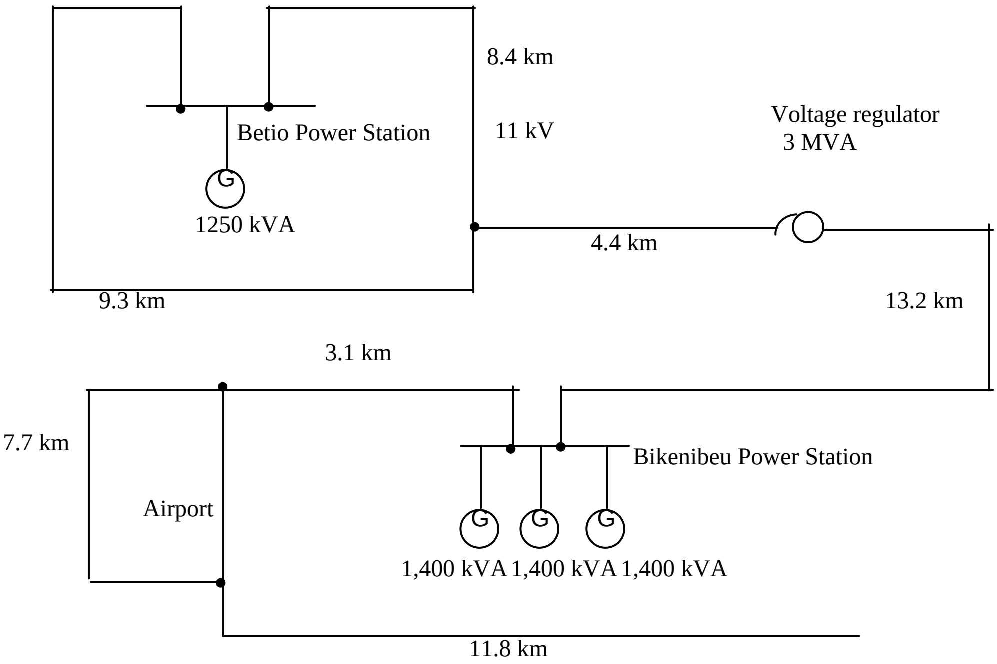



**Figure 3-2 Power Network System on Tarawa**

(4) Cost of Power Generation

Power generation operation costs are summarised in the next table.

**Table 3-6 Power Generation Operation Costs**

| | |
|---|---:|
| Fuel of Power House (Jan to Dec 2008) | $7,784,153 |
| Other Costs | $761,328 |
| Total Operation Cost (for Jan to Dec 2008) | $8,545,481 |

Other costs mentioned above include motor vehicle fuel, engine lubricant oil, direct labour, overtime, bonuses, maintenance etc. all related to power generation only. The fuel cost contributes to the large portion of the cost of power generation on Tarawa, where the fuel cost per kWh is calculated at around 0.37 AUD.

### 3.2.5 Power Development Plan

According to a document on power development plan provided by PUB (in April 2009), elaborated in the next table, a new generator (1.4MW) would be required by year 2010 because any outage of the largest unit will cause a significant power shortage as shown in the line of “Stand-by Capacity” as detailed in the next table.

**Table 3-7 Power Development Plan and Strategy**

| Description | Installed Capacity [kW] | Forecast 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | |
|---|---|---|---|---|---|---|---|---|
| 1 Peak Demand | | | | | | | | |
| 1.1 Existing Consumer | | 4920 | 5120 | 5320 | 5750 | 5980 | 6220 | *1 |
| 1.2 Waiting Consumers | | 125 | | | | | | |
| Total | | 5045 | 5120 | 5320 | 5750 | 5980 | 6220 | |
| 2. Generating Output | | | | | | | | |
| 2.1 Betio Power Station | | | | | | | | |
| No.1 Daihatsu (2004) | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | |
| Subtotal of Available Capacity | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | 1250 | |
| 2.2 Bikenibeu Power Station | | | | | | | | |
| No.3 Daihatsu (2002) | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | |
| No.4 Daihatsu (2002) | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | |
| No.5 Daihatsu (2005) | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | |
| Subtotal of Available Capacity | 4200 | 4200 | 4200 | 4200 | 4200 | 4200 | 4200 | |
| 2.3 Total Available Capacity [kW] | | 5450 | 5450 | 5450 | 5450 | 5450 | 5450 | |
| 3. Power Balance (2.3-1) [kW] | | 405 | 330 | 130 | -300 | -530 | -770 | *2 |
| 4. Maximum Unit Capacity [kW] | | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | *3 |
| 5. Stand-by Capacity (3-4) [kW] | | -995 | -1070 | -1270 | -1700 | -1930 | -2170 | *4 |

*1 : Average of Annual Increasing Ratio for FORECAST is 4.0%
*2 : The remaining generation capacity during Peak Demand
*3 : This value means available capacity of the Largest Unit
*4 : Remaining capacity during Peak Demand WITHOUT Largest Unit

The PUB is now considering the power supply in Tarawa main grid in its power development plan (a provided document by PUB in April 2009) as follows:

Strategy 1:
This involves the usual practice of installing required diesel engine capacity onto the existing systems.

a) 1.4 MW Daihatsu DEG would be required and installed at Bikenibeu Power Station, along with associated switchgears that would allow for easier integration with existing set up at Bikenibeu, and that would also allow easier control (starting/stopping) operation.

b) A 1.25 MW Daihatsu DEG if option a) should not be obtainable (however option a) would be more favored for many reasons). The 1.25MW DEG to be installed in Bikenibeu.

Strategy 2:
In order to meet peak demand, some 300 kW or more SOLAR ENERGY, grid connected to be introduced preferably at Bikenibeu Power Station.
However, some considerations may have to be considered, especially with;

a) Cost of Solar Energy if introduced and cost of acquiring 1.45 MW diesel engine generator (DEG) in relation to meeting demand.
b) Long term benefits, eg cost savings on fuel cost that could be achieved monthly/yearly once some portion of power is produced by solar power and not diesel, against the length of time this would be able to meet peak demand before a new set is required.
c) Cost of DEG operation in a monthly/yearly period against its longer term availability once procured in meeting supply demand and providing reliable power.

Strategy 3:
Due to the high cost of diesel fuel and provided the cost of coco-fuel (coconut oil) could remain at an attractive lower price than the fluctuating diesel cost, then coco-diesel (bio fuel) may be looked into.
Thus if possible, it would have to be considered as a pilot project and implemented to the Betio Power Station, having only one DEG. The engine Manufacturer, Daihatsu would of course, be involved and consulted beforehand in relation to the specifications or modifications of its engine parts or engine performance that might result from this. A move into this bio-fuel generation may require a large number of utilities (say several Pacific Power Utilities) and may be several (or a few interested) engine manufacturers to maintain the availability of engine spare (special) parts. (ie if the parts for DEG would be somehow be different for an engine driven by bio-fuel).
The existing Betio Power Station could still be used, provided the older part of the building (now showing signs of cracking) is upgraded and the next door Plant and Vehicle Unit relocated to allow for direct pipeline access from Kiribati Copra Mill Company Limited. (Alternatively a complete new location for the Betio power station).

## 3.3 Current Situation of Renewable Energy and a Course of Action

### 3.3.1 Potential

(1) Solar

According to the result of JICA's study on rural electrification by solar powers in 1994, the averaged solar radiation for seven years was recorded 5.69 kWh/$m^2$/day that is 1.5 times averaged solar radiation in Japan.

The report of Pacific Islands Renewable Energy Project in 2004 mentioned the potential of solar power energy as follows.

"Though the resource varies somewhat from North to South with the southern islands having a larger and more constant resource, the level of solar energy for all of Kiribati is very good with estimates for some islands indicating over 6 kwh/$m^2$/day is available for water heating or electricity generation. Since all of Kiribati is close to the equator, annual variation is not great though there is likely to be some cyclic change due to the El Niño/El Niña climate cycle." (Source: PREA 2004)

Furthermore, because of the fact that PV systems for households are widely applied for and used in the outer islands of Kiribati Group attests to the fact that there is considered to be an appropriate level of solar power potential in Kiribati that make such an application economically and financially feasible.

Solar PV systems for households are widely utilised in the outer islands of Kiribati. Basically, KSEC manages the PV system installation and their maintenance in outer islands. The following are examples of current/future activities in outer islands in Kiribati.

- PV system at a secondary school in an outer island to power a water pumping system: Funded by Italy, around 140,000 USD
- PV system in the outer islands installed with a capacity of 10 kW, with diesel generators providing a back-up as necessary: Funded by Italy, around 350,000 USD
- PV system installation at 2,400 households in outer islands: Funded by EU

  The project is originated from the JICA supporting former projects, where a further 600 households require PV systems to be installed. Each household is currently paying 9AUD/month for the solar PV home systems.

(2) Wind

PREA 2004 mentioned the potential of wind power energy as follows:

> "The wind energy resource is poorly understood and resource surveys need to be carried out before there is any consideration of investment for wind power for power generation. Wind installations are particularly difficult for atoll islands due to their lack of significant elevation and the dominance of tall coconut trees over most land areas. Installation of wind machines in shallow lagoons or on the reef well away from trees may be required if wind power is to be practical for Kiribati"

Although there is a plan of the project containing the measurement of the wind and carrying out a feasibility study in Christmas Island, whether or not the utilization of wind energy to supply the firm electricity can be realized is uncertain. Considering that the islands in the Kiribati Group are wide spread, it is anticipated that there might be some possibility of utilizing the wind energy, but this still remains to be ascertained. However, wind resource measurements would be essential for determining the resources and assessing the feasibility (The average wind velocity at islands other than Tarawa in Gilbert Islands is estimated to be around 5 m/s). Limited wind resource potential has been observed in Kiribati. However, there is a proposal to assess the wind resource potential on Christmas Island which will be funded by Italy, where the budget is expected to be around 105,000 USD.

(3) Biofuel

According to EPU, utilization of coconut oil to biodiesel is evaluated as follows.

"At current coconut oil production capacity by the KCMC of 5500 MT/annum (2004-06 average), the country can replace at least 30 % of diesel fuel imports. This clearly implies that a large scale investment in coconut oil biofuel can displace considerable amount of diesel fuel. The current fuel shortages on the islands which correlate with inadequate fuel supply reserves, is bound to persist in the next decades or so given the economic vulnerability of the country to soaring world prices of petroleum fuels."

A coconut oil / diesel blended fuel for power generation has potential. Though its viability has been proven using up to 15-20% of coconut oil by Samoa Power Utility and but other utilities in similar ratios but its high kinematic viscosity and the quality of coconut oil remain critical parameters as poor fuel may produce additional maintenance through clogged filters and deposits in engines if not run on optimal load.

So far, Kiribati does not use biofuel for power generation. There is a coconut oil company in Kiribati, Kiribati Copra Mill Corporation Limited, owned by the Government where it is proposed that a biofuels project will be developed through support from the Italian Government (IUCN). The coconut oil produced by this company is mainly for the export. The company has once consulted with PUB on the possibility of using coconut oil as a blend for fueling the generators, however, PUB has expressed negative opinion. (The reason may be attributed to a difficulty with applying the existing diesel generators or high costs of coconut oil.)

### 3.3.2 Needs Collected from the Interview

This project conducted an interview survey with relevant agencies. From the interview survey the current situation and needs in the power sector are summarized as follows.

- PUB has already considered the installation of grid-connected solar power system as the one strategy of the power development plan. However, the appropriate capacity of the solar power system may be not 300 kW as mentioned in the PUB's strategy.
- The possible candidates / location for the installation: The public facilities are preferable for installation such as Bikenubeu Power Station, Tungaru Hospital, KSECL or Airport buildings
- The examination of the power grid and the existing generators will be essential for making the plan for the grid-connected solar power system. To secure the demand-supply controlling ability of the system, the limitation of the capacity of solar power systems may be around 10% of the total system. Power system protection relays or other devices should be considered.
- According to the current ordinance of PUB, the PUB has the exclusive right to supply the electricity to the grid. The current law/s in Kiribati regarding electricity should be examined to assess the necessary approvals required before installing a PV system to the grid.
- The application of a grid-connected PV solar power system simultaneously requires the protection of power systems and the establishment of the rules of solar system connecting to the grid. The training/capacity building about these types of installations and development of national skills will be necessary.

### 3.3.3 Consideration on Cooperation Fields

(1) Medium to Large Scale Grid Connected Solar (PV) System

As mentioned there is significant solar radiation where PV solar power potential in Kiribati (South Tarawa grid) could contribute significantly to the meeting the daily demand, however this has not been exploited in the form of a grid connected PV system. It can reduce diesel fuel usage contributing to mitigation of climate change and contribute greatly to country's economy through reducing import bills and the balance of payment. Potential sites were identified, such as hospitals, council buildings and the airport where these buildings have extensive roofs, however there is generally limited spare areas of land.

A central grid-connected solar PV generator with the capacity of several tens or a hundred kW can be considered. However, the specification of the plant should be made with access to precise data and information about the power demand forecast, land acquisition, existing diesel generation and solar radiation.

At the moment, it seems that an assumed implementing agency, i.e. PUB does not have enough knowledge about the impact of integrating PV into the grid and how to manage it. Therefore, it is essential to provide support for the over all planning/design for the installation of PV and connection to the grid and to provide training on how to manage and maintain the PV system and the connection to the power system. It is considered essential to develop and provide technical guidelines for grid connected PV systems as it is anticipates that other countries such as Samoa may move toward the installation of large arrays of grid connected PV systems in the near future.

(2) Training Programme

Training programme can be provided through 2 ways, namely dispatching expert and invitation to Japan. Training programme for renewable energy, targeting at engineers, and energy efficiency, targeting at policy makers, can be held in Japan. Training programme in Japan expects the following agenda. The above programmes in the recipient country and Japan can be conducted through a regional assistance programme.

- Site visits to assess each renewable energy technology
- Lecture for planning and design of large scale grid-connected solar power
- Lecture for design and site visit of solar home system (captured and reverse flow)
- Lecture for planning and design of wind power
- Lecture for energy conservation programmes
- Site visits of each energy efficiency technology
- Lecture for maintenance of solar power
- Factory tour for solar power

## 3.4 Current Situation of Energy Conservation and a Course of Action

### 3.4.1 Current Situation

(1) Energy Consumption in Demand Side

The traditional use of biomass for cooking and copra drying remains the largest use of renewable energy providing around 5% of the gross national energy production (KNEP, Kiribati National Energy Policy). Even in Tarawa, people use biomass for cooking due to price rises in petroleum products. South Tarawa electricity demand in 2007 was 34% government, 48% domestic, 18% commercial and others 0.1% with a total demand of 16,734 MWh. Kiritimati Island on the other hand has a total demand of 2,362 MWh in 2006 (KNEP).

Electricity tariff is updated regularly to keep up with change in fuel prices with the current tariff rate of AUD0.40 per kWh for domestic, AUD0.55 per kWh for commercial and AUD0.70 per kWh for industrial consumers.

(2) Energy Efficiency

(a) Overall Efficiency

A factor to indicate energy efficiency could be electricity consumption per GDP is shown in the next table along with the electricity consumption per capita that gives an indication of the countries state of the economy.

In making this assumption a country in a development stage would ideally have lower consumption, however as it develops the GDP will increase as will the ability to spend, hence consumption increases and efficiency decreases.

Therefore the figures indicate that in Kiribati energy consumption is relatively low and therefore at the same time the levels of efficiency are deemed to be moderately high.

**Table 3-8 Overall Energy Efficiency**

| | Electricity consumption per capita (kWh/year) | Electricity consumption per GDP (Wh/GDP (USD)) |
|---|---|---|
| Nauru | 2,843 | 569 |
| Samoa | 534 | 114 |
| Kiribati | 101 | 31 |
| PNG | 432 | 206 |
| Solomon | 132 | 83 |

(Source: CIA World Fact Book: Samoa, Kiribati, PNG and Solomon: 2006, Nauru: 2005)

(b) Supply Side Efficiency

All the generators (diesel) in operation except the one in Betio were constructed after 2000. They are relatively new and it is assumed that their efficiency and output are still within the manufacturers name plate rating. However the power generation efficiency / fuel consumption is 0.262 L/kWh (2008) or about 38%, which is considered very high and efficient for a diesel generator. Transmission and distribution losses are about 16.3% (2008) which are also considered high.

**Table 3-9 Transmission and Distribution Loss (2008)**

| | |
|---|---|
| Electricity generated | 21,274,440 kWh |
| Electricity sold | 17,799,512 kWh |
| Transmission and distribution loss including non-technical loss | 16.3% |

(Source: information provided by PUB)

(3) Energy Efficiency Policy, Measures and Programmes

A draft of Kiribati National Energy Policy (under review) mentions in Section 3.5 “Energy Efficiency and Conservation” as follows, with the description of four policies:

“The heavily reliance on imported fuel coupled with increasing demand and inefficient appliances and equipment warrants an optimal use of available energy sources.”

Measures or programmes that MPWU have been trying to implement are raising awareness on energy efficiency/conservation of the public and secondary schools by radio communication and inputs in school curriculum.

(4) Donor Programmes

Currently, there is no particular support for energy efficiency and conservation. EPU has its own budget for addressing energy efficiency and conservation issues.

(5) Potential

Brief observation gives us an insight that hotels and houses use compact fluorescent lamps, which are more efficient than incandescent lamps and a number of inefficient air conditioners installed in hotels. There is always a potential in energy efficiency, when ignoring the scale of the effects. However, in Kiribati, standard houses seem to have no TVs or refrigerators in many instances. The power consumption per capita is therefore quite low, about 100kWh/year.

### 3.4.2 Consideration of Cooperation Fields

This survey identified no big expectations in progressing activities in the energy efficiency and conservation field, compared to those profiled for energy supply by renewable energy.

As mentioned above, energy efficiency/conservation is not the first priority area in Kiribati at this stage. To find appropriate measures for Kiribati, staff in charge of energy efficiency should be trained through training program in Japan.

# Chapter 4. Independent State of Papua New Guinea

## 4.1 Profile of the Country

### 4.1.1 General Information

(1) General Information

Papua New Guinea (PNG) is located in the South Western Pacific Ocean, in a region defined since the early 19th century as Melanesia. Its capital, and one of its few major cities, is Port Moresby. It is one of the most diverse countries on Earth, with over 850 indigenous languages and at least as many traditional societies, out of a population of just under 6 million.

Although PNG is made up of over 600 islands, 80% of its population (i.e. over 4 million people) live on the eastern half of New Guinea, the world's second largest island (396,500 km$^2$), with 85% of the country's total land area of 462,800 km$^2$. The remaining 20% (about 1 million people) live on islands ranging from as small as 0.2 k m$^2$ to several thousand square kilometres. Many of the small islands are very remote and accessible only by boat.


**Figure 4-1 Map of PNG**

(2) Economy

(a) Main Industry

Mining (Gold, Crude Oil, Copper), Agriculture (Palm Oil, Coffee), Forestry (Wood)
(Source: Website of MOFA of Japan)

(b) Gross National Income (GNI)

4,559 million US$ (2006) (Source: Website of MOFA of Japan)

(c) GNI per Capita

770 US$ (2006) (Source: Website of MOFA of Japan)

(d) Economic Growth

2.4% (2005) (Source: Website of MOFA of Japan)

(e) Inflation Rate

2.3 % (2006) (Source: Website of MOFA of Japan)

(f) Trading Amount

Export: 14,584 million Kina (2008)
Import: 7,710 million Kina (2008)
(Source: Website of MOFA of Japan)

(g) Trading Item (2004)

Export: Gold, Crude Oil, Copper, Wood, Palm Oil, Coffee, Cocoa
Import: Rice, Meat, Tire Tube, Can, Paper
(Source: Website of MOFA of Japan)

(h) Trading Countries (2003)

Export: Australia (27.3%), Japan (7.4%), China (5.9%), German (3.8%)
Import: Australia (44.0%), Singapore (20.3%), New Zealand (7.6%), China (4.9%)
(Source: Website of MOFA of Japan)

(i) Currency

Kina and Toea (1/100 of Kina), 39.8 JY=1 Kina (Source: Bank of PNG 2009/4/7)

(3) Japan's Cooperation to PNG

The following table provides a record of Japan's cooperation and assistance to PNG in recent years which was undertaken through ODA Loans, Grant Aid and Technical Cooperation..

**Table 4-1 Record of Japan's Cooperation**

| | 2005 | Accumulated Amount by 2005 |
|---|---|---|
| ODA Loan | 0 | 62.2 Billion Yen |
| Grant Aid | 0.55 Billion Yen | 30.4 Billion Yen |
| Technical Cooperation | 0.90 Billion Yen | 22.0 Billion Yen |

(Source: MOFA of Japan)

### 4.1.2 Geography and Weather

(1) Geography

PNG extends over 1,300 km from North to South-from the equator to $12^0$ South latitude - and 1,200 km from the border with Indonesia in the West to $160^0$ East longitude. It borders the waters of Australia to the South and Solomon Islands to the Southeast. PNG is mostly mountainous (highest peak: Mount Wilhelm at 4,509 m; 14,793 ft) and mostly covered with tropical rainforest, as well as very large wetland areas surrounding the Sepik and Fly rivers.

(2) Weather

PNG is positioned in a tropical monsoon area which has a rainy season (November-April) and a dry season (May-October). The average temperature through out the year is always high and flat at the coastal areas and recording temperatures at around 24℃ to 35℃. In the highland areas, temperatures usually range from 14℃ to 28℃. Annual rainfall through out PNG varies from 1,200 mm to 9,000 mm by area. The following tables provide a record of the Port Moresby (the capital city) weather data .

**Table 4-2 24 Hours Average Temperature (Port Moresby)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| °C | 27.6 | 27.4 | 27.3 | 27.1 | 26.8 | 26.1 | 25.6 | 25.6 | 26.1 | 26.9 | 27.5 | 27.9 | 26.8 |

(Source: World Climate Website, 1903-1990, Station at about 9.43°S 147.19°E. Height about 28m / 91 feet above sea level.)

**Table 4-3 Monthly Average Rainfall (Port Moresby)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 178.7 | 195.9 | 190.1 | 119.6 | 65.2 | 39.3 | 26.5 | 25.5 | 32.8 | 34.8 | 55.5 | 121.3 | 1,083.8 |

(Source: World Climate Website, 1891-1990, Station at about 9.43°S 147.19°E. Height about 28m / 91 feet above sea level.)

## 4.2 Outline of Power Sector

### 4.2.1 Legal Framework of the Power Sector

The PNG Power Sector is mainly governed by the Electricity Industry Act 2002 and is regulated by the Independent Consumer and Competition Commission Act of 2002 (ICCC Act 2002). Under this two main Acts, PNG Power Ltd, the nation's dominant power supplier is the legally recognised producer and supplier of electricity to certain markets in and around the Port Moresby area and the 19 provincial capitals.

Provided below is a brief summary of the Legislations that deal directly or indirectly with the power sector in PNG:

- Electricity Industry Act of 2002 (formerly the ELCOM Act) - this Act provides for the functions and powers of the Electricity Commission (now PNG Power Ltd) to *"plan and coordinate the supply of electricity throughout the country and determine the standards and inspect and control the application of all matters relating to the operations of the supply of electricity."*
- Independent Consumer and Competition Act of 2002. This Act provides for the Independent Consumer and Competition Commission (ICCC) as the only national regulatory body that acts as a consumer and business watchdog. The provisions of the ICCC Act apply to all businesses in Papua New Guinea including government enterprises. Under this Act, its 2003 regulations, and the Electricity Industry Act, ICCC is responsible for regulating electricity, petroleum and their pricing.
- Independent Public Business Corporation Act of 2002. Under this Act, the Independent Public Business Corporation holds all shares of PNG Power Ltd on behalf of the GoPNG making PPL a corporatized company.
- Organic Law on Provincial Government and Local Level Government (1995). The Organic Law grants authority to the 19 provincial governments and 299 local (district/sub-district) governments to pass laws and develop regulations for electricity generation and distribution in their areas of jurisdiction. Under the Law, responsibility for C-centre management and maintenance was transferred to provincial and local level government.

### 4.2.2 Institutional Framework of Power Sector

(1) Structure of Power Sector

Ssummarised diagrammatically below is an overview of major institutions/sectors that are involved in the generation and/or supply of electricity in PNG.

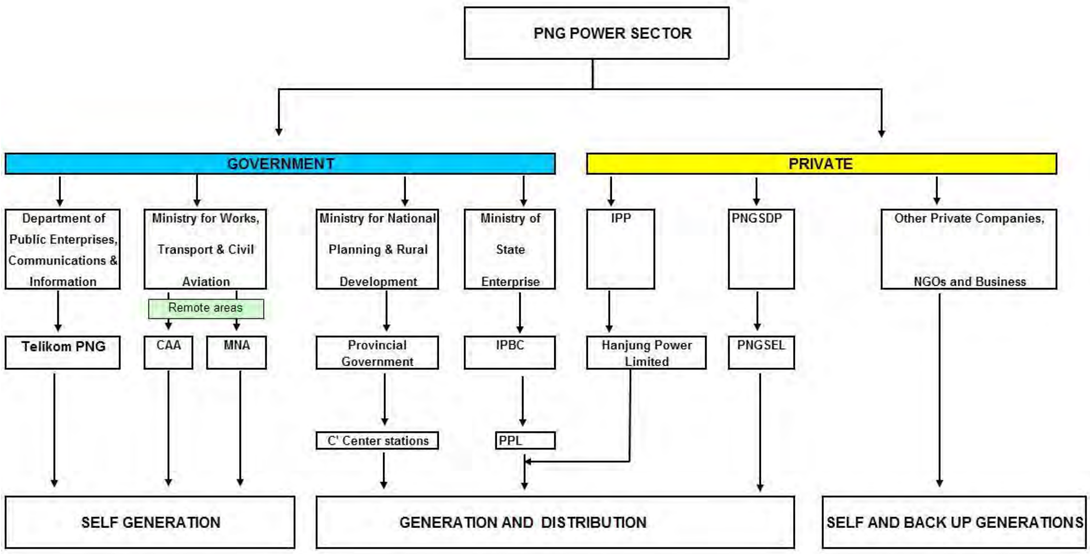



**Figure 4-2 PNG Power Sector Distribution and Generation Overview**

The total installed generating capacity in PNG is around 580 MW. At the current findings, PPL has an installed capacity of about 300 MW, of which about 250 MW has been estimated as being capable of producing power. Another 280 MW has been estimated to belong to other entities, most of which is used for self-consumption. The following provides a detailed description of the respective stakeholders in the PNG power sector.

(2) Government Organisations

A simple organization chart of the PNG power sector depicting its major players with respect to government ownership and policy is outlined in the following figure. Other publicly owned utilities and institutions operating in the power sector, but not shown in the figure, include Telicom PNG Limited, Civil Aviation Authority, National Maritime Safety Authority and training institutions.

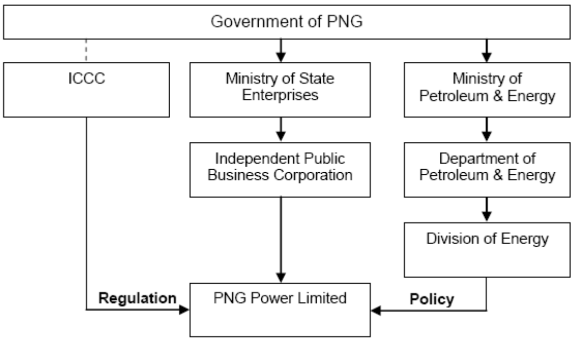



**Figure 4-3 PNG Government Power Sector Organization**

(a) PNG Power Ltd

(i) Overview

PNG Power Limited (PPL) which is a private corporatized state owned enterprise is the main distributor of electricity in PNG and is granted exclusive retail licence from ICCC for the generation and distribution of electricity through the existing grid network and connection to premises in certain markets in and around the Port Moresby area and 19 provincial centres. The consumer base of PPL translates into less than 10 percent of the total population who are primarily urban dwellers. PPL operates 17 independent systems, including three main hydroelectricity facilities, that is, the Ramu (Yonki) hydropower station in Eastern Highlands, supplying the Highlands region, and Morobe and Madang Provinces; Laloki (Rouna) Hydro in Central Province, supplying the National Capital District of Port Moresby; and Warangoi Hydro (Gazelle Peninsula) in East New Britain. The remainder are isolated thermal based systems using diesel (light fuel oil) as fuel.

The Government's ownership of PPL is through the Ministry of State Enterprises and, specifically, through the Independent Public Business Corporation (IPBC). In 2002, the IPBC was formed pursuant to the IPBC Act 2002, ostensibly to fast track implementation of the Government's privatisation programme. This Act provided for the transfer of ownership and control over various state-owned assets to the newly formed IPBC. PPL came under IPBC in 2003.

Other current roles of PPL in the power sector through delegation from ICCC is to be responsible for the technical regulation of the electricity sector. It is intended that these regulatory roles will eventually be transferred to the Energy Division of the Department of Petroleum and Energy.

(ii) Budget

The latest annual report from PPL was published in 2006. Based on figures presented, the following is a tabulated summary of the PPL's Operating Budget.

**Table 4-4 PPL's Operating Budget**

| PNG Power Ltd Operating Budget | | | |
|---|---|---|---|
| | 2005 K'000 | 2006 K'000 | 2008 Projected K'000 |
| Operations and Maintenance | 220,969 | 222,443 | 225391 |
| Administration | 53,524 | 80,191 | 133525 |
| Depreciation | 21,780 | 18907 | 13161 |
| **Total** | **296,273** | **321,541** | **358,916** |

For 2006, the operating budget for PPL was at 321,541,000 Kina. Based on the trend highlighted in table, it is estimated that 358,916,000 Kina was the operating budget in 2008 for PPL. An estimate of PPLs operation and administration budget for 2009 is around 460,000,000 Kina, where 393,000,000 Kina will be directed for operations and maintenance.

(iii) Staff

Based on the 2006 annual report, a tabulated summary on the number of employees for PPL were developed as seen below.

**Table 4-5 PPL's Employees**

| PNG Power Ltd Employees | | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | 2005 | 2006 | 2008 forecast |
| Permanent Staff | 1235 | 1161 | 1292 | 1308 | 1476 | 1546 |
| Unattached Employees | 3 | 70 | 38 | 22 | 31 | 36 |
| Graduates/Trainees/ Apprentices | 180 | 141 | 113 | 103 | 82 | 30 |
| Casual Employees | 350 | 401 | 236 | 332 | 263 | 219 |
| **Total Employees** | **1768** | **1773** | **1679** | **1765** | **1852** | **1831** |

It is estimated that the total number of employees for PPL stands at around 1,831 employees a projected reduction of approximately 1 %. This decrease is based on the projected reduction of graduates/trainees and apprentice attachments. By observation the employee numbers from 2002 to 2005, remained relatively constant. This however increased significantly by approximately 10 % in 2006.

(iv) Legal Basis

PPL has a number of statutory, regulatory and licence obligations imposed by various statutes as listed below.

- Companies Act 1997;
- Income Tax Act;
- Electricity Industry Act 2002; and
- Independent Consumer and Competition Commission Act 2002.

As a monopoly service provider within its service area, PPL is subject to economic regulation by the ICCC which has responsibility for regulating competition, controlling prices and protecting consumers in a number of industries including electricity supply. A Regulatory Contract between the ICCC and PPL was established in August 2002 and is valid until 31 December 2011. This Contract provides the mechanism for establishing and changing retail tariffs and sets out required service levels and performance.

(b) Division of Energy – Department of Petroleum and Energy

The Division of Energy has evolved out of continuous institutional restructuring. In 1992, the Energy Division (formally known as Department of Energy Development) was established with a mandate to promote a nationwide program of rural electrification through improvement of existing rural electrification facilities as well as implementation of new projects using environmentally sound energy conversion technologies. Subsequently, it was abolished in 1995 and was reconstituted into the Office of Energy Development within the Department of Mining and Petroleum. In 1997, the Department of Petroleum and Energy (DPE) was constituted, leaving the Department of Mining as a separate standalone entity. Within DPE, the Office of Energy Development was reconstituted and named as the Division of Energy.

As stated in the Draft National Energy Policy, the DPE is responsible for monitoring, reviewing and providing recommendations on fuel pricing, electricity tariffs and Government charges and subsidies, to ensure that the full and correct price signals are conveyed to consumers wherever possible, and developing and maintaining the capacity to monitor and evaluate the equivalent landed price of petroleum products, the petroleum company cost elements, the pricing formula, and Government charges so as to negotiate and maintain equitable pricing and proper contractual arrangements for petroleum products. In summation, DPE is majorly involved in the planning and policy development for the power sector. Also as per findings from the preparatory survey, DPE is involved with rural electrification projects.

(3) Other Agencies and Private Sector including NGOs

(a) C - Centers

These are off-grid Government owned distributed generation assets that generate electricity in rural communities through government centres and that deliver social services such as health, education, policing etc. With the passing of the Organic Law in 1995, responsibility for coordination of electricity provision by C-Centres shifted from the Energy Division of DPE into the hands of the Provincial and Local government authorities. Since then maintenance of these generation sets have fallen into disrepair where to date very few of the original 150 to 200 C-Centers are currently operational. The generating units at each of these C-Centers would have capacities of not more than a few hundred kW each.

(b) PNG Sustainable Energy Ltd.

The PNG Sustainable Energy Ltd (PNGSEL) operates under the parent company – PNG Sustainable Development Programme (PNGSDP) and has in recent years, begun to play a major contestant in PNG's power sector. PNGSDP was formed under the agreement between BHP Billiton, which owns the Ok Tedi Mine Ltd (OTML) in Western Province, and the Government of PNG. As the mine is set to close sometime during the next decade, it was agreed that some dividends from OTML that once would have gone to BHP Billiton would now be turned over to PNGSDP, which would then invest these proceeds into the development of PNG in general and Western Province in particular.

PNGSEL have been involved in the promotion of a number of potential power projects in PNG where they have revived and extended a few of the C-Centers in Western Province, as an initial step in its broader objective of acting as a catalyst to electrify all rural areas of PNG. Six mini-grid systems have been established throughout Western Province since 2005, with about 500 connections serving about 3,000 people. Current plans call for electrifying an additional 2,300 houses and 10,000 people along the Kiunga-Tabubil highway. An interesting feature of the PNGSEL plan is to install solar power in about 120 isolated houses located away from the mini-grid. PNGSEL also plans to undertake a solar power project in Mabuduwan, Western Province, which will supply power to 200 dwellings, including schools, a health centre, churches and family residential houses.

(c) Independent Power Producers (IPP)

There is only one company that is set up in PNG for the sole purpose of producing electricity and sells to PPL. This is the Korean Company – Hunjung Power Ltd which has a 26 MW Kanudi diesel plant in Port Moresby.

(d) NGOs and Churches

The NGOs and churches also are involved in electrification and transport provision prior to and after independence. Most of these projects are implemented in the community areas.

(e) Other Private Companies

The following are a list of private companies that produces their own electricity and also for some they sell excess electricity to PPL.

1. PNG Forest Products Limited, Morobe Province. This company owns the 5.7 MW Baiune/ Bulolo hydro development in southern Morobe province. The plant is actually connected to the Ramu system through its link to the town of Baiune. However, the main purpose of the plant is to supply PNG Forest Products.

2. Lihir Gold Mine, West New Britain Province. The mine is powered with a 53 MW geothermal plant. This power plant is the only CDM funded initiative realized in PNG to-date.
3. Tolukuma Mines, Central Province. This mine is actually within 100 km of Port Moresby, but it is located in an area unserved by electricity. The mine's power source is a group of hydro and diesel units having capacities of 1.5 MW and 3.2 MW respectively.
4. Porgera JV Mines, Enga Province. This mine's power supply is from a 62 MW gas-fired plant at the Hides gas field.

(4) Organization in Charge of Renewable Energy

In PNG, PPL has predominantly been involved with renewable energy development projects as art of its electrification program. However renewable energy project development is also undertaken in a number of organizations as listed.

- Division of Energy – Department of Petroleum and Energy
- PNG Sustainable Energy Ltd (PNGSEL)

### 4.2.3 Laws and Regulation regarding Renewable Energy

Renewable energy development is covered under the Electricity Act 2002 and the technical regulation from the ICCC Act 2002 which applies to electricity production and supply, of which development of renewable energy technologies is covered under. In addition to this, other associated laws which apply to renewable energy development includes the following:

- Environmental Laws:

The Environment Act, 2002 is the principle act dealing with environmental protection and conservation of natural resources in the country. Among other provisions, it sets the legal framework for regulating the environmental effects of development activities in order to promote sustainable development in PNG. Legal obligations are incorporated under Section 51 and Section 53 of this Act for Environmental Impact Assessment (EIA) requirements in the country. Beside the Environment Act, 2000, the other legislations with environmental implications include the Conservation Areas Act, National Parks Act, Fisheries Act, Forestry Act, Prevention of Pollution of the Sea Act, and the Water Acts. Subsequent to the Environment Act, the Department of Environment and Conservation has published a number of regulations and technical guidelines in the form of amendments to support the Act.

- Land Ownership and Development Issues:

In PNG, ownership of land falls under two main categories - Alienated Land and Customary Land. The term "Alienated Land" refers to land that was acquired from the customary land owners initially and is now owned and administered by the State through leasehold and freehold interest. Alienated Land in PNG comprises only 3 % of the total land mass. This 3 % includes State vacant and undeveloped land, State leasehold land, freehold and private land. Towns and urban centres occupy most of the Alienated Land. The other 97 % belongs to "Customary Land" which refers to land owned by the indigenous people whose ownership rights and interests are regulated by Customary Law. Major renewable energy development like hydro power, covers rivers which are in customary land where land issues need to be dealt with effectively. The following are key Acts related to the land:

- Land Act 1996;
- Land Groups Incorporation Act, 1974;
- The Valuation Act 1967, relating to the valuation of property, the registration of land values and other purposes;
- The Survey Act 1969, to provide for the registration of surveyors and the regulation of land surveying and other related purposes; and
- The National Land Registration Act, for establishing a Register of National Land.

### 4.2.4 Power Demand and Supply Status

(1) Power Network System

There is at present no nation-wide grid system in PNG due mainly to challenges posed by PNG's difficult topography and vast distances between the various towns and load centres.

Total generation capacity in PNG is 551 MW in actual capacity, where by, PNG Power Ltd (PPL) has a total 276 MW capacity in their on-grid and off-grid areas. Other than PPL, some entities have generation capacities for self-consumption (mainly for mining consumption). In addition, PNG Sustainable Energy Ltd (PNGSEL) provides electricity in areas of Western Province (10kW-100kW in each area).

**Table 4-6 Existing Power Capacity in PNG**

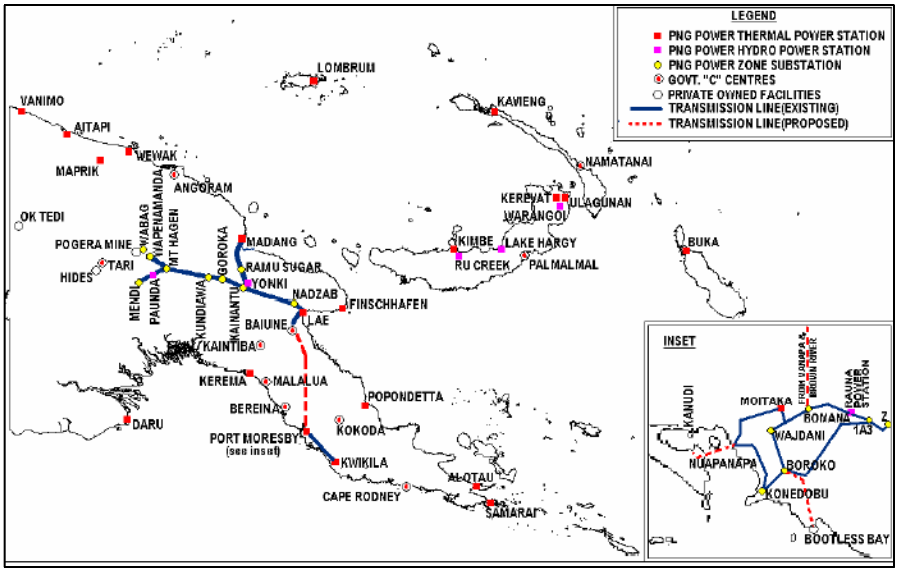
| System | Generation Type | Actual Capacity (MW) | PPL Possession Ratio (%)*1 |
|---|---|---|---|
| Port Moresby and Central Province | Hydro | 66.0 | 100% |
| | Thermal | 64.5 | 62% |
| Ramu | Hydro | 87 | 100% |
| | Thermal | 26 | 100% |
| Gazelle | Hydro | 9.4 | 100% |
| | Thermal | 8.8 | 100% |
| Western | Hydro | 60.4 | 0% |
| | Thermal | 53.4 | 3% |
| Isolated Area | Hydro | 9.4 | 21% |
| | Thermal | 113.4 | 31% |
| | Geothermal | 52.8 | 0% |
| PPL Possession | | 276 | |
| Other Entities | | 275 | |

*1: The ratio is the share of PPL actual capacity to the total actual capacity in the system.

(Source: Draft Report as of 2009/1, Power Sector Development Plan, ADB)

According to the PPL's website, PPL has plans to interconnect the Ramu and the Port Moresby systems. The project however depends entirely on the planned construction of a trans-island road to link the New Guinea Highlands to Papua, which itself has not eventuated.

Location of power stations and power system in PNG is shown below.

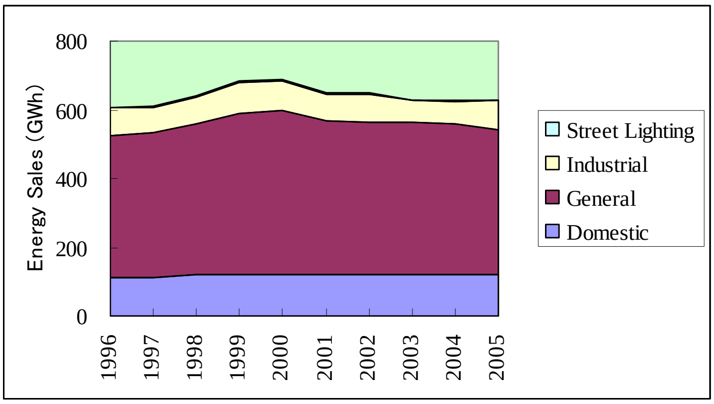



(Source: Draft Report as of 2009/1, Power Sector Development Plan, ADB)

**Figure 4-4 Power System Network in PNG**

(2) Electricity Consumption in the Past

As shown below, the power demand within the PPL system for the past 10 years has not increased significantly (Growth rate from 1996 to 2005: 3.2%). Of note is the growth rate from 2001 to 2004 which recorded negative growth despite PPL's customer numbers steadily increasing during these years (from 57,629 in 1996 to 73,514 in 2005). This is attributed to a drop in consumption from the General and Industrial Customers (middle and large consumers) during that time.




(Source: National & Provincial Ten Year Power Development Plan 2007-2016)

**Figure 4-5 Power Demand and Consumption by Customer Category within PPL**

(3) Power Demand and Generation in the Past

The following table provides an outline of the power generation and demand for the whole PPL system. As indicated in the table more than 60% of the power produced by PPL comes from hydro. In addition, it is noticed that there is a recorded increase in purchasing power from the IPP and other private business that sell excess electricity to PPL since 1999.

Based on the figures obtained for the annual generation and maximum demand, the system load factor was determined as per the table which averages around 60% over the past years and is considered to be relatively low (60.4% in TEPCO, 2007). Assuming PNG has a significant seasonal difference throughout the year, it is implied that the PPL system has a sharpening peak duration in the daily load curve.

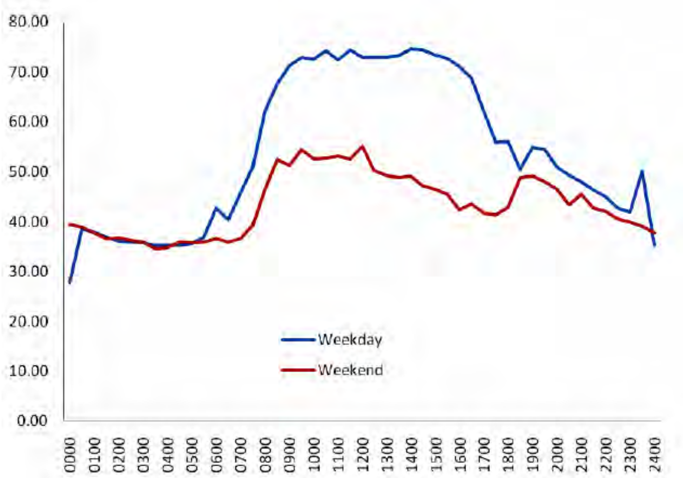
**Table 4-7 Generation Record and Maximum Demand**

| | Generation (GWh) | | | | | | Maximim Demand | Load Factor | System Loss |
|---|---|---|---|---|---|---|---|---|---|
| | Hydro | Diesel Heavy Oil | Diesel Light Oil | Gas Turbine | Power Perchase | Total | (MW) | | |
| 1996 | 576.9 | 6.0 | 116.4 | 0.7 | 1.7 | 701.7 | 130.9 | 61% | 13.3% |
| 1997 | 532.1 | 0.0 | 166.1 | 8.3 | 1.7 | 708.2 | 138.2 | 58% | 13.7% |
| 1998 | 502.8 | 0.0 | 202.1 | 26.1 | 3.4 | 734.4 | 140.5 | 60% | 12.6% |
| 1999 | 544.5 | 0.0 | 106.8 | 1.9 | 131.6 | 784.8 | 145.6 | 62% | 12.9% |
| 2000 | 541.6 | 0.0 | 113.5 | 8.5 | 139.7 | 803.3 | 153.4 | 60% | 14.4% |
| 2001 | 546.5 | 0.0 | 99.1 | 18.5 | 104.7 | 768.8 | 146.8 | 60% | 15.5% |
| 2002 | 508.8 | 0.0 | 98.9 | 13.5 | 156.4 | 777.6 | 148.6 | 60% | 16.5% |
| 2003 | 501.9 | 0.0 | 102.2 | 6.0 | 157.7 | 767.8 | 150.1 | 58% | 18.1% |
| 2004 | 479.2 | 0.0 | 110.4 | 2.3 | 163.7 | 755.6 | 148.9 | 58% | 16.9% |
| 2005 | 510.2 | 0.0 | 111.3 | 0.0 | 157.5 | 779.0 | 150.7 | 59% | 19.3% |

(Source: National & Provincial Ten Year Power Development Plan 2007-2016)

(4) Load Curve of Port Moresby System

Shown in the following figure is a typical load curve of the Port Moresby System that was taken for the month of May 2007. It can be seen that the demand rapidly increases from 7:00 AM and reaches its maximum value of about 75 MW to 80 MW at about 10 AM and continues throughout the day till around 17:00 PM. By assumption, the trend leading to the high power demand during the day is the result of power consumption from the commercial and industrial sector.



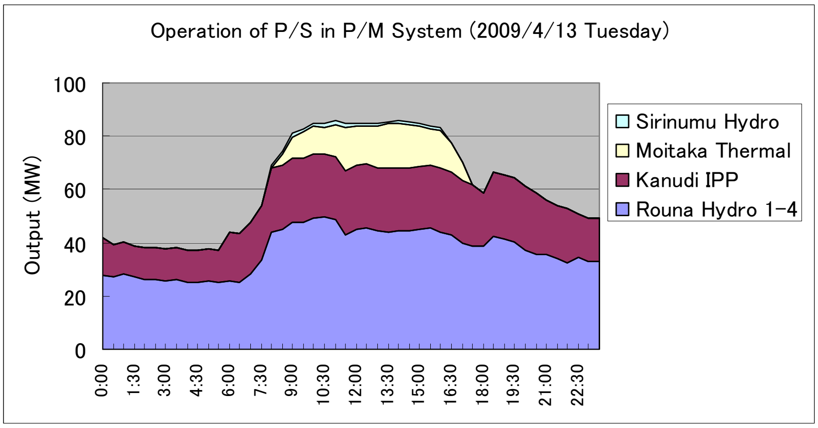

(Source: Draft Report as of 2009/1, Power Sector Development Plan, ADB)

**Figure 4-6 Typical Daily Load Curve of the Port Moresby System**

According to the "Draft Report (as of 2009/01), Power Sector Development Plan, Asian Development Bank (ADB)", the Ramu System has a similar load curve to the Port Moresby System.

(5) Generation Pattern of the Port Moresby System

The following figure is the typical operation pattern of the Port Moresby System on a weekday. Rouna 1-4 is operated as a base power resource. Kanudi IPP that has 24 MW diesel generators operates at high utilization rate. It is guessed that Kanudi IPP operates at high utilization on a contract basis. Moitaka diesel generators play a peaking supply role in the system.




(Source: PPL)

**Figure 4-7 Generation Pattern of the Port Moresby System**

According to PPL a total capacity of 100 MW is provided by self-generators on the consumer side within the Port Moresby System. In cases where a power deficit is forecasted, at the most 7 MW is able to be secured for emergency supply from such consumers by contract basis.

### 4.2.5 Power Development Plan

(1) Policy and Strategy

(a) National Energy Policy

Since 2004, Pacific Island Energy Policies and Strategic Action Planning (PIEPSAP) Project, implemented by United Nations Development Program (UNDP) and funded by the Danish Government had assisted with the development of national energy policies and strategic action plans for Pacific Islands countries including PNG. The PIEPSAP aimed at (i) increased availability of adequate, affordable and environmentally sound energy for the sustainable development of all Pacific islanders; and (ii) accelerated transfer and adoption of clean and renewable energy technologies in the Pacific. The executing agency for the PIEPSAP was the Secretariat of the Pacific Islands Applied Geoscience Commission (SOPAC).

Through the PIEPSAP, the Department of Petroleum and Energy (DPE) established new National Energy Policy. The policy was developed along the three main themes of sustainable development, i.e. economic, social and environment. The policy describes the following principles in each theme.

**Table 4-8 Theme and Principle in the National Energy Policy**

| Theme | Principle |
|---|---|
| Economic | Principle 1<br>Promote adequate, safe, reliable, and affordable supplies of oil, gas and other non-renewable energy sources |
| | Principle 2<br>Ensure that all sectors of the economy have access to adequate, safe, reliable and affordable electricity supplies |
| | <u>Principle 3</u><br><u>Promote a 15 per cent renewable energy target</u> |
| | <u>Principle 4</u><br><u>Wise and cost-effective utilization of energy in national development</u> |
| | Principle 5<br>Encourage involvement of the private sector in the development and provision of energy services |
| Social | Principle 1<br>Ownership of energy resource is vested with the resource owners and that there development should be of benefit to all stakeholders including the private sector |
| | Principle 2<br>Develop and enhance human and institutional capacity to plan and manage the energy sector |
| | Principle 3<br>Establish and develop an integrated planning process for sustainable energy supply and use |
| | Principle 4<br>Promote accessible, reliable, safe, affordable and efficient electric power supply |
| Environment | Principle 1<br>Develop energy resources in an environmentally sustainable manner and ensure wise use of energy |
| | Principle 2<br>Promote environmentally clean, efficient and cost effective energy in the transportation sector |

(b) Strategies in Renewable Energy and Energy Conservation

In the Economic theme of National Energy Policy, 2 principles (Principle 3 and 4) are set up for promotion of renewable energy and energy efficiency. These principles have their strategies as follows.

<u>Strategies of Principle 3 (Promote a 15 per cent renewable energy target)</u>

- Promote the use and sustainable development of renewable energy sources for both process heat and electricity generation.
- Promote the effective management of both grid-connected and stand-alone renewable-based power systems.
- Promote a level playing field for application of renewable energy sources and technologies
- Promote the provision of electricity based on a least cost development strategy utilizing proven technologies, with adequate support using local manpower and resources, and are suited to the needs the user.
- Ensure that renewable energy systems are sustainable.
- Promote renewable electrification systems that are implemented, managed and operated in a manner that empowers rural community involvement.

- Promotion and development of CDM renewable energy projects approved by relevant authority to be developed and administrated in partnership with other stakeholders and recipient communities.

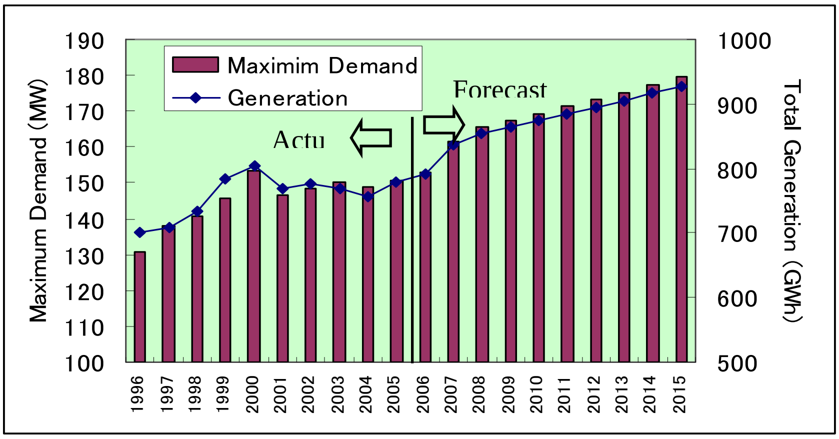
Strategies of Principle 4 (Wise and cost-effective utilization of energy in national development)

- Improve the efficiency of energy production, transmission, and distribution through supply side management.
- Promote demand side management programmes in all sectors of the economy.
- Promote appropriate incentives to encourage efficient energy use.
- Encourage cooperation in energy efficiency and conservation programs in all sectors.
- Promote public awareness on energy efficiency and CDM projects.

(2) Power Demand Forecasts

(a) Whole PPL System

The following figure shows actual demand (1996-2005) and forecasts (2006-2015) for the whole PPL system. Currently the actual demand has not been increased. In 2006 forecasts, PPL revised the latest forecasts to average growth 1.7% from average growth 2.9% (2000 forecasts).

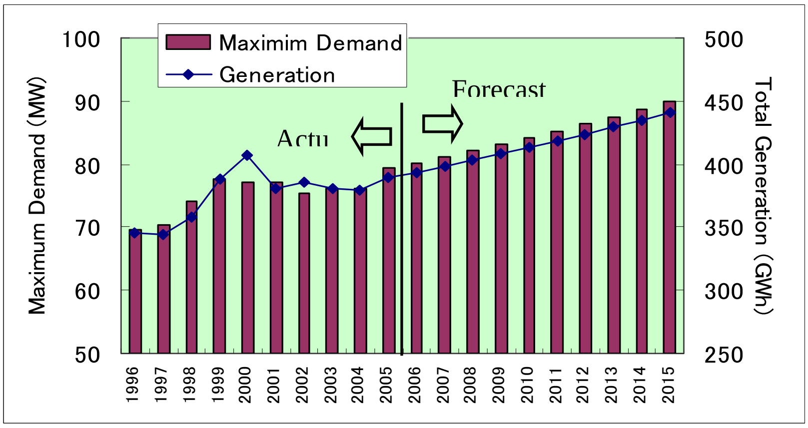



(Source: National & Provincial Ten Year Power Development Plan 2007-2016)

**Figure 4-8 Actual Demand and Forecasts of the Whole PPL System**

(b) Port Moresby System

The Port Moresby System is forecasted as follows. The growth rate of generation is estimated at 1.2-1.4% per annum.




(Source: National & Provincial Ten Year Power Development Plan 2007-2016)

**Figure 4-9 Actual Demand and Forecasts of the Port Moresby System**

(3) Power Development Plan

(a) Port Moresby System

The latest power development plan was prepared by PPL in 2006. The development plan is based on demand forecast of each province. For the Port Moresby System, the plan forecast 1.2-1.4% per annum which is relatively low level of increase per annum. The PPL's plan (2006) expected only 2 large hydro projects (Brown and Vanapa River) to be newly constructed and contributing capacity to the system. This capacity was not considered in PPL's plan (2006) that covered the period from 2007-2016, because the available power capacity was considered sufficient for low demand forecasts.

However, the latest ADB's study (Draft Report as of 2009/1, Power Sector Development Plan) forecasts about 6 % per annum considering the latest situation (the latest study seems to be more realistic than PPL's 2006 planning). The ADB Study plans more aggressive installation of diesel generation to maintain the reliability of the Port Moresby System until a large hydro (Udava 2: 47.6 MW) is constructed and comes on line (2015 is expected). To reduce the need for further installation of diesel generation in the next 10 years, the development of hydro or any other renewable energy sources of energy are crucial and required so as to minimise reliance on imported fossil fuel and reduce environmental impacts.

**Table 4-9 PPL's Plan and ADB Study Plan**

| | Unit | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| Peak Demand in Generation (PDP 2006) | MW | 80.9 | 81.7 | 82.4 | 83.1 | 83.9 | 84.7 | 85.6 | 86.4 | 87.3 |
| Existing Capacity (after derating) | | | | | | | | | | |
| Rouna 1-4 and Sirinumu | MW | 52.0 | 52.0 | 52.0 | 52.0 | 52.0 | 52.0 | 52.0 | 52.0 | 52.0 |
| Moitaka | MW | 30.4 | 29.7 | 28.9 | 28.2 | 27.5 | 26.7 | 25.9 | 27.1 | 26.2 |
| Kanudi IPP | MW | 22.8 | 22.5 | 22.3 | 22.0 | 21.7 | 21.4 | 21.1 | 20.8 | 20.4 |
| Total | MW | 105.1 | 104.2 | 103.2 | 102.2 | 101.2 | 100.1 | 99.0 | 99.8 | 98.6 |
| Reserve Margin (PDP 2006) | % | 30% | 28% | 25% | 23% | 21% | 18% | 16% | 16% | 13% |
| Peak Demand in Generation (ADB Study 2008) | MW | 87.0 | 92.3 | 98.0 | 103.9 | 110.6 | 117.8 | 125.4 | 132.8 | 142.2 |
| Existing Capacity (after derating) | MW | 105.1 | 104.2 | 103.2 | 102.2 | 101.2 | 100.1 | 99.0 | 99.8 | 98.6 |
| New Installation planned by ADB Study | | | | | | | | | | |
| New Diesel | MW | | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| New Diesel | MW | | | | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| New Diesel | MW | | | | | 10 | 10 | 10 | 10 | 10 |
| New Diesel | MW | | | | | | 10 | 10 | 10 | 10 |
| Udava 2 | MW | | | | | | | | 47.6 | 47.6 |
| Total (Existing and New) | MW | 105.1 | 124.2 | 123.2 | 142.2 | 151.2 | 160.1 | 159.0 | 207.4 | 206.2 |
| Reserve Margin (ADB Study 2008) | % | 21% | 35% | 26% | 37% | 37% | 36% | 27% | 56% | 45% |

(Source: National & Provincial Ten Year Power Development Plan 2007-2016, and Draft Report as of 2009/1, Power Sector Development Plan, ADB)

(b) Ramu System

At this moment the Ramu System has utilises the available water resources and is deemed to provide enough power. However additional capacity has been committed from the resource (Yonki Hydro: 15 MW in 2011, and Ramu 2 Phase 1 Hydro: 120 MW in 2012). In the next 10 years, no new installations are planned.

### 4.2.6 Tariff and Collection

(1) Tariff and Collection

The tariff system for PPL is regulated by the Independent Consumer and Competition Commission (ICCC) where it has set maximum tariff and charge in 2008. Under ICCC regulation, tariff charges for PPL are uniform throughout the country. The following table provides a summary of PPL's latest tariff charges. Tariff allocation and charges for PPLs customers is distributed into three groups – Industrial Customers, General supply customers and Domestic customers.

The electricity consumption is metered and billing revenue is collected at PPL's Office either through conventional collection or through a new 'Easipay' system, that is a prepaid system using the internet. PPL is actively promoting a shift from conventional collection to Easipay.

**Table 4-10 PPL's Scheduled of Electricity Tariff**

| PNG Power Ltd Scheduled of Electricity Tarriff | | | |
|---|---|---|---|
| TARIFF CATEGORY | UNIT | OLD TARIFFS (2007) | NEW TARIFFS (Applied on the 1st Jan 08) |
| **A. Industrial Customers (Credit Meters)** | | | |
| All energy | toea/kWh | 38.13 | 43.7 |
| Demand charge | Kina/kVA/month | 46.46 | 53.25 |
| Minimum Demand | kVA/month | 200 | 200 |
| **B. General Supply Customers (GS)** | | | |
| ***B.1 Credit Meters*** | | | |
| All energy | toea/kWh | 63.53 | 68.14 |
| Minimum charge | Kina/month | 12.17 | 13.05 |
| ***B.2 Easipay*** | | | |
| All energy | toea/kWh | 61.97 | 66.47 |
| Minimum charge | Kina/receipt | 44.93 | 48.19 |
| Easipay Emergency Receipt-GS | Kina/receipt | 44.93 | 48.19 |
| Easipay Emergency Service Fee-GS | Kina/receipt | 11 | 11 |
| **C. Domestic Customers (DC)** | | | |
| ***C1. Credit Meters*** | | | |
| First 30 kWh/month | toea/kWh | 31.33 | 34.43 |
| Balance | toea/kWh | 51.83 | 58.51 |
| Minimum charge | Kina/month | 9.2 | 10.24 |
| ***C2 Easipay*** | | | |
| All energy | toea/kWh | 43.23 | 48.11 |
| Minimum charge | Kina/receipt | 10 | 10 |
| Easipay Emergency Receipt-DC | Kina/receipt | 10 | 10 |
| Easipay Emergency Service Fee-DC | Kina/receipt | 10 | 10 |

(Source: PPL Website)

## 4.3 Current Situation of Renewable Energy and a Course of Action

### 4.3.1 Potential

(1) Hydro

Hydropower potential is in PNG is substantial, as a large part of the country is mountainous and receives substantial rainfall. The past reports estimated the potential of hydropower as follows.

- Hydropower Resources Inventory Study (1994) funded by World Bank (WB) estimated the gross theoretical hydropower potential of PNG as roughly 175,000 GWh/year (20,000 MW). Defined as the sum of 90% dependable outputs with about 10 MW or larger capacity, the technically feasible potential was estimated at 122,640 GWh/year (14,000 MW).
- The International Energy Agency (IEA) estimates the economically feasible hydro potential at approximately 36,800 GWh/year (4,200 MW) (IEA Small Hydro website, 2004).
- In 1980, ADB conducted a comprehensive survey for hydro potential sites in 14 provinces (5 provinces were excluded). The survey report indicated large and medium and small hydro potential sites as follows.

**Table 4-11 Identified Hydro Potential Sites**

| Province | Large and Medium | Small |
|---|---|---|
| Central | 5 sites (866 MW) | 2 sites (3.25 MW) |
| East New Britain | 5 sites (117 MW) | 5 sites (5.0 MW) |
| East Sepik | 3 sites (53.75 MW) | - |
| Gulf | 6 sites (136 MW) | 1 sites (0.75 MW) |
| Madang | 1 site (90 MW) | 2 sites (4.32 MW) |
| Manus | 3 sites (10.8 MW) | 5 sites (2.86 MW) |
| Milne Bay | 6 sites (72.1 MW) | 1 site (0.16 MW) |
| Morobo | 2 sites (150 MW) | 8 sites (4.8 MW) |
| New Ireland | 1 site (6 MW) | 9 sites (11.55 MW) |
| Northern | 4 sites (65 MW) | 8 sites (16.25 MW) |
| North Solomons | 6 sites (232 MW) | - |
| Western | 3 sites (57.9 MW) | 4 sites (0.67 MW) |
| West New Britain | 2 sites (80 MW) | 15 sites (10.53 MW) |
| West Sepik | 2 sites (8.4 MW) | 1 site (0.12 MW) |
| Total | 2,005 MW | |

(2) Solar

Solar energy represents one of the largest potential sources of energy in PNG. The average insolation in most parts of the country is in the range of 400-800 W/m$^2$, with mean sunshine hours ranging from 4.5 - 8 hours a day. Insolation averages 6 kWh/m$^2$/day with average sunshine hours varying across the country. The driest location, Port Moresby, has 2,478 sunshine hours per year and a daily range of 5.8 to 8.2 hours. The lowest sunshine duration is at Tambul in the Western Highlands, with an estimated mean annual of 1,292 hours due to frequent fog and mist.

(3) Biomass

In PNG, there are many wood processing factories in West New Britain, East New Britain, Bulolo, Morobe, Panakawa, Western, and Port Moresby. These factories produce waste wood products providing the potential for using these for energy production. Next to wood processing, oil palm industry is a more popular business that has 323,900 tonnes/year (2002) in production and about 400 million Kina in export value (PNG Budget 2004). The largest company, New Britain Palm Oil Ltd. utilized waste of oil palm for generation of 2.5 MWh/year for their own use.

(4) Geothermal

No systematic assessment of PNG’s geothermal energy potential has been carried out. However, reconnaissance studies of the country’s geothermal potential suggest that the most promising area for investigation is the Northern coast of New Britain Island, from the Willaumez Peninsula Eastward to the Gazelle Peninsula. There are at least seven geothermal sites in the region: Bamus, Galloseulo, Walo, Kasoli-Hoskins, Garbuna, Pangalu-Talasea and Bola. There is only one geothermal power station (first 6 MW) built by Lihir Gold Ltd. in 2003. The station has expanded to 55 MW to cover all electricity of Lihir Gold Ltd. This project is also only one CDM approval project in PNG.

(5) Wind

In the late 1970s, an assessment of PNG’s wind resource was carried out by the Australian Commonwealth Industrial and Scientific Research Organisation (CSIRO). CSIRO estimated annual generation potential in 19 sites from 321 kWh/kW to 1,089 kWh/kW (average 607 kWh/kW). PREA 2004 reported that the latest technology improved the generation volume from 607 kWh/kW to about 2,600 kWh/kW. In general, commercial base wind power needs more than 25% capacity factor (2,190 kWh/kW), where the identified sites might be viable to build commercial base wind power but still require full resource monitoring and feasibility studies.

### 4.3.2 Donor Assistance

(1) Major Donors for Renewable Energy Development

(a) PNG Sustainable Energy Ltd. (PNGSEL)

PNGSEL has been established by PNG Sustainable Development Program Ltd. (PNGSDP) and Snowy Mountain Engineering Corporation (SMEC) investing 50:50 respectively. The main purposes of the company are management of Ok Tedi Mining Ltd (OTML), management of "Long Term Fund" and contribution to sustainable development of Western Province. The Long Term Fund provides monetary assistance to sustainable development of Western Province and the whole of PNG for 40 years after closure of the OTML. In this context, this seems one kind of compensation program for mining activities. The PNGSEL activities in renewable energy and rural electrification are summarized as follows.

**Rural Electrification (Distribution)**

- Western Province Small Distribution Projects: Rehabilitation of existing 6 grids (Wipim Balimo Awaba Morehead Lake Murray Obo Kaviananga). PNGSEL possesses and maintains the facilities.
- 40 Small Distribution Systems

**Rural Electrification (Solar)**

- Photovoltaic (PV) Panel Installation in 1,000 Households: Installation of PV panels for 1,000 non-electrified households around Fly River.
- Teacher's Solar Lighting Project: Installation of PV panels through 5 years low interest loan (Joint project with WB).
- Solar Projects in Mabuduwan and Tutuwe (Western Province)

**Rural Electrification (Small Hydro)**

- Murua Small Hydro and Water Supply Project: 2 MW hydro power development in Gulf Provice Murua River and water supply to 1,000 households in Keramam village.
- Hydro Potential Survey in New Ireland Province
- Survey on O'Mara Small Hydro Development: Survey on small hydro development with 1,150 households electrification in O'Mara River in Central Province.
- Togarao Hydropower Development: 2 MW hydropower development with 1,700 households electrification in Bougenville.

**Rural Electrification (Others)**

- Pomio Bio Diesel Project

**Commercial Base Hydropower Development**

- Kurumbakari Hydropower: 15 MW hydropower development in Madang Provice Imbrum River for Ramu Nickel Mine and villages around the mine.
- Pongema Hydropower Development: 3 MW hydropower development in Enga Province. It has 190 m head by run-off river type. The power is supplied to Porgera Mine and the villages around the mine.
- Study on Purari Hydropower Development: Planning of large-scale hydropower (estimated 1,800MW) in Gulf Province, Wabo River, and Purari Zriver. It plans to supply electricity to a planned aluminum refinery factory and PNG grid.

(b) World Bank (WB)

Through GEF, "Teacher's Solar Lighting Project" assisted for 2,500 solar PV by teachers in 5 provinces. The project provides purchaser training program in place, affordable financial package, certified solar PV catalogue, and battery recycling regulations.

(c) Asian Development Bank (ADB)

There are 2 on-going projects (technical assistance) from ADB as follows.

- Power Sector Development Plan (2007/5/25 approved): The project assisted power development plan of PNG including pre feasibility studies of hydro projects in Udava and Lake Kosipe.

- Power Sector Development Project (2008/8/8 approved): The project includes (i) updated least-cost power sector development plan, (ii) preliminary design and costing of prioritized core subprojects, (iii) financial and economic analysis of the power sector development plan and its core subprojects, (iv) environmental and social safeguards due diligence of the core subprojects, (v) climate-proofing analysis, (vi) recommendations for power sector governance framework, and (vii) public consultations and an awareness campaign.

(2) Past Experience in Renewable Energy

(a) Hydro (Community-Based Small Hydro)

Although a lot of small and mini hydro exists in PNG, there is limited information on community-based small hydropower station. PREA 2004 estimated that there may have been as many as 200 pico-, micro- and mini-hydro systems installed in rural PNG between 1960 and 2004. Of these, about 20-25% are still functioning with 20-25 systems still operational in Bougainville.

According to PREA 2004, from 1988 - 1997, Bougainville suffered from civil strife, and the island was blockaded by the GoPNG throughout much of the 1990s. Some communities used coconut oil to fuel vehicles and developed tiny hydro schemes to deliver very limited service (essentially lighting only), due to lack of voltage and frequency control. In 2001, Australian Appropriate Technology for Community and Environment (APACE) conducted a two-week training programme in Arawa for village operators of existing micro- and picohydro systems to improve safety and future design. The 55 participants represented some 40 communities, mainly from central Bougainville, which had established micro hydro during the conflict.

In 2002, Australia and New Zealand team held a pico-hydro forum in central Bougainville. This resulted in initiatives to use a pool of skilled labour to provide training and local manufacture of robust hydro turbines. PREA 2004 reported that, as a result of the training and forum, there is now a mechanical workshop in Arawa which has produced several good quality cross flow and pelton type pico-turbines.

(b) Solar

PV technology was introduced to PNG in late 1970s. Over the following 30 years, solar PV use has spread gradually through our PNG. The main applications of the solar PV systems are for lighting, radio communication, and home appliances.

The first large-scale user of solar PV is PNG Telecom which uses the technology to power repeater stations. PREA 2004 reported that a recently inventory including 173 sites where solar PV systems have been installed. PREA 2004 estimated that at the 173 Telecom sites, nearly 5,000 solar PV panels have been installed since 1978, with a combined capacity of over 200 kW.

As for donor assistance project, a project entitled ‘Solar Lighting Kits for Rural Primary Schools’ was carried out in 1997 in rural areas throughout the country. With a grant of K15.4 million from the Japan International Cooperation Agency (JICA), the project has electrified 320 schools in all 20 provinces. Each system included solar panels, a controller, a battery, four 40-watt lights and power outlets. According to PREA 2004, few of the systems were functioning by early 2004 due to several problems including the following:

- Lack of access to maintenance and support services. Although they were trained in maintenance, teachers in rural PNG are very mobile. Many who were trained had moved elsewhere so the maintenance capacity was lost. Although maintenance was available on a return-to-base arrangement, the transport costs were prohibitive for rural schools;
- Poor quality of installation. Some systems had the PV panels orientated in the wrong direction; and
- Poor security. Rural teachers rarely work in their home village and students are usually boarders. At the term breaks, schools tend to be empty but schools cannot afford security services. Even with strong mounting brackets, solar PV panels are vulnerable to theft and many have been stolen.

### 4.3.3 Needs Collected from the Interview

(1) Current Situation and Issues in Power Sector

This project conducted an interview survey with relevant agencies. From the interview survey the current situation and issues in the power sector of PNG are summarized as follows.

- There is a lot of hydro potential. However, the most critical issue in hydropower development is its location far from load centers. This means, utilization factor of hydropower might be limited and transmission lines might be difficult to construct and maintain due to land issues.
- PPL selects economically viable projects. This means that new electricity supply to rural area is slow due to higher construction costs including land compensation and maintenance.
- In rural area, road construction between cities does not proceed well due to difficulty with land acquisition. Transmission lines between existing grid systems, normally are constructed along inter-city roads, where difficulties are also experienced.
- As a result, the existing PPL system such as Port Moresby System has consumers who live in the city area. The daily load curve of Port Moresby System indicates a daytime peaking shape which is similar to advanced country's shape. It is guessed that main load in daytime is air-conditioning consumption of offices and other facilities.
- Current maximum demand in Port Moresby System is about 90 MW, where this is an almost constant load except for during the winter season (June to August). PPL power supply system sometimes encounters power supply shortage. To avoid such a situation eventuating PPL secures 7 MW from the private sector on an agreed tariff basis. Cooperative suppliers are compensated about 22 Toea/kWh, however this depends on a calculation formula.
- Only one CDM project has been approved in PNG (Lihir Geothermal). Office of Climate Change and Carbon Trade (OCCCT) established in 2008 and has the role of Designated National Agency (DNA) for CDM. However, according to the OCCCT staff, appraisal capacity for CDM should be improved allowing the development of further CDM applications.
- Currently some power stations have been maintained by local governments 3 years after DPE completed their installation. According to DPE staff, local government staff should be given training programmes for operation and maintenance (O&M).

(2) Needs of the Recipient Country

Through the interview survey, the following needs were identified from each agency.

(a) PNG Power Ltd. (PPL)

- Repowering of 2 units of Rouna No.1 (8 MW newly installation).
- Installation and repair of remote control system of Rouna No.1, 3, and 4 to control from Rouna No.2 Control Center.
- Repair of leaking penstocks of Rouna No. 3.
- Newly installation of small hydropower (about 500 kW) between Rouna No.2 and No.3.
- Feasibility study packaging the above components.

The profile of Rouna No.1-4 are shown as follows.

**Table 4-12 Profile of Rouna No.1-4**

| | Commissioning | Installed Capacity | Current Capacity | Note |
|---|---|---|---|---|
| Rouna 1 | 1957 | 1 MW | Demolished | Newly 8 MW installation is expected instead of demolished 2 MW. |
| | 1957 | 1 MW | Demolished | |
| | 1957 | 1 MW | 1 MW | |
| | 1961 | 2.5 MW | 2.5 MW | |
| Rouna 2 | 1967 | 6 MW | 8 MW | Repowering in 2008 (using local commercial loan) |
| | 1967 | 6 MW | 6 MW | |
| | 1967 | 6 MW | 6 MW | |
| | 1967 | 6 MW | 8 MW | Repowering in 2008 (using local commercial loan) |
| | 1967 | 6 MW | 8 MW | Repowering in 2008 (using local commercial loan) |
| Rouna 3 | 1975 | 6 MW | 6 MW | |
| | 1975 | 6 MW | 6 MW | |
| Rouna 4 | 1986 | 6.5 MW | 6.5 MW | Japanese ODA project |
| | 1986 | 6.5 MW | 6.5 MW | Japanese ODA project |

(b) Department of Petroleum and Energy (DPE)

- Small hydro potential sites development in 14 provinces identified by ADB study in 1980.
- Training program of O&M for operators of power facilities in local governments.

(c) Office of Climate Change and Carbon Trade (OCCCT)

- Capacity building for appraisal staff of CDM
- Training program for renewable energy and energy efficiency in Japan

### 4.3.4 Consideration of Cooperation Fields

(1) Consideration

(a) Middle Scale Hydro in On-Grid System

In existing grid of PPL, Port Moresby System has met shortage situation in power supply. To avoid increase of diesel generation, renewable energy generation is crucially required. The most realistic generation except for diesel generation is hydropower in Port Moresby System. However, considering land and the associated compensation issues, location should be close to load center. In this context, ADB is now assisting with the preparation of pre-feasibility studies for 2 middle scale hydropower sites near Port Moresby (Udava and Lake Kosipe). However, these projects probably need several (or ten years) to complete feasibility study, EIA, and construction. Therefore these two projects need to be considered over a longer-term time span.

On the other hand, considering a short or middle-term time span there is one potential project that would have the effect of increasing capacity of Port Moresby System through using renewable energy, where this is repowering of existing Rouna No.1 (increase of 8 MW). This utilizes existing facilities / infrastructure so the environmental and social issues would be minimised. At first, a feasibility study for the repowering and other components requested is expected

(b) Small Hydro in Off-Grid System

As for off-grid electrification, DPE has an expectation of small hydro development in 14 provinces. However, the expectation is based on the ADB study conducted in 1980. As for small hydro in off-grid, a master plan study including updating of demand forecast of area is one candidate of cooperation fields. Training of local government staff is possible to be included in the master plan study.

(c) Training Program

Training program can be provided through 2 ways, namely dispatching expert and invitation to Japan. Capacity building for appraisal staff of CDM can be assisted through dispatching expert.

Training program for renewable energy and energy efficiency can be held in Japan. Training program in Japan expects the following agenda.

- Site visits to view each renewable energy projects
- Lecture for planning and design of large scale grid-connected solar power
- Lecture for design and site visit of solar home system (captured and reverse flow)
- Lecture for planning and design of wind power
- Lecture for planning and design of small hydropower
- Lecture for energy conservation programs
- Site visits of each energy efficiency technology
- Lecture for maintenance of solar and small hydropower
- Factory tour for solar and small hydropower

The above programs in the recipient country and Japan can be conducted through a regional assistance program.

## 4.4 Current Situation of Energy Conservation and a course of Action

### 4.4.1 Current Situation

(1) Power Sharing Program

As demand side management, PPL has implemented a program, “Power Sharing Program”, that is power supply from contracted private sector (self owned and operated diesel generators) in emergency cases. PPL can request 7 MW to contracted counterparts at this moment.

(2) Power Factor Improvement

PPL is planning to improve power factor of large consumption customers (not less than 200 kW). PPL plans to compensate for the installation cost of capacitors in consumers equipment (motors etc) where high loads are metered on start up.

### 4.4.2 Consideration of Cooperation Fields

As for energy efficiency including energy conservation, PNG seems to be at a beginning stage. To find appropriate measures for PNG, staff in charge of energy efficiency should be trained through training program in Japan.

# Chapter 5. Solomon Islands

## 5.1 Profile of the Country

### 5.1.1 General Information

(1) General Information

The Solomon Islands, which became an independent member of the British Commonwealth on 7 July 1978, is one of the island countries located in South Pacific Ocean. The capital city is Honiara. The total land area is 28,370 km$^2$ and the islands are located between 5°and 12° South latitude and 155°and 170° East longitude. The country consists of six major islands including Guadalcanal, Malaita, Santa Isabel, New Georgia, Choiseul and San Cristobal, and about 1000 small islands and stretch in the form of double chains in the north-eastern direction from the Bougainville Island of Papua New Guinea. Over 90% of the population of about 500,000 is Melanesian, with Polynesians and Micronesians making up most of the remainder.


**Figure 5-1 Map of Solomon Islands**

(2) Economy

(a) Main Industry

Agriculture (Copra, Wood), Fishery (Source: Website of MOFA of Japan)

(b) Gross National Income (GNI)

0.36 billion US$ (2007) (Source: Website of MOFA of Japan)

(c) GNI per Capita

730 US$ (2007) (Source: Website of MOFA of Japan)

(d) Economic Growth

5.7% (2007) (Source: Website of MOFA of Japan)

(e) Inflation Rate

4.7% (2007) (Source: Website of MOFA of Japan)

(f) Trading Amount

Export: 101.2 million US$ (2005)
Import: 118.3 million US$ (2005)
(Source: Website of MOFA of Japan)

(g) Trading Item (2004)

Export: Wood, Fish, and Cocoa
Import: Fuel, Food, and Machine/Vehicle
(Source: Website of MOFA of Japan)

(h) Trading Countries (2003)

Export: China, Korea, and Thailand
Import: Australia, Singapore, and New Zealand
(Source: Website of MOFA of Japan)

(i) Currency

Solomon Dollars (SI$), 11.73 JY= 1 SI$ (Source: Central Bank of Solomon Islands 2009/5/25)

(3) Japan's Cooperation

Record of Japan's cooperation to Solomon Islands is shown below, which are ODA loans, Grant Aid and Technical Cooperation.

**Table 5-1 Record of Japan's Cooperation**

| | 2007 | Accumulated Amount by 2007 |
|---|---|---|
| ODA Loan | 0 | 0 Billion Yen |
| Grant Aid | 208 million Yen | 17.95 Billion Yen |
| Technical Cooperation | 353 million Yen | 8.0 Billion Yen |

(Source: MOFA of Japan, April 2009)

### 5.1.2 Geography and Weather

(1) Geography

The Solomon Islands is a complex island arc. Most of the territory belongs to the Solomon arc, which includes the six major islands. Temotu province including the Santa Cruz Islands belong to the Vanuatu arc. The Solomon arc are arranged in an echelon double chain. This arc stretches in a NW-SE direction and the six major islands have the same long axes.

(a) Guadalcanal

The island is 160 km long by 30 to 48 km wide, and has an area of 5,336 $km^2$. It is characterized by East-West belt like regions, and the elevation decreases toward the North. The Northwestern Volcanic Area has up to 1,000m in height, steeply dissected cones with well-developed radial drainage.

(b) Malaita

The island is 191 km long by 20 to 40 km wide, and has an area of 4,225 $km^2$. It is characterized by a NNW-SSE trend major axis with echelon ridge-bay arranges, and elevations are symmetrical toward both coasts. The Northern and Western Foothills to terraces are below 200 m in height. The Northern and Central to the Southern Hills and Mountains are 200 to 1,300m in height.

(c) Santa Isabel

The island is 200 km long by 20 to 30 km wide, and has an area of 4,136 $km^2$. It is characterized by NW-SE belt like regions and symmetrical elevations toward both coasts. The Central Ridges, Mountains or Plateaus are over 600 to 1,000m in height, long narrow spine.

(d) New Georgia Group

The group area is 200 km long by 50 km wide, and has an area of 5,475 $km^2$. The main volcanic chain is 700 to 1,800m in height, and consists of largely of composite volcanic cones, or their remnants.

(e) San Cristobal

The island is 139 km long by 25 to 40 km wide, and has an area of 3,188 $km^2$. The Western Terraces and Hills, Northern Foothills and Plains are mainly below 200m in height and have an upraised reef coast. The Western Lowlands and Ridges are below 600m in height, characterized by close-spaced narrow steep valleys and gorges.

(f) Choiseul

The island is 161 km long by 20 to 35 km wide, and has an area of 3,537 $km^2$. Northwest hills are below 400m in height, rolling hills with moderate to gentle slopes interspersed with rocky outcrops and gorge-like valleys. Central highlands, covering two thirds of the island, is a generally rugged region up to 1,000m in height with a dominant NW-SE to the angular, largely fault controlled drainage pattern.

(g) Santa Cruz Islands

The island has another name Nendo Island, is 46 km long by 10 to 15 km wide, and has an area of 604 $km^2$. Central Ridges and Cuestas Area is ridges of the island, has up to 520m in height, steeply dissected. Eastern Plateau and Plains Area, 300 to 500m in height, is formed by high-level alluvial valleys among rocky karst and low volcanic ridges. Western Plateaux Area is extensive raised reef, has up to 160m in height, consists of level to gently rolling land, and stepped limestone cliffs on seaward margins.

(2) Weather

Solomon Islands has a climate that is typical of any tropical region being warm and humid. The temperature shows little variation during the year, with a mean daily maximum temperature of about 30 degrees celsius and a mean daily minimum of about 23 degrees celsius. Rainfall distribution in Solomon Islands varies a lot over space and time. The annual average rainfall is normally within the range 3000 to 5000mm. Often drought in the country is associated with the El Nino Southern Oscillation phenomenon (ENSO). From about December to March, is a period of west to north-westerly monsoonal winds and abundant rainfall can be expected. This is also a period where tropical cyclones could form and affect the islands. The south-east trade winds (SE trades) blows from around May to October and could trigger higher rainfall particularly on the windward side of the islands. The average temperature and rainfall are shown in the next tables.

**Table 5-2 24 Hours Average Temperature (Solomon Islands)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| °C | 26.8 | 26.7 | 26.6 | 26.6 | 26.6 | 26.3 | 26.0 | 26.0 | 26.3 | 26.5 | 26.6 | 26.7 | 26.5 |

(Source: World Climate Website, 1951 and 1990, Weather station at about 9.42°S 160.00°E. Height about 8m / 26 feet above sea level.)

**Table 5-3 Monthly Average Rainfall (Solomon Islands)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 281.5 | 293.0 | 316.6 | 201.6 | 130.9 | 82.6 | 97.7 | 97.6 | 98.3 | 129.7 | 155.8 | 220.4 | 2093.5 |

(Source: World Climate Website, 1951 and 1990, Weather station at about 9.42°S 160.00°E. Height about 8m / 26 feet above sea level.)

## 5.2 Outline of the Power Sector

### 5.2.1 Legal Framework of the Power Sector

The legal system of the Solomon Islands is built on the constitution, which has primacy, a system of Customary Law that is derived from the countries indigenous traditions and English Common law inherited from its colonial past. The National parliament is empowered under the constitution to enact laws. Legislation dealing directly or indirectly with the power sector is outlined as follows:

(1) Electricity Act:

The electricity act was enacted in 1969 and provides for the establishment of the Solomon Islands Electricity Authority and authorizes it to provide electricity to urban and provincial centres and other supply areas as instructed by the Minister.

Electricity supplies provided by anyone other than SIEA must be licensed. The licensing system authorizes private and community-based operators to supply rural areas and establishes a mechanism for regulating their activities and maintaining appropriate safety and technical standards. Licenses are issued by SIEA. SIEA is also the authority for licensing electricity installations and electricity contractors and electricians.

Exemptions to licensing provisions of the Act are specified in the electricity (Exceptions) Order (1992) where supplies less than 50 kW are exempt unless they serve hotels, resorts, labour lines or staff quarters) and this puts the majority of rural electrification schemes beyond the control of the licensing system.

The authority to sell electricity under a license applies only within defined geographical areas specified in the license. The maximum term for license is 21 years unless excess approval is obtained by the Minister.

(2) Environment Act:

The Environment Act (1998) was gazetted in 2003 but regulations are not yet in place. However the areas of focus/attention of the Environment Act are to:

- Provide for and establish integrated systems of development control, environment impact assessment and pollution control;
- Prevent control and monitor pollution;
- Reduce risks to human health and prevent degradation of the environment by all practical means; and
- Comply with and give effect to regional and international conventions and obligations relating to the environment.

(3) River Waters Act (1964)/ Water Resources Bill (2001)

In the generation of electricity for hydropower, there will be some form of impact on the river and stream on which they are sited. They therefore have to be developed within the constraints of the River Waters Act and when it is passed by law, and then it will have to comply with the criteria of the Water Resources Bill (still in draft format). The stated purpose of the River Waters Act is to provide for the control of river waters and for its equitable and beneficial use.

(4) Provincial Government Act (1981)

The Provincial Government Act establishes provincial administrations in the Solomon Islands where the Act provides for the creation of a provincial executive to undertake the function and exercise the powers as set out in the Act and as ordered by the Minister. With respect to the supply of electricity, the provincial executive may provide services in respect of any matters listered in the schedule of the Act.

(5) Land Tenure Legislation

Land in the Solomon Islands is a sensitive issue; group and individual identity are defined by their relationship with the land. Two distinct systems of land tenure exist in the Solomon Islands. Alienated Land which comprise of 13% of total land area was procured during the colonial times and the Customary Land comprising of 87% of total land area and is based on traditional tenure and boundaries. Ownership of customary land in cases in Solomon Islands are officially clarified in some areas but not in others. The following are key land legislations governing land acquisition for development:

- Land and Titles Act (1969); and
- The Customary Land Records Act (1994).

(6) Other Minor and Relevant Legislation

The following Acts also governs the power sector legal frame work.

- Consumer Protection Act (1996) and Price Control Act (1975);
- Companies Act (1961);
- Labour legislation;
- Town and Country Planning Act (1980); and
- Foreign Investment Act:

### 5.2.2 Institutional Framework of the Power Sector

(1) Structure of the Power Sector

The power sector is broadly grouped into two categories – Implementation institutions and the regulatory institutions. Those such as SIEA, various NGOs and private sector entities that are involved in the implementation of projects, and those such as MMERE, Department of Commerce, Industries and Employment, Chiefs Committees and Customary Lands Appeal Court that play a regulatory role.

The roles and duties of the main participants in the development, operation and regulation of the power sector are outlined below.

(a) Ministry of Mines, Energy and Rural Electrification (MMERE)

Responsibility for electricity falls under the Ministry of Mines, Energy and Rural Electrification. The Ministry through the Energy Division is represented on board of SIEA and performs the regulatory role in overseeing its performance. It is directly responsible for promoting rural electrification and developing renewable energy in the Solomon Islands.

Figure 5-3 provides an outline of the organisation chart for the Ministry of Mines, Energy and Rural Electrification showing the various areas which the Ministry is responsible for:

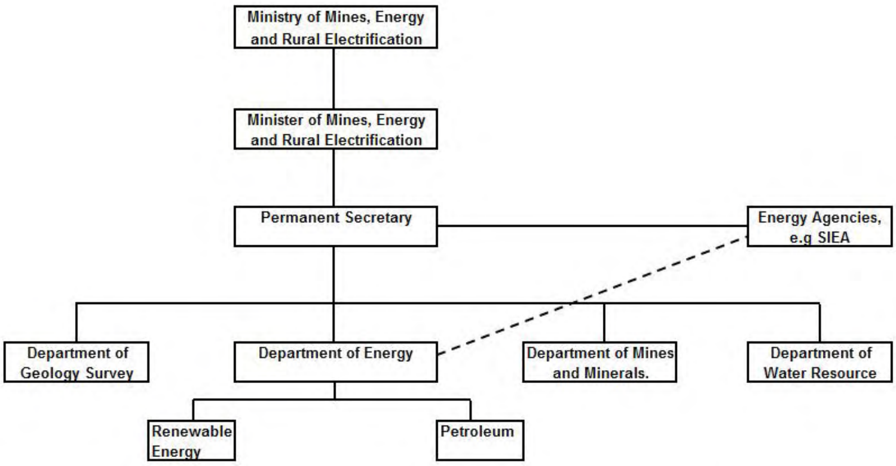



**Figure 5-2 Ministry of Mines, Energy and Rural Electrification**

(b) Department of Energy (DOE)

The department of Energy is established under MMERE to oversee the management of four important areas of Natural resource management.

- Administer relevant legislation, including the Electricity Act, River Waters Act, Petroleum Act and the Solomon Islands Water Act.
- Bear responsibility for the statutory authorities dealing with natural resources, including SIEA and SIWA.
- Liase with regional and international organizations and to act as the focal institution for the implementation of regional and international conventions, treaties and programs in matters relating to Earth Science, natural resources and energy.
- Execute activities and pursue targets relating to natural resources and energy as specified in the Government' national policies and development plans.

Energy Division is the unit within the Department administering electricity, petroleum, renewable energy and rural electrification. Among its current responsibilities are policy formulation, legal and regulatory development and institutional strengthening.

(c) Solomon Islands Electricity Authority (SIEA)

The generation and distribution of electricity within urban populations for the Solomon Islands is the responsibility of the Government owned Solomon Islands Electricity Authority (SIEA). SIEA is responsible for supplying the capital (Honiara), eight provincial centers and the township adjoining the Noro fish processing facility. The present installed capacity is in the order of 25

MW, almost all being diesel generation but 0.18 MW from two micro-hydro schemes, providing total energy production in excess of 30 GWh/year.

(d) Provincial Governments

Being the tier of government closest to village affairs, provincial governments could be expected to play an important role in the planning an implementation of rural electrification schemes where by this is reflected in the provincial Government Act which states that a Provincial Executive may provide services for the province, including the supply of electricity outside the supply areas.

(e) Environment and Conservation Division

The Environment and Conservation Division of the Department of Forest, Environment and Conservation is responsible for overseeing the application of the Environment Act.

(f) Price Control Unit

The Price Control Unit of the Ministry of Commerce and Industry is responsible for reviewing and controlling prices of prescribed products and services which are listed in schedules to the Price Control Act and electricity services are included among them.

By this process, SIEA provides a submission for tariff adjustments through the Department of Energy for reviewing the submission before forwarding them to the Price Control Unit for approval. As per discussion with management from SIEA, the automatic Fuel Adjustment Mechanism adjusts prices quarterly without intervention by the Price Control Unit.

(g) Non- Governmental Organisations

Several NGOs are active in the Solomon Islands in promoting and developing rural electrification. The following is a description of the more prominent examples:

1) Solomon Islands Village Electrification (SIVEC)

SIVEC is an NGO committed to community based village electrification where it has representation from the community, NGOs and the Government and advises the Government and advises the Government on Village electrification policy. It works closely with APACE, an Australia NGO with expertise in the development of micro-hydro systems.

SIVEC draws upon political, community and grassroot support for resources and assistance but has been constrained in its activities. As reported from the ADB Power Development plan (main report), these constrains are due to inadequate institutional capacity at the principal and village level, a lack of support in the operation and maintenance of village schemes and the lack of funding for implementing projects.

2) Solomon Islands Rural Electrification Agency (SIREA)

SIREA formerly known as the Guadalcanal Rural Electrification Agency (GREA) is a local partner of the Solar Electric Fund (SELF). Its main focus is electrification using PV systems and their main area of activities to date have been around Guadalcanal.

SIREA’s financing model uses instalment credit for the purchase of solar home systems (SHS) accessed through a revolving credit fund managed by SIREA; participants make a down payment to the fund managed by SIREA; followed by monthly instalments over a four-year period. Money repaid to the fund allows the entry of new participants.

(h) Private Sector Participants:

Currently the private sector plays only a minor role in electricity supply in the Solomon Islands, but their involvement provides experience to build on. The following are of three prominent private participants:

1) Willies Electrical and Solar Power:

Willies electrical and solar power specializes in solar PV systems. Its activities include standard or customized project installation and training in their use. Among Willies customers are government institutions, churches, rural industries and individuals. Solar PV products marketed by Willies include solar panels, batteries, lights, controllers and solar appliances such as fridges, lights and radios. Willies receive British funding support for some of its operations and most of its trade is funded by development agencies.

Training is a core activity. In-house training programmes are offered in basic electricity and solar PV installation (certificate), or through a TAFE programme in Sydney. Willies also works with the Department of Fair Trading in Sydney in training electricians.

2) Solomon Islands Tropical Products Limited (STP)

STP is running a pilot project with aims to commercialize the production of coconut oil where as part of their development models, STP plans to electrify villages using raw coconut oil as a fuel.

(2) Organizations in Charge of Renewable Energy

The Ministry of Mines, Energy and Rural Electrification through SIEA and the Department of Energy is directly responsible for developing renewable energy in the Solomon Islands. Description of the activities undertaken by these organisations is described in the institutional framework of the power sector.

### 5.2.3 Management of Organisation in Charge of Renewable Energy

Under the Ministry of Mines, Energy and Rural Electrification (MMERE) following is a summary break down of the two main organisations in charge of renewable energy projects in the Solomon Islands – refer to the next table. Unfortunately no annual reports were made available. Figures obtained were from the preparative study interviews.

**Table 5-4 Management of Organisation**

| | SIEA | ED - MMERE |
|---|---|---|
| Budget allocation | For 2009 under the proposed budget, SIEA plans to spend $221,702,344 SBD for operations, administration and maintenance**.** | As per discussion with the Energy Officers, a rough figure of around SBD 5 million was the proposed budget for operations, administration and maintenance |
| No of staff | As per the monthly reports for the first six months of 2008, there were an average number of 212 employees by forecasting at end of the year in 2008, SIEA total employee stands at around 220 persons. | From the interview meeting it was identified that the Department of Energy currently have 11 staffs. |

### 5.2.4 Laws and Regulation regarding the Renewable Energy

As per the endorsed National Energy Policy for the Solomon Islands laws and regulations, the following policy statements describe the commitment of the Solomon Islands Government to Renewable Energy development.

- Promote the use of renewable energy resources.
- Ensure the renewable energy resources are used in an economically and environmentally sustainable manner.
- Support efforts on research and development of appropriate renewable energy technologies.

### 5.2.5 Power Demand and Supply Status

(1) Power Network System

Most of all power supply sources of Solomon Islands are diesel power, while two-small hydropower systems are installed in Buala 150kW (Santa Isabel Island) and Malu'u 35kW (Malaita Island). Both the diesel and hydro have been operated by SIEA.

(a) Honiara-Lungga

The available rating of the Lungga power station is 14,250 kW (5 units), and that of the Honiara power station is 1,950 kW (3 units), being the total available rating 16,200 kW (8 units) in the Honiara-Lungga Grid. The power stations in Lungga and Honiara are connected by 33kV and 11kV overhead line and underground cable. In Honiara city, 11kV distribution lines constitute the base grid, and the distribution to each user is provided by a 3-phase 4 wire distribution line after step down to 415 V by an 11kV/415V transformer.

(b) Auki

The available rating in Auki power station, which has been operated since 1991, is 600 kW (3 units), but 2 units are currently out of order, therefore, available capacity is 200kW as of April 2009. In Auki, the main centre in the Malaita Province, 11kV distribution lines constitute the base grid, and the distribution to each user is provided by a 3 phase 4 wire distribution line after step down to 415V by a 11kV/415V transformer.

(c) Malu’u

The available rating in Malu’u power station, which has been operated since 1984, is 35 kW (1 unit). Since January 2009, the power station has stopped operation due to water right dispute with the villagers who lives at the upper stream of the river. In Malu’u, the second main city in Malaita Province, the power generated at 415 V is stepped up to 11 kV, and distributed to the each user by a 3 phase 4 wire distribution line after step down to 415 V by an 11 kV/415 V transformer.

(d) Buala

A hydropower station was installed in 1993, and new diesel generator was newly replaced in 2006. Therefore, total generation capacity becomes 253kW. However, due to mechanical problems, hydro unit has been stopping operation at this moment. The generated power at 415V in the hydropower station is distributed to each user in Buala, the main centre of Isabel Province, and Jejevo centre, near from Buala, directly by a 3 phase 4 wire distribution line without transformation.

(e) Kirakira

At Kirakira power station, new diesel generator of 100kW was installed in 2005, and total capacity became 207 kW. However, old 2 units has been out of order due to mechanical problems. Therefore, actual capacity at this moment is just 100kW from the new unit. Because the town area is small in Kirakira, the main centre of Makira Province, the generated power at 415V is distributed to each user directly by a 3 phase 4 wire distribution line without transformation.

(f) Lata

Total capacity of the Lata power station becomes 208kW since the new diesel generator of 103kW was installed in 2005. However, one unit was broken due to mechanical problem, and available capacity is 163kW at this moment. Because the town area is small in Lata, the main centre of Temotu Province, the generated power at 415V is distributed to each user directly by a 3 phase 4 wire distribution line without transformation.

(g) Gizo

Three units of new diesel generators of 260kW were newly installed and total capacity becomes 780kW. However, due to mechanical problems, available capacity decreased to 200kW at this moment. In Gizo, one of the main centres in the Western Province, 11kV distribution lines constitute the base grid, and the distribution to each user is provided by a 3 phase 4 wire distribution line after step down to 415V by an 11kV/415V transformer.

(h) Noro-Munda

The two outstations in Noro and Munda were connected by an 11 kV underground transmission line in 1996, and the two diesel power units in Munda were transferred to the Noropower station at the same time. The available rating of the Noro power station, which has been operated since 1987, is 2,700kW (3 units). However, one unit is scheduled to retired soon, and total available capacity is 1,800 kW. 11 kV distribution lines constitute the base grid, and the distribution to each user is provided by a 3 phase 4 wire distribution line after step down to 415V by an 11 kV/415 V transformer.

(i) Tulagi

In 2005, new diesel generator of 129 kW was installed and total capacity increased to 305kW. Hwever, No.1 unit (88kW) is currently out of order due to mechanical problem, and even No.2 (88kW) unit's available capacity decreased to 45kW due to deterioration of mechanical conditions. As a result, total available capacity is 174kW at this moment. In Tulagi, the main centre of Central Province, the generated power at 415V is stepped up to 11kV, and is distributed to each user by a 3 phase 4 wire distribution line after step down to 415V by an 11kV/415V transformer.

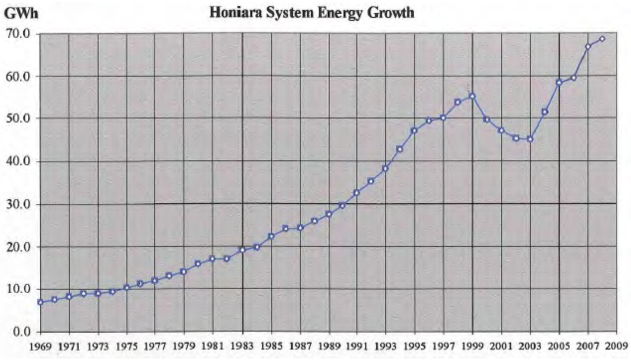
**Table 5-5 Existing Generators (Provincial-wise/Islands-wise)**

| Name of Province/Island | Name of P/S | Type of P/S | Unit No. | Name plate Rating | De-Rated (kW) | In Service | Available (kW) | Installed Year | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Guadalcanal P. /Guadalcanal | | | | 30,800 | 16,200 | | 16,200 | | |
| | Honiara | | | 5,100 | 1,950 | | 1,950 | | |
| | | Diesel | 1 | 1,700 | 650 | no | 0 | 1997 | Out of service |
| | | | 2 | 1,700 | 700 | yes | 700 | 1997 | Out of service |
| | | | 3 | 1,700 | 600 | yes | 600 | 1997 | In service |
| | Lungga | | | 25,700 | 14,250 | | 14,250 | | |
| | | Diesel | 4 | 1,500 | 0 | no | 0 | 1971 | Retired in 2007 |
| | | | 5 | 1,500 | 850 | yes | 850 | 1971 | In service |
| | | | 6 | 2,900 | 2,300 | yes | 2,300 | 1998 | Out of service |
| | | | 7 | 2,800 | 0 | no | 0 | 1987 | Retired in 2003 |
| | | | 8 | 4,300 | 0 | no | 0 | 1993 | Retired in 2004 |
| | | | 9 | 4,200 | 3,200 | yes | 3,200 | 1999 | In service |
| | | | 10 | 4,300 | 3,800 | yes | 3,800 | 2005 | In service |
| | | | 11 | 4,200 | 4,100 | yes | 4,100 | 2006 | In service |
| Malaita P. /Malaita | | | | 875 | 685 | | 200 | | |
| | Auki | | | 780 | 600 | no | 200 | | |
| | | Diesel | 1 | 260 | 200 | no | 0 | 1991 | Out of service |
| | | | 2 | 260 | 200 | no | 0 | 1991 | Out of service |
| | | | 3 | 260 | 200 | yes | 200 | 1991 | In service |
| | Malu'u | | | 95.0 | 85.0 | | 0.0 | | |
| | | Hydro | 1 | 35.0 | 35 | no | 0 | 1984 | Shutdown due to land and water right issues |
| | | Diesel | 1 | 60.0 | 50 | no | 0 | 1996 | Out of service |
| Isabel P. /Santa Isabel | | | | 253 | 203 | | 203 | | |
| | Buala | | | 253 | 203 | | 203 | | |
| | | Diesel | 1 | 103 | 103 | yes | 103 | 2006 | In service |
| | | Hydro | 1 | 150 | 100 | no | 0 | 1993 | Out of service |
| Makira P. /San Cristobal | | | | 296 | 207 | | 100 | | |
| | Kirakira | | | 296 | 207 | | 100 | | |
| | | Diesel | 1 | 80 | 57 | no | 0 | 1998 | In service |
| | | | 2 | 91 | 50 | no | 0 | 1993 | Out of service |
| | | | 3 | 125 | 100 | yes | 100 | 2005 | In service |
| Temotu P. /Nendo | | | | 308 | 208 | | 208 | | |
| | Lata | | | 308 | 208 | | 208 | | |
| | | Diesel | 1 | 88 | 45 | no | 0 | 1993 | Out of service |
| | | | 2 | 88 | 60 | yes | 60 | 1995 | In service |
| | | | 3 | 132 | 103 | yes | 103 | 2005 | In service |
| Western P. /New Georgia | | | | 4,380 | 3,300 | | 3,100 | | |
| | Gizo | | | 780 | 600 | 0 | 400 | | |
| | | Diesel | 1 | 260 | 200 | yes | 200 | 2003 | In service |
| | | | 2 | 260 | 200 | no | 0 | 2002 | Out of service |
| | | | 3 | 260 | 200 | yes | 200 | 2002 | In service |
| | Noro | | | 3,600 | 2,700 | | 2,700 | | |
| | | Diesel | 1 | 1,200 | 900 | yes | 900 | 1987 | In service |
| | | | 2 | 1,200 | 900 | yes | 900 | 1987 | In service |
| | | | 3 | 1,200 | 900 | no | 0 | 1987 | Will be retired |
| Central P. /Tulagi | | | | 305 | 234 | | 234 | | |
| | Tulagi | | | 305 | 234 | | 174 | | |
| | | Diesel | 1 | 88 | 60 | no | 0 | 1998 | Out of service |
| | | | 2 | 88 | 45 | yes | 45 | 1993 | In service |
| | | | 3 | 129 | 129 | yes | 129 | 2004 | In service |

(Source: SIEA, as of April 2009)

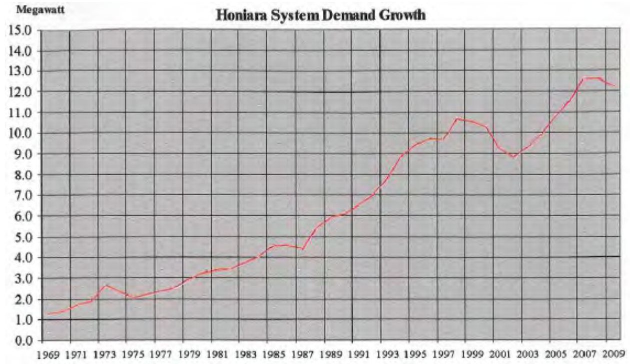
(2) Electricity Consumption in the Past

The following figures show electricity consumption in SIEA's Honiara system from 1969 through 2008. It has continuously increased in line with economic development. During ethnic tension, consumption had rapidly decreased due to the economic recession.




(Source: SIEA 2008)

**Figure 5-3 Honiara Demand Growth (kWh)**




(Source: SIEA 2008)

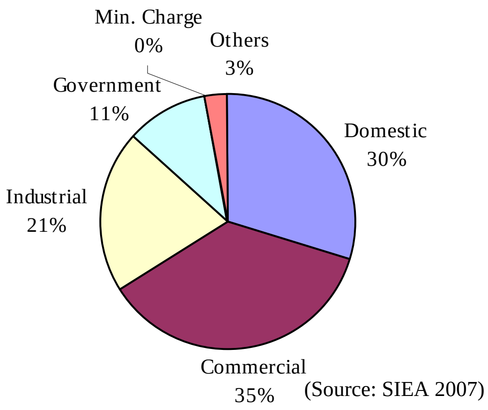
**Figure 5-4 Honiara Demand Growth (MW)**

(3) Customer-wise consumption

The following left figure shows, total consumption is composed of domestic consumers accounted for 30%, commercial for 35%, Industrial for 21%, government for 11%, and others for 3%.

(4) Load Curve of Honiara-Lungga Grid

The typical load curve of the Honiara-Lungga Grid System (March 2009) is shown in the right figure. The demand rapidly increases from 08:00 AM and continues to 17:00 PM. It is guessed that the shape of the load curve is led by office, service and industry sectors that use electricity in the daytime and the weekend.




(Source: SIEA 2007)

**Figure 5-5 Customer-wise Consumption**


(Source: SIEA 2008)

**Figure 5-6 Typical Daily Load Curve (Honiara-Lungga Grid)**

5.2.6 Power Development Plan (PDP)

The next table shows historic generation and sales of electricity and forecasts for 2003-2015. The forecasts assume projected average annual growth rate of 5.5-5.8% for generation and sales, according to the SIEA document in 2009. For the past years, peak demand has usually exceeded firm capacity. This continuous shortage is caused by not only insufficient investment for generation but also a lack of maintenance capability and capacity.

**Table 5-6 Power Balance in Honiara-Lungga Grid (2003-2015)**

| FY | | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 Peak Demand | | | 9,280 | 9,900 | 10,500 | 11,100 | 12,150 | 12,900 | 13,700 | 14,500 | 15,400 | 16,300 | 17,300 | 18,300 | 19,400 |
| Total Rated Output | | | 21,500 | 12,900 | 15,200 | 18,000 | 22,200 | 22,200 | 22,200 | 22,200 | 22,200 | 22,200 | 19,000 | 17,300 | 15,600 |
| Derating Factor (%) | | | 74.0% | 83.7% | 64.5% | 71.1% | 60.4% | 73.0% | 74.3% | 72.5% | 72.1% | 69.8% | 74.2% | 76.9% | 80.8% |
| Honiara P/S | #1(1997) | 1,700 | 1,000 | 0 | 700 | 700 | 700 | 650 | 650 | 650 | 600 | 600 | retired | | |
| | #2(1997) | 1,700 | 800 | 0 | 700 | 700 | | 700 | 650 | 650 | 650 | 600 | 600 | retired | |
| | #3(1997) | 1,700 | 1,000 | 0 | 700 | 700 | 600 | 600 | 600 | 550 | 550 | 550 | 500 | 500 | retired |
| | #5(1985) | 1,700 | 500 | retired | | | | | | | | | | | |
| | #6(1985) | 1,700 | 500 | retired | | | | | | | | | | | |
| 2.1 Supply of Honiara P/S | Total | 8,500 | 3,800 | 0 | 2,100 | 2,100 | 1,300 | 1,950 | 1,900 | 1,850 | 1,800 | 1,750 | 1,100 | 500 | 0 |
| Lungga P/S | #4(1971) | 1,500 | 900 | | 800 | | | retired | | | | | | | |
| | #5(1971) | 1,500 | 900 | 900 | 800 | 800 | 900 | 850 | 800 | 750 | 700 | 650 | retired | | |
| | #6(1998) | 2,900 | 2,300 | 2,200 | 2,200 | 2,100 | | 2,300 | 2,300 | 2,200 | 2,200 | 2,100 | 2,100 | 2,000 | 2,000 |
| | #7(1987) | 2,800 | 0 | retired | | | | | | | | | | | |
| | #8(1993) | 4,300 | 4,000 | 3,800 | retired | | | | | | | | | | |
| | #9(1999) | 4,200 | 4,000 | 3,900 | 3,900 | 3,800 | 3,200 | 3,200 | 3,700 | 3,600 | 3,600 | 3,500 | 3,400 | 3,400 | 3,300 |
| | #10(2005) | 4,300 | 0 | | | 4,000 | 3,800 | 3,800 | 3,700 | 3,700 | 3,700 | 3,600 | 3,600 | 3,600 | 3,500 |
| | #11(2006) | 4,200 | 0 | | | | 4,200 | 4,100 | 4,100 | 4,000 | 4,000 | 3,900 | 3,900 | 3,800 | 3,800 |
| 2.2 Supply of Honiara P/S | Total | 25,700 | 12,100 | 10,800 | 7,700 | 10,700 | 12,100 | 14,250 | 14,600 | 14,250 | 14,200 | 13,750 | 13,000 | 12,800 | 12,600 |
| 2.3 Total Available Capacity(A.C) | | 34,200 | 15,900 | 10,800 | 9,800 | 12,800 | 13,400 | 16,200 | 16,500 | 16,100 | 16,000 | 15,500 | 14,100 | 13,300 | 12,600 |
| 3.0 Power Balance (A.C-Demand) | | | 6,620 | 900 | -700 | 1,700 | 1,250 | 3,300 | 2,800 | 1,600 | 600 | -800 | -3,200 | -5,000 | -6,800 |
| 4.0 A.C of the Largest Unit | | | 4,000 | 3,900 | 3,900 | 4,000 | 4,200 | 4,100 | 4,100 | 4,000 | 4,000 | 3,900 | 3,900 | 3,800 | 3,800 |
| 5.0 Stable Capacity (2.3-4.0) | | | 11,900 | 6,900 | 5,900 | 8,800 | 9,200 | 12,100 | 12,400 | 12,100 | 12,000 | 11,600 | 10,200 | 9,500 | 8,800 |
| 6.0 Urgent Reserve Capacity (5.0-1.0) | | | 2,620 | -3,000 | -4,600 | -2,300 | -2,950 | -800 | -1,300 | -2,400 | -3,400 | -4,700 | -7,100 | -8,800 | -10,600 |
| 7.0 A.C of the Second Largest Unit | | | 4000 | 3800 | 3900 | 3800 | 3800 | 3800 | 3700 | 3700 | 3700 | 3600 | 3600 | 3600 | 3500 |
| 8.0 Firm Capacity (6.0-7.0) | | | -1,380 | -6,800 | -8,500 | -6,100 | -6,750 | -4,600 | -5,000 | -6,100 | -7,100 | -8,300 | -10,700 | -12,400 | -14,100 |

### 5.2.7 Tariff and Collection

The national tariff applies to all SIEA supply areas, and is fixed by regulation. The current tariff is outlined in the following table. The tariff comprises of two components: a base price determined from time to time based on adjustment tied to the Retail Price Index; and an Automatic Fuel Price Adjustment (AFPA) determined quarterly according to the price of diesel fuel.

Commercial and industrial consumers generating from privately – owned power plants during times when the SIEA supply is available are charged by SIEA for the energy they generate at a price of up to 50% of the National Tariff.

The national tariff defines three consumer categories – domestic, commercial and high voltage. It includes no lifeline tariff to allow the poor access to modest amounts of electricity for basic services. Implied in the national tariff are cross subsidies, firstly, between domestic and commercial/HV consumers, and, secondly between the consumers of Honiara and those of SIEA provincial centres.

Non-SIEA generation includes electricity supplied by community or church-owned schemes or by private plants operated by plantations, processing plants and individuals. Under Section IV of the Electricity Act, any such supply must be licensed unless it is less than 50kW or is otherwise exempted under the Electricity (exceptions) order (1992).

**Table 5-7 Summary of SIEA Tariff Adjustments – 2005 to 2015**

| DATE | | BASE TARIFF ($/kWh) | | | FUEL TARIFF | TOTAL TARIFF ($/kWh) | | |
|---|---|---|---|---|---|---|---|---|
| | | Domestic | Commercial | High-Voltage | ($/kWh) | Domestic | Commercial | High Voltage |
| 2005 | 1-Jan | 0.5617 | 0.8292 | 0.7292 | 1.0400 | 1.6017 | 1.8692 | 1.7692 |
| | 1-Apr | 0.5617 | 0.8292 | 0.7292 | 1.0400 | 1.6017 | 1.8692 | 1.7692 |
| | 1-Jul | 0.5617 | 0.8292 | 0.7292 | 1.1958 | 1.7575 | 2.0250 | 1.9250 |
| | 1-Oct | 1.7575 | 2.0250 | 1.9250 | 0.0000 | 1.7575 | 2.0250 | 1.9250 |
| 2006 | 1-Jan | 1.8954 | 2.1839 | 2.0760 | 0.1306 | 2.0260 | 2.3145 | 2.2066 |
| | 1-Apr | 1.8954 | 2.1839 | 2.0760 | 0.0380 | 1.9334 | 2.2219 | 2.1140 |
| | 1-Jul | 1.8954 | 2.1839 | 2.0760 | 0.1516 | 2.0470 | 2.3355 | 2.2276 |
| | 1-Oct | 1.8954 | 2.1839 | 2.0760 | 0.3542 | 2.2496 | 2.5381 | 2.4303 |
| 2007 | 1-Jan | 2.4011 | 2.7090 | 2.5939 | 0.2499 | 2.6510 | 2.9589 | 2.8438 |
| | 1-Apr | 2.4011 | 2.7090 | 2.5939 | 0.1101 | 2.5112 | 2.8191 | 2.7040 |
| | 1-Jul | 2.4011 | 2.7090 | 2.5939 | 0.1644 | 2.5655 | 2.8734 | 2.7583 |
| | 1-Oct | 2.4011 | 2.7090 | 2.5939 | 0.2990 | 2.7001 | 3.0080 | 2.8929 |
| 2008 | 1-Jan | 2.9649 | 3.3030 | 3.1766 | 0.4604 | 3.4252 | 3.7633 | 3.6370 |
| | 1-Apr | 2.9649 | 3.3030 | 3.1766 | 0.6836 | 3.6485 | 3.9866 | 3.8602 |
| | 1-Jul | 2.9649 | 3.3030 | 3.1766 | 1.0832 | 4.0481 | 4.3862 | 4.2598 |
| | 1-Oct | 2.9649 | 3.3030 | 3.1766 | 1.8518 | 4.8167 | 5.1548 | 5.0284 |
| 2009 | 1-Jan | 3.5133 | 3.9139 | 3.7641 | 0.9520 | 4.4653 | 4.8659 | 4.7161 |
| | 1-Apr | 3.5133 | 3.9139 | 3.7641 | 0.4501 | 3.9633 | 4.3640 | 4.2142 |
| | 1-Jul | 3.5133 | 3.9139 | 3.7641 | - | - | - | - |
| | 1-Oct | 3.5133 | 3.9139 | 3.7641 | - | - | - | - |

(Source: SIEA 2008)

## 5.3 Current Situation of Renewable Energy and a Course of Action

### 5.3.1 Potential

(1) Hydropower

Many of the islands of the Solomons are large, high, and volcanic and have heavy rainfall. There is substantial potential for electricity from hydro resources on at least seven islands but efforts to evaluate the resource have been limited. However, adverse geological conditions make the construction of dams and the impoundment of water in storage reservoirs technically difficult and expensive. The most practical option is generally run-of-river hydropower schemes.

The JICA-funded Master Plan Study for Power Development in Solomon Islands, carried out in 1999- 2000 identified nearly 330 MW of hydroelectric potential on seven islands.

The Australian organisation APACE has been a driving force behind micro-hydropower development in the Solomon Islands for over twenty years. APACE, its development, and the establishment of the Village First Electrification Programme (VFEP) and the Solomon Islands Village Electrification Council (SIVEC) are briefly described in the next table.

**Table 5-8 Community-based Micro-hydropower Systems**

| Location | Year Installed | Turbine Capacity | Generation | Funding | Comments |
|---|---|---|---|---|---|
| Iriri settlement (Kolombangara) WESTERN PROVINCE | 1983 | 10 kW | 3 - 4 kW | UNIDO | Not operating due to weir and penstock failures, etc. Community is still considering whether to refurbish this system. |
| Vavanga (Kolombangara) WESTERN PROVINCE | 1994 | 12kVA | 4 - 5 kW (now 8 kW) | AusAID + Australian Citizens | Reconstructed on a new site with a new 8 kW turbine / genset. Commissioned June 2006. Currently operating reliably. |
| Ghatere (Kolombangara) WESTERN PROVINCE | 1997 | 12 kW | | AusAID + Australian Citizens | Not operating due to turbine failure, flood damage, theft of electrical equipment, etc. Community is still considering whether to refurbish this system. |
| Manawai Harbour MALAITA | 1997 | 50 kW | 15 – 25 kW | Republic of China | Operating. Various economic and rural development spin-offs. |
| Bulelavata (New Georgia) WESTERN PROVINCE | 1999 | 29 kW | 14 kW | AusAID | Has operated reliably. Supplies power to 20 houses plus a large boarding school. |
| Raeao MALAITA | 2002 | 25 kW | 14 kW | Republic of China | Operational |
| Nari'ao'a MALAITA | Feb. 2004 | 25 kW | | Republic of China | Understand that project has been completed, but its current operational status is not known. |

(Source: MMERE proposal 2009)

(2) Solar

Since the Solomon Islands lies near the equator, it is in a favourable geographical location for year-round solar energy application. Insolation is relatively high, where records for the period 1987-1989 give an average annual total insolation of 6,600 MJ per $m^2$ of horizontal surface for the Henderson Airfield site on Guadalcanal.

Solar photovoltaic is a proven technology that had been used to provide light to rural community and villages. Several companies in the country have developed their business in selling and installing solar products. The examples of PV installation are shown below.

- In the 1970s and 1980s, some church missions switched from diesel generators to photovoltaic (PV) lighting with kits purchased from Guadalcanal Electric Co.
- Solomon Telekom began using solar PV to power radio transceivers and repeater stations in the thenexpanding rural telephone network.
- The 1984-1994 Lomé II regional energy programme financed six Electrolux PV refrigeration systems for provincial health clinics.
- In 1997 and 1998, the Solar Electric Light Fund (SELF) of the USA and its local NGO partner, the Guadalcanal Rural Electrification Agency (GREA) provided solar home systems (SHS) to 46 homes and a school in Sukiki, Guadalcanal and to 65 homes, a school and several churches in Makaruka, also in Guadalcanal. During the unrest, the GREA office was burned down and many of the SHS were destroyed.
- SELF also installed solar systems at seven rural houses in Gatokiae, Western Province and at four rural health clinics on the island of Santa Isabel.
- One company, however, deals solely with solar PV. Willies Electrical and Solar Power offers four brands of PV modules (Sharp, BP, Photowatt, Unisolar) from two Australian suppliers (Rainbow Power Company, NSW and Choice Electronic, Brisbane, Queensland). Willies has sold, or has confirmed orders for, approximately 200 systems since starting business in July 1998. Customers include churches, health clinics, schools, marine users for navigational aids, and a few private persons such as private resort operators.
- The equipment is usually funded by aid agencies. Through AusAID, the Ministry of Health bought about 50 PV systems from Willies for installation at rural health centres. Consisting of a light, a dryer, and a microscope (all converted to 12 Volt DC operation), they are used to test blood samples for malaria infection.
- With funding from the European Union (EU) Micro Projects Programme, solar powered water pumps were installed by Willies at Vatu Rural Training College and Biakapu Village in 2002 and 2003 respectively.
- Solomon Telekom has solar PV operated radiotelephones in almost all provinces, with most systems located in Western and Choiseul provinces. They use equipment imported from Australia. Its largest solar powered unit is a repeater station on Ngella Islands having 1,600 peak watts (Wp), using twenty 80 Wp panels
- Italy Government fund: SHS electrification for rural boarding school. Installation of SHS at teacher’s house, classrooms and dormitories at over 20 high schools. Total project cost is USD 350,000.
- In July 2008 the Government has launched together with the World Bank the “Sustainable Energy Financing Project” to enable rural people obtain loans through the ANZ Bank to purchase solar home systems for themselves. Other commercial banks and financial institutions will later join the scheme.

(3) Biofuel

Coconut oil has a great potential for future development and support the rural economy. It is a product that has already been established for the last 20 years. Ministry of Mines and Energy has a plan to test a transesterification of the coconut oil using ethanol and soda. The trial will be carried out by the Ministry of Mines and Energy with the engagement of a consultant as technical expert. The trial will develop a manual or guideline for the process and procedure to production of 100% bio–diesel. The trial will also includes a standby generator set for the Energy Building at the Ministry.

Evergreen Pty Ltd of Australia had proposed a bio-diesel power plant in Honiara. However, in 2006, and assessment concluded that there was not enough coconut oil production to supply a bio-diesel fueled energy generation system to be established in the Solomon Islands. Therefore, Evergreen decided on business interest basis not to invest in the plant. In 2007, another MOU with the Ministry of Agriculture and Livestock was made to undertake an assessment of the copra industry and production of coconut oil for further study.

(4) Wind

Solomon Islands has been said to located in an area with limited wind energy resources. As such there has been limited interest in wind energy and therefore there is no data available which would allow an assessment of the likely wind energy potential of the Solomon Islands. To confirm this, the Government under its development budget looked at establishing a wind monitoring station at Gizo, Tingoa, and Lata. In addition, five wind turbines will be purchased and five pilot project sites will be established where the objective is to use the installed wind turbines for rural electrification. The sites for proposed pilot projects are as follows. However, long-term observations are necessary to determine wind potential for further implementation.

<Monitoring Station>

- Gizo
- Tingoa
- Lata

<Pilot Scheme>

- Bebea, Western Province
- Talakali, Malaita Province
- Santa Cruz, Temotu Province
- Lord Howe, Malaita Outer Island
- Belona, Rennel Province

(5) Geothermal

The report of Pacific Islands Renewable Energy Project in 2004 mentioned the potential of geothermal energy as follows. “The Solomon Islands has many hot springs and there are indications of possibly exploitable geothermal resources in a number of locations. Although no systematic assessment of geothermal energy potential has been carried out, there are surface geothermal manifestations in at least at four locations the Solomon’s archipelago: West Guadalcanal, the Paraiso field in the Ngokosoli river valley of Vella Lavella, Simbo Island, and Savo Island. On West Guadacanal, 40km north-east of Honiara and 5km island from the sea, there are four known thermal areas: Nggurara, Kunjuku, Saikotulu and Koheka. Another resource in Paraiso Bay on Vella Lavella Island, with surface temperature up to 99$^{o}$C, considerable outflow and a geothermometrically calculated equilibrium temperature of 160$^{o}$C, appears to be suitable for power generation. A shallow temperature survey by the UK Institute for Geological Studies in 1979 indicated power potential at Paraiso field of about 10 MW (WB & UNDP 1983; WB et al, 1992 and SOPAC 2002). However, the absence of a nearby market for electricity, with the exception of the capital city of Honiara, means that exploitation of geothermal resources is unlikely to be practical for some time.”

### 5.3.2 Needs Collected from the Interview

This project conducted an interview survey with relevant agencies. From the interview survey the current situation and needs in the power sector are summarized as follows.

(1) System Reliability

The power supply is generated by diesel generators except for 2 hydropower stations, 150kW in Buala and 35 kW in Malu’u. Those hydro stations have been operated by SIEA. In 2008, SIEA does not have enough power in the Honiara-Lungga system although there is 16 MW capacity that exceeds the maximum demand of 12 MW. Because the actual capacity has dropped below the maximum demand due to lack of good maintenance. As a result, the capital city, Honiara, meets frequent outage. New power capacity development and appropriate maintenance of existing diesel generators are crucial required in the short term.

(2) Small Hydro Development

MMERE has now been preparing 15 micro hydropower development schemes to seek Grant Aid from Japan. According to the discussion with MMERE, those 15 sites are selected among 49 potential sites requested by the local community.

The study team has implemented 4 sites survey among 15 selected sites in order to identify the soundness of the project. As a result, it was found that there are still non-matured in terms of basic survey data and accessibility. Out of the 15 sites, Rori site was identified as a good potential site (300 kW) in JICA M/P conducted in 1999. The site is more matured in data preparation.

MMERE will implement all the sites and confirm by themselves whether the selected projects does not have any development risk such as insufficient water, land issue, and so on. Those sites should be discussed after the MMERE's self survey.

**Table 5-9 15 Selected Hydropower Potential Sites (community request basis)**

| No. | Name of site | Province |
|---|---|---|
| 1. | Bisuana | Marovo, Western Province |
| 2. | Barakoma | Vella Lavella island, Western Province |
| 3. | Kolomola | Hograno District, Ysabel province |
| 4. | Piru piru | Ulawa island Makira/Ulawa province |
| 5. | Rori | North West Malaita, Malaita Province |
| 6. | Hunanawa | East Are' Are, Malaita |
| 7. | Wakisi – Kiu village | West Are Are, Malaita |
| 8. | Komuvaolu | East Guadalcanal |
| 9. | Belanimanu | East Guadalcanal |
| 10. | Avu Avu | East Guadalcanal |
| 11 | Gounabusu | East Kwaio, Malaita |
| ,12 | Ubuna | Makira island |
| 13. | Heranigau | Makira island |
| 14. | Patu Village | Ranonga Island, Western Province |
| 15. | Panggoe Village | Choiseul Province |

(3) Solar System

Solar system in off-grid area has been already diffused. Many NGOs has assisted to install Solar Home System (SHS) in remote area. SHS with battery is mainly used for lighting in houses and radio wave power in clinics. In the case of such limited purpose, solar system has an advantage against hydropower.

For good maintenance, skilled engineers for SHS should be secured. Capacity building for such engineers is also expected.

### 5.3.3 Consideration of Cooperation Fields

(1) Improvement of System Reliability

The most critical issue is frequent outage in Honiara-Lungga System. To strengthen the system, stable power facility is expected to be installed.

(2) Small Hydropower Development

MMERE proposed 15 small hydropower sites. However, the expectation is based on community basis. Further feasibility study is required in order to identify and confirm potential.

Out of which, Rori site in Malaita was identified as a good potential site in terms of demand, accessibility, water volume, by JICA M/P. The planned capacity of Rori site was 300 kW that might be large capacity comparing to actual demand. It needs demand forecasts for the planning.

(3) Grid Connected Solar System

Solomon Islands have much potential for solar power, but and it has not yet an experience of grid connected PV system. It can reduce diesel fuel usage contributing to mitigation of climate change and also greatly to country's economy. Before installation, a detail study is required for confirmation of soundness of grid operation.

(4) Off-Grid Solar System

Several kW PV system covering a whole community is possible. However, it is not easy to select sites from many candidate sites.

(5) Training Programme

Training programme can be provided through 2 ways, namely dispatching expert and invitation to Japan. Capacity building for appraisal staff of CDM can be assisted through dispatching expert.
Training programme for renewable energy, targeting at engineers, and energy efficiency, targeting at policy makers, can be held in Japan. Training programme in Japan expects the following agenda.

- Site visits to a range of renewable energy technology projects
- Lecture for planning and design of large scale grid-connected solar power
- Lecture for design and site visit of solar home system (captured and reverse flow)
- Lecture for planning and design of wind power
- Lecture for planning and design of small hydropower
- Lecture for energy conservation programmes
- Site visits to observe energy efficiency technologies
- Lecture on maintenance of solar and small hydropower
- Factory tour for solar and small hydropower

The above programs in the recipient country and Japan can be conducted through a regional assistance program.

## 5.4 Current Situation of Energy Conservation and a Course of Action

### 5.4.1 Current Situation

The Ministry has prepared a project for Energy Efficiency and Conservation in the Solomon Islands. The Ministry made the requested for the project budget from the Ministry of Finance. In 2008, the Ministry of Finance approved SB$540,000 for the project. The project on energy efficiency and energy conservation is intended to achieve the following objectives;

- Educate the public, public servants and private sector on the importance of using electricity wisely and put on measure that needs to be taken to manage power usage, through energy auditing workshops, TV, radio, newspaper, and posters,
- Educate the public on measures that need to be taken to use fossil fuels wisely and to take measures to minimize its usage through energy efficiency programmes.
- Raise energy awareness in schools about the importance of using energy efficiency and conserving energy.
- Reduce government bills on electricity

### 5.4.2 Consideration of Cooperation Fields

As for energy efficiency including energy conservation, Solomon Islands seem to be at beginning stage. To find appropriate measures for SI, staff in charge of energy efficiency should be trained through training programme in Japan.

# Chapter 6. Independent State of Samoa

## 6.1 Profile of the Country

### 6.1.1 General Information

(1) General Information

Samoa, officially the Independent State of Samoa (formally known as Western Samoa), is a country governing the western part of the Samoan Islands in the Pacific Ocean. Samoa has 2,934 km$^2$ of land area, mostly in the islands of Savai'i (58% of land) and Upolu (38%). In 2006, Samoa had a population of 179,186. About 22% of the population resided in the Apia urban area, 30% in northwest Upolu, 24% elsewhere in Upolu, and most of the remaining 24% in Savai'i. There is a high rate of migration into Apia and northwest Upolu from the rest of the country.


**Figure 6-1 Map of Samoa**

(2) Economy

(a) Main Industry

Copra, fish and tourism (Source: Website of MOFA of Japan)

(b) Gross National Income (GNI)

0.45 billion US$ (2007) (Source: Website of MOFA of Japan)

(c) GNI per Capita

2,430 US$ (2007) (Source: Website of MOFA of Japan)

(d) Economic Growth

3% (2007) (Source: Website of MOFA of Japan)

(e) Inflation Rate

2.9% (2007) (Source: Website of MOFA of Japan)

(f) Trading Amount

Export: 10.6 million US$ (2006)
Import: 196.5 million US$ (2006)
(Source: Website of MOFA of Japan)

(g) Trading Item (2004)

Export: Fish, Noni goods, Beer, Coconut cream
Import: Food, Meat, Machinery
(Source: Website of MOFA of Japan)

(h) Trading Countries (2006)

Export: American Samoa, US, New Zealand, Australia
Import: New Zealand, Australia, US, China
(Source: Website of MOFA of Japan)

(i) Currency

Samowan Tala, 1 SWT = 33.77 JPY (2009/4/29) (http://www.oanda.com)

(3) Japan's Cooperation

Record of Japan's cooperation to Kiribati is shown in the next table, which are ODA loans, Grant Aid and Technical Cooperation.

**Table 6-1 Record of Japan's Cooperation**

| | 2007 | Accumulated Amount by 2007 |
|---|---|---|
| ODA Loan | 4.6 billion Yen | 4.6 billion Yen |
| Grant Aid | 4.3 million Yen | 22.9 billion Yen |
| Technical Cooperation | 555 million Yen | 10.7 billion Yen |

(Source: MOFA of Japan, accessed in April 2009)

### 6.1.2 Geography and Weather

(1) Geography

The country is located East of the international date line and south of the equator, about halfway between Hawaii and New Zealand in the Polynesian region of the Pacific Ocean. The Samoan islands have been produced by volcanism, the source of which is a geologic hotspot which is the probable result of a mantle plume. While all of the islands have volcanic origins, only Savai'i has had recent eruptions and could be considered volcanically active. The last major eruption occurred in the 1700's, and smaller eruptions occurred between 1904-1906. The highest point in Samoa is Mauga Silisili, at 1858 m. The Saleaula Lava Fields were produced by Mt. Matavanu during its eruption 102 years ago leaving 50 square kilometres of solidified lava.

(2) Weather

The climate is warm, humid and tropical with distinct wet (October – April) and dry seasons. The annual rainfall is 2.90 metres, with considerable variation by location. Mean annual temperature vary from a low of 20$^{o}$C to a high of 30$^{o}$C with limited seasonal variation. Sunshine averages 2,500 hours annually. Severe cyclones have caused considerable damage, a potentially serious issue for biomass energy development. Apia, the capital , has the following climate records as detailed in the next tables.

**Table 6-2 24 Hours Average Temperature (Apia)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| °C | 26.5 | 26.6 | 26.5 | 26.5 | 26.2 | 25.9 | 25.6 | 25.7 | 25.9 | 26.2 | 26.3 | 26.4 | 26.2 |

(Source: World Climate Website, 1890-1991, Station at about 13.80°S 171.80°W. Height about 2m / 6 feet above sea level.)

**Table 6-3 Monthly Average Rainfall (Apia)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 436.8 | 359.6 | 355.9 | 236.3 | 173.6 | 135.2 | 100.1 | 111.2 | 144.1 | 205.6 | 259.2 | 373.9 | 2901.2 |

(Source: World Climate Website, 1890-1990, Station at about 13.80°S 171.80°W. Height about 2m / 6 feet above sea level.)

## 6.2 Outline of the Power Sector

### 6.2.1 Legal Framework of the Power Sector

There are several Acts of the Legislative Assembly of Samoa that deal directly or indirectly with power issues. These are:

- The Price Control Act establishes the procedures under which the maximum prices of certain commodities, including wholesale and retail prices of petroleum fuels, are controlled. This is formally administered by the Ministry of Commerce, Industry and Labour.
- The Electric Power Corporation (EPC) Act of 1972, revised in 1980 with subsequent amendments, established the power utility. It does not give EPC exclusive rights for the generation of electricity but EPC issues permits required to generate electricity. EPC owns the grid and can refuse the use of the grid by outside generators. The legislation does not establish any financial performance targets or other measurable indicators of performance.
- The petroleum Act of 1984 makes provision for the supply, transport and storage of petroleum. It gives the MoF Chief Executive Officer the power to award tenders and determine levies for petroleum fuels. The MoF is responsible for oil storage licensing, inspection, monitoring and safety regulation.
- The PUMA Act of 2004 established the Planning and Urban Management Agency (PUMA), which is responsible for the development, regulation, sustainable use, and management of land. PUMA can require environmental impact assessments (EIAs) and management plans for a range of activities. The Act includes requirements to mitigate the impacts of deforestation and waste disposal so there may be implications for energy production from biomass or wastes. PUMA is also involved in greenhouse gas and climate change issues, which have close links with energy policy.
- The Public Bodies (Performance and Accountability) Act of 2001. This Act requires state owned enterprise and other public bodies to operate in an accountable manner, be as profitable and efficient as comparable private businesses, and meet certain community service obligations (CSO) which could include universal access to a necessary good or service as directed by the Minister. Presumably, a CSO could include provisions of electricity in remote or low income areas.

### 6.2.2 Institutional Framework of the Power Sector

#### (1) Structure of the Power Sector

The Energy Unit of the Ministry of Finance (MoF) is responsible for overseeing and coordinating national activities for donor-supported energy projects, to developing, coordinating and implementing of the Samoa National Energy Policy (SNEP) in collaboration with all relevant energy stakeholders. The Energy Unit is also responsible for the administration of the Petroleum Act which includes issuance of petroleum licenses and the rationalisation exercise of the supply and distribution of petroleum products in Samoa. Other duties include the development of an energy supply and demand database to collect and compile all energy related information in the country.

The Ministry of Works, Transport and Infrastructure includes among its responsibilities the Electric Power Corporation (EPC), which provides electrification through grids throughout the country. EPC is operated commercially but wholly owned by the Government of Samoa with polices determined by a Board of Directors chaired by the Minister of Works. The eight Board Members are chosen by Cabinet.

The Ministry of Natural Resources and Environment (MNRE) is responsible for environmental aspects of energy use including greenhouse gas emissions and climate change. The Attorney General’s Office has the responsibility for drafting, reviewing and presenting new energy or regulatory related legislations.

#### (2) Organisations in Charge of Renewable Energy

According to the SNEP, developments in the field of renewable energy have been on an ad-hoc basis driven mainly by the various donor funded projects with their separate coordinating committees.

### 6.2.3 Laws and Regulation regarding Renewable Energy

There is not a specific law on renewable energy. Again referring to the SNEP which was endorsed by the Samoan Cabinet in 2007, highlighted the following strategies with regard to the development of renewable energy:

1. Promote sustainable use of indigenous energy resources and renewable energy technologies;
2. Enhance public knowledge and understanding on renewable energy; its costs and benefits;
3. Promote partnerships with communities and all energy stakeholders especially potential development partners in the development of renewable energy programmes in Samoa;
4. Explore training opportunities to build up capacity in renewable energy technologies; and
5. Encourage the use of renewable energy research findings of the Research and Development Institute of Samoa on a commercial basis.

### 6.2.4 Power Demand and Supply Status

(1) Past Records and Current Annual Power Consumption (kW, kWh)

Electrification ratio of Samoa has reached to 95%. Past annual electricity consumptions has been recorded as show in the next table. The annual electricity consumptions per capita has been around 0.6-0.7 MWh about 3 times of Kiribati. The peak load in dry season is currently recorded as 18 MW. (Interview with EPC, April 2009)

**Table 6-4 Past Annual Electricity Consumptions in Samoa**

| | Year | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|
| Annual Energy | Million kWh | 124 | 125 | 123 | 129 | 113 |
| Averaged | MW | 14.2 | 14.3 | 14.0 | 14.7 | 12.9 |
| Population | thousand | 177.2 | 177.7 | 178.2 | 178.7 | 179.2 |
| Annual Electricity Consumption per Capita | MWh per capita | 0.70 | 0.70 | 0.69 | 0.72 | 0.63 |

(Source: Key Indicators for Asia and the Pacific, 2008, ADB)

(2) Past Records and Current Annual Power Generation

Samoa mainly consists of two large islands, Upolu and Savai'i. Electricity in Upolu is supplied by Tangamanono diesel power station and two hydropower station. Four diesel generators in Tangamonono power station in Upolu were in operation during our visit (April 20,2009). One of them was being overhauled. The hired-diesel generators were used for compensating the power supply during the overhaul period. Diesel generators were installed at approximately 17MW in total (including overhaul unit).

**Table 6-5 Diesel Units in Tangamonono Power Station in Upolu (April 2009)**

| Unit No. | Capacity |
|---|---|
| G12 | 3.5 MW |
| 9 | 3.5 MW |
| 7 | 4.2 MW |
| 5 | 4.2 MW |
| Hired-unit | 0.6 MW |
| Hired-unit | 1.0 MW |

5% of the fuel used in the diesel generators in Upolu is coconut oil. EPC is placing the target of usage of coconut oil as 15 %. The other power source on Upolu is hydropower. EPC has eight small hydroelectric turbines (800–2000 kW, mostly run-of-river) at five locations on Upolu totaling 11.7 MW of effective capacity. Dry season hydro capacity of those small hydroelectric plants is said to fall to around 4 MW. The capacities of the existing hydropower units on Upolo are as follows including Afilio reservoir-type hydro power station. Total amount of hydropower capacity is 15.7 MW, however, in dry season, the capacity is significantly decreased.

**Table 6-6 Hydropower Stations in Upolo**

| | | | | | |
|---|---|---|---|---|---|
| Lalamauga | | Taelefaja | | Alaoa Pa | |
| Unit 1 | 1.7 MW | Unit1 | 2MW | Unit1 | 1MW |
| Unit 2 | 1.7 MW | Unit2 | 2MW | | |
| Total | 3.4 MW | Total | 4 MW | Total | 1 MW |
| Samasoni | | Fale | | Aflilo | |
| Unit1 | 0.8 MW | Unit 1 | I.7 MW | | 4 MW |
| Unit2 | 0.8 MW | | | | |
| Total | 1.6 MW | Total | 1.7 MW | Total | 4 MW |

Savai'i is exclusively served by diesel generation from some 4.5 MW of effective capacity Salelologa diesel power plant is the sole station supplying power to the grid on Savai'i including a saw-mill company, Samoa Forest Corporation, has their own generators. EPC is currently purchasing the surplus power from the saw-mill company.

(3) Power Network System

There are two power systems in Samoa covering Upolu and Savai'i respectively. They are not connected to each other. The voltage levels of Samoa's power system consists of 33kV, 22kV and 415V. There is a connection point between 33kV and 22kV with the step-up transformer in Upolu. The system diagrams are shown in the next figures, omitting the medium voltage to low voltage transformers, switch gear and circuit breakers.

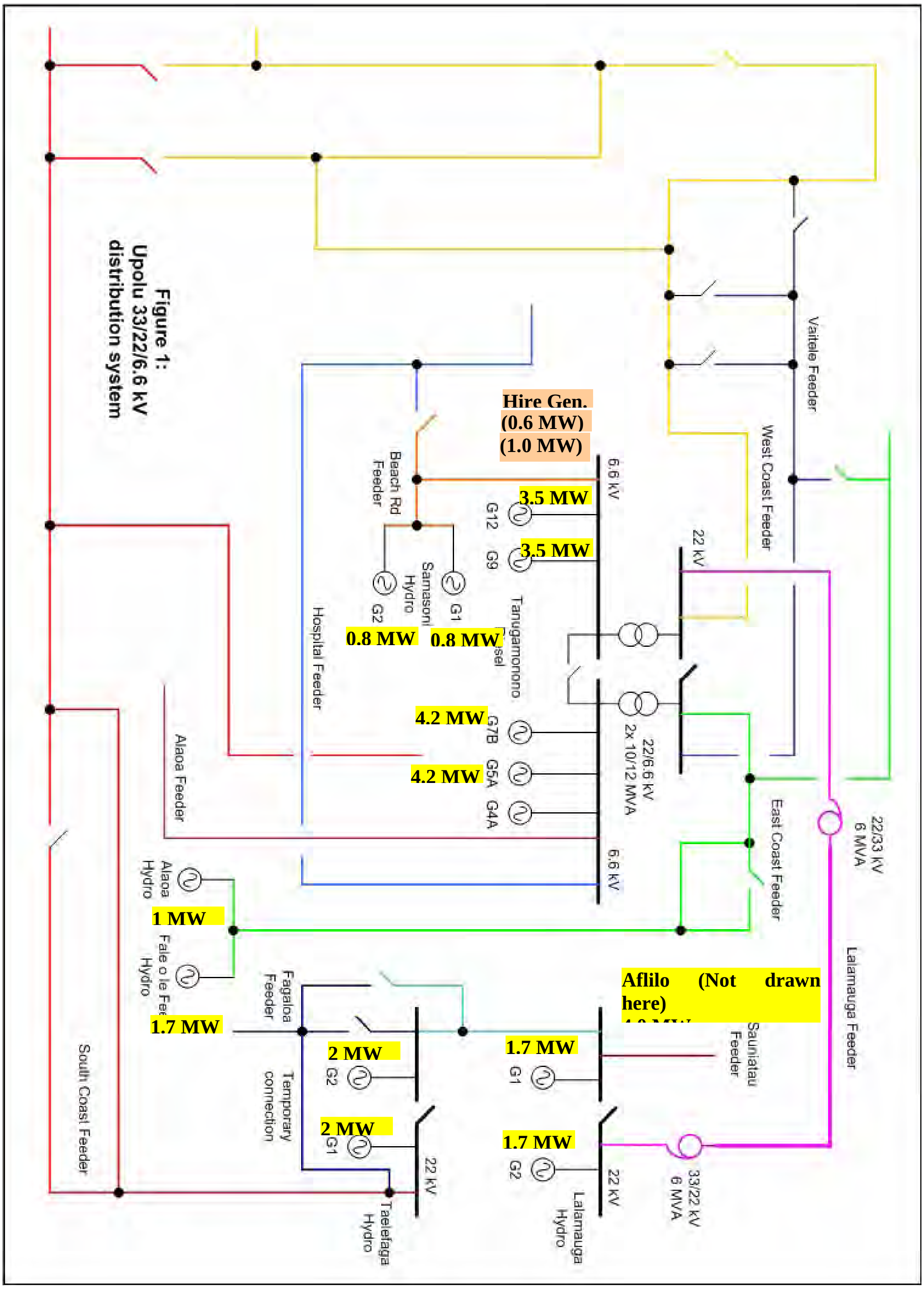



**Figure 6-2 Power Network System**

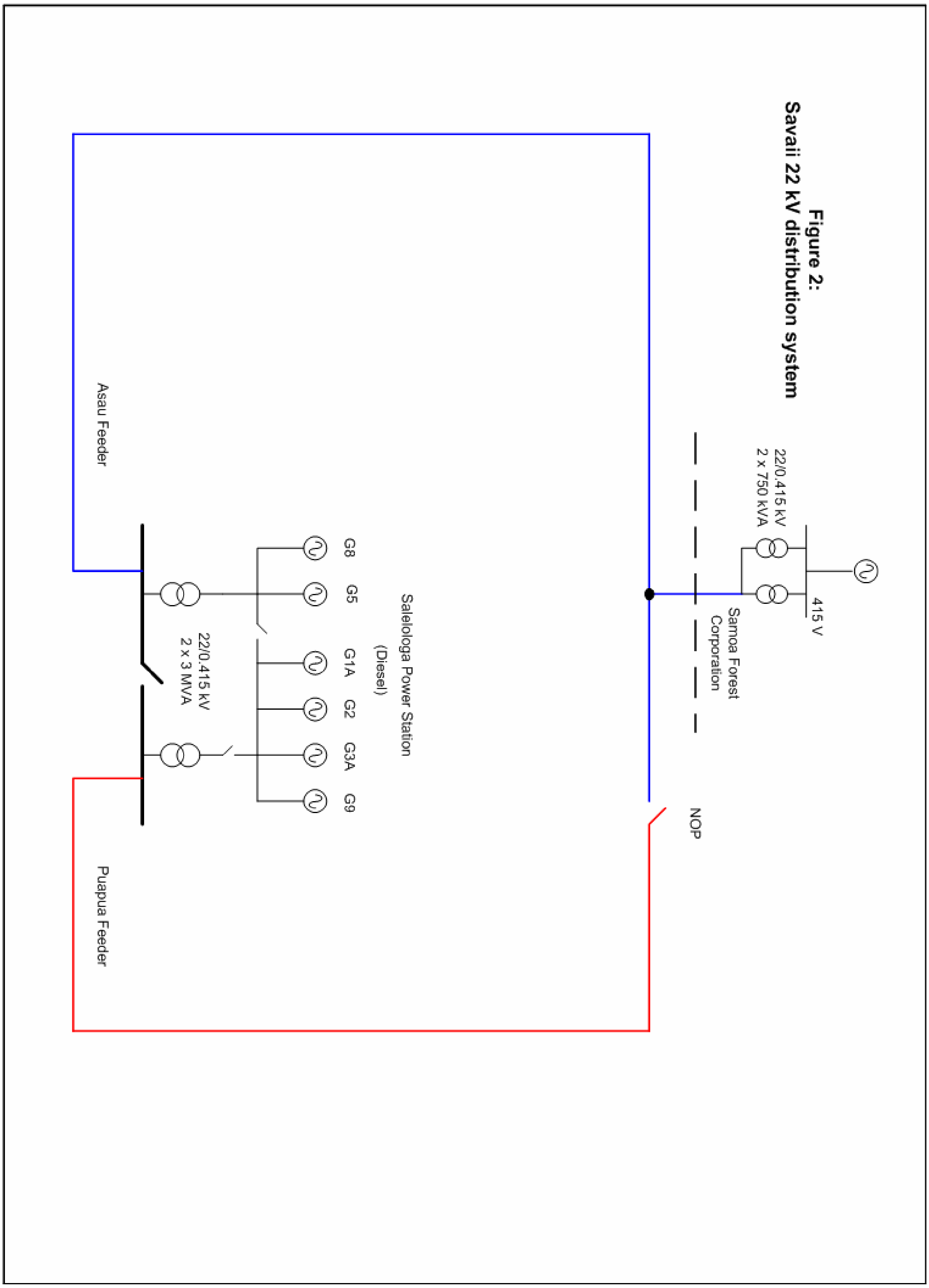



**Figure 6-3 Power Network System**

(4) Cost of Power Generation

The cost of fuel used for power generation is estimated at 0.26 Australian Dollars per kWh on the average where the splits are as follows.

EPC uses a coconut oil / diesel blend where 5 % of the fuel is coconut oil and 95% diesel oil. The unit price of coconut oil is 2.1 Samoan Dollars per litre where it is estimated to be 10% less efficient than diesel oil which is 2.0 Samoan Dollars per litre. It has been estimated that for the Samoa situation that 1 litre of diesel oil can generate the power of 3.9 kWh. Thus, the averaged fuel price for generating electricity can be calculated as 0.52 Samoan Dollars (0.26 AUS) as show in the next tables.

**Table 6-7 Fuel Prices Used for Diesel Generators**

| Fuels | Price (April 2009) | Notes |
|---|---|---|
| Coconut | 2.1 SWT/l | 10% less power |
| Diesel | 2.0 SWT/l | |

**Table 6-8 Calculation of the Averaged Fuel Price**

| | Energy produced per litter | Unit price per litter |
|---|---|---|
| Coconuts | 3.5 | 2.1 |
| Diesel | 3.9 | 2 |

| | Share | Energy produced (kWh) | Price contained (SWT) | Averaged Energy price (SWT/kWh) |
|---|---|---|---|---|
| Coconuts | 0.05 | 0.177 | 0.105 | |
| Diesel | 0.95 | 3.705 | 1.900 | |
| Total | 1.00 | 3.882 | 2.005 | 0.516 |

### 6.2.5 Power Development Plan

Major power generation projects in Samoa will be covered by “Power Sector Expansion Project (ADB/JICA/AusAid)”. The project will include the following sub-projects.

- Alaoa Power Plant Refurbishment in Upolu
- Upolu New Diesel Power Station
- Refurbishment of Salelologa in Savaii
- Hydropower Scheme in Savaii (details are not yet determined)

Aside from the abovementioned projects, there is a plan of enhancing the capacity of Aflilo hydropower plant from 4MW to 6MW.

## 6.3 Current Situation of Renewable Energy and a Course of Action

### 6.3.1 Potential

(1) Small Hydropower

Samoa has a huge potential of small hydropower energy. However, as is the case with Vaitai’i hydropower sources in Savai’i, many potential sites are now facing the difficulties with being developed due to the land acquisition problems or communities’ lack of understanding concerning hydropower developments.

(2) Solar PV

A Chinese company is now promoting the sale of a 5MW solar power system intended to be connected to the power grid. Although the capacity of this system seems too large to connect to the power grid with the peak load of 18 MW, the sun radiation data shows that approximately 6 $kW/m^2$ is available in Samoa and would provide enough radiation for the solar power system when the appropriate capacity is selected.

Preparatory work to electrify the remaining approximately 3-5% households will be carried out by SPREP, SOPAC and UNDP that are un-electrified with mainly solar PV.

(3) Wind

Wind measurement has started on the top of the mountain in the center of Upolo Island by the New Zealand Government. The location seems suitable for installing a wind power farm as the land is owned by the Samoan Government and is adjacent to a power distribution line and road. Although there is a constant wind direction is expected that the wind velocity will not be high enough to justify the installation of wind turbines

The JICA Study (Project Formation Study on Samoa Renewable Energy 2001) reported the that the average wind velocity observed was around 3 m/s and therefore the identification of feasible sites for the development of wind farms was not expected to be the case.

(4) Biofuel

As referenced in Section 4 – Cost of Power Generation, EPC now uses a coconut oil / diesel fuel blend in their generators, where EPC has set the target to increase the ratio of coconut oil in the blend up to 20%.

### 6.3.2 Needs Collected from the Interview

This project conducted an interview survey with relevant agencies. From the interview survey the current situation and needs in the power sector are summarized as follows

- Grid connected solar power system could be considered as a viable option. Utilization of the building of an university is one option.
- A grid-connected solar power system can assist in conserving the hydropower reservoir water especially in dry season and lead to a reduction in the use of diesel oil. The symbolisation of the utilisation of renewable energy in schools would also contribute to an increased understanding of the opportunities offer by using natural renewable resources such as solar radiation to create energy.
- The examination of the power grid and the existing diesel generators will be essential for developing a plan for the introduction of grid-connected solar power. To secure the demand-supply controlling ability of the system, and the limitation on the size / capacity of solar power system. From a technical requirement this will generally be restricted to around 10 % of the total system capacity. Power system protection, relays and other control equipment should also be considered.
- Small hydropower plants have potential. However, “Power Sector Expansion Project (ADB/JICA/AusAID” would appear to have already covered the wider areas of power sector including the identification of viable projects for small hydropower especially in Savai’i. The development of many of the potential sites face the difficulty of land acquisition / access and a general lack of understanding and appreciation of the communities’ concerning hydropower development.
- The application of the wind energy should be considered. Although the viability of wind has not yet been considered there is the need to observe and fully assess any potential sites before discounting wind energy as not being a viable option.

### 6.3.3 Consideration on Cooperation Fields

(1) Medium to Large Scale Grid Connected Solar (PV) System

As mentioned, it is estimated that there is sufficient solar power potential in Samoa to consider the feasibility of grid connected PV, however Samoa has not yet any experience with grid connected PV systems. It can reduce diesel fuel usage contributing to mitigation of climate change and also greatly to country's economy. There seems to be enough potential sites in Samoa, which should be identified, such as universities or schools with many building roofs and available ground areas. A central grid-connected solar generator with the capacity of several tens or a hundred kW can be considered. However, the specification of the system should be made with precise data and information about the power demand forecast, land acquisition, existing diesel generators and solar radiation.

However, at the moment, it seems an assumed implementing agency, i.e. EPC, has not enough knowledge about the impact of PV to the grid and how to manage it. Therefore, it is essential to provide support for plan/design for the installation of PV and connection to the grid and to provide training on how to manage the power system connected to PVs. It may also be essential to provide technical guidelines for grid connection, since Samoa may consider a number of grid connected PV systems in the future.

(2) Training Programme

Training programmes can be provided through 2 ways, namely dispatching expert and invitation to Japan. Training programme for renewable energy and energy efficiency can be held in Japan. Training programme in Japan expects the following agenda. The above programmes in the recipient country and Japan can be conducted through a regional assistance programme.

- Site visits to a range of renewable energy technology projects
- Lecture for planning and design of large scale grid-connected solar power
- Lecture for design and site visit of solar home system (captured and reverse flow)
- Lecture for planning and design of wind power
- Lecture for planning and design of small hydropower
- Lecture for energy conservation programmes
- Site visits to energy efficiency technology installations
- Lecture for maintenance of solar and small hydropower
- Factory tour for solar and small hydropower

## 6.4 Current Situation of Energy Conservation and a Course of Action

### 6.4.1 Current Situation

(1) Energy Consumption in Demand Side

PREA 2004 that the latest 2002 census indicated that 93% of Samoa's 23,079 households were electrified. Currently the electrification rate is 95% as of 2008 and the last 5% will be electrified with SHS supported by UNDP.

Domestic sector consumers numbering 17,467 comprise 85% of the total customers and account for about 30% of electricity sales. On the other hand the commercial sector comprises about 38.5% with only 1,726 customers (2001-2003). Most households use woody biomass for cooking.

(2) Energy Efficiency

(a) Overall Efficiency

A factor to indicate energy efficiency could be electricity consumption per GDP is shown in the next table along with the electricity consumption per capita that gives an indication of the countries state of the economy.

In making this assumption a country in a development stage would ideally have lower consumption, however as it develops the GDP will increase as will the ability to spend, hence consumption increases and efficiency decreases.

Therefore the figures indicate that overall energy efficiency in Samoa places it in the middle group amongst Pacific countries, however as it develops further it is likely that consumption will increase and at the same time there will be a decrease in efficiency.

**Table 6-9 Overall Energy Efficiency**

| | Electricity consumption per capita (kWh/year) | Electricity consumption per GDP (Wh/GDP(USD)) |
|---|---|---|
| Nauru | 2,843 | 569 |
| Samoa | 534 | 114 |
| Kiribati | 101 | 31 |
| PNG | 432 | 206 |
| Solomon | 132 | 83 |

(Source: CIA World Fact Book: Samoa, Kiribati, PNG and Solomon: 2006, Nauru: 2005)

(b) Supply Side Efficiency

Energy efficiency data of generation was not available during this survey. However, according to existing report (CDM Project Potential Survey in South Pacific Islands, 2002), that of power plants in Upolu was 39% and that of Savai'i is 32%. In addition, one of the diesel generators was repaired last year with the result of 6% efficiency improvement (reported by EPC).

Transmission and distribution losses are 17% including non-technical losses as of 2008. EPC has a target to improve it down to 10% in a few years.

(3) Energy Efficiency Policy, Measures and Programmes

The necessity for energy efficiency/conservation is well recognised with concerned parties such as MNRE and EPC. The "National Greenhouse Gas Abatement Strategy 2008-2018" describes its objectives as follows:

- Objective1: Reduced GHG emissions from the land transport sector
- Objective2: Reduced GHG emissions from the electricity sector
- Objective3: Reduced GHG emissions from buildings
- Objective4: Reduced GHG emissions from deforestation and degradation
- Objective5: Reduced GHG emissions from the aviation and maritime transport sectors
- Objective6: Reduced GHG emissions from replacing fossil fuel with biofuel
- Objective7: Reduced GHG emissions from through new sources of renewable energy
- Objective8: Regulator framework to mitigate GHG emissions strengthened

Energy efficiency in the electricity sector is stated under Objective 2 and in the building sector as Objective 3.

It seems they cover main concerns and measures for energy efficiency. Apart from this, there are no specific energy efficiency measures and programmes being implemented by the government or utility as of April 2009.

One of the measures the power utility can adopt for energy/power saving is an incentive tariff system. The next table shows the EPC tariff structure, which is rather simple but has an incentive that the more customers use, the high rate they have to pay at.

**Table 6-10 EPC Tariff of Domestic Sector (2009)**

| kWh/month | WST/kWh |
|---|---|
| 1-50 | 0.64+0.3=0.67* |
| 51-above | 0.76+0.4=0.80* |

*: Base Rate + Fuel Surcharge

(Source: www.epc.ws, accessed 1 May)

(4) Donor Programmes

Energy efficiency improvement in supply side, i.e. efficiency improvement of generation, transmission and distribution is included as one of the sub-programmes in the power sector loan by

ADB together with JICA. ADB also provides other support for a TA in energy efficiency for the demand side. The Government is considering for future measures and activities, including establishment of Clean Energy Fund, introduction of minimum standards for appliances and promotion of solar thermal water heaters.

(5) Potential

Judging from the observations during the survey, appliances are old and look inefficient. In conjunction with the overall energy efficiency indicators mentioned in 6.4.1 there must be certain potential for energy efficiency, e.g. introduction of efficient equipment such as lighting and air-conditioners and training for energy management.

### 6.4.2 Consideration of Cooperation Fields

Support for energy efficiency is already being provided in Samoa through the ADB power sector loan and another TA by ADB. Therefore, additional support for cooperation was not requested during this survey. It may be a filed for cooperation to provide training program in Japan for staff and policy makers in charge of energy efficiency.

# Chapter 7. Conclusion

## 7.1 Identified Issues in Renewable Energy

Existing grid area (on-grid area) have the following common issues.

- Ratio of diesel generation capacity in existing grids is high in capital cities as well as provincial towns. It is expected that the introduction of renewable energy will contribute to a decrease in the percentage/ratio of diesel generation.
- Hydropower, which can be expected to provide reliable renewable energy capacity within the range of seasonal rainfall variability, however needs more time and has higher costs due to land/conflict issues and its often remote location. It is expected to develop hydropower near load centers and consider less land/conflict issues.
- Peak load is sharpening in the daytime and sometimes the supply capacity is stretched to (mainly diesel generators) meet the power shortage. Development of power systems that can be utilised during peak demand periods should be examined.

Independent grid area (off-grid area) has the following common issues.

- In off-grid areas where they have never utilised electricity, it must forecast an appropriate demand to match the design capacity and operation pattern of renewable energy systems.
- Entities ensuring appropriate operation and maintenance (O&M) must be formulated for sustainable use.
- To avoid land/conflict issues, site selection should be considered with balance and fairness.

## 7.2 Renewable Energy Development Considering Impacts on Mitigation for Climate Change

In general, application of renewable energy is categorized into 4 groups, namely, (i) Reliable Power Resource in On-Grid (Hydro, Geothermal and Biomass), (ii) Unstable Resource in On-Grid (Solar and Wind), (iii) Reliable Power Resource in Off-Grid (Small/Mini Hydro), (iv) Unstable Resource in Off-Grid (Distributed Solar). Application cases of renewable energy are evaluated, considering impacts on mitigation for climate change, as follows.

**Table 7-1 Matrix of Application of Renewable Energy**

| | Effects on Reduction of $CO_2$ Emission | Existence of Potential Site | Development Risk | Evaluation |
|---|---|---|---|---|
| Reliable Power Resource in On-Grid (Hydro, Geothermal and Biomass) | **A**<br>It contributes to reduction of new installation of diesel and/or its generation. | **C**<br>Potential sites which are close to demanding area is limited. | **C**<br>In case that land/conflict issues exist, development requires long lead-time. | **B**<br>In general, one project has a middle or large scale that has a big impact on mitigation. Possibility should be considered in middle/long term. |
| Unstable Resource in On-Grid (Solar and Wind) | **B**<br>It contributes to reduction of partial diesel generation. | **A**<br>Solar can be basically installed in any grid. Wind resource is limited. | **B**<br>There is a limitation of capacity to install. It needs to study possible capacity not to affects on operation of grid. | **B**<br>Several tens kW – 100 kW class can be examined. There are impacts on mitigation to some extent. |
| Reliable Power Resource in Off-Grid (Small/Mini Hydro) | **C**<br>It might contribute to reduction of installation of diesel and/or its generation. | **B**<br>There are some potential sites for small or mini hydro in terms of technical. | **C**<br>There are some critical issues such as existence of demand, formulation of executing entity, and land/conflict issues. | **C**<br>Impacts on mitigation are not so large. |
| Unstable Resource in Off-Grid (Distributed Solar) | **C**<br>It does not contribute to replacement of diesel generation. Kerosene users can be replaced. | **A**<br>Distributed solar can be basically installed in any area. | **C**<br>It can be installed in any area. In other words, site selection is not so easy. | **C**<br>Impacts on mitigation are not so large. It is necessary to replace kerosene utilization for contribute to mitigation. |

A: Very Good, B: Good, C: Fair, D: No Good

## 7.3 Cooperation Fields to Each Country

### 7.3.1 Cooperation Fields in Each Renewable Energy

As proposed the above, from the viewpoint of mitigation for climate change, a priority sets on (i) reliable power source in on-grid (which has a large impact in 1 project) and (ii) unstable resource in on-grid (which has many sites with middle scale impacts). Considering this priority and needs collected from the interview survey, possible cooperation fields to each country are summarized below (colored columns have more priority).

**Table 7-2 Summary of Possible Cooperation Fields**

| | | Nauru | Kiribati | PNG | Solomon Islands | Samoa |
|---|---|---|---|---|---|---|
| **Hydro** | | ● No potential | ● No potential | ● Repowering and rehabilitation of existing Rouna P/S. | ● Potential survey and construction of proposed 15 small hydro sites | ● ADB/JICA is now assisting through a sector loan. |
| **Solar** | **On-Grid** | ● Possibility study and installation of grid-connected solar power. | ● Possibility study and installation of grid-connected solar power in south Talawa system.<br>● Preparation of grid-connection guideline. | ● No specific request from interviewed agencies. | ● Possibility study and installation of grid-connected solar power in Honiara and provincial cities systems. | ● Possibility study and installation of grid-connected solar power in Upolo island. |
| | **Off-Grid** | ● Taiwan has assisted. | ● EU has assisted. | ● PNGSEL, WB, etc. have assisted. | ● Italian government has assisted. | ● For un-electrified area, UNDP has completed the study. |
| **Biomass and Wind** | | ● Wind data is now being collected. | ● Wind data is now being collected. | ● No specific request from interviewed agencies. | ● No specific request from interviewed agencies. | ● No specific request from interviewed agencies. |
| **Energy Efficiency** | | ● A mining company RONPHOS (a large consumer) seeks energy efficiency methods. | ● Needs is still low. | ● PPL is now conducting demand side management. | ● Needs is still low. | ● Needs is still low. |
| **Training Program on Renewable Energy and Energy Efficiency** | | ● Training on renewable energy and energy efficiency. | ● Training on renewable energy and energy efficiency. | ● Capacity building of CDM appraisal staff.<br>● Training on renewable energy and energy efficiency. | ● Assistance for formation of DNA.<br>● Training on renewable energy and energy efficiency. | ● Training on renewable energy and energy efficiency. |

### 7.3.2 Soft Component for Mitigation for Climate Change

From this survey, some institutional issues have been identified as follows.

- Lack of skilled staff of appraisal of CDM (PNG)
- No DNA for appraisal of CDM (Solomon Islands)
- No legal basis and technical guideline for grid connection (Kiribati, Samoa)

- Lack of knowledge for planning and design for renewable energy (All 5 countries)
- Lack of human resource, budget and skill for energy conservation and efficiency (All 5 countries)

To tackle such issues, soft component as shown below is one of possible programs through regional cooperation framework.

- CDM capacity building
- Assistance for DNA formulation
- Preparation of grid-connection guideline
- Training program on renewable energy and energy efficiency in Japan

As for training program on renewable energy and energy efficiency in Japan, to be effective training program, it is proposed to include the following agenda. Engineers are expected to be targeted as trainees in the program. These engineers will obtain skills and know-how for transference of such contents to their colleagues or users in their own countries.

**Table 7-3 Example of Training Program in Japan**

| | Planning, Design and Maintenance Skill | Introduction of Institution, Application and New Technology | Site Visit and Factory Visit |
|---|---|---|---|
| Expected Agenda | ● Case study of planning<br>● Practice of design, analysis and consideration points<br>● Case study for each failure mode<br>● Transfer know-how of operation and maintenance to users | ● Presentation of institutional framework and programs<br>● Introduction of application cases of renewable energy technology<br>● Introduction of new technology (battery, high efficiency technology, monitoring technology, etc.) | ● Visit of renewable energy and efficiency technology sites<br>● Factory visit of major renewable energy technology |
| Target Technology | ● Large solar connected<br>● SHS connected<br>● Small hydro<br>● Wind power | ● Energy conservation policy and programs<br>● All renewable energy<br>● All energy efficiency technology | ● Large solar and SHS<br>● Small hydro<br>● Wind power<br>● Geothermal<br>● Biomass<br>● New and high efficiency technology |