Review of Tariff of Palau Utility Corporation
Final Report

Prepared for the Palau Energy Office (PEO) as the Implementing Partner for the United Nations Development Program (UNDP)

13 January 2010
Review of Tariff of Palau Utility Corporation

Final Report

Prepared for

The Palau Energy Office (PEO) as the Implementing Partner for the Government of Palau/United Nations Development Program (UNDP)/Global Environment Facility (GEF) Sustainable Economic Development through Renewable Energy Applications (SEDREA) project

Prepared by

Ridgway Capital Projects Limited
Level 9, Craigs Partners House, PO Box 1284, Christchurch, New Zealand
T +64 3 367 3150 F +64 3 367 3151 www.ridgway.co.nz

and

Empower Consultants Limited
32/40 Salamanca Road, Kelburn, Wellington, New Zealand
T +64 4 471 2525 F +64 4 471 2526

13 January 2010

PPUC01

© Ridgway Capital Projects Limited 2009

The information contained in this document produced by Ridgway Capital Projects Limited is solely for the use of the Client identified on the cover sheet for the purpose for which it has been prepared and Ridgway Capital Projects Limited undertakes no duty to or accepts any responsibility to any third party who may rely upon this document.

All rights reserved. No section or element of this document may be removed from this document, reproduced, electronically stored or transmitted in any form without the written permission of Ridgway Capital Projects Limited.
Quality Information

Document Review of Tariff of Palau Utility Corporation

Ref PPUC01

Date 13-Jan-10

Prepared by JS/TW

Reviewed by RBM/TH/PC/CM

Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Revision Date</th>
<th>Details</th>
<th>Authorized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Name/Position</td>
</tr>
<tr>
<td>1</td>
<td>3-Dec-09</td>
<td>Draft Final Report</td>
<td>RBM</td>
</tr>
<tr>
<td>2</td>
<td>31-Dec-09</td>
<td>Final Report (draft)</td>
<td>RBM</td>
</tr>
<tr>
<td>3</td>
<td>13-Jan-10</td>
<td>Final Report</td>
<td>RBM</td>
</tr>
</tbody>
</table>
# Table of Contents

**Executive Summary** 1  
1 **Introduction** 7  
1.1 Background and Appointment 7  
1.2 Objectives of the Review 8  
1.3 Implementation Schedule and Deliverables 8  
1.4 Consultations and References 9  
1.5 Structure of the Report 11  
1.6 Acknowledgments 12  

2 **Setting** 13  
2.1 Country Profile 13  
2.2 Overview of the economy of Palau 14  
2.3 PPUC and its Objectives 14  
2.4 PPUC System Overview 15  
2.5 Current PPUC Electricity Tariffs 18  

3 **Demand Development of PPUC Operated Grids** 21  
3.1 Overview 21  
3.2 Historical Trends in Demand Development 21  
3.3 Potential for Growth 23  
3.4 Development of Productive Use Programs 26  
3.5 Development of Demand Side Management 26  

4 **Investment Requirements to meet Demand** 28  
4.1 Introduction 28  
4.2 Loss Reduction Program 28  
4.3 Potential for Energy Efficiency and Diesel Substitution 30  
4.4 Energy Efficiency and Productive Use Programs 31  
4.5 Fuel Substitution 32  
4.6 Solar Thermal 35  
4.7 Solar PV 36  
4.8 Wind Power Options 38  
4.9 Hydro-Electric Potential 39  
4.10 Ocean based power generation 40  
4.11 Net Metering vs Net Billing 40  
4.12 Indicative Investments for Alternative Generation Options 41  

5 **Required Revenue Analysis** 42  
5.1 Methodology 42  
5.2 Expected Operating Cost 47  
5.3 Future Capital Requirements 49  
5.4 Current Asset Values 50  
5.5 Estimated Required Revenue 51  
5.6 Long-Run Marginal Cost and the Required Revenue Summary 52  

6 **Fuel Adjustment Mechanism** 53
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Overview</td>
<td>53</td>
</tr>
<tr>
<td>6.2</td>
<td>Fuel and Lubes Adjustment Mechanism</td>
<td>53</td>
</tr>
<tr>
<td>6.3</td>
<td>Mechanism Implementation Schedule</td>
<td>55</td>
</tr>
<tr>
<td>7</td>
<td>Electricity Requirements of Low Income Households</td>
<td>56</td>
</tr>
<tr>
<td>7.1</td>
<td>Introduction</td>
<td>56</td>
</tr>
<tr>
<td>7.2</td>
<td>Tariff Subsidies and their Financing</td>
<td>56</td>
</tr>
<tr>
<td>7.3</td>
<td>Types of Pro Poor Mechanisms</td>
<td>57</td>
</tr>
<tr>
<td>7.4</td>
<td>Pacific Experience with Lifeline Tariffs</td>
<td>58</td>
</tr>
<tr>
<td>7.5</td>
<td>Willingness to Pay for Electricity</td>
<td>59</td>
</tr>
<tr>
<td>7.6</td>
<td>Possible Domestic Tariff Arrangements for PPUC</td>
<td>61</td>
</tr>
<tr>
<td>7.7</td>
<td>Financial Analysis of Proposed Lifeline Tariff</td>
<td>62</td>
</tr>
<tr>
<td>8</td>
<td>Tariff Structure and Rate Determination</td>
<td>63</td>
</tr>
<tr>
<td>8.1</td>
<td>Introduction</td>
<td>63</td>
</tr>
<tr>
<td>8.2</td>
<td>Issues in Tariff Design</td>
<td>63</td>
</tr>
<tr>
<td>8.3</td>
<td>Recommended Electricity Rate Structure</td>
<td>69</td>
</tr>
<tr>
<td>8.4</td>
<td>Developing Educational Material</td>
<td>70</td>
</tr>
</tbody>
</table>

Attachment 1 – Scope of Work 72
Attachment 2 – Consultations 76
Attachment 3 – References 77
Attachment 4 – Work and Action Plan 78
Attachment 5 – Personnel Schedule 79
Attachment 6 - NDBP Energy Efficiency Outline 799
Tables, Figures and Attachments

Tables
Table 1 – Average Tariffs Required: 5% & 10% Diesel Price Rises and Status Quo Generation 1
Table 2 – Average Tariffs Required: 5% & 10% Diesel Price Rises and 100% RE Target 4
Table 3 - Consultant Team 7
Table 4 - Project Deliverables 9
Table 5 - PPUC Generation System 15
Table 6 - Average Tariffs of Pacific Island Countries 20
Table 7 - PPUC Customer Numbers by Class and Location - FY2009 23
Table 8 - Current PPUC Debt Facilities 46
Table 9 – PPUC FY2010 Budget. 48
Table 10 – PPUC Fixed Asset Register and 2010 Depreciation Schedule 50
Table 11 – LRMC and Required Revenue by Island – 100% RE by 2030 52
Table 12 – Residential and Commercial Willingness to Pay Calculations 60
Table 13 – Billing Classes, Volumes, Current and Proposed Tariffs (FY2010) 62
Table 14 – Billing Classes, Volumes, Current and Proposed Tariffs by Island (FY2010) 67
Table 15 – Average Tariff Collected/Required and Subsidy per Island (FY2010) 68

Figures
Figure 1 – Average Diesel Based Tariff Required. 2
Figure 2 - Photographs from PPUC Site Visits (November 2009) 10
Figure 3 - Map of Republic of Palau 13
Figure 4 - PPUC Customer Connection – Koror/Babeldoab September 2009 16
Figure 5 - PPUC Customer Connections – Outer Islands September 2009 17
Figure 6 - PPUC KWh Sales – Koror/Babeldoab FY2009 17
Figure 7 - PPUC KWh Sales – Outer Islands FY 2009 18
Figure 8 - PPUC Tariffs 2001 – 2009 19
Figure 9 – Comparison of selected Pacific Island average tariffs 20
Figure 10 - PPUC Customer Connections by Category (2004 - 2009) 21
Figure 11 - PPUC Fuel Price History (2003 - 2009) 22
Figure 12 - PPUC KWh Sales (2004 - 2009) 22
Figure 13 - Advertising for Compact Fluorescent Light (CFL) campaign 26
Figure 14 – Forecasted Annual Generation (MWh) (2009-2029) 28
Figure 15 – Loss Reduction Program Targets 2010-2029 29
Figure 17 – Comparison between grid connected PV and PPUC generation costs 37
Figure 18 - Wind Resources Map for Palau 39
Figure 19 – PV kW Required for 100% Diesel Independence by 2030 49
Figure 20 – PV Capital Investment Program 2010-2030 50
Figure 21 – Annual PPUC Revenue Requirements Status Quo vs 100% RE Generation 51
Figure 22 – Average Tariff Required for PPUC Breakeven – 2009-2029 70
Figure 23 – PPUC 2010 Average Tariff Revenue Requirements (USc per kWh) 70
Glossary

ADB  Asian Development Bank
Assignment  Review of Base Tariff of Palau Utility Corporation
Consultant  Consultant team lead by Ridgway Capital Projects
DFI  Development Finance Institutions
EBRD  European Bank for Reconstruction and Development
EU  European Union
GoP  Government of Palau
GWh  Gigawatt hour
IDA  International Development Association
JICA  Japan International Cooperation Agency
kW  Kilowatt
kWh  Kilowatt Hour
kWpk  Kilowatt Peak
LRMC  Long Run Marginal Cost
LRMCC  Long Run Marginal Capital Cost
LRMOC  Long Run Marginal Operating Cost
MDG  Millennium Development Goals
MW  Megawatt
NDBP  National Development Bank of Palau
NGO  Non Government Organizations
NPV  Net Present Value
NZ  New Zealand
NZD  New Zealand Dollars
OTEC  Ocean Thermal Energy Conversion
PEO  Palau Energy Office
PPO  Pure Plant Oil
PPUC  Palau Utility Corporation
PPP  Public/Private Partnership
PV  Photovoltaic
Review  Review of Base Tariff of Palau Utility Corporation
RFQ  Request for Quotation
ROP  Republic of Palau
UNDP  Pacific Islands Applied Geoscience Commission
SOW  Scope of Work
Study  Review of Base Tariff of Palau Utility Corporation
TOR  Terms of Reference
USD  US Dollar
WACC  Weighted Average Cost of Capital
WB  World Bank
WTP  Willingness to Pay
Executive Summary

The Palauan Generation Context.

With 99.3% of its electricity being produced from diesel based generation, Palau is exposed to the risk of volatile and rising electricity prices. As fuel costs comprise almost two thirds of all operating expenses, any rise in the price of diesel has a consequent impact on required tariffs.

While in theory PPUC’s fuel-pass-through mechanism works to ensure that the utility does not bear the burden of diesel price rises, end users and the Palau economy feel such consequences. Increases in the price of diesel and the subsequent increases in tariffs affect all customer classes. Residential customers are likely to experience decreases in the standard of living as disposable income falls. Commercial customers would see profits fall and potentially be forced to raise prices to cover such increases, which affect their competitiveness. Overall Palau is likely to see economic growth reduced and macro-economic indicators such as the current account deteriorate as receipts to external oil supplier’s increase.

While oil prices have fallen from their August 2008 high of USD 3.95 per gallon to USD 2.12 per gallon as of November 2009, Palau would be wise to still plan to reduce reliance on diesel generation where possible. Such low prices are unlikely to last and the chances are the United States and other major consumers will recover, seeing demand for oil and diesel increase in price and, perhaps, volatility.

To demonstrate the relationship between diesel prices and end user tariffs, two scenarios are detailed below in Table 1. The first assumes diesel price increases of 5% per annum and the second assumes 10% diesel price increases per annum (keeping in mind that PPUC’s diesel price increased on average by over 80% per annum from October 2003 to August 2008).

<table>
<thead>
<tr>
<th>Year</th>
<th>5% Diesel Price Increase</th>
<th>10% Diesel Price Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Tariff Required (U$ per kWh), % Increase from 2009 (nominal)</td>
<td>Average Tariff Required (U$ per kWh), % Increase from 2009 (nominal)</td>
</tr>
<tr>
<td>2010</td>
<td>34.60, 8.9%</td>
<td>35.07, 10.4%</td>
</tr>
<tr>
<td>2015</td>
<td>35.87, 16.0%</td>
<td>43.14, 35.6%</td>
</tr>
<tr>
<td>2020</td>
<td>33.52, 21.2%</td>
<td>40.41, 55.5%</td>
</tr>
<tr>
<td>2029</td>
<td>35.15, 10.6%</td>
<td>37.57, 18.2%</td>
</tr>
</tbody>
</table>
The tariff projections above have not taken into account any additional costs that may be associated with long term climate change obligations on developing countries. The December 2009 discussions at Copenhagen concerning the post-Kyoto era may see nations such as Palau obligated to reduce their emissions or purchase offsets, which would further increase the cost of diesel generation.

The reality facing Palau is that diesel is not a renewable resource, supply is limited and demand is likely to increase, taking prices with it. For a nation dependent on diesel generation this is a grave concern.

In comparing tariffs of other utilities around the Pacific, Palau’s average tariff, while still high, is in the mid range of comparable countries. The average of the countries analysed below (excluding the high Vanuatu tariff) is US¢ 29.37 per kWh.

---

Supply Options Available to Insure Against Future Tariff Increases.

There are a number of alternatives to diesel generation of electricity for Palau. These include biodiesel, geothermal, hydro, Ocean Thermal Energy Conversion (OTEC), solar photo-voltaic (PV), solar thermal, wave and wind power. Some options, such as solar PV and biofuels are already proven, mature technologies, whereas others like OTEC and wave power are not proven, but may become viable in the future. Given Palau’s natural resources, geographic location and the size and shape of the demand curve, solar PV and jatropha based bio-diesel are seen to be the most likely to effectively displace diesel generation.

Palau receives over 2500 hours of sunshine per annum, making it an ideal candidate for solar PV generation. One of the major benefits of solar PV is the very low operating costs which results in a very accurate levelized cost estimate. The high capital cost/low operating cost aspect of solar PV also means it is an ideal candidate for donor funding as, by in large, donors prefer to fund capital costs as opposed to ongoing expenses. The current Long Run Marginal Cost (LRMC) of a large scale solar PV array is approximately 20¢ per kWh making it viable from an economic perspective based on current fuel prices, in addition to the ‘insurance’ it provides against future diesel price rises.

Palau also lends itself well to bio-diesel generation. Currently, the most realistic biofuel crop for Palau is likely to be the oilseed crop Jatropha. This plant already grows wild in Palau having been released during World War 2. It has proven its ability to grow in the depleted soils of the central Palau Islands and is regarded as having the potential to become a significant commercial crop, supplying oilseed to PPUC for processing into generator fuels. Coconut oil also has some potential, but is currently only grown in much smaller quantities than would be required to make a significant impact on PPUC’s requirements.

Oil from crops such as jatropha can be used to replace imported diesel oil. While current price estimates of Palauan bio-diesel production are lower than that of diesel (approximately USD 1.40 per gallon) the two additional benefits from bio-diesel are that it is not subject to the same price volatility as imported diesel and that it is produced domestically.

PPUC is forecast to spend over USD 17 million on diesel in FY 2010. The value of these funds sent out of Palau are equivalent to the total cash injection into Palau from the USA Compact Agreement. However, if PPUC was to switch to bio-diesel generation, even at comparable prices, this results in USD 17 million being for the benefit of Palauan companies, suppliers and workers every year. Such a shift would see a significant transformation in Palau’s current account deficit as well as the flow-on-effects for Palauan economic growth.

Bio-diesel has an additional benefit of being able to utilize PPUC’s existing generation assets, however additional investigations are required before the practice of putting Pure Plant Oil (PPO) into the generators is applied. This is because there can be serious implications from using biodiesel in generators that are not so designed. Hence the biodiesel specification must first be cleared with the manufacturers.

To produce jatropha in the quantities that PPUC is likely to require would require significant planting. There would be an environmental impact to a large scale jatropha plantation, as with any large scale agricultural project. However since the tree is not cut or damaged during harvest, and the soil is not disturbed after the initial planting stage, it is not expected that a formal environmental study would conclude that a net negative impact should be caused by the project.
Nonetheless, the impact should be formally assessed prior to a large scale plantation being commenced.

Both solar PV and bio-diesel are renewable energy sources and their environmental friendliness means that, depending on the outcome of the Copenhagen talks, Palau might be eligible for credits for its carbon offsets. These technologies should also avoid any additional carbon tax obligations that may be imposed in the future and would reduce Palau’s current carbon footprint. While the outcome of the Copenhagen talks is not yet clear, under existing arrangements Palau would be a candidate for receiving revenues under the Clean Development Mechanism (CDM). The country should embark on a baseline study in order to be eligible for the CDM however.

Additionally, electricity losses through station usage (6.5% of generation), transmission/distribution (6% of generation) and non-technical losses (8.5% of generation) increase PPUC’s cost of production and subsequently the required tariff. A loss reduction program is recommended to bring these figures in line with manufacture recommendation and international benchmarks.

A Path Forward.

If the Government of Palau (or PPUC itself) were to maintain the status quo and diesel prices were to rise by 10% per annum, PPUC would need to recover a levelized tariff of approximately 45.8¢ per kWh. However if a policy of being diesel-independent by 2030 were to be implemented, PPUC would only need to recover a levelized tariff of approximately 31.8¢ per kWh. A more moderate approach could be taken by adding some solar PV and bio-diesel technology but unless the Government of Palau/PPUC believe that diesel prices will decrease in the future, such an option is not financially optimal and is thus not recommended.

On a year by year basis, the impact of PPUC pursuing a 100% RE generation system utilizing solar PV and bio-diesel can be seen below in Table 2.

<table>
<thead>
<tr>
<th>5% Diesel Price Increase</th>
<th>10% Diesel Price Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Tariff Required</strong></td>
<td><strong>% Increase from 2009 (nominal)</strong></td>
</tr>
<tr>
<td>2010</td>
<td>33.12</td>
</tr>
<tr>
<td>2015</td>
<td>36.96</td>
</tr>
<tr>
<td>2020</td>
<td>38.55</td>
</tr>
<tr>
<td>2029</td>
<td>34.83</td>
</tr>
</tbody>
</table>

As previously mentioned, while certain RE technologies (such as solar PV) are cost effective from an operating expense perspective, they do have relatively high capital costs. To account for the differing balances between capital expenditure and operating costs that are particular to each type of generation, it is necessary to conduct a long run marginal cost (LRMC) analysis for each. Provided these LRMCs are lower than the fuel risk and environmental costs adjusted LRMC for diesel gensets, these technologies offer better value for money than diesel generation. The

---

2 Levelized tariff calculation based on a 20 year term
Consultant estimates that the LRMC for large-scale solar PV is approximately 25.48¢ per kWh and 23.44¢ per kWh for biodiesel. This is approximately half the diesel generation LRMC at 46.23¢ per kWh (assuming a 10% fuel price increase per annum) even before making adjustments for carbon costs. The costs associated with smaller solar PV systems of up to 5 kWpk is higher on a per kWh basis, but is still viable in Palau on an economic basis.

If it is anticipated that a programme of capital expenditure directed toward developing solar and biodiesel capacity is in Palau’s best interest, decisions need to be made regarding the funding of that expenditure. The Consultant calculates that some USD 158 million would be required to ensure Palau’s independence from imported diesel over the 2010-2029 period. Different funding mechanisms (commercial loans, concessionary loans from development agencies and Public/Private Partnerships (PPPs)) for this expenditure will bring with it different risks. PPUC has a sound and established relationship with the Palau based commercial banks and it is recommended that this source is pursued initially due to favorable financing terms available.\(^3\)

From a political and legislative perspective, PPUC is free to select generation options as it sees fit. Whilst PPUC is independent from the government and the PEO in this sense, it is possible that a partnership may evolve to assist Palau move towards more environmentally friendly, cost effective and lower risk generation options.

### Additional Issues Facing PPUC

While diesel dependence is the major challenge facing PPUC, other issues of note include the challenge of attracting back major customers (who chose to generate their own power during the system wide disruptions in April 2009), implementing prudent financial management measures and the implementation of a sound net metering bill.

PPUC lost several large customers during the period of interrupted supply in April 2009. Anecdotal evidence suggests that self generation options, in addition to providing greater reliability than PPUC could previously offer, was also cheaper (in the short term) than the PPUC tariff. However, once these generators necessarily incur the additional expense of the 24,000 hour overhaul, it is calculated that the PPUC commercial tariff will be relatively attractive and these customers are more likely to return to PPUC supply.

A study commissioned after the April 2009 disruptions concluded that a lack of adequate maintenance was the primary cause of these disruptions. The PPUC Generation Manager has devised a maintenance schedule for 2010 to see all generation plant properly serviced and operating as efficiently as possible. To facilitate this schedule from a financial perspective, it is recommended that PPUC create an audited appropriation account. This account would be funded directly from the tariff in line with the annual maintenance budget and would be solely for use for maintenance items.

A second audited appropriation account is also recommended as a sinking fund for additional/replacement capital assets. This account would be funded directly from the depreciation expense category of the budget. It is recommended that this normally ‘non-cash’

---

\(^3\) As a state owned enterprise, PPUC is able to access commercial funds through the GOP and take advantage of low interest rates and long tenors.
expense is instead treated as any other cost in order to see the appropriation account reach a level that can meet capital expenditure needs.

The Net Metering Bill currently before the Senate is likely to benefit both PPUC and its customers. The installation of small scale residential solar PV systems at a subsidized cost - including via the planned Renewable Energy Fund Window (REFW) at the National Development Bank of Palau (NDBP) - should see customers generate towards their day-time electricity requirements with any surplus being traded back into the PPUC grid as a future energy credit. Residential consumers should benefit through lower electricity bills. PPUC should also benefit through a more even load curve (as residential PV generation matches the day time air-conditioning load). As a result, PPUC should require lower levels of future capital investment in generation capacity.

PPUC should benefit through a reduction in grid based demand from these residential customers. As these customers first 500 kWhs per annum are heavily subsidized from other customer classes (only covering the current fuel component meaning no contribution to the fixed costs of PPUCs operation) each kWh offset from this bracket represents a reduction in PPUC’s fuel expense and a saving to the company and those other customers.

Conclusion

Overall, PPUC has made significant progress since April 2009 in the areas of generation reliability, corporate structure and financial management. As such, it is well placed to address the additional challenges it currently faces. If PPUC wishes to reduce its exposure to fuel price risk then it must reduce its diesel consumption insofar as is practically possible. Renewable energy generation coupled with expanded energy efficiency measures offer significant potential to achieve this goal if political and corporate alignment can be achieved.
1 Introduction

The Palau Utility Corporation (PPUC) has undergone significant changes during 2008-9. The Board of Directors was reformed in 2009 and this was followed by the appointment of a new Managing Director/Chief Executive Officer (CEO) in April 2009. These actions have strengthened governance and management to address the many challenges facing PPUC.

One of the most important issues to be addressed by PPUC is its high dependence on imported diesel for generation. This is the main reason for the high tariff and financial losses experienced by PPUC. PPUC has found itself caught in a spiral where its costs of production have increased and this has led to customer payment problems which have in turn reduced PPUC’s cashflows available to fund its business. The consequence has been that maintenance has suffered and power outages have increased. The combination of high tariffs and low reliability of supply has led some customers to install their own generation and this has reduced the customer base against which PPUC’s costs can be spread, further increasing the tariff.

A decline in global oil prices from their peak in August 2008 has provided PPUC with a slight reprieve from high diesel costs. However it is not certain that world oil prices will remain at these relatively low levels and PPUC should consider options to displace diesel consumption and reduce its exposure to this fuel price volatility.

This Review of the Tariff for the PPUC (Study/Assignment) requires the Consultant to undertake an analysis of the Corporation’s operations, an assessment of future demand, and review petroleum based and renewable energy options to meet this demand. From this analysis, the Consultant is to make recommendations on a tariff structure that would allow PPUC to operate in a commercially sustainable manner.

1.1 Background and Appointment

In July 2009, the United Nations Development Program (UNDP) and the Palau Energy Office (PEO) called for Request for Quotations (RFQ) from qualified consultants to undertake this Study as outlined in the TOR (refer Attachment 1). Following the submission date of 11 August 2009, PPUC evaluated the proposals and subsequently the PEO appointed Ridgway Capital Projects (New Zealand) in association with Empower Consultants (New Zealand), to conduct this Review.

The Consultant Team is as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Firm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richard MacGeorge</td>
<td>Project Director</td>
<td>Ridgway Capital Projects</td>
</tr>
<tr>
<td>James Stewart</td>
<td>Financial Specialist / Field Team Leader</td>
<td>Ridgway Capital Projects</td>
</tr>
<tr>
<td>Tony Woods</td>
<td>Technical Electricity Sector Expert</td>
<td>Empower Consultants</td>
</tr>
<tr>
<td>Peter Cole</td>
<td>Energy Specialist</td>
<td>Empower Consultants</td>
</tr>
</tbody>
</table>
The contract is administered and supervised through Gregorio Decherong of the PEO.

1.2 Objectives of the Review

As electricity employs assets that have long economic lives and require maintenance at planned intervals, the Government of Palau (GoP) and PPUC require advice and recommendations on a tariff structure that allows the commercially sustainable operation of the utility while balancing the interests of its consumers.

To be operationally viable, PPUC must recover its operating costs and also recover an amount sufficient to replace assets that wear out or become obsolete (usually as approximated by depreciation). To be financially viable, PPUC needs also to recover the opportunity cost of the capital it has employed in its networks. The opportunity cost of capital reflects the returns that PPUC could earn by investing the funds it has employed in another investment with similar risk. The opportunity cost could also reflect an objective set by shareholders and other stakeholders.

Therefore, the process of determining tariffs is highly iterative to the extent that it involves optimizing an outcome constrained by:

- A minimum required rate of return objective by the ultimate owners of the electricity supplier; and,
- The price that consumers can afford to pay based on the cost of the next best alternative supply of electricity services.

Our understanding of the objective of this Study is to derive a set of tariffs that reconcile these two competing requirements, and in so doing, identify issues that PPUC needs to address to make electricity supplies in Palau more affordable for both domestic and commercial consumers.

1.3 Implementation Schedule and Deliverables

The agreed commencement date for the Review was 1 October 2009 and the completion date is 31 December 2009.

The Consultant mobilized for the first field trip to Palau on Wednesday 4 November 2009, although desktop work had commenced prior to this mobilization date. During the first field trip, the Consultant conducted a range of preliminary discussions with stakeholders including GoP and PPUC staff, other governmental agencies, customers and other stakeholders. In addition, the Consultant inspected a number of PPUC’s operational sites in both Koror and the Outer Islands and collected available reference data. A summary of the interviews, field visits and reference material is recorded below and documented in Attachments 2 and 3.

The preliminary discussions and communication between GoP and PPUC have allowed the Consultant to more clearly map out how the assignment should be conducted and to amend the Work and Action Plan to reflect those discussions. The Work and Action Plan is referred to in Attachment 4.
The Consultant conducted the second field trip during 2-9 December 2009. During this time the Consultant presented the draft report containing its preliminary findings and recommendations to GoP and PPUC through pre-arranged meetings. In addition, the Consultant conducted a stakeholder workshop to discuss preliminary findings and to seek feedback from other key stakeholders.

Time was also scheduled with PPUC Management and its financial staff to provide training on the use of the financial model. Following this second mission the Consultant returned to their home offices and completed the Final Report and Tariff Setting Guideline document.

The approach and methodology in responding to the Terms of Reference (TOR) for this Review will generally be as described in the Consultant’s Proposal and as further summarized below with corresponding milestones:

<table>
<thead>
<tr>
<th>Deliverables</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft Inception Report</td>
<td>19 November (7 weeks from 1st October contract signing)</td>
</tr>
<tr>
<td>Final Inception Note</td>
<td>26th November (8 weeks after contract signing)</td>
</tr>
<tr>
<td>Draft Report</td>
<td>3 December (9 weeks after contract signing)</td>
</tr>
<tr>
<td>LRMC Calculations and Financial Models</td>
<td>3 December (9 weeks after contract signing)</td>
</tr>
<tr>
<td>Draft Stakeholder Workshop Report</td>
<td>17 December (11 weeks after contract signing)</td>
</tr>
<tr>
<td>Final Stakeholder Workshop Report</td>
<td>24 December (12 weeks after contract signing)</td>
</tr>
<tr>
<td>Draft Tariff Setting Guideline</td>
<td>24 December (12 weeks after contract signing)</td>
</tr>
<tr>
<td>Final Tariff Setting Guideline</td>
<td>31 December (13 weeks after contract signing)</td>
</tr>
<tr>
<td>Final Report</td>
<td>31 December (13 weeks after contract signing)</td>
</tr>
</tbody>
</table>

1.4 Consultations and References

The Study is a multi-disciplinary exercise and involves an assessment of financial, technical and economic issues. To ensure that implementation of the Study is balanced amongst all stakeholders, close cooperation between relevant Government of Palau agencies is essential. The participation of key agencies in the execution of this assignment has therefore been given priority and opportunities to provide feedback have been elicited in the Consultant’s first field visit.

The TOR makes provision for the Consultant to conduct field inspections of PPUC’s operations and conduct interviews with appropriate staff, governmental agencies, major customers and other
stakeholders. This provision enables the Consultant to gain a wide-ranging understanding of the issues which have an impact on the operations of the PPUC.

During the first field trip, inspections of PPUC’s key electricity assets were conducted by James Stewart and Tony Woods, accompanied by Ken Uyehara and Lorenzo Mamis from PPUC.

In addition, interviews and meetings were held with PPUC Board members, governmental agencies and major customers. PPUC did not attend any customer consultations because staff were conscious of the need for customers to be able to speak openly.

Consultations were also held with PPUC personnel including Jacqueline Alexander (Chief Financial Officer), Lorenzo Mamis (Generation Manager) and staff from the billing and outer islands generation departments.

During the second field trip, follow up meetings were held with the key staff of the PEO and PPUC. Additionally, two stakeholder workshops were held for members of the business community and the general public. Details of these workshops and lessons learned can be found in the Stakeholder Workshop Report.
1.5 Structure of the Report

This Report explains the Consultant’s general approach to the issues raised in the TOR and to describe how each of the Terms of Reference (TOR) tasks will be completed. The report is organized under the following sections:

Executive Summary:
This section sets out the principal findings of the Study.

Section 1 - Introduction, (this section):
This section states the objectives of the Study, describes its context and the background to the Consultant’s appointment. It outlines the organization of the Study and records some administrative matters.

Section 2 – Setting:
Describes the principal geographic features and economic issues of Palau as they relate to this study

Section 3 – Demand Development of PPUC operated Grids:
Describes the basis for projecting efficient electricity growth in each of the islands served by the PPUC distribution systems

Section 4 – Investment Requirements to meet Demand:
Provides an indicative investment plan largely designed to substitute diesel for renewable energy.

Section 5 – Required Revenue Analysis:
Reviews the revenue that PPUC reasonably needs to operate on a cost recovery basis. This is achieved through an examination of Long Run Marginal Cost methodology that is then applied to electricity to estimate the required revenue.

Section 6 – Fuel Adjustment Mechanism:
Describes the process and impact of implementing an automatic process to regulate the tariff based upon fuel cost and fuel efficiencies.

Section 7 – Electricity Requirements of Low Income Households:
Reviews the willingness to pay of Low Income Households and the alternatives available to meet their needs. Particular consideration is given to life line tariff approaches and their potential application in PPUC’s situation.

Section 8 – Tariff Structures and Rate Determination:
Deals with two issues. The first involves tariff design questions and considers other tariff structures that might be applied to PPUC services. The second recommends a rate structure that might be adopted by PPUC for electricity services.
1.6 Acknowledgments

The Final Report was prepared by the Consultant's team, namely James Stewart and Tony Woods. In assisting us to prepare this Report, the Consultant team is grateful for the generous cooperation and support of staff from PPUC and PEO, with particular gratitude for the assistance of PPUC General Manager, Ken Uyehara and the PPUC Chief Financial Officer, Jacqueline Alexander.
2 Setting

2.1 Country Profile

The Republic of Palau is located in the North-Western Pacific Ocean about 900 kilometers east of the Philippines. Situated in the Micronesian group of islands, the western end of the Caroline archipelago which represents Palau consists of six island groups totaling more than 300 islands, although only nine of the islands are inhabited. Geologically, the islands vary from the high, mountainous main island of Babeldoab to low, coral islands.

Babeldoab is the largest island and makes up 78% of the country's total land area of 458 square kilometers. A bridge links Babeldoab to the capital of Koror, the largest urban area in Palau where more than 70% of the population lives (est. 20,7964). Palauans account for 70% of the population with Asians, mainly Filipinos, accounting for nearly all of the balance.

Palau was for three decades a part of the United Nations Trust Territory of the Pacific under the administration of the United States (US). In 1978, this westernmost cluster of the Caroline Islands opted for independence rather than join the Federated States of Micronesia. A Compact of Free Association with the US was approved in 1986 although was not ratified until 1993. This Compact entered into force the following year when the islands, namely the Republic of Palau, gained independence.

Figure 4 - Map of Republic of Palau

Source: Asian Development Bank

---

2.2 Overview of the economy of Palau

The economy consists primarily of tourism, subsistence agriculture, and fishing with the population enjoying a per capita income roughly three times that of the Federated States of Micronesia.

Tourism is Palau’s main source of income with long-term prospects for the sector bolstered by the expansion of air travel in the Pacific, the prosperity of leading East Asian countries, and foreign investment in infrastructure development. However, this sector has suffered a recent setback due to the financial crisis with visitor arrivals, particularly from the key Taipei-Chinese tourist market, falling 11.3% in year ending August 2009\(^5\).

Beyond subsistence fishing and a small local market, Palau’s main source of income from the fishing sector comes from the sale of licenses to fishing vessels from Japan, China, the US, and Taipei-China for tuna fishing in Palau’s extensive exclusive economic zone. Palau also has a small-scale manufacturing sector producing mainly handicrafts and garments for the local market and for tourists.

Recently, economic activity has been dampened by uncertainty over financial assistance from the US. Although funding has been provided for the 2010 fiscal year, the continuation of long-term US financial assistance is under review. The Government is facing the challenge of managing a possible decline in disbursements under the Compact with the need to expand local revenue sources, which will require the development of a framework to encourage broad-based private sector participation.

A USD 53 million budget for the fiscal year ending September 2010 has recently been approved by the Government, which includes a 10% cut in government spending and the removal of a financial assistance program for low income families. This budget demonstrates the GoP’s strategy to reduce the level of government expenditures and to reprioritize its goals.

2.3 PPUC and its Objectives

PPUC is a public corporation under the PUC Act (RPPL No. 4-13) dated 16th of February 1994 with Ken Uyehara acting as its General Manager and CEO. Under the Act PPUC is charged with 15 tasks, three of these being primary responsibilities and central to this Study. These are:

1. Establishing and operating electrical power services within the Republic;
2. Establishing and implementing a structure of rates for its electrical power services and facilities calculated to ensure that adequate and equitable charges are imposed for its services; and,
3. Investigating, researching and implementing where feasible and practicable the application of appropriate renewable energy resources including solar power, tidal power, and wind generated power.

PPUC supplies power to the two main islands of Koror and Babeldoab through the Malakel and Aimeliik power plants. Three outer islands, Kyangel, Peleliu and Angaur are also supplied.

\(^5\) Pacific Economic Monitor – November 2009 published by the Asian Development Bank (ADB)
2.4 PPUC System Overview

Diesel generation underpins the PPUC system across Babeldoab/Koror and the three outer islands. As at 12 November 2009, 21.3 MW of generating capacity was available on Koror/Babeldoab, 1.5MW on Peleliu, 0.65 MW on Angaur and 0.3 MW on Kayangel. Full details of PPUC’s generation system are listed in the table below.

<table>
<thead>
<tr>
<th>Power Station</th>
<th>Unit</th>
<th>Rated Output</th>
<th>Available Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malakal</td>
<td>Wartsila -1</td>
<td>2.0</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>Wartsila -2</td>
<td>2.0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Wartsila -3</td>
<td>2.0</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>Mitsubishi -12</td>
<td>3.4</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Mitsubishi -13</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>Caterpillar -1</td>
<td>1.825</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Caterpillar -2</td>
<td>1.825</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Alco - 9</td>
<td>1.25</td>
<td>0.5</td>
</tr>
<tr>
<td>Aimeliik</td>
<td>Pielstick -2</td>
<td>3.27</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Pielstick -3</td>
<td>3.27</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Pielstick -4</td>
<td>3.27</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Pielstick -5</td>
<td>3.27</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal</strong></td>
<td><strong>30.78</strong></td>
<td><strong>18.1</strong></td>
</tr>
<tr>
<td>Peleliu</td>
<td>Yanmar -1</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Yanmar -2</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Denyo</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal</strong></td>
<td><strong>2.0</strong></td>
<td><strong>1.5</strong></td>
</tr>
<tr>
<td>Angaur</td>
<td>Denyo -1</td>
<td>0.25</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Denyo -2</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Caterpillar -1</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal</strong></td>
<td><strong>0.65</strong></td>
<td><strong>0.40</strong></td>
</tr>
<tr>
<td>Kayangel</td>
<td>Denyo -1</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Denyo -2</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal</strong></td>
<td><strong>0.3</strong></td>
<td><strong>0.3</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>36.43</strong></td>
<td><strong>20.30</strong></td>
</tr>
</tbody>
</table>

The Wartsila-2 generator is currently inoperable requiring a new crankshaft. No plans are in place to replace this crankshaft due to the high cost of replacement (estimated to be USD 1.2m). Both the Mitsubishi 12 generator (Malakal) and the Denyo 1 generator (Aimeliik) are also out of service with no scheduled date for repair.
A new 10 MW diesel generator has recently been procured and is expected to come on line in mid 2010. The entire USD 4 million cost is being funded through existing PPUC investment account reserves.

An additional 10 MW generator has also been procured through JICA funding for the Aimeliik power plant in 2011.

A 100 kWpk grid-connected photovoltaic (PV) system was installed at the Capitol in Melekeok in December 2008 with grant funding from the European Union (EU). This asset has been transferred to PPUC ownership. Since its installation it has produced approximately 110MWh of energy offsetting almost 80 tonnes of CO2, which amounts to an estimated 7,900 gallons of diesel (over USD 16,000 at November 2009 prices). A second grant funded PV system located at the Koror hospital is scheduled to be transferred to PPUC ownership in mid-2010.

Transmission lines in Palau use 34.5 kV with 74.5 kilometers across the network. Distribution lines operate at 13.8 kV with 195.1 kilometers in place.

As at September 2009 there were a total of 7,112 customers in Koror/Babeldoab and 335 in the three outer island systems. Approximately 78% of these connections are residential consumers, 13% commercial, 5% ROP and 4% Government.

![Figure 5 - PPUC Customer Connection – Koror/Babeldoab September 2009](image)

---

6 PPUC classifies central government customers as “ROP” and local government customers as “Government”
Overall commercial users account for approximately 34% of all energy consumption, residential consumers 34%, ROP 25% and Government 5%. This trend is vastly different in the outer islands where commercial consumption is far lower and residential consumption forms the majority of energy demand.
2.5 Current PPUC Electricity Tariffs

PPUC currently categorizes its tariffs into four separate customer classifications. Residential customers pay an increasing tariff based on their level of demand. The first 500 kWh per annum are billed at US 19.2¢ per kWh, units 501-2000 are billed at US 27.2¢ per kWh and any additional units are billed at US 31.7¢ per kWh. As the lowest residential/lifeline tariff is below the actual cost of generation of FY2009 (28.1¢ per/kWh), an implicit subsidy was in place for these customers.

Energy consumed by commercial or government customers is billed at a flat rate of USD 31.7¢ per kWh although some large commercial customers are offered discounted rates to entice them to stay on the PPUC grid.

Prior to July 2008, commercial and government tariffs were differentiated based on usage, with a lower charge for consumption under 2,000 kWh per annum. This structure was discontinued with a single flat rate (equal to the over 2,000 kWh residential rate) being applied.

As illustrated in the figure below, tariffs have steadily increased in the period 2001-2008, with a noticeable decrease in 2009 due to a fall in the price of diesel.
Actual tariffs are comprised of an ‘energy’ component and a ‘fuel’ component. The ‘energy’ component is established to recover all non-fuel costs of the PPUC operation. The ‘fuel’ component is intended to recover the total fuel cost associated with each kWh generated. In reality, the subsidy applied to the Residential 0-500 kWh category means that this customer class only pays the fuel component of each kWh and makes no contribution to PPUC’s non-fuel expenses.

PPUC customers on the outer islands of Angaur, Peleliu and Kayangel pay the same tariffs as customers on Koror and Babeldoab. This tariff rate essentially equates to an outer island subsidy as the additional costs associated with outer island generation (additional transportation and less efficient generators) are not passed on to outer island customers. It has been estimated that the outer islands will make an operational loss of USD 900,000 in the financial year ending September 2009, which amounts to USD 77.4¢ for each of the 1.16 GWh sold in the three outer islands.

Overall, for the financial year ended September 2009, total PPUC billings were USD 20.013 million. During this period PPUC customers consumed 62.985 GWh resulting in an average tariff of USD 31.77¢ per kWh required for the utility to breakeven.

In comparing tariffs of other utilities around the Pacific, Palau’s average tariff, while still high, is in the mid range of comparable countries. The average of the countries analysed below (excluding the high Vanuatu tariff) is USD 29.37¢ per kWh.
Table 6 - Average Tariffs of Pacific Island Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Tariff (USD)</th>
<th>% difference to PPUC average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palau (2009)</td>
<td>0.3177</td>
<td></td>
</tr>
<tr>
<td>North Mariana</td>
<td>0.24</td>
<td>-1.28%</td>
</tr>
<tr>
<td>Tuvalu (2006)</td>
<td>0.25</td>
<td>2.84%</td>
</tr>
<tr>
<td>Nauru (2006)</td>
<td>0.25</td>
<td>2.84%</td>
</tr>
<tr>
<td>American Samoa</td>
<td>0.29</td>
<td>19.29%</td>
</tr>
<tr>
<td>Tonga (2006)</td>
<td>0.31</td>
<td>27.52%</td>
</tr>
<tr>
<td>FSM (2006)</td>
<td>0.31</td>
<td>27.52%</td>
</tr>
<tr>
<td>Chuuk (2007)</td>
<td>0.37</td>
<td>52.20%</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>0.38</td>
<td>56.31%</td>
</tr>
<tr>
<td>Vanuatu (2007)</td>
<td>0.73</td>
<td>200.29%</td>
</tr>
</tbody>
</table>

Figure 10 – Comparison of selected Pacific Island average tariffs

---

3 Demand Development of PPUC Operated Grids

3.1 Overview

Based on 2005 census data, there were a total of 4,707 households in Palau. At the same time, PPUC had between 4,767 and 5,201 residential household connections. Although it is not clear what proportion of households have more than one electricity connection, it demonstrates that Palau has a very high residential electrification rate.

Until 2008, the number of customer connections increased across all classes. However, since this time and as illustrated in the figure below, the number of connections has decreased slightly.

Figure 11 - PPUC Customer Connections by Category (2004 - 2009)

3.2 Historical Trends in Demand Development

PPUC has seen a steady decline in energy consumption across all customer classes since early 2008. This decrease in demand corresponds with an increase in tariffs as a direct result of an increase in world oil prices and the pass-through of these increased charges to the customer. This information is provided in the figures below.
Furthermore, the combination of a complicated fuel pass through mechanism and the decision by the previous Board of Directors to hedge fuel prices near the global peak left customers paying high tariffs which in turn provided insufficient revenue for PPUC to cover operating expenses, including repairs and maintenance. As a consequence, in April 2009 PPUC customers experienced generation failures and load-shedding.

Several large commercial customers, frustrated by the instability of supply, installed their own generators and either stopped or reduced their energy requirements from PPUC. This action further compounded the decrease in load on the PPUC grid and revenues flowing to the Corporation. The Consultant notes that due to the competitive diesel prices provided by both
Shell and Blue-Bay to large commercial users, off-grid generation seems viable in the short-term i.e. 1 to 2 years. However, it appears that these users have not factored the very costly expense of the 24,000 hour major maintenance overhaul into their pricing. When this cost is considered, it is expected that the medium term (2-4 year) economics of their investment will be more expensive than the PPUC rate offered to large commercial users.

3.3 Potential for Growth

Six key factors have been taken into account when considering the potential for growth in the PPUC network. These are:

- Increasing population of Palau;
- Increasing energy demands of each connection;
- Large commercial users returning to the PPUC grid;
- Price elasticity;
- The impact of residential PV systems and the net-metering bill; and,
- Energy efficiency measures.

3.3.1 Population Increase

The estimated 2009 population increase for Palau is 0.428%. While this rate of increase is not large it is expected that it will lead to increased PPUC connections and is therefore a factor to be considered when forecasting future growth.

The Consultant has assumed that the growth rate of 0.428% will be constant over the 20 year period to be modeled. It has also assumed that a 0.428% increase in population will lead to an equivalent increase in the number of households (and hence the number of PPUC residential connections), the Palauan economy (number of commercial connections) as well as Government and ROP connections.

3.3.2 Increasing Energy Demand

In addition to an increase in the number of PPUC connections, the Consultant has assumed that the average customer will consume more energy in the future than they have in the past. As electrical technologies become more prevalent and common place in Palauan life, and as GDP per capita rises, it can be expected that more energy will be consumed by each customer.

---

In recent years, this concept has been largely offset due to large increases in tariffs. However, if electricity prices were held constant in real terms it is expected that an increase in demand would have been evident. If PPUC chooses to employ more Renewable Energy (RE) technology (such as solar PV), this would reduce the Corporation’s dependence on diesel generation and the impact of higher fuel charges.

It has been assumed that electricity sales per customer per class will remain static (from currently levels) over the forecast period. PPUC’s historical data shows a marked decrease in consumption per connection, largely due to increases in the electricity tariffs. This visible impact of elasticity of supply is predicted to become less apparent as electricity prices stabilize in real terms under a 100% RE scenario.

3.3.3 The Return of Off-Grid Commercial Users

As previously mentioned, it is expected that several large commercial users will return to the PPUC grid as their own generation units reach 24,000 hours of operation. This factor would add substantial load to the PPUC grid and is a factor that has been incorporated into tariff projections.

3.3.4 Price Elasticity

As illustrated in the kWh sales data above (Figure 13) it is clearly evident that all classes of PPUC customer are price sensitive. As the fuel component of the tariff increased in early 2008, a subsequent decrease in kWh demand was experienced. This correlation suggests that the current tariffs are very close to the average customer’s ‘willingness to pay’ (WTP) and at this threshold customers will respond to any increases by marked decreases in demand.

The concept of WTP is discussed in further detail in Section 7 and provides guidance on upper limits for each customer class and the extent to which price elasticity will impact upon demand.

3.3.5 Residential PV Systems and the Net-Metering Bill

The GoP and the National Development Bank of Palau (NDBP) are working together on a residential PV program. This scheme will provide subsidies for small scale residential PV systems. During daylight hours, residential users would generate some or all of their own electricity, reducing the load on the PPUC grid and decreasing demand for energy.

A Net Metering Bill is currently before the Senate of Palau which, if passed, would enable households to send any excess energy generated from PV systems, back into the PPUC grid during daylight hours. Users will receive a credit for these kWh which they can use during times their PV panels are not generating sufficient energy to meet their household needs.

While it cannot be known with any certainty how many consumers will take part in the residential small scale PV program, the impact is not likely to be substantial in 2010. The NDBP aims to establish a small number of pilot programs during 2010 before opening the scheme up to the wider public in 2011 and beyond. The Renewable Energy Fund Window (REFW) has made predictions about the amount of solar PV that could be installed for domestic systems over the first 3 years of the program. A total of 1% penetration has been assessed as realistic, and this would equate to a total of 43 homes installing a solar grid tie system through the PV program.
This bill would also have consequences for the growth potential of the PPUC network. These two schemes will impact PPUC in two major ways. Firstly, it is likely that PPUC will require less additional generation capacity in the future. It is thought that the daytime peak of PPUC’s daily load curve will decrease. The daytime peak is largely due to air-conditioning usage. With the proposed installation of residential solar PV systems, generation from these systems will coincide with peak daytime power demand when air-conditioning usage increases. Not only will small residential PV users offset their own usage (allowing more energy to be allocated to other users), but under the proposed Net Metering Bill, they will likely ‘top-up’ the PPUC network with their surplus generation at the very time in the day that PPUC requires it most.

Secondly, overall demand for PPUC energy is likely to decrease as residential PV users offset their own demand during the day depriving PPUC of a kWh sale. Furthermore, any surplus generation that is fed into the PPUC grid will result in a kWh credit to residential users which can be used at a later time e.g. for cooking, thereby depriving PPUC of a kWh sale.

The first impact is likely to have positive benefits for PPUC as less additional generation capacity may be required to meet the daily peak. This may allow a reduction in PPUC’s tariff as capital expenditure may decrease compared to current estimates. In contrast, the second impact may have a negative influence on the tariff as the fixed costs of electricity supply need to be recovered from a smaller pool of energy sales.

3.3.6 Energy Efficiency Measures

In January 2008 Executive Order No. 245 was enacted requiring all Palau government ministries to reduce their energy usage by 10% from their historical (previous two years) average. This Executive Order was the originated from the SOPAC/UNDP/PIEPSAP assisted Palau Energy Conservation Strategy (PECS) - Strategies and Action Plans to Reduce Energy Consumption by Government (2007).

The PEO is also active in promoting energy efficiency programs across Palau including the Compact Fluorescent Light (CFL) campaign. In this campaign, consumers are provided with CFL bulbs to replace standard incandescent bulbs (see Figure 14 below). Such programs are likely to decrease demand for PPUC generation and as such, need to be considered when forecasting future growth in the PPUC grid. Other measures such as reviewing the state of repair of domestic and commercial air conditioning appliances and refrigeration could have an equally, if not more significant impact on demand.

The PECS notes a mandate towards more energy efficient government vehicles. If the implementation of this strategy was to involve electric or hybrid vehicles this would add increased load to the PPUC grid.
3.4 Development of Productive Use Programs

The productive use of power\(^9\) is essential for ensuring Palau's consumer base remains willing and is able to afford the cost of power in the future. While PPUC is not directly involved in the wide variety of productive uses of power undertaken by its clients, it nevertheless has a significant impact on the ability of its clients to meet the demands of the commercial sector, such as tourism, banking, services and others.

It is clear that PPUC has an interest in supporting the increased consumption and utilization of energy, and the commercial sector is the main driver for this. PPUC can facilitate an increase in the productive use of power by ensuring a stable and cost effective supply and also by ensuring self generation is not a more attractive option for its commercial consumers, through reasonable and consistent pricing.

3.5 Development of Demand Side Management

Demand side management practices may provide PPUC with the scope to maintain greater control over the patterns of consumption and modify energy demand to match PPUC's generation mix on an hour by hour basis. However, currently there appears to be no urgent need to adopt these practices as PPUC's demand curve is predictable and relatively stable.

Following discussions with PPUC generation staff, the Consultant has not identified any significant issues with major power consumers placing large loads on and off the network, and

---

\(^9\) Defined as the direct or indirect use of electricity for a purpose that leads to economic growth.
therefore there is no major energy peak that is difficult for PPUC to meet. Therefore, the advantage for PPUC in managing demand is to match generation capacity that is operating at the time. Technology for this purpose is not new and includes ripple control for specific heavy load appliances such as air conditioning or water heating loads that may be taken off line for periods of time without inconveniencing consumers.

Ripple control is a well proven technology that has been used for decades in western power networks to control peak loads and match to generation capacity. The technology is relatively inexpensive and may be able to be used to provide PPUC with the ability to match generation and consumption effectively so as to maximize efficiency and reduce operational costs. The potential for ripple control to assist PPUC with improving efficiency has been discussed with PPUC generation plant management so that this may be included in future planning.

More sophisticated solutions may involve smart metering technology to allow consumers to defer loads at their discretion, or at the discretion of PPUC. These meters are able to respond by way of communications over the power lines, or via a cell phone network. Either way, the advantage to PPUC may be to provide an adjusted tariff for consumers that allows PPUC control over specific loads at pre-determined times.

As with ripple control, this technology is proven and commercially available now, but at a cost of approximately $200 per meter it will require considerable capital investment to achieve in Palau on a significant scale. As with grid connected solar PV, there are more pressing issues with a stronger financial argument to address at this stage, however it should not be discounted as smart metering does have potential to add a market response mechanism to higher power prices in peak load periods.
4 Investment Requirements to meet Demand

4.1 Introduction

Based on the six major factors outlined in Section 3.3 (Potential for Growth), the Consultant has forecast annual generation requirements as illustrated in Figure 15 below.

![Figure 15 – Forecasted Annual Generation (MWh) (2009-2029)](image)

From the period 2010-2014 it has been assumed that PPUC undertakes a significant loss reduction program. As described in more detail below, the aim of this program is to decrease the energy lost and to more efficiently meet the forecast levels of demand.

The impact of this program is that, whilst both the number of customers and generation demanded by PPUC’s customer’s increases, actual generation required decreases. Past 2015, the impact of customer base and customer demand growth can be seen. Annual demand is forecast to reach almost 100 GWh by 2029.

4.2 Loss Reduction Program

The PPUC power generation department has initiated a power loss reduction program, as they are aware that there are losses occurring in the network that can be addressed and reduced, and yield a positive return on investment to PPUC.

Current figures from FY2009, provided by PPUC’s generation department indicate losses of 6.5% for station usage (2% target), 6% for transmission and distribution losses (4% target), and 8.1% for non-technical losses (0% target). It has been forecast that a loss reduction program will decrease the losses of each respective category by 5% per annum until the target is achieved.
Unfortunately, this data is not able to be taken at face value as the power station metering and transformer station metering has not been calibrated for accuracy for ten years. Calibration needs to be undertaken annually so that metering is accurate at the various stages of the network, otherwise it becomes impossible to assess where PPUC should focus its resources to address the issue of reducing losses in the network, as it is unable to determine where those losses are occurring. For example, the 6.5% lost in generation is very high, compared to an international average figure of 2%. Inaccurate metering is the most likely reason for this, but without the meters being calibrated, this cannot be determined.

The impact of poor metering is that it is no longer clear if the information reported is correct. Therefore determining exactly which parts of the network offer scope for improvement is commensurately more difficult. The consultants have therefore recommended that, as an immediate step, critical metering equipment is calibrated and correctly set. This will provide a baseline from which other network assessments can be made with confidence.

The power generation department does not have a power loss reduction budget, and is funding minimal activities to identify and reduce losses out of its own power station budget resources first. The primary focus for the department is identifying non technical losses, and reducing these, as in most cases these can be reduced with no capital cost to PPUC at all. Some instances of significant losses have been detected in this area, and PPUC is moving quickly to correct these errors when found.

PPUC also have a thermal imaging camera (infrared) that is typically used to identify sections of the transmission and distribution network that are operating inefficiently, due to the energy lost in heat at those points. The camera is presently inoperable and the Consultant recommends that the camera is repaired or replaced so that this thermal imaging work can resume.

Immediate actions undertaken by PPUC to reduce losses include (as mentioned earlier) the identification and reduction of non technical losses. Other power loss reduction initiatives include:
The installation of capacitors at strategic points in the network to improve network power factor, particularly on the end of long and lightly loaded lines;

Monitoring of transformer station status is underway and data is being collected. The generation department is intending to report on this to PPUC management in early 2010; and,

Power planning software has been identified as allowing PPUC staff to more accurately plan their power network components. This software has been included in the budget under consideration by the PPUC Board now, but since the budget has not been accepted, it is currently on hold.

Each of these activities is to be supported and encouraged, and a budget detailing the expected return on investment will accompany the 2010 power loss reduction report.

**Generation losses and inefficiencies**

PPUC staff are also aware that there are times when they are unable to efficiently match supply to demand. The Consultants have suggested additional research be undertaken on ripple control systems, as this gives the generator the ability to control various loads around the network that are not time critical. Examples might be controlling hot water heating loads in hotels, or perhaps water pumping loads that do not need to run at critical times. The ability to bring several hundred kW on line or off line for brief periods, will allow PPUC to adjust the loadings on their generators and ensure that generators do not have to be brought on line to serve inefficient part load duty. The low loading has two impacts on the generation side. Firstly the generators themselves consume more diesel per kWhr at lower power loadings than they do at high loadings. Secondly the maintenance of the diesels is very expensive, and is undertaken on an ‘hours run’ basis.

Turbo charger efficiency is also under review on the generating plant, and efficiency improvements are also possible there. A report from the Australian generator maintenance company Bailey’s Diesel Fuel Injection is pending on this aspect, but early indications may be that significant savings are possible through engine adjustments and tuning.

**4.3 Potential for Energy Efficiency and Diesel Substitution**

There is a clear opportunity for expanded energy efficiency and diesel substitution measures in Palau. With average fuel costs currently approaching USD 20 ¢ per kWh, measures to reduce a) the total quantity of energy consumed, and b) the cost of the energy consumed, make sound commercial sense.

Typically, energy efficiency measures have a faster return on investment than energy substitution measures such as the introduction of renewable energy systems. A general rule applied\(^\text{10}\) to energy efficiency measures is that the return on investment on energy efficiency measures provides a 3:1 advantage over investing in new generation capacity. However, Palau must consider both measures although it is likely that energy efficiency offers the ‘lowest hanging fruit’ in terms of economic benefits to Palau. For example, the November 2008 Palau case study on Energy Investments shows that energy efficiency activities such as CFL lighting, or energy auditing can save around $1 million per annum for an expenditure of less than $200,000. Other

\(^{10}\) Used by the renewable energy industry in New Zealand
activities identified in the report point to efficiency savings of around $1 million a year resulting from improvements to the waste water treatment and pumping system (although the costs of this are yet to be assessed).

The PEO has already identified the need to reduce the total quantity of energy consumed, and one of the first activities has been to actively promote the expanded use of compact fluorescent lighting. Based on the Consultant’s experience from other energy efficiency related projects, it is recommended that a brief study be undertaken on the quality of CFL bulbs currently being used in Palau to assess their impact on power factor. With some bulbs, the power factor correcting ballasts are absent completely, leading to degradation in power factor that offsets the consumer’s belief that they are assisting to save energy.

A brief study has also been undertaken by the Consultant during this field work time in November 2009 on the scope for reducing demand from domestic refrigeration appliances. A summary of this study was presented to the NDBP and is included as Attachment 6.

As is similar in other Pacific Island Countries, domestic fridges and freezers are often poorly designed for high ambient temperatures experienced in these countries, and are also insufficiently insulated, leading to excessive compressor use and power consumption. Based on the Consultant’s brief assessment, it is possible that the return on investment from the replacement of an old/damaged or poorly maintained freezers could be as high as USD 1,500 over ten years, or an Internal Rate of Return (IRR) of around 50%. A replacement program could be introduced offering ‘cash for clunkers’ where the older and most wasteful of Palau’s refrigeration appliances could be very profitably decommissioned. The profit would accrue to PPUC, who are then subsidizing less power to domestic connections, and to the householder who sees a lower power monthly bill. The estimated 50% IRR for the replacement program exceeds the return on investment from grid connected renewable energy sources by a margin of approximately 40% and warrants specific attention by the PEO/PPUC.

One further recommendation is to set up a refrigeration team to assist with the identification of air conditioning and refrigeration equipment that is either in a state of disrepair or in reasonable mechanical condition but needs re-gassing or maintenance work undertaken. This action may also offer a high IRR if the costs are paid by the state or by PPUC, particularly if focused on subsidized consumers and if offered to commercial consumers as a chargeable service.

As discussed above, the relatively short payback of energy efficiency measures and given the lead time required to identify, fund and construct many types of renewable energy projects, it may be useful to undertake energy efficiency and diesel substitution / renewable energy initiatives simultaneously.

4.4 Energy Efficiency and Productive Use Programs

To summarize the comments above, in a power generation environment based solely on diesel, and where there is a subsidy for low income households, there is a clear advantage to PPUC in identifying and supporting energy efficiency as it reduces the losses made on subsidized connection points. The PEO is already focusing on CFL lighting, with its public awareness program, and there is scope to expand this into air conditioning, refrigeration and other areas of power consumption. Certainly there is an argument to support the unrestricted use of power by customers that are paying the fully unsubsidized tariff, however the wider economic impact on
Palau means that there are advantages to the nation by reducing demand and further mitigating the reliance on diesel.

Productive use of power is also covered earlier in the report. In summary, the network costs are supported by commercial consumers who use power profitably, and also by domestic consumers who use more than the lifeline amount and can afford to pay the full unsubsidized tariff. Specifically, PPUC is not in the business of using power productively. It is in the business of generating and distributing power efficiently and profitably. However, it is in PPUC’s interests to facilitate the productive use of power to ensure that its customer base remains profitable and able to buy its product. Therefore, PPUC has an interest to create a power consumption environment that is predictable and user-friendly for its customer base. This may involve a ‘no surprises’ approach to tariffs and implications of fuel price increases in future.

### 4.5 Fuel Substitution

With a generation system the size of Palau’s, including the outer island networks, it is very difficult to avoid the use of a liquid fuel resource as current technology does not yet offer an energy storage system that can viably meet the demands of a 15 to 20 MW overnight load. Liquid fuels such as biofuels possibly offer the best opportunity for Palau to use existing generating technologies while taking advantage of land area, either public or private, to grow a commercial crop such as jatropha where the plant seeds are crushed to produce a biodiesel. Jatropha appears to offer the most likely source of biofuel for Palau owing to its ability to be growing on degraded and/or arid soils. To make significant impact on the liquid fuel consumption of PPUC, an equally significant area of land is required for planting Jatropha. Initial estimates point to around 10,000 hectares required for this activity, and to secure this quantity of land it is necessary to utilize the large tracts of degraded but unused land in the inland areas of Palau. Jatropha appears to have the ability to thrive in this environment and hence must be considered a serious contender for this application.

The use of biofuels is not the overall solution to the fuel related issues facing PPUC, however there are several examples of biofuel resources being used throughout the Pacific and these experiences are useful for PPUC to review. The US Forces in World War 2 frequently used blended coconut oil and diesel as a transport fuel, and more recently, technically successful biofuel pilot programs have been initiated in Vanuatu, the Marshall Islands and the Solomon Islands.

There are issues associated with biofuel use that need to be considered. Modern direct injection diesel engines are much more finely tuned now than in the past, which has improved efficiencies, but has meant that the engines are more reliant on very specific fuel standards. Biofuels are typically not manufactured with the same consistency as diesel, and are also impacted by variables such as temperature, which changes the viscosity of the fuel. In contrast, indirect injection engine designs of the type typically used during World War 2 are able to cope with variable fuel qualities with a lower chance of engine damage.

The oil producing Jatropha plant offers Palau scope to harness under-utilized land to grow an indigenous fuel crop. Wild jatropha is already established in Palau, by definition not on a structured or commercial manner. The natural presence of jatropha removes the risk of introducing an invasive, non-native species into the ecosystem, with the associated unintended environmental consequences.
Jatropha use on Palau

Jatropha is a plant that grows naturally on Palau, but has not yet been cultivated for any product use, as it is not a food or forage crop (it is actually toxic to humans and animals). The primary useful part of the plant is its seeds, and there are no known dangers from the handling of the oil or the seed cake to workers.

Jatropha seeds can be pressed into an oil product that is suitable for use as a fuel in diesel generators. The residue, husks and foliage can be used for compost, fertilizer, or used in biogas digesters to produce methane gas. This can also be used for power generation.

Jatropha has the advantage of being a very tough and hardy plant. It grows naturally in arid climates and in poor and degraded soil conditions. The plant grows as a small tree, or large bush up to around 6m tall. The lifespan of this perennial bush is more than 50 years, and it can grow on marginal soils with low nutrient content. The tree itself has green leaves with a length and width of 6 to 15 cm. The fruits have an oval shape, of about 40 mm length and each contains 3 seeds (on average), which look like black beans. The seed weight per 1000 seeds is about 750 grams. Of most interest, the seeds contain more than 30% of oil by weight.

After pressing the seeds, the filtered oil can be directly used as PPO (pure plant oil) in diesel engines. Because of the slightly different properties of PPO compared with fossil diesel, newer types of diesel engines must be adapted. Generally diesel engines are able to run on PPO, but care must be taken when doing so as if the engine is not suitable for direct use of plant oil, significant damage can be inflicted on the engine due to the variation in fuel viscosity, and its performance in the injectors.

Many types of diesel engines have indirect injection (IDI) with pre-chambers. The pre chamber is more suitable for use with variable quality fuels as it is able to evaporate the fuel just prior to entering the combustion cylinder, and avoid the issues that can happen with incomplete combustion. Plant oils can sometimes be used freely in these pre chamber engines, which are still commonplace in some countries, but care must be taken to contact the engine manufacturer prior to using PPO to ascertain what percentage of PPO is possible to use, as it may need to be blended with standard diesel prior to use. At this point it is unclear if Palau’s existing stock of Wartsila, Pielstick and Mitsubishi engines are able to operate with Jatropha oil, but it is suggested that this line of discussion is opened with the generator manufacturers. In addition it is suggested that future purchases of engine stock is done with the understanding that in future the engines may need to operate in a multi-fuel or PPO environment.

Modification of direct injection engines is also possible, and in addition there is also the potential to use an esterification process to create biodiesel, using methanol and sodium hydroxide. This produces a fuel much more similar in performance to standard diesel, but does require the importation of additional chemicals to use in the process.

Farming Practices

Jatropha can produce harvestable seeds within the first year of planting. In warm, humid locations such as Palau, the plant can flower and produce seed pods year round.
Jatropha can produce around 2,000 kg of seeds per hectare, per annum, or around 700 liters of oil per hectare. Since Palau uses around 1.7 million gallons of fuel per annum, and if one hectare of land can produce 185 gallons, it can be seen that for Palau to be completely independent using on Jatropha, would require harvesting around 9,000 hectares planted in Jatropha. This is a significant quantity of land given that Palau has a total land area of 45,800 hectares. Clearly it will be difficult to secure this amount of land to just produce biofuel. Other options must be used in conjunction with biofuel to reduce the loads, and make the biofuel option viable.

If government land is made available, perhaps on preferential terms for an initial period to encourage early uptake, the commercial sector will be able to expand into the market. For example, if PPUC was to announce a set target for the purchase of Jatropha starting on a certain date, then a price and market signal is immediately sent to the market. This then places a value on the unused or underutilized lands around Palau, and the potential for it to be used for productive use is immediately visible.

As with any major agricultural endeavor, land use impacts will be present, and will need to be identified and mitigated as a part of the exercise. In the case of Palau erosion and run-off of sediment and fertilizers into local waterways are among the impacts necessary to be dealt with. With much of Palau’s economy reliant on its tourism industry, the state of the environment is an important factor when considering new energy initiatives. Because the streams and rivers deliver any sediment directly to the coast, and into the lagoons and reef areas, the potential downside from failing to handle this correctly could be significant. Likewise the over-use of fertilizers, leading to excessive weed growth has shown to be a problem in other countries but can be avoided with proper soil and crop management.

Currently, the use of diesel for virtually 100% of Palau’s energy carries environmental multiple risks, including fuel handling and storage, lubrication oil use and disposal, plus the noise and air pollution associated with diesel generators. Adopting options for future energy production will balance up the improvements on the current situation, weighed against the environmental costs of whichever option(s) are progressed.

### Costs per litre

The exact costs per liter of Jatropha in Palau can only be estimated at this point as the production rates and oil yields for jatropha grown in Palau is an unknown at this time. However, working on information gathered from overseas studies the following estimates are made:

#### Production rates and costs

- Jatropha is expected to produce around 2 tons of oil seed per hectare, per annum.
- 2 tons of seed will produce around 185 gallons of oil.

Current market prices for Jatropha oil are around US$55\(^{12}\) per barrel, or around USD 1.05¢ per gallon for oil produced on an industrial scale. Allowing for the difficulties of production in Palau and environmental mitigation, an additional 30% is allowed for the purposes of defining an estimated price per liter of oil, thus giving a price to PPUC of approximately USD 1.37¢ per gallon.

---

11 Such as ‘The Jatropha System’, Henning and Rothkreuz, 2004

To achieve this price, and to provide an incentive for farmers to begin to harvest it, two recommendations are made by the Consultant.

1. PPUC make a decision to use jatropha oil in its generators, and begin to create a market for farmers.
2. PPUC consider providing the oil mill machinery and buying the unprocessed seed from farmers, giving PPUC control over the quality of the oil produced.

To further develop this opportunity, the Consultant recommends that a study could be undertaken among others to assess the following matters:

1. How much land is required to produce sufficient oil to make a difference to Palau’s oil dependant status?
2. Based on No 1 above, can land be identified that has suitable access, irrigation (if required) and other features needed to grow jatropha successfully?
3. What process technology is needed?
4. What modifications to the existing generator units is required, and should plans for future generators be adjusted to ensure that flex-fuel units (duel biofuel and/or diesel) are installed rather than engines that can only run on diesel?; and,
5. Can the commercial sector be incentivized to produce biofuel in an economically viable manner?

4.6 Solar Thermal

Grid connected solar energy has taken two main technical directions. The first is solar thermal using large arrays of mirrors to focus the sun’s energy onto a single point, raising temperatures on the collector to hundreds of degrees. This energy produces steam to operate a standard steam turbine for generating electricity. The second is solar PV involving the traditional approach of using a silicon PV panel to feed power back into the grid and this is discussed in more detail in the following section.

Solar thermal is rapidly gathering momentum as a cost effective method of generating electricity on a utility scale. Installations in Europe and the USA now approach 500 MW in scale, with smaller systems of 5 MW also now standardized.

A key advantage of solar thermal over solar PV is its ability to store heat, and hence electricity, to cover the intermittent fluctuations in power supply caused by cloud, bad weather, or if sufficient thermal storage is included in the design, even covering fluctuations through part of the night.

The use of solar thermal in Palau is attractive if undertaken on a scale to have a significant impact on diesel consumption. However, preliminary research suggests that this technology needs a large amount of relatively flat land. Palau has very limited access to flat land and a detailed topographical study would be necessary to identify a suitable site. A potential location would be one of the mangrove flats, however this may not meet with approval from environmental stakeholders therefore requiring an assessment of possible inland locations.

Alternatively a third party private oil producer could be the sole purchaser of the Jatropha pods to produce the biodiesel for PPUC
Large scale solar thermal installations will have an environmental impact during the initial construction phases as earthworks are involved, but again, these can be mitigated with attention to avoiding run-off and contamination of local waterways. Visual impacts from such projects are not so easy to reduce, however even this can be reduced as future technologies allow more compact designs to be implemented.

Another aspect of solar thermal is the use of solar hot water units to reduce energy demand from water boiler units. The REFW report also concludes that solar hot water systems offer significant scope to reduce direct costs due to the high demand for hot water by Palau’s tourist industry. This is most likely to be of interest from commercial users, such as the hotels, that have a high demand for hot water from their guests, and for laundry and kitchen requirements. Solar hot water offers the most attractive IRR for a commercial consumer looking to offset their energy demands compared to grid tie solar PV, and there is also a clear financial advantage to domestic consumers also.

The National Development Bank of Palau is likely to offer a 100% loan on solar hot water units (SHW), and this has lead to expected uptake of SHW units of 12.4% (340 households) over 3 years from the start of the program. This is a significantly higher expected uptake of solar hot water systems over solar PV systems, and reflects the faster payback, lower capital cost and/or loan required for SHS systems. With a simple payback period of 0.72 years for commercial consumers, the financial argument is clearly compelling.

4.7 Solar PV

The installation of solar PV technology has the potential to provide immediate results in reducing diesel consumption for energy generation. Solar PV is one of the simplest forms of renewable energy technologies enabling immediate installation and generation (approval and equipment supply issues permitting). With successful pilot projects already in operation at the Palau National Hospital, as well as the National Assembly Building, there is enough evidence to demonstrate the technical viability of large-scale grid-connected solar PV in Palau. The issues that now remain are to demonstrate the financial viability of the technology, particularly on a household scale where the financial viability is marginal, as assessed in the REFW report showing grid tie PV costs at the household scale to be USD 0.364¢ to USD 0.384¢ per kWh. For larger scale installations (above 50 kWpk) where the economies of scale can be achieved to advantage, the financial viability is significantly better, with best case costs approaching USD 0.20¢ per kWh in the United States mainland.

Discussions with stakeholders in Palau have suggested that the previous solar PV grid connected installations have been undertaken on non-commercial grounds resulting in the perception of high costs and dampening enthusiasm for the wider application of PV technology. The exact installation costs for the two primary examples of grid tie systems in Palau (the hospital and National Assembly Building) are unclear, as the funding from donor sources as not clear on what the construction costs were, or how competitive the process was). It is likely that better prices can be achieved once a more commercial approach is taken, assuming that this was not the case for the first two installations. Based on the information available in the REFW report, it appears that the National Assembly Building installation cost a total of USD 1.35 million, or an installed cost of USD 13.5 per kWpk.
However, current market research\textsuperscript{14} into large scale installations indicates that solar PV is indeed commercially comparable with diesel generation, as the figure below shows. This is consistent with the REFW report which also concludes that solar PV holds the most promising short term ability to competitive with diesel consumption going forward into a future where higher diesel costs appear highly likely.

As with solar thermal, large scale installations will have an environmental impact during the construction requiring careful planning and implementation for the necessary mitigation. Visual impacts from solar PV is not so easy to reduce, however this has the potential to be reduced with future technologies allowing the integration of PV into building products and hence the blending of solar into existing structures.

Figure 17 – Comparison between grid connected PV and PPUC generation costs

The graph illustrates that when PPUC’s generation costs are compared to the cost of grid connected PV in the USA (including costs associated with environmental mitigation), solar PV installations of 50 kW per week and above are able to generate electricity cheaper than PPUC can generate using diesel. This graph is based on the installed costs of PV in the USA, and is therefore likely to be slightly overstating the competitiveness of solar PV as the construction costs of PV in Palau will be higher than in mainland USA. Nevertheless, the margins are such that even given an allowance for additional installation costs, solar PV is a competitive form of energy in Palau.

The REFW report listed solar PV costs at around USD 7.50 to USD 8.50 per kWpk installed, however given that solar PV costs are now wholesaling at well under USD 3.00 per watt, and

\textsuperscript{14} www.solarbuzz.com
given low labour costs in Palau, it is possible that costs of around USD 6.50 to USD 7.00 per kWpk installed may be achievable in Palau if PV prices remain low, labour costs remain low and no import taxes are applied. With no actual small scale domestic reference installations in Palau, the final costs are estimates only at this stage however reference costs can be noted on solar PV industry information websites.\(^\text{15}\)

Based on the above data, the generation costs from small 2 kWpk residential arrays is the same cost as PPUC's diesel generation. International resource mapping for Palau\(^\text{16}\) indicates an average annual figure of 4.5 solar hours per day which the Consultant estimates would generate approximately 9 kWh per day output from a 2 kW residential array. This application is therefore worthy of further consideration by the PEO/PPUC (particularly if fuel prices continue to increase) and by the Development Bank of Palau when assessing the proposed net metering program.

### 4.8 Wind Power Options

Wind power in Palau is an unknown renewable energy source, as there is little data available to assess the potential of this resource. In agreement with the findings of the REFW report, the Consultant recommends, based on past experience, that at least one 60m wind tower is installed at a site that offers the potential for wind power and with access to the national power grid. This tower will provide Palau with the information in future as to the true viability of their wind resource, whereas at present it is an unknown or estimated resource based on satellite data. This installation of wind monitoring equipment will take place under the SEDREA and or EDF10 projects.

This United States Department of Energy wind resources map below suggests that Palau does not offer a viable wind resource. Nonetheless, the cost of gathering the specific data needed to verify the map below is not considered too expensive. To do so accurately would involve the monitoring tower being in place to track and log wind speed and direction over a period of a minimum of two years. With this data, an informed investment decision can be made by PPUC regarding the installation of wind turbines. The Consultant notes the meteorological office near the Belau National Museum has a single 10m tower with wind monitoring equipment installed. However this meteorological tower is not suitable for assessing power generation potential as it is located in a relatively sheltered location, surrounded by buildings and may only be useful for assisting to correlate wind speed information including from satellite based information, such as the wind map shown below.

As with solar thermal and solar PV, large scale wind power installations will have an environmental impact during the construction phase and, as such careful planning and implementation is essential to ensure the necessary mitigation. Visual impacts from wind power is not so easy to reduce, however this too has the potential to be reduced with future technologies potentially resulting greater efficiencies resulting in lower turbines and smaller blades, thus minimizing the visual impact.


\(^{16}\) The National Renewable Energy Laboratory, USA
4.9 Hydro-Electric Potential

Palau’s hydroelectric resources were surveyed in October 2005 by consultants from the Philippines company Vergel3 and the following key results were noted:

- Palau’s topography is reasonably flat and is therefore unsuited to run of the river type hydro designs as insufficient head is available to generate meaningful quantities of power.
- A reservoir type design is preferred as it creates a viable amount of head needed to generate power. Furthermore, dependent on reservoir capacity, these schemes have the ability to store water during high flow periods for later use, particularly at peak times.

The survey\(^{17}\) concluded that Palau has approximately 4 MW of hydro generation capacity available at three potential sites; ‘Diongradid’ has 2 MW potential, ‘Ngermeskang’ has a 1 MW potential, and Ngrikill has a 1MW potential. These sites have been assessed as being able to contribute 14.35 GWh per annum. Using typical remote construction costs for developing countries of an installed cost of USD 5,000 per kW, the capital cost of these sites are estimated at USD 20 million. The Consultants stress that these costs need validation, but this is beyond the scope of this Study. However, a 4 MW renewable energy resource available 24 hours per day is of significant value to Palau in terms of its ability to be energy self sufficient, and hence the Consultant recommends that a follow up study is conducted to formally assess the costs of developing the resources identified. The need for construction of dams on each system will

\(^{17}\) Vergel3 Consultants, October 2005
significantly increase the costs involved, but this is balanced though the ability to produce continuous power or cover for night time and bad weather when solar is reduced or inoperative.

At a preliminary estimated generation cost of USD 30¢ per kWh (including costs associated with environmental mitigation), the gross return on this investment would be in the vicinity of USD 5 million per annum. This warrants further investigation to confirm the exact availability and size of the hydro electric resource, and to more accurately approximate the cost of development.

4.10 Ocean based power generation

The ocean surrounding Palau potentially contains enormous energy reserves in the form of ocean thermal energy conversion (OTEC) and wave power, which are described in more detail below. Internationally, research on both of these technologies have been underway for years however it is only recently that these technologies are being trialed.

4.10.1 Ocean Thermal Energy Conversion (OTEC)

OTEC is a technology that could potentially be very suitable for Palau, both in terms of scale (5 to 15 MW), and also due to Palau's access to warm surface water and deep water relatively close to shore. In brief, OTEC harnesses the temperature differential present between the cold deep water and the warm surface water to drive a heat engine process. Studies have already been completed on the use of OTEC in Palau by Saga University of Japan, and preliminary plans identifying some 30 MW of OTEC power generation capacity have already been developed.

4.10.2 Wave Power

Wave power technology can be considered to be on the cusp of technical and commercial viability, with significant investment now being focused on proving the systems at commercial MW scale. The next 5 to 10 years could prove this technology as commercially and technically sound, reducing both technological risks and also capital costs.

Based on the above and given Palau's geographical location, both OTEC and wave power will possibly play a part in Palau's energy future. Despite the potential application for these technologies in Palau, the Consultant recommends that more proven renewable energy technologies be considered in the short-term with a review of ocean based options for future deployment as technology is improved and costs become more commercially attractive.

4.11 Net Metering vs Net Billing

As discussed in Section 3, the GoP is currently considering a net metering system. Net metering involves the use of a single meter which is typically a uncomplicated system allowing small domestic or commercial consumers to offset their power consumption by feeding self generated power back into the national grid. The simplicity of net metering stems from the use of a single power meter to monitor the overall power use of the property. When a solar array is fixed to the roof of a dwelling, the incoming solar generated electricity is fed into the consumption side of the power meter, thus reducing the demand for energy registered by the meter, or even reversing the meter when the production of energy exceeds the domestic consumption. It is typical in net metered systems for the meter to run backwards during the day, when the house occupants are at work, and the backwards running meter creates a ‘credit’ on the meter that is then able to be consumed by the resident at night.
Net metering systems are typically installed with the intention of reducing demand, not with the intention of making a profit for the homeowner. A key advantage of net metering is that it is less expensive to set up for the homeowner as there is no additional metering costs, and also involves no complicated billing or accounting mechanism either for the client or the power company. The disadvantage of net metering is that there is no ability for the power company to differentiate between power generated and power consumed, as only the net difference is monitored.

A second option is net billing. Net billing differs from net metering in that the netting out of consumption is not done by the power meter, but instead consumption is netted out on the billing side of the equation. In order to do this, a second power meter is installed, and power from the solar array is monitored separately from domestic consumption, and power is then fed into the grid on the generation side of the meter. With this system, the cost of a second meter is incurred, and additional complexity is introduced to read two meters and then undertake the accounting exercise of subtracting the generated power away from the consumed power, with the balance being billed to the consumer.

Net Billing is considered more appropriate for consumers on a commercial tariff, or who are installing solar PV or other generation capacity with the intention of generating more power than they consume themselves, and potentially setting themselves up as a profit making entity or possibly as an independent power producer.

Care is required to ensure that the definitions of each class of solar PV installation (such as domestic net metering, small commercial net metering, and large scale commercial PV) for either net metering or billing and/or IPP status is clearly understood. There is no intention by GoP under the proposed net metering program to create barriers for the wider use of solar PV either as an IPP or as a net metered domestic installation, as both reduce Palau’s dependence on diesel. However the impact on PPUC from private or commercial power generation is likely to be significant in future, and the precedent set in the early stage of the NDBP’s solar program can be expected to become embedded over time. Hence care is required in the early stages to ensure that PPUC’s ability to operate sustainably is not compromised.

4.12 Indicative Investments for Alternative Generation Options

With a present power generation cost of just over USD 30¢ per kWh (as at December 2010), a number of energy generation technologies become viable. However, as discussed earlier, solar PV offers PPUC with a technology without high upfront commitments to either technical scale or cost, if introduced in a controlled manner. The hydroelectric potential of Palau is worthy of further analysis to build greater reliability in PPUC’s generation base, not forgetting the high initial capital costs for hydro development which needs to be factored into this analysis.

The investment required to commence solar PV generation on a larger enough scale to tangibly offset Palau’s reliance on diesel is dependent firstly on the installed cost of solar PV, and secondly on the quantity of non diesel generation assessed to count as ‘tangible’. Discussions with PPUC have indicated a reluctance to exceed more than 10 to 15% of the base load generated from solar PV sources, as rapid changes in weather may produce instability in the network by requiring diesel generation plant to come on and off line too quickly. This concern may be mitigated if the NDBP’s upcoming residential solar PV program is successful, as the installation of PV technology will be widely dispersed and not uniformly impacted by dispersed cloud activity.
5 Required Revenue Analysis

5.1 Methodology

In a market with workable and efficient competition, the prices of products or services are largely the result of the interaction of supply and demand. However, where competition is limited or there is only one supplier of the good or service, prices are usually set through regulation in a way that attempts to mimic how prices are determined in a more competitive environment. This usually means that the entity supplying the good or service is permitted to charge enough to cover its operating costs as well as recovering depreciation and a fair return on the capital employed in providing the service.

To provide efficient pricing signals about the cost of providing the services, prices should bear some relation to the marginal cost of supply. Marginal cost refers to relationship between total costs and output and how costs change as output increases or decreases. As some costs are fixed in the short run while others are completely variable, marginal cost can be considered from a short run or long run perspective. In very general terms:

Short run marginal cost (SRMC) is the cost of meeting an additional unit of demand holding capacity constant, and;

Long run marginal cost (LRMC) is the cost of meeting an additional unit of demand assuming that all factors of production can be varied.

This analysis focuses on the assessment of long run marginal cost as the TOR requires.

5.1.1 Long Run Marginal Cost Methodology

Long Run Marginal Cost (LRMC) can be thought of as the levelized cost of meeting an increase in demand over an extended period of time. In effect it is the Net Present Value (NPV) of the change in generation or production load, divided by the NPV of the increase in load. Therefore LRMC estimates the marginal cost of meeting additional demand when all of the factors of production, including capital, are variable.

In effect, LRMC is the sum of the long run marginal operating cost (LRMOC) and the long run marginal capital cost (LRMCC).

The LRMOC is estimated as the NPV of the forecast operating cost over the forecast time horizon, divided by the present value of the forecast output. Therefore, the LRMOC of electricity generation can be expressed in terms of ¢/kWh.

The LRMCC is estimated in a similar fashion however, in this case, the LRMCC is the present value of the optimal capital expenditure, all divided by the present value of the output over the time period. The LRMCC treats the existing plant and equipment as a sunk cost.
The capital expenditure used in the forecasts should be optimized insofar as the capital program should provide the least cost solution to the supply demand imbalance.

Therefore, the steps in determining the LRMCC are:

1. Forecast the demand over a suitable time horizon – between ten and 20 years (the latter being the case in this study);
2. Identify the possible capital projects that could be implemented to meet the demand;
3. Select the least cost combination of projects; and
4. Estimate the LRMCC as:

\[
\text{LRMC} = \frac{\text{NPV(Forecast Demand)}}{\text{NPV(Optimal Capex)}}
\]

Therefore the LRMCC of electricity expresses the capital “used up” over the period of the analysis on USD ¢/kWh as appropriate.

The required inputs for the analysis of LRMC comprise:

- Forecasts of demand over the nominated time horizon;
- Capital expenditure profiles and forecasts for projects that have the capacity to provide the required supply;
- Operating expenditure forecasts associated with each capital expenditure scenario; and,
- An estimate of required return on investment.

Based on these inputs it is possible to estimate the LRMCC and LRMOC for a range of possible options for the supply of electricity services.

5.1.2 Marginal Cost and Required Revenue

The two broad approaches that can be taken when reviewing tariffs are an embedded cost (sometimes called an average historical cost) tariff analysis or a marginal cost study. The terms of reference for this study required a marginal cost approach be used.

An average historical cost approach takes the revenue requirement for a given year and allocates it between customers based on a number of identified cost drivers. However a marginal cost approach attempts to identify the incremental costs associated with a marginal increase in throughput or load. In contrast to the embedded approach, the marginal cost approach is a forward-looking but largely hypothetical exercise.

5.1.3 Reconciling Marginal Cost and Required Revenue

One of the key issues with a marginal cost exercise is that the total revenue from tariffs based on marginal cost does not normally equal the revenue required by the utility. In general, required
Revenue is the sum of the forecast operating expenditure plus depreciation and a fair return on capital of the assets associated with providing the services. When estimating required revenue, the values of the assets currently employed are not regarded as a sunk cost but are recognized as having a positive opportunity cost.

Therefore to bridge the gap between marginal cost and required revenue some form of adjustment to the marginal cost based tariffs is needed so that the tariff structure can be financially sustainable and produce total revenues equal to the required revenues.

The overall objective of any form of adjustment is to preserve as much of the LRMC type price signals as possible while permitting PPUC to be financially sustainable. The LMRC type tariffs can be adjusted in a number of ways, including:

- The inclusion of fixed charges as part of the tariff;
- Scaling of the variable component of the charge, or;
- A fixed increase in tariffs.

The approach taken in this study has been to scale the tariffs to meet the required revenue objective.

The Consultant has used a 20 year discounted cash flow model to estimate the required revenue for the generation and supply of power by PPUC.

The steps in estimating the required revenue for each part of the PPUC business are as follows:

1. Forecast demand over the nominated time horizon;
2. Estimate the value of the existing assets that are required to provide the service;
3. Forecast the capital expenditure profile associated with the least cost generation or supply options;
4. Forecast operating expenditure; and,
5. Estimate the level of tariff in each year of the forecast that results in a zero NPV when the cash flows are discounted at the required rate of return.

A zero NPV being achieved using this approach means that the utility will recover operating expenses, depreciation, capital expenditure and the cost of capital during the study period. In individual years, the utility will recover its operating expenses and depreciation, although it might not fully recover its capital expenditure. This capital expenditure recovery is “smoothed” over the study period.

Therefore, under this approach PPUC will earn its cost of capital, on average, over the twenty year period. The tariffs estimated in the approach are approximately the same as those estimated in the pure marginal cost approach but are scaled uniformly.
5.1.4 Rate of Return Assumptions

The required rate of return reflects the opportunity cost of capital invested in a project. In the case of a specific project, the required rate of return should reflect the relative risk of the investment and the cost of financing. The weighted average cost of capital (WACC) is now the most commonly used and recommended approach for determining the appropriate cost of capital for firms and hurdle rates, or acceptable rates of return, for projects.

The key concept underpinning WACC is that if an investment generates enough return to pay the interest on the debt used to finance it, and also generates a satisfactory expected return on equity, then the project is acceptable.

A firm’s cost of capital is not a cash cost but rather the opportunity cost of the capital that is tied up in the business or the asset that is being bought. The cost of capital is, in effect, a market based measure of the notional rate of return that could be earned on a portfolio of shares and debt instruments with the same risk as the investment under consideration.

The cost of capital reflects the trade-off between risk and return undertaken by the providers of both equity and debt capital. Put simply, the greater the risk, the greater the required return of both shareholders and lenders.

WACC components

By definition, the capital employed in a project is provided from either:

- Debt, from banks or other lenders, or
- Equity from shareholders or new capital introduced by grants.

The WACC is, in effect, a blended composite of the costs of equity and the debt capital. Therefore it is calculated as:

\[
WACC = Re \times E + Rd \times D
\]

where:

- \(Re\) = the required post tax return on equity
- \(Rd\) = the cost of debt,
- \(E\) = the proportion of equity in the target or long-term capital structure,
- \(D\) = the proportion of debt in the target or long-term capital structure.

The cost of equity

For commercial entities the capital asset pricing model (CAPM) is the model most commonly used for deriving risk-adjusted rates of return on equity. The CAPM expresses the rate of return on equity as: (a) the rate of return on a risk free investment, plus, (b) a risk premium. The risk premium is scaled up or down depending upon the risk of the project.
In the case of PPUC, the Consultant has been advised by the shareholder’s representative that the GoP as shareholder does not expect a dividend return. However, the consequence of using 0% in the return on equity calculation (especially in a utility with only 25.77% debt) will be a very low discount rate and therefore a long run marginal cost that does not accurately reflect the time value of money.

On this basis, a cost of equity of 10% has been assumed. This will not result in a 10% return on equity for the GoP investor, it will only provide for a more realistic discount rate/LRMC calculation.

**The cost of debt**

The after tax required return on debt is the rate on fixed rate debt, such as the swap rate, plus the appropriate margin that reflects the default risk of the business. In general, for the purposes of calculating WACC, the maturity of the debt should match the time horizon of the project or investment of the assets. In practice, this assumption usually differs from the debt maturities that are actually available in the market, so it is implicitly assumed that loans can be refinanced from time to time on their original terms.

PPUC currently has three debt facilities as follows illustrated below. The weighted average cost of debt based on the loan balances as at September 2009 and their respective interest rates is 3.53% p.a. This figure is almost identical to the current ten year swap rate providing some certainty in forecasting these (and additional) loans into the medium term.

<table>
<thead>
<tr>
<th>Facility One - Smith Barney Fuel Subsidy</th>
<th>Facility Two - Mobile Gen and Servicing</th>
<th>Facility Three - 2010-2014 Capex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount: 1,671,134</td>
<td>Amount: 7,000,000</td>
<td>Amount (per annum): 3,690,005</td>
</tr>
<tr>
<td>Interest Rate: 4.00%</td>
<td>Interest Rate: 3.50%</td>
<td>Interest Rate: 3.50%</td>
</tr>
<tr>
<td>Tenor: 5.00</td>
<td>Tenor: 20.00</td>
<td>Tenor: 20.00</td>
</tr>
<tr>
<td>Start Date: Oct-09</td>
<td>Start Date: Oct-09</td>
<td>Start Date: Oct-09</td>
</tr>
<tr>
<td>End Date: Sep-14</td>
<td>End Date: Sep-29</td>
<td>End Date: Sep-29</td>
</tr>
<tr>
<td>Annual Payment Required: 375,382</td>
<td>Annual Payment Required: 492,528</td>
<td>Annual Payment Required: 259,633</td>
</tr>
</tbody>
</table>

---

Review of Base Tariff of Palau Utility Corporation - Final Report
Capital structure

More debt, all other things being equal, means a higher required return on equity. Debt introduces interest into the analysis, and interest on debt is another fixed cost. In general, firms with higher levels of fixed costs have higher risk, once again, all other things being equal. Therefore, firms with more debt have higher fixed costs, and more risk, from an equity investor’s point of view.

In practice, firms trade off the increased risk of employing more debt against the higher returns to shareholders that result. However, one of the key principles of corporate finance is that “capital structure does not matter” in so far as the value of operating assets is concerned. The intuition behind this is that as firm takes on more debt, any benefits associated with the lower cost of capital are offset by the increase in the required return on equity.

Therefore, the WACC, which is the return on all of the capital employed, should be expected to be the same, irrespective of the level of leverage.

Key Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Re</th>
<th>10.0% p.a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Return on Equity</td>
<td>Re</td>
<td>10.0% p.a</td>
</tr>
<tr>
<td>Cost of debt</td>
<td>Rd</td>
<td>3.53% p.a</td>
</tr>
<tr>
<td>Debt to Debt plus Equity</td>
<td>D</td>
<td>74.2% p.a</td>
</tr>
<tr>
<td>Equity to Debt plus Equity</td>
<td>E</td>
<td>25.8% p.a</td>
</tr>
</tbody>
</table>

WACC Estimate

The cost of debt is a weighted estimate based on the expected mix of funding. Based on the inputs set out above we have used a required rate of return estimate of around 8.83% in estimating PPUC’s required revenue for electricity.

5.2 Expected Operating Cost

PPUC’s provisional financial statements for FY 2009 provide a breakdown of operating and maintenance costs for electricity generation and distribution as follows:

<table>
<thead>
<tr>
<th>Operating Expenses FY 2009 (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Fuel &amp; POL</td>
</tr>
<tr>
<td>Maintenance Cost</td>
</tr>
<tr>
<td>Personnel Costs</td>
</tr>
<tr>
<td>Depreciation Expense</td>
</tr>
<tr>
<td>Services</td>
</tr>
<tr>
<td>Board of Directors</td>
</tr>
<tr>
<td>Miscellaneous Others</td>
</tr>
<tr>
<td>Travel &amp; Training</td>
</tr>
<tr>
<td>Supplies</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

18 Debt to Equity ratios have been taken from sep09.xls and debt levels from ‘all puc budget.xls’
Non fuel operating expenses were the equivalent of USD 6.59¢ per kWh of gross generation in 2009. This is within the accepted bounds for a system of this size in a developing country.

The PPUC FY2010 has been used as a basis for forecasting for the Required Revenue analysis as detailed in the table below.

<table>
<thead>
<tr>
<th>FY 2010 Budget</th>
<th>Koror-Babeldoab</th>
<th>Outer States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>2,022,800</td>
<td>309,300</td>
</tr>
<tr>
<td>Health Insurance</td>
<td>144,100</td>
<td>33,000</td>
</tr>
<tr>
<td>Bad Debt*</td>
<td>500,000</td>
<td>-</td>
</tr>
<tr>
<td>Fuel*</td>
<td>16,828,700</td>
<td>660,800</td>
</tr>
<tr>
<td>Other services</td>
<td>264,060</td>
<td>5,900</td>
</tr>
<tr>
<td>Professional services</td>
<td>118,500</td>
<td>9,000</td>
</tr>
<tr>
<td>Supplies</td>
<td>129,250</td>
<td>11,900</td>
</tr>
<tr>
<td>Travel and Training</td>
<td>116,900</td>
<td>8,000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>3,412,250</td>
<td>685,500</td>
</tr>
<tr>
<td>Depreciation*</td>
<td>2,231,100</td>
<td>214,300</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>100,350</td>
<td>3,500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>25,870,010</strong></td>
<td><strong>1,941,200</strong></td>
</tr>
</tbody>
</table>

These figures show non fuel operating expenses to account for approximately 37.1% of operating expenditure, with the balance being taken up by fuel. Unless PPUC generates or purchases electricity from more cost-effective sources, the cost of diesel fuel will remain the most significant cost that the utility faces.

PPUC currently has 130 employees and 7,433 customer connections. This equals approximately 57 connections per employee which is considerably lower than the Pacific benchmark of 240\(^{19}\). It is not recommended that PPUC should endeavor to achieve this benchmark target (resulting in 31 staff for the entire utility) however staff costs do comprise a substantial portion of the 2010 budget (8.4%) and there may be potential for cost savings in this area.

It is recognized that while PPUC has one large customer base (Koror/Babeldoab) which comprises the vast majority (99%) of all kWh sales, it also has a mandate to service the three smaller outer stations. These stations require a minimum staffing level for generation and distribution and these personal distort the staffing ratios. However, the provision of electricity to small customer bases is not unique to Palau. Whilst this expense is unlikely to be minimized for 2010, consideration should be given to how to improve this staff/connection ration in 2011 and beyond.

For the purposes of the LRMC Calculation, the cost of diesel fuel is assumed to increase at 10% per annum from a base of USD 2.11 per gallon in nominal terms.

\(^{19}\) ADB Power and Water Sector Benchmarking Report 2005
The possible impact of any possible carbon tax (or credit) on the tariff has been considered in the required revenue calculations for 2010 and beyond. At the timing of writing, discussions on this matter were underway in Copenhagen and any such outcomes from this meeting will have a significant impact on the likelihood and extent of any such costs that may be incurred. These costs could either be incurred through a carbon tax for diesel based generation (if the PEO/PPUC was to maintain the status quo), or carbon credits if additional renewable energy was to be employed. With no definite outcome regarding the future of a carbon trading environment, the impact on the tariff cannot be forecast with any certainty and as such, has not been included in the required revenue assessment.

5.3 Future Capital Requirements

PPUC has budgeted an additional USD 3.69 million for additional capital expenditure for 2010. The vast majority of this capital expenditure is associated with the delayed repairs and maintenance from previous years or damage to plant as a result of this delayed maintenance. The collection of an additional USD 3.69 million from tariffs in 2010 would place a very high burden on the tariff, adding an additional USD 5.3¢ per kWh. As the capital expenditure in 2010 will have an impact beyond that financial year it makes sense to spread the costs of this expenditure over the assets life span. For the required revenue assessment it has been assumed that this USD 3.69 million has been financed over a 20 year term at 3.5%. This financing mechanism adds only USD 0.37¢ per kWh to the average tariff.

Beyond 2010, PPUC’s ongoing capital investments could be partially funded from the depreciation appropriation account as previously discussed. Additional funds for PV capital investment will be required however, while it is very likely that some donor funds may be available, the required revenue analysis has taken a conservative approach and has made the forecasts based on PPUC funding these costs themselves. If a 50:50 split was to be taken between bio-diesel generation and PV generation, the following PV investment as illustrated in the figure below would be required (note biodiesel generation would utilize the existing diesel gensets, following confirmation that Jatropha is an acceptable fuel). If any engine modifications, such as additional fuel filtering or pre-heating are required then they will be taken into account prior to the use of any new biofuel).

Figure 19 – PV kW Required for 100% Diesel Independence by 2030
PV has a current cost of approximately USD 6.50 per watt installed, according to current international estimates, and taking into account the lower prices available for solar PV technologies in 2009/2010. These costs are lower than of the Capitol installation as detailed in Section 4.6, primarily due to the fall in global solar panel prices since this installation. Based on the above implementation timetable and these costs escalating at 3% per annum, the following PV capital investment program would be required.

![Figure 20 – PV Capital Investment Program 2010-2030](image)

As with the capital investment program for 2010, the long term nature of these assets lends this expenditure to be funded with long term finance. The same tenor and parameters have been applied as was confirmed in discussions with PPUC management during the second field mission.

### 5.4 Current Asset Values

The FY2010 PPUC Fixed Asset Register and Depreciation Schedule provides a breakdown of assets as follows:

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>Historic Cost</th>
<th>Sept 2009 Value</th>
<th>Average Expected Life</th>
<th>2010 Depreciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLD</td>
<td>910,743</td>
<td>565,384</td>
<td>13</td>
<td>53,330</td>
</tr>
<tr>
<td>CHS</td>
<td>120,511</td>
<td>108,893</td>
<td>4</td>
<td>30,912</td>
</tr>
<tr>
<td>DTS</td>
<td>17,732,247</td>
<td>11,669,131</td>
<td>28</td>
<td>561,280</td>
</tr>
<tr>
<td>EP</td>
<td>19,675,294</td>
<td>9,644,632</td>
<td>19</td>
<td>971,196</td>
</tr>
<tr>
<td>OEF</td>
<td>61,371</td>
<td>44,313</td>
<td>5</td>
<td>13,458</td>
</tr>
<tr>
<td>OME</td>
<td>577,086</td>
<td>436,340</td>
<td>9</td>
<td>38,923</td>
</tr>
<tr>
<td>TME</td>
<td>15,800</td>
<td>8,152</td>
<td>30</td>
<td>700</td>
</tr>
<tr>
<td>VHE</td>
<td>620,428</td>
<td>462,162</td>
<td>7</td>
<td>73,070</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>39,713,278</strong></td>
<td><strong>22,939,007</strong></td>
<td></td>
<td><strong>1,742,870</strong></td>
</tr>
</tbody>
</table>
During the course of 2010, it is recommended that USD 1.74 million be collected and assigned to a separate, audited appropriation account. This will add USD 2.49¢ per kWh to the average tariff.

Historically, PPUC has been the recipient of capital grants from international donors. These grants have provided a lifeline to PPUC in the form of modern, reliable and efficient technology, particularly with regards to generation. Additionally, many of these generous capital grants are also combined with technical studies which add significant value to PPUC through both capacity building and knowledge transfer. Caution must be taken, however, to separate these two components when applying these new capital grants to PPUC’s balance sheets. If the actual cost of information gathering, field missions and donor consultant/staff time are not separated from the purely physical capital cost of the grant item this can have a detrimental impact on the recipient’s balance sheet (whilst at the same time having a positive influence on the utilities operations). If the capital cost of the asset includes all the non-capital items then the utility will need to over-recover the depreciation cost of the asset, placing a greater than necessary burden on both the tariff and the consumer.

5.5 Estimated Required Revenue

The required revenue for PPUC’s electricity business has been forecast on a year by year, breakeven basis. The required revenue for the PPUC electricity business has been estimated for the twenty years from 2010-2029 given assumptions regarding forecast operating expenses, capital expenditure, current asset values and demand growth.

This approach assumes that the base tariff is reviewed annually. The resulting required revenue for all electricity generation is summarized in the following table across both of the alternative scenarios discussed – status quo diesel generation or 100% renewable energy by 2030.

Figure 21 – Annual PPUC Revenue Requirements 2010-2029: Status Quo vs 100% RE Generation
From the table above it is clear to see that, in an environment where the major cost of production (fuel) is escalating a significant rate, the annual revenue requirements also increase substantially. However if PPUC were to make the strategic decision of being 100% diesel independent by 2030, their total required revenues could actually fall below those which are required today. This translates to a substantial fall in real total revenue required when annual inflation (assumed to be 3% per annum) is considered.

5.6 Long-Run Marginal Cost and the Required Revenue Summary

When the estimated required revenue in the section above is discounted back using the WACC to calculate a long run marginal cost and a required revenue estimate on a kilowatt hour basis, the following results can be tabulated.

| Table 11 – LRMC and Required Revenue by Island – 100% RE by 2030 |
|---|---|---|---|---|
|   | Koror-Babeldaob | Palau | Angaur | Kayangel | Total PPUC System |
| LRMC (USDC per kWh) | 94.18 | 157.55 | 110.14 | 0.91 | 39.16 |
| FY 2010 Required Revenue (USDC per kWh) | 92.12 | 187.54 | 115.64 | 77.28 | 33.58 |

The table shows the long run marginal cost and required revenue for each of the individual grids and also shows the cost of delivering service for the whole PPUC system. It should be noted that this is an average cost across all customer classes, and a further breakdown is required to be determined for the tariff that should be applied for each customer group.

It should also be noted that the long run marginal cost differs slightly from the required revenue calculations because required revenue takes into account the value of the existing asset base. The long run marginal cost calculation, on the other hand, only accounts for projected expenditure looking forward.
6  Fuel Adjustment Mechanism

6.1  Overview
The Consultant has reviewed the concept of a fuel surcharge formula with respect to:

- Creating incentives to increase operating efficiency;
- Compensating for reductions in specific fuel consumption due to employment of new technology (state of the art diesel generators);
- Possible introduction of alternative generation options resulting in reduced overall consumption of diesel; and,
- Promoting better customer understanding of tariff composition.

Based on the analysis above the Consultant is to propose a fuel and lubes adjustment formula and a schedule for its application.

The fuel surcharge formula has been reviewed in the sub-section below with respect to whether it is possible to create incentives to increase operating efficiency. The least cost generation plan described in Section 4 provides guidance on how reductions in specific fuel consumption from new diesel generators are possible or whether alternative generation options might reduce reliance on diesel fuel.

6.2  Fuel and Lubes Adjustment Mechanism

6.2.1  Background
The existing fuel tariff structure has been in place since it was proposed by a Consultant in 2007 (Economist.com) and has not been without its problems. Foremost amongst these are that it is said to be too complicated. The mechanism is a lengthy calculation that attempts to deliver a highly accurate and apportioned fuel tariff. Whilst this is advantageous in some settings, in Palau its level of detail has not been well received. Most PPUC staff are unable to comprehend (and therefore communicate) the calculation of this mechanism. This has caused considerable problems with PPUC customers especially as its introduction coincided with a period of steep fuel price rises. As a result a lack of transparency, and therefore understanding between PPUC and customer, surrounds the fuel adjustment mechanism.

Given that no fuel tariff was in place prior to 2007, and PPUC customers were unfamiliar with the concept of a fuel adjustment mechanism, in hindsight a simpler (if perhaps slightly less accurate) mechanism may have been advantageous.
The adjustment of the fuel tariff was also being conducted monthly. During the time of steep fuel prices rises in 2007 and 2008 this resulted in significant and frequent increases in the fuel tariff. This resulted in considerable working capital problems for PPUC consumers, especially large commercial customers (such as hotels) who were faced with large increases in their electricity bills.

The key issue regards to the timing of the fuel tariff adjustments is that of timing risk. Ideally from PPUC’s perspective, fuel tariffs would be adjusted daily. This would result in all consumers paying the exact fuel cost that PPUC incurs and PPUC bearing no risk if fuel prices increased. This however is not practical from a consumer’s perspective as some degree of certainty regarding their next electricity bill is desirable.

A compromise needs to be found where PPUC does not suffer financially for the period prior to the next fuel price rise and where consumers do not carry the burden of too frequent updates. It is recommended that PPUC implement a quarterly fuel adjustment process that forecasts what the average fuel price is likely to be for the upcoming period. This provides PPUC with some degree of buffer as it is not liable for any price increases (up to the projected level) between quarterly updates.

Under this scenario, an additional adjustment would happen at the end of each quarter. If, for example PPUC had forecast that the average fuel price in Q1 would be USD 2.20 per gallon but in reality it was only USD 2.18 per gallon, the additional revenue that PPUC collected in Q1 would be deducted from the fuel revenue requirement for Q2. Conversely, if the PPUCs fuel bill for Q1 was over what it had estimated, this shortfall would be recovered in Q2.

6.2.2 Calculation

It is proposed that a fuel adjustment mechanism recalculates the fuel tariff is every quarter with five steps in the calculation:

1. Forecast Quarterly Average Fuel Cost;
2. The Allowable Fuel Efficiency Rate of the PPUC grid;
3. A check on a maximum permitted level of network and station losses;
4. A balancing between the previous quarter and the current period; and,
5. The calculation of the Quarterly Fuel Tariff itself.

The purpose of the Allowable Fuel Efficiency Rate is to calculate the actual fuel efficiency of PPUC by comparing fuel consumption per kilowatt hour against targeted rates. The fuel efficiency in Year\textsubscript{n-1} is multiplied by the percentage change in efficiency in Year\textsubscript{n} to calculate a Provisional Allowable Fuel efficiency Rate for the current year;

This rate of fuel efficiency is then adjusted so that PPUC is unable to claim the cost of fuel that is used to produce electricity that is lost through technical and commercial losses above a certain threshold. This upper threshold will be subject to a loss reduction path culminating at a target of eight per cent from its current 20.5 per cent.
Using these measures the Quarterly Fuel Tariff is calculated for all customer categories. It is the aggregate of the Quarterly Average Fuel Cost less the Basic Fuel Price multiplied by an efficiency incentive factor of 0.95 and then further multiplied by the Allowable Fuel Efficiency Rate.

The fuel adjustment formula adjusts fuel efficiency so that network losses above a threshold of eight per cent of sales do not form part of the fuel surcharge, limiting the rate at which the tariff would otherwise increase. The reason for imposing this limit is to encourage PPUC management to ensure that losses do not exceed the threshold.

The proposed fuel adjustment mechanism is based on those proposed for implementation in Pohnpei, the Solomon Islands and Tuvalu (as part of assignments undertaken for the SOPAC/UNDP/Government of Denmark PIEPSAP project) and is designed so that, whatever the future generation mix, the fuel adjustment formula takes this into account. Therefore, if for instance an increasing amount of solar generation is employed, then the level of fuel consumed would fall relative to gross generation and this would be reflected in the allowable fuel efficiency rate. The same approach should also follow if PPUC buys in electricity from third parties, provided these purchases are reflected in the calculation of electricity generation in the check on network losses.

It should be noted that historically amongst other utilities, as tariffs increase, commercial losses are also likely to increase as customers face higher electricity charges. To address this, management needs to implement a policy to minimise these losses. It is recommended that one way PPUC could manage these losses is by installing additional prepaid meters, beginning with customers with existing arrears balances.

6.3 Mechanism Implementation Schedule

The final report of this Study will not be completed until the end of December 2009. The Consultant recommends that the proposed fuel adjustment mechanism, if adopted, is brought into effect in April 2010, the start of the second quarter of PPUC’s financial year. This approach will allow the billing and finance departments to focus on the implementation of the new tariffs, likely to be in February 2010. It will also allow a full three months of fuel price data from Q1 FY2010 to be used as the basis for Q2s fuel tariff.
7 Electricity Requirements of Low Income Households

7.1 Introduction

The 2006 Palau: Analysis of Poverty from 2005/2006 HIES report details that 19.2% of urban households and 20.8% of rural households in Palau fell into the lowest quintile (broadly defined by the study to the below the Basic Needs Poverty Line (BNPL)). Over 50% of the heads of households in this group were not recipients of wages or salaries, with 39% being listed as unemployed. In the highest quintile only 11% of the heads of each household are listed as unemployed. This indicates a wide split between rich and poor in Palau, a challenge which must be addressed when assessing residential tariffs.

The HIES report states that whilst electricity is the primary energy source for lighting in Palau, gas is most often the preferred option for cooking (53.9%). Across the bottom three deciles (roughly equivalent to the bottom quintile), 52.2% of households report kerosene as the primary fuel for cooking. On this basis, Kerosene has been used as a proxy for gauging ability to pay for electricity when setting the lifeline tariff.

Additionally, the Consultant assessed what level of electricity consumption can be assumed to fulfill lifeline criteria for low-income households. The lifeline requirements are to be compared with the ability and willingness to pay of low income urban and rural households. Based on this analysis the Consultant proposes the continuation of a lifeline tariff that allows low-income households to fulfill their minimum requirement.

The TOR asks that the Consultant discuss financing options for a lifeline tariff including:

- Cross subsidies;
- Direct Government support;
- Donor funding; and
- Other possible models.

The opportunity costs of lifeline tariff subsidies are discussed below together with alternatives to ensure equitable development.

7.2 Tariff Subsidies and their Financing

One area where governments and utilities have difficulty in reaching agreement is on how pricing for the poor is best achieved. Utilities see subsidized pricing for this group as a means of government implementation of a social policy that potentially comes at the expense of the utility.
Whatever the mechanism that is employed, pro-poor utility pricing involves a subsidy that is funded either internally by the utility or by external sources. If funded within the utility, recapitalization (as the utility makes losses and its balance sheet shrinks) or price discrimination are the two ways that are usually used to fund the subsidy. If funded externally, this is usually from governments that have a policy of lowering pricing for the poor.

Many donors have policies of encouraging the removal of cross subsidies and are therefore an unlikely source of financing support for such a scheme.

Recapitalization is not a recommended approach because the financial wellbeing of the utility deteriorates with time, ultimately damaging overall service levels. Price discrimination works if other customer classes have reasonably inelastic demand. In Palau, business customers have relatively elastic demand because many have their own standby generators and fuel is priced at the same level for them as it is for PPUC.

Therefore, subsidization of some or all residential consumers could only work equitably if all non-residential customers shared the additional pricing burden.

7.3 Types of Pro Poor Mechanisms

The key determinants of a successful subsidy scheme involve: (a) coverage; (b) targeting; (c) measuring the benefits to the poor; (d) what price distortions and other side effects might be caused by the subsidy and (e) the administration cost and difficulty of implementing the scheme.

Increasingly, the consensus on tariffs and the provision of subsidies for the poor is that they should be avoided because often the poor do not receive the benefit from broadly based schemes. Targeted schemes deliver greater benefit to the poor but these schemes need to be designed carefully so that establishment and administrative costs are not unduly costly. There are a number of ways that subsidies can be delivered, including:

No disconnection – which involves the utility not having the authority to disconnect non-paying customers. This arrangement provides coverage to all and targets defaulters (who should be the poor but this is not always the case). However, while a no disconnection policy is easy to administer, it encourages arrears that cannot be easily predicted and significant price distortions can occur;

Across the board price subsidies - entail all customers paying a price for service that is lower than the marginal cost of production. This approach is contrary to PPUC’s commercial mandate. Broad brushed schemes are also usually so expensive that they are generally not employed now. Implicitly, the GoP and PPUC have been providing across the board subsidies to consumers for some time, as the Corporation has not made an operating profit in recent years.

Across the board subsidies are, in fact, in existence for PPUCs outer station customers. These islands have higher fixed costs (primarily staff), higher fuel costs (additional transportation) and higher operating costs (smaller generators with lower efficiencies). Despite these higher required revenues per kWh, each outer island customer pays the same rate as those on Koror-Babeldoab.
Lifeline tariffs - involve certain customers being given a certain amount of discounted electricity per household per month. The amount is usually based on the minimal amount that consumers need to maintain a household. Cashpower meters supplied by Landis and Gyr have a built in lifeline tariff function. This function is modeled on South Africa’s “Electricity Basic Services Support Policy” (EBSST) for free basic electricity;

Price discounts for privileged customers – is a further form of price discrimination because this scheme sees certain types of customers (often based on occupation) receiving discounts on their services. This approach can be seen by those not receiving the subsidy as being highly discriminatory and therefore inequitable. From a political standpoint, price discounts for privileged customers can lead to negative perceptions that outweigh the benefits;

Burden limits – involve selecting poorer households whose utility bills exceed a set percentage of household income. A calculation is made by considering actual utility bills as a percentage of household income as verified by employer certificates. However, burden limits are difficult to police and the administrative costs are high;

Other earmarked cash transfers – are the reverse of Burden Limits because this form of subsidy is based on households having a certain level of “non utility” income. This means of subsidy has similar drawbacks to Burden Limits;

Non earmarked cash transfers – are general social assistance provided to help households meet their utility bills. These transfers can be made directly by the State and can be targeted but are generally only recommended where connection levels amongst the poor and metering levels are low.

There is general accord, if subsidies must be provided to the poor to assist them with their utility bills, that lifeline tariffs are the most expedient method. These tariffs can have several forms, but two stage and three stage tariffs are the most popular. The two stage lifeline tariff has a discounted block of service for the first stage and a non subsidized tariff as its second stage. Three stage tariffs have an additional stage that has a penalty tariff for higher levels of consumption as a means of dissuading customers from consuming too much service and creating a means of funding part or all of the lifeline tariff.

7.4 Pacific Experience with Lifeline Tariffs

Having reviewed other Pacific utilities the Consultant has identified that Fiji, Vanuatu, Samoa, the Marshall Islands, Tonga and Tuvalu have implemented a range of lifeline tariffs of one sort or another.

All but three of these utilities have two levels of domestic tariff. However, Vanuatu, Samoa and Tuvalu have three levels of domestic tariff. The purpose of this latter arrangement is to provide a low tariff for poorer customers, a medium tariff for most electricity consumption and a higher tariff to act as an incentive for those who have higher domestic consumption of electricity to conserve power, particularly for those that run air-conditioners. This “Conservation Tariff” also serves to provide a cross subsidy for the Lifeline Tariff.
The general approach amongst utilities that offer a Lifeline Tariff is to discount the standard domestic tariff by 20% on average. Some utilities offer only a 5% discount whilst Vanuatu has a lifeline tariff that is half of the standard domestic tariff.

On average the first step of lifeline tariffs among Pacific utilities is for the first 200 kWh per month to be at the lowest rate. However, the range varies markedly between 50 kWh per month to 500 kWh per month. Samoa and Vanuatu have lifeline tariffs for the first 50 kWh and 60 kWh per month respectively.

A consumption of only 500 kWh per year indicates that only the basic need in electricity can be met by this quantity. Most probably, a representative low-income private household in Palau will only be equipped with two or three CFL electric bulbs of 60 to 100 W incandescent equivalent and will eventually own a small fridge for the cooling of food stuff or a small transistor radio or a modest TV set.

The current lifeline tariff in Palau of 500 kWh per annum is a reasonable starting point and in the range of other similar Pacific countries. Therefore it is reasonable to assume that the first 42 kWh per month attracts the cheapest tariff which is priced at the level of the fuel portion of the tariff for 2010 (19.85c per kWh) assuming a 5% increase in fuel prices over this period. This is only a 3.4% increase on the current rate of 19.2c per kWh, essentially in line with inflation. It is important to note that even though the fuel tariff has been used as a basis for setting this rate, it will still be termed the ‘base tariff for lifeline customers.

Another approach would be to price a lifeline tariff at the marginal cost electricity generation, which is effectively the cost of the fuel burnt although this would lead to a substantial discount to the standard domestic tariff and a significant cross subsidy from the productive commercial sector.

When it comes to the higher domestic tariffs, on average this is usually triggered at 775 kilowatt-hours per month around the Pacific but the range is diverse, between 120 kilowatt-hours per month and 2,000 kilowatt-hours per month. In the case of Palau, PPUC has three bands of residential tariff, the second being at 501-2,000 kWh per annum and the third for all units over 2,001 kWh. These brackets are in line with other similar countries. It is recommended that these are not changed in order to minimize disruption to PPUC customers and PPUC systems.

7.5 Willingness to Pay for Electricity

Methodology

The Consultant has calculated the “Willingness to Pay” for domestic and commercial customers (see tables below). The Willingness to Pay calculation makes an assessment of the greatest amount that a customer class could pay for electricity without being economically worse off.

Under the calculation, the electricity market is divided into two groups; Households and Commercial and the costs of various alternatives for electricity supply are considered. A weighted average cost is then calculated through the associated costs for each method of supply and is termed The Willingness to Pay. Kerosene lamps are applied to consumers as this represents the ‘next best alternative’ for cooking and lighting which PPUC residential customers are likely to turn...
to if on-grid electricity supply was not available and similarly off-grid diesel power generators for commerce/industry.

Table 12 – Residential and Commercial Willingness to Pay Calculations

<table>
<thead>
<tr>
<th>Calculation of Upper Limits</th>
<th>Residential (Kerosene Lamp)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power Value</strong></td>
<td><strong>Unit</strong></td>
<td></td>
</tr>
<tr>
<td>Equipment Price</td>
<td>USD</td>
<td>10</td>
</tr>
<tr>
<td>Durable Years</td>
<td>Years</td>
<td>5</td>
</tr>
<tr>
<td>Annual Cost</td>
<td>UAD/Year</td>
<td>2.00</td>
</tr>
<tr>
<td>Equivalent Wattage</td>
<td>Watt</td>
<td>36.15</td>
</tr>
<tr>
<td>Hours per Day</td>
<td>Hours</td>
<td>4.80</td>
</tr>
<tr>
<td>Equivalent kWh per Year</td>
<td>kWh/Year</td>
<td>63.33</td>
</tr>
<tr>
<td>Power Value</td>
<td>USD/kWh</td>
<td>0.03</td>
</tr>
</tbody>
</table>

**Energy Value**

| Unit Price of Kerosene       | USD/Gallon                  | 1.45 |
| Fuel Used per Year          | Gallon/Year                 | 16.19 |
| Fuel Cost per Year          | USD/Year                    | 2347619 |
| Energy Value                | USD/kWh                      | 0.3707 |
| **Total Cost**              | USD/kWh                      | 0.4022 |

<table>
<thead>
<tr>
<th>Calculation of Upper Limits</th>
<th>Commercial + Industrial (Diesel Power Generator)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power Value</strong></td>
<td><strong>Unit</strong></td>
<td></td>
</tr>
<tr>
<td>Construction Cost</td>
<td>USD/kW</td>
<td>2500</td>
</tr>
<tr>
<td>Durable Years</td>
<td>Years</td>
<td>20</td>
</tr>
<tr>
<td>Discount Rate</td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>CRF</td>
<td></td>
<td>0.1175</td>
</tr>
<tr>
<td>Annual Power Value</td>
<td>USD/kW/Year</td>
<td>293.6491</td>
</tr>
<tr>
<td>Plant Factor</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>Total Loss</td>
<td></td>
<td>15%</td>
</tr>
<tr>
<td>Fixed O&amp;M Cost</td>
<td></td>
<td>3%</td>
</tr>
<tr>
<td>Equivalent Energy Value</td>
<td>USD/kWh</td>
<td>0.2031</td>
</tr>
</tbody>
</table>

**Energy Value**

| Price of Fuel               | USD/Gallon                  | 2.32 |
| Fuel Cost                   | USD/kWh                      | 0.1717 |
| Energy lost                 |                                | 5%  |
| Variable O&M Cost           |                                | 3%  |
| Energy Value                | USD/kWh                      | 0.1862 |
| **Total**                   | USD/kWh                      | 0.3893 |
As can be seen in the above tables, Willingness to Pay for consumers in Palau is calculated to be USD 0.4153 per kWh and Willingness to Pay is assumed to be constant over time. By multiplying this Willingness to Pay by the quantity of power PPUC sold in FY2009 (65.6 GWh) the Economic Benefit of PPUC on-grid supply can be established as USD 6.4 million.

As residential consumers should be willing to pay USD 40.22¢ per kWh and current tariffs range between USD 19.2¢ per kWh and USD 31.7¢ per kWh this group is theoretically (as a whole) willing to pay the current rates. This also applies for commercial and government consumers who are calculated to be willing to pay up to USD 38.9¢ per kWh and are currently being charged USD 31.7¢ per kWh.

### 7.6 Possible Domestic Tariff Arrangements for PPUC

The Consultant recommends continuing with the current three part domestic tariff as follows:

- A Lifeline Tariff for the first 500 kilowatt-hours per annum priced at the current fuel cost;

- A Standard Tariff for the next 1,500 kilowatt-hours per annum, and;
• A Conservation Tariff from 2001 kilowatt-hours per annum priced of approximately 120% of the Standard Tariff in order to maintain required revenues at a single tariff rate.

As previously mentioned, this structure is identical to the current PPUC tariff brackets.

Overall, the best way for PPUC to finance a lifeline tariff is to improve its operating efficiency, particularly in the area of network losses and collections. By doing so, it will increase its cash flows substantially.

7.7 Financial Analysis of Proposed Lifeline Tariff

The Consultant has taken the required revenue calculation for FY2010 and divided the amount by each customer category, having due regard for the existing differences between the tariff for each customer class. Taking the three-stage domestic tariff structure discussed in the preceding section, and assuming that commercial & Government customers pay a tariff equal to the highest domestic tariff, the following suggested tariff structure results:

<table>
<thead>
<tr>
<th>Tariff Allocation 2010</th>
<th>Sales (MMkWh)</th>
<th>2009 Tariff (US$)</th>
<th>Proposed Tariff</th>
<th>% Increase</th>
<th>Revenue (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic &lt;500</td>
<td>2,513</td>
<td>19.20</td>
<td>19.27</td>
<td>0.50%</td>
<td>48.1</td>
</tr>
<tr>
<td>Domestic 501-2000</td>
<td>14,073</td>
<td>27.20</td>
<td>30.23</td>
<td>11.13%</td>
<td>4,254</td>
</tr>
<tr>
<td>Domestic 2000+</td>
<td>7,037</td>
<td>31.70</td>
<td>35.23</td>
<td>11.13%</td>
<td>2,479</td>
</tr>
<tr>
<td>Commercial</td>
<td>24,585</td>
<td>31.70</td>
<td>35.23</td>
<td>11.13%</td>
<td>8,802</td>
</tr>
<tr>
<td>Govt</td>
<td>3,504</td>
<td>31.70</td>
<td>35.23</td>
<td>11.13%</td>
<td>1,245</td>
</tr>
<tr>
<td>ROP</td>
<td>17,600</td>
<td>31.70</td>
<td>35.23</td>
<td>11.13%</td>
<td>5,200</td>
</tr>
<tr>
<td>Total Revenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23,541</td>
</tr>
<tr>
<td>Revenue Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23,541</td>
</tr>
</tbody>
</table>
8 Tariff Structure and Rate Determination

8.1 Introduction

A tariff structure for all PPUC customer classes based on the analysis set out in the preceding sections is set out below. This includes:

- Domestic Consumers;
- Commercial Consumers;
- Governmental Consumers;

Consideration has also been given to a special tariff for large commercial users. This additional tariff class is established with the two purposes. First, it is hoped this discount will entice large users with off-grid supply to return to the PPUC network. Secondly, it is hoped that this discount will provide sufficient incentive for current large customers to remain with the PPUC grid.

For each category secondary objectives such as appropriate price signals targeted towards energy conservation and environmental issues have been considered. Tariff structures such as increasing block tariffs and/or lifeline tariffs have also been considered in Section 8.

The tariff proposal and suggested adjustment mechanisms is summarized in the separate document called the “Tariff Setting Guideline”. This guideline will contain a brief description of the approach towards tariff design together with annotated formulae and relevant financial models and adjustment schedules.

8.2 Issues in Tariff Design

8.2.1 General Principles Underlying Tariff Design

Tariff design deals with the link between the individual prices that PPUC charges each class of customer and the manner in which these tariffs are structured. As PPUC is generally considered to be responsible for proposing tariffs and there is no set regulator in place, it is important that the conditions for tariff setting are known so that outcomes acceptable to the GoP, PPUC and its customers are achieved.

The GoP’s interest in tariff design is in ensuring that welfare is maximized and an affordable service is provided to customers, especially the poor. Both PPUC (as a state owned enterprise) and the GoP have an aligned interest in ensuring that tariffs are set so that consumers are understanding of both the tariffs and the tariff setting process and a stable political environment is maintained as a result.

Optimal pricing decisions are based on marginal cost so that under perfectly competitive conditions the price that is charged is equal to the marginal cost of producing a single further unit of electricity. This
concept of marginal cost pricing is allied to the objective of maximizing welfare, so governments favor market conditions that are very competitive.

The creation of a competitive market in PPUC is not a realistic goal, however, because the diseconomies of scale that would occur are likely to far outweigh the benefits of competition (other than in the area of third party generation). In the absence of competition, a degree of price control is needed and to make recommendations in this regard, consideration of the methods of price control and how they might be applied in PPUC’s case is needed.

A fully competitive market involves competition at the generation, distribution and retailing levels of the electricity supply chain. With the smaller economies of scale associated with the electricity system in Palau, it is unlikely that competition would provide economic benefits within the transmission, distribution and retailing sub-sectors.

However, in future there is the possibility of obtaining some market signals from third-party generators that are willing to supply the PPUC system, especially if these generators can produce electricity from renewable resources using Palau’s natural bounty. For the time being it makes sense to contract with these third-party providers on the basis of PPUC’s avoided costs, which is the short run marginal cost (effectively the cost of fuel per kilowatt hour). Future tariff studies might take these price signals into account.

Overall, price determination needs to strike a balance between excessively low prices that might be politically driven and yet protect consumers from excessively high prices and the loss of associated macro-economic gains to Palau. Price determination also needs to ensure that PPUC is delivering services efficiently. Price controls are usually managed by placing limits on the overall revenues that a utility can receive and these are discussed in the following section.

8.2.2 Usual Approaches to Price Setting

There are following three main approaches to price setting and these are (a) rate of return pricing; (b) price cap pricing and (c) benchmark pricing.

Rate of return pricing sets prices based on permitted costs, which include a return on the capital invested. When the utility seeks a tariff change a review is made of the reasonableness of its costs and its weighted average cost of capital might also be considered. This method matches costs and revenues well but does not offer much incentive for efficient operation or development of the system.

Price cap pricing is also sometimes called “RPI-X Regulation” and was developed in the United Kingdom as a counter to rate of return pricing. Under this regime, utilities can change tariffs and tariff structures as long as they do not exceed revenues adjusted against an index that is made up of an inflation allowance and an efficiency factor. This arrangement disconnects costs and revenues and places further pressure on utilities to become more efficient.

However, it is possible to place undue pressure on utilities if the “X” factor is misjudged. It also assumes that the base revenue that is to be indexed is calculated fairly. In this study, no “x” factor is applied but targets are set regarding collections and network loss reduction targets.

Benchmarking pricing is an assessment of the reasonableness of tariffs by comparison to comparable utilities. It presumes that truly comparable utilities can be found, although there is an incentive if the target
utility is able to be more efficient than its benchmark counterparts because it will realize additional profits. It is accepted, however, that it is difficult to rely on benchmarking because the conditions of other utilities often differ quite markedly. If adjustments need to be made to help align the benchmarking assignment, this can call the exercise into further question.

The Study employs a rate of return pricing methodology because this is the most appropriate method to use in the case of this PPUC tariff review (and further indicated in the TOR).

8.2.3 Alternative Tariff Structures

The previous sub-section deals with marginal cost as a basis for determining tariffs and also several means through which overall revenues to a utility can be limited. Marginal cost pricing at its simplest level results in a linear price for all users. However, there are several forms of non-linear pricing and these include: (a) multipart prices; (b) price discrimination; (c) optional tariffs (d) volume based pricing and (e) peak load pricing. The TOR also requires that for industrial consumers the merits of a reactive power metering and a demand charge are also considered. That analysis is set out below.

Multipart prices are where a utility charges different prices for different parts of the service, such as charging a monthly connection fee and then a fee for consumption. Multipart prices are very common and PPUC employs this arrangement for the provision of electricity. For large users it does not charge a price per kW or KVA. It then charges for the consumption of kWh based on non fuel operating costs and a fuel charge (in addition to a small fixed monthly charge) and this is an appropriate charging mechanism.

Price Discrimination involves different prices being charged to different customer classes even though the cost of providing the service to those customers is the same. Price discrimination is also called “Ramsay Pricing” and the premise that underlies the practice is that pricing is based on the elasticity of demand displayed by each customer class. Customers whose demand is relatively inelastic are charged at rates above the marginal cost of providing the service, whereas customers whose demand is relatively elastic are charged tariffs that are closer to the marginal cost.

When Ramsay pricing is applied, the result is usually that those who can afford to pay more for the services (such as businesses) are charged more and other users (such as residential consumers) can be charged at lower rates. These lower rates can sometimes be lower than the marginal cost of providing the service, creating a cross subsidization from one customer group to another.

Price discrimination often appears to be unfair to customers and this can make the practice politically difficult. However, price discrimination can also be consistent with government policy of providing more affordable services to the poor.

Therefore, while price discrimination can help deliver a fair balance to consumers if it is well structured, customers need to be informed through a consultative process as to why this arrangement is in the collective best interests of end users.

PPUC does price discriminate for electricity sales. Residential and small power users pay a lower tariff than the Commercial and Government Tariffs (see Section 2) for further details regarding the current rate structure). This approach is consistent with Ramsay Pricing because, as Section 8 discusses, residential and small general power service customers have an opportunity cost that is higher than the rates charged by PPUC. Price discrimination is dealt with more fully in Section 7.
Optional Tariffs are like multipart tariffs in that services are priced in a variety of ways. They differ in that customers choose from a “menu” of options that suit their consumption style best. Optional tariffs can work well if tariffs are set at levels above marginal cost, but require considerable thought if a utility is seeking to simply recover its costs, as in the case of PPUC.

Volume based pricing sees tariffs being based on the level of consumption, with higher levels of consumption being charged at higher rates than lower levels of consumption. This approach is helpful as a means of demand side management, provided consumers are able to judge when they are being charged the higher rate.

Volume based tariffs can also be useful where a utility has constraints in its ability to meet peak load demand. PPUC does not currently have capacity constraints, however, and as there is a fuel cost pass-through in the tariff, there is no particular incentive for PPUC to introduce volume based pricing for electricity other than for general demand side management.

With demand side management in mind, however, the TOR requires the Consultant to consider whether step up tariffs would be beneficial in conserving electricity. Section 7 advocates a three-part tariff for all domestic consumers so that there is provision for a lifeline tariff and also a conservation component for larger domestic consumers.

It is suggested that commercial/government consumers pay the same tariff as the highest domestic tariff. That tariff is classed as a conservation tariff and is priced at a slight premium to the long run cost. Further consideration of this recommendation is required because non-domestic consumers have a greater capacity to pay for their electricity than domestic consumers. However they also, for the most part, represent the productive sector and it would be unreasonable to penalize these customers as the government tries to promote economic development in the country.

The counter to this argument is the effect that the tax deductibility of commercial electricity expenditure has on commercial customers.

### 8.2.4 Reactive Power Metering and a Demand Charge

In a mainly diesel based system with ample reserve capacity, demand charges are not a significant factor in considering new investments. On the other hand reactive power usage should be a cause for concern in that this is a direct contributor to technical losses and unless corrected can adversely affect voltage regulation conditions. In this respect many of the industries and larger commercial users in Koror-Babeldoab use a variety of electric motors in their processing, air conditioning, and refrigeration plant all of which are large consumers of reactive power.

### 8.2.5 Uniform Tariff Versus Grid based Tariffs

The TOR requires the Consultant to consider the LRMC and Required Revenue for each of the Grids operated by PPUC. The table below shows the marked differences between the pricing required for each of the grids. From this it can be seen that there would be major winners and losers if consumers were to pay for electricity based on the cost of delivering the service in their area.
### Table 14 – Billing Classes, Volumes, Current and Proposed Tariffs by Island (FY2010)

<table>
<thead>
<tr>
<th>Koror/Babeldoab Tariff Allocation 2010</th>
<th>Sales (MWH)</th>
<th>2009 Tariff (USDc)</th>
<th>Proposed Tariff (USDc)</th>
<th>% Increase</th>
<th>Revenue (USD 000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic &lt;500</td>
<td>2,773</td>
<td>19.20</td>
<td>19.20</td>
<td>0%</td>
<td>532</td>
</tr>
<tr>
<td>Domestic 501-2000</td>
<td>13,782</td>
<td>27.20</td>
<td>30.23</td>
<td>11%</td>
<td>4,166</td>
</tr>
<tr>
<td>Domestic 2000+</td>
<td>6,891</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>2,428</td>
</tr>
<tr>
<td>Commercial</td>
<td>24,922</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>8,780</td>
</tr>
<tr>
<td>Govt</td>
<td>3,481</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>1,226</td>
</tr>
<tr>
<td>ROP</td>
<td>17,394</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>6,128</td>
</tr>
<tr>
<td>Total Revenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23,262</td>
</tr>
<tr>
<td>Revenue Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>22,240</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Peleliu Tariff Allocation 2010</th>
<th>Sales (MWH)</th>
<th>2009 Tariff (USDc)</th>
<th>Proposed Tariff (USDc)</th>
<th>% Increase</th>
<th>Revenue (USD 000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic &lt;500</td>
<td>88</td>
<td>19.20</td>
<td>19.20</td>
<td>0%</td>
<td>17</td>
</tr>
<tr>
<td>Domestic 501-2000</td>
<td>182</td>
<td>27.20</td>
<td>30.23</td>
<td>11%</td>
<td>55</td>
</tr>
<tr>
<td>Domestic 2000+</td>
<td>91</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>32</td>
</tr>
<tr>
<td>Commercial</td>
<td>21</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>7</td>
</tr>
<tr>
<td>Govt</td>
<td>18</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>6</td>
</tr>
<tr>
<td>ROP</td>
<td>69</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>24</td>
</tr>
<tr>
<td>Total Revenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>142</td>
</tr>
<tr>
<td>Revenue Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>879</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anguar Tariff Allocation 2010</th>
<th>Sales (MWH)</th>
<th>2009 Tariff (USDc)</th>
<th>Proposed Tariff (USDc)</th>
<th>% Increase</th>
<th>Revenue (USD 000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic &lt;500</td>
<td>31</td>
<td>19.20</td>
<td>19.20</td>
<td>0%</td>
<td>6</td>
</tr>
<tr>
<td>Domestic 501-2000</td>
<td>65</td>
<td>27.20</td>
<td>30.23</td>
<td>11%</td>
<td>20</td>
</tr>
<tr>
<td>Domestic 2000+</td>
<td>32</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>11</td>
</tr>
<tr>
<td>Commercial</td>
<td>21</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>7</td>
</tr>
<tr>
<td>Govt</td>
<td>18</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>6</td>
</tr>
<tr>
<td>ROP</td>
<td>69</td>
<td>31.70</td>
<td>35.23</td>
<td>11%</td>
<td>24</td>
</tr>
<tr>
<td>Total Revenue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>Revenue Required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>272</td>
</tr>
</tbody>
</table>
8.2.6 Conclusions

PPUC has authority to set tariffs after consultation and approval with the Board of Directors. Tariffs are ideally determined by a market operating in a competitive environment so that rates equal marginal cost as closely as possible.

In the absence of a market, a degree of price regulation and control is necessary and this is usually achieved through rate of return pricing, the imposition of price caps or by reference to comparable utilities through benchmarking. The Study employs rate of return pricing as the principal means of tariff determination and this is a reasonable basis for striking tariffs.

The report considers a range of tariff mechanisms such as multipart prices, price discrimination, optional tariffs and volume based prices. Analysis of these approaches suggests that multipart prices with price discrimination is employed by PPUC for electricity and that there is economic rationale to do so. At present commercial and governmental customers pay more than domestic customers (at the first two tiers) and this is appropriate given that these larger customers have a greater capacity to pay for electricity than smaller domestic customers.

The value of tariffs being set on a grid by grid basis has also been considered and it is concluded that PPUC continue with a uniform tariff for each customer class right across the country. The Consultant believes that to do otherwise would lead to inequitable differences between grids. Instead, PPUC should analyze further why those differences arise and how it would be possible to reduce costs in the more
expensive outstations. The size and load curves of each of the outer Islands make them ideal candidates to be the pilot projects for 100% RE generation.

If the tariff regime were adopted, it would be appropriate to continue with a two part charge (fuel or non fuel O&M) for consumption. This arrangement would need to be reviewed as the fuel mix for generation changes if the Consultant’s recommendation regarding renewable implementation is adopted.

Several pro-poor tariffs have been considered, including (i) no disconnection; (ii) across the board price subsidies; (iii) lifeline tariffs; (iv) price discounts for privileged customers; (v) burden limits; and (vi) cash transfers.

Of these tariffs, only lifeline tariffs, that provide some discounted basic electricity, have particular merit, especially a three-stage arrangement that has an incentive to conserve electricity consumption.

8.3 Recommended Electricity Rate Structure

The tariff profiles that result from the 100% Renewables System differ markedly from the Status Quo System. Based on this premise it is recommended that PPUC undertakes a 20 year program to become 100% independent of diesel in 2030. Tariffs are based on the information available to the Consultant as of the Reporting Date.

Adopting a 100% RE strategy (by 2030) provides three main benefits to PPUC and Palau. It has been forecast that this strategy will result in lower cost electricity, decrease exposure to volatile/risky fuel sources (through decreased dependence on diesel) and provide significant macro economic benefits through local jatropha production

8.3.1 Tariff Analysis

The following analysis sets out the tariff paths for the preferred generation configuration. The analysis assumes that prices are reviewed annually and that the price path for tariffs results a break even return on investment (ROI) each year.
8.4 Developing Educational Material

The Consultant has found the use of the following stacked bar chart useful in describing the components that make up the average tariff. At the recent Stakeholder Workshops participants were very receptive to the chart illustrated below as it provided them with a clear explanation of the cost component make-up. Customers were able to see what the major components were and what proportion of these (and the average tariff) was outside of the control of PPUC.
Clearly evident is that large fuel component, which consumers recognize is currently difficult for the PPUC to control. Participants of the Workshop were appreciative of Palau’s exposure to the often highly volatile world oil markets and the impact this has on PPUC operating costs and the required average tariff. When they heard that PPUC was considering offsetting diesel consumption with lower cost renewable energy this proposed program was well received.

Consumers also were understanding of the high maintenance costs required for 2010 resulting from deferred maintenance from previous years.

The General Manager of PPUC has indicated as desire to, in early 2010, to provide all PPUC customers with a brochure which is based around this stacked bar chart in early 2010. This brochure will advise customers of the new tariffs, the implementation date for the new tariffs and further detail on each component indicated in the figure above.
Attachment 1 – Scope of Work

Scope of Work (from the Request for Quotation – July 2009)

In reviewing the PPUC tariff the consultant shall undertake the following activities:

- Project demand development of all PPUC operated grids (Koror and three outer islands mini grids) over a twenty year period
- Estimate operating expenditures over the twenty year period
- Estimate investment requirements to meet demand
- Determine a weighted average cost of capital for Long Run Marginal Cost (LRMC) and Required Revenue calculations
- Calculate LRMC over a 20 year horizon
- Estimate revenue requirements under various financing/ownership scenarios
- Review appropriateness of fuel adjustment provision
- Assess minimum electricity requirements of low income households and discuss costs and benefits of a cross-subsidized lifeline tariff for basic consumptions (lifeline tariff)
- Propose a tariff structure including adjustment provisions and adjustment frequency
- Develop educational material that PPUC can use in consultation processes with the Government of Palau (GoP) and in relation with its customers
- Assess pricing issues on renewable energy based power generation to make it competitive with petroleum based generation

The Consultant shall compile a collection of relevant data and information and contact all stakeholders namely GoP institutions including PPUC, the Energy Office, relevant bi- and multilateral donors such as JICA, ADB, UNDP, EU/EDF, World Bank, NGOs and private sector representatives. The Consultant will conduct field inspections of the PPUC’s operations, including interviews with staff, governmental agencies, major customers and others. Further, a review of operational planning and human resource management, equipment and supply requirements is required by function and cost.

1 Project demand development of all PPUC operated grids

The Consultant shall project demand development for capacity and energy of all PPUC operated grids. This will include but not be limited to the following:

- A review of recent studies and reports addressing the issue of future demand development
- An analysis of historic trends in demand development broken down into:
  - Development in the Koror/Babeldoab Grid
  - Development in three outer island grids operated by PPUC
- A discussion of price elasticity of the demand for the two categories above
- A discussion of the impact of widespread use of pre-paid meters on demand
- The consultant shall present demand development in Excel format and provide a range of scenarios reflecting assumptions with respect to economic growth.

2 Estimate investment requirements to meet demand

The Consultant shall estimate investment requirements over a 20 years period. The consultant shall suggest an optimal capital expenditure program for the demand scenarios defined under 4.1. The estimates will be guided by least cost supply considerations and be broken down into three categories:
• Generation
• Distribution
• Administration and Human Resource Development

Alternative supply options such as solar energy will be discussed and included into the investment estimates if considered viable (including if environmental costs of various power generation technologies are to be reflected). The consultant shall also assess the impacts of conservation efforts and of a net metering program (demand and supply side management options) on investment requirements and on revenue.

3 Calculate Long Run Marginal Cost of Supply
The Consultant shall calculate LRMC for electricity supply for all major supply systems broken down into:
• LRM capital; and
• LRM operating cost.

The consultant shall propose a LRMC based base tariff that excludes fuel and lubricants. A tariff for dedicated rural electrification schemes shall also be proposed.

4 Estimate revenue requirements under various financing and ownership scenarios
Based on the demand scenarios developed the Consultant shall develop a 20 years discounted cash flow model to calculate revenue requirements of PPUC. Assumptions have to be taken with respect to financing including commercial financing and concessionary loans or grants supported by donors.

The Consultant shall base estimates of revenue requirements on a review of operational performance and a comparison with benchmark values from other Pacific power utilities (tariff review studies recently undertaken with support from SOPAC/UNDP/Government of Denmark include Pohnpei Utility Corporation, Tuvalu Electricity Corporation and Solomon Islands Electricity Authority that will be made available to the Consultant). The consultant shall also review the 2007 tariff review performed by economists.com for PPUC.

For the different ownership/financing scenarios the Consultant shall present the cash flow models in Excel format and discuss tension between purely LRMC based pricing and revenue requirements of PPUC.

The Consultant shall propose reconciliation between revenue requirements and LRMC that ensures financial sustainability of PPUC under the different ownership and financing options assumed. The Consultant shall discuss the model with PPUC management and train financial staff to use the model.

5 Develop a fuel adjustment mechanism
The Consultant shall develop a fuel surcharge formula with respect to:
• Incentives to increase operating efficiency
• Reductions in specific fuel consumption due to employment of new technology (state of the art diesel generators)
• Introduction of alternative generation options such as the use of heavy fuel oil resulting in reduced overall uplift of diesel.

Based on the analysis above the Consultant shall propose a fuel and lubes adjustment formula and a schedule for its application.

6 Assess minimum electricity requirements of low income households
The Consultant shall assess what level of electricity consumption can be assumed to fulfill lifeline criteria for low-income households. The lifeline requirements shall be compared with ability and willingness to pay of low income urban and rural households. Based on this analysis the consultant shall propose a lifeline tariff that allows low-income households to fulfill their minimum requirements.

The Consultant shall discuss financing options for a lifeline tariff including:

- Cross subsidies
- Direct Government support
- Donor funding
- Other possible models

Opportunity costs of lifeline tariff subsidies shall be discussed together with alternatives to ensure equitable development.

7 Assess pricing issues on renewable energy based power generation to make it competitive with petroleum based generation

An important aspect of energy policy is renewable energy pricing. As part of the assignment the Consultant should assess the competitiveness of renewable energy against diesel generated electricity including pricing barriers to encourage investments in renewable energy and recommend a guaranteed minimum tariff enabling renewable energy investors and financial institutions to have fair a return on renewable energy investments. Review in context of Palau relevant approaches, best practices and experiences in other small countries such as possibly investment tax incentives, production tax credits, property tax reductions, accelerated depreciation, direct production incentives, etc.

The Consultant should also assess the environmental costs of various power generation technologies and how this could be reflected in energy pricing. The intention with this component of the tariff review is to enable an increased understanding of pricing issues associated with renewable energy based power generation to make it competitive with petroleum based generation.

8 Propose a tariff structure including adjustment provisions

Based on the analysis above the Consultant shall propose a tariff structure for all PPUC customer classes including adjustment mechanisms for the base tariff and the fuel surcharge. This will include but not necessarily be limited to:

- Urban Domestic Consumers
- Commercial Consumers
- Government
- High Voltage Consumers
- Low Income Rural Consumers

For each category secondary objectives such as appropriate price signals targeted towards energy conservation and environmental issues shall be considered. Tariff structures such as increasing block tariffs and/or lifeline tariffs will be considered. For industrial consumers, the merits of a reactive power metering and a demand charge will be analyzed.

Specifically the Consultant will also analyze and discuss the following issues:

- Merit of meter rental and administration fees to be included in the tariff
- instead of being a separate item
- Disconnection/reconnection fees for overdue accounts
- Criteria to distinguish between commercial and private customers and merit of using a uniform tariff
The tariff proposal and suggested adjustment mechanisms will be summarized in a separate document “Tariff Setting Guideline”. This guideline will contain a brief description of the approach towards tariff design together with annotated formulae and relevant financial models and adjustment schedules.

9 Develop educational material for tariff consultations

Sustainable tariffs have to be transparent and acceptable to the customers. The Consultant will therefore develop consultation and education material that enables PPUC to communicate with its customers and the Government (as the regulator) on the methodologies and data used in the setting of electricity tariffs. The development of such brochures, posters etc will be performed in close co-operation with PPUC management and other key stakeholders.

The Consultant shall also assist in presenting study findings and recommendations to the Government, the Legislature, the PPUC Board, and to the public at large. This activity will takes place during the time of the consultation workshop.
## Attachment 2 – Consultations

Consultations conducted during 1st Field Trip (5 – 13 November 2009)

<table>
<thead>
<tr>
<th>Date</th>
<th>Meetings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thursday 5 November</td>
<td>Ken Uyehara – PPUC General Manager/CEO</td>
</tr>
<tr>
<td>Friday 6 November</td>
<td>Kayangel Station Manager</td>
</tr>
<tr>
<td></td>
<td>Kayangel Generation Manager</td>
</tr>
<tr>
<td>Monday 9 November</td>
<td>Jacqueline Alexander – PPUC Chief Financial Officer</td>
</tr>
<tr>
<td>Tuesday 10 November</td>
<td>Members of the Palau Chamber of Commerce</td>
</tr>
<tr>
<td></td>
<td>Tmetuchl Baules – Executive Director of Palau Chamber of Commerce</td>
</tr>
<tr>
<td>Wednesday 11 November</td>
<td>Gregorio Decherong – Director of the Palau Energy Office</td>
</tr>
<tr>
<td></td>
<td>Nyk Kloulbak – Energy Efficiency Specialist of the Palau Energy Office</td>
</tr>
<tr>
<td></td>
<td>Makoto Noda - Resident Representative of JICA’s Palau Office</td>
</tr>
<tr>
<td></td>
<td>PPUC Board Members</td>
</tr>
<tr>
<td></td>
<td>Jacqueline Alexander – PPUC Chief Financial Officer</td>
</tr>
<tr>
<td></td>
<td>Janice – Operations Manager for Palasia Hotel</td>
</tr>
<tr>
<td>Thursday 12 November</td>
<td>Lorenzo Mamis – PPUC’s Generation Manager</td>
</tr>
<tr>
<td>Friday 13 November</td>
<td>Kaleb Udui Jr – President of National Development Bank of Palau</td>
</tr>
</tbody>
</table>
## Attachment 3 – References

<table>
<thead>
<tr>
<th>Organization</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May 2009-11-18</td>
</tr>
<tr>
<td></td>
<td>Palau Facility for Economic and Infrastructure Management</td>
</tr>
<tr>
<td></td>
<td>June 2008</td>
</tr>
<tr>
<td>ADB</td>
<td>Energy Sector Investments in PDMCs</td>
</tr>
<tr>
<td>Economists.com</td>
<td>PPUC 2007 Electric Rate Study</td>
</tr>
<tr>
<td>JICA</td>
<td>Draft Final Report on the Master Plan Study for the Upgrading of Electric</td>
</tr>
<tr>
<td></td>
<td>Power Supply in the Republic of Palau</td>
</tr>
<tr>
<td></td>
<td>May 2008</td>
</tr>
<tr>
<td>Nelson Associates</td>
<td>Report to the President of Palau – Causes of PPUC Electrical Outages</td>
</tr>
<tr>
<td></td>
<td>April 2009</td>
</tr>
<tr>
<td></td>
<td>in Palau – Preliminary Report</td>
</tr>
<tr>
<td></td>
<td>March 2009</td>
</tr>
<tr>
<td>Zieroth, Gerhard</td>
<td>Palau Energy Sector Review (Development of Palau National Energy Policy)</td>
</tr>
<tr>
<td></td>
<td>June 2009-11-18</td>
</tr>
</tbody>
</table>
### Attachment 4 – Work and Action Plan

<table>
<thead>
<tr>
<th>TASK NO</th>
<th>DESCRIPTION OF TASKS</th>
<th>Richard MacGeorge</th>
<th>James Stewart</th>
<th>Tony Woods</th>
<th>Peter Cole</th>
<th>Local Consultant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Establish information base of key documents</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2</td>
<td>Review aligned information and seek certification from PRUC and other advisors as required</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>3</td>
<td>Meet with SEDEIA, GPEF and PRUC to discuss and confirm goals, objectives, timeline and process</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>4</td>
<td>Revise work plan to reflect needs of GPEF, PRUC and SEDEIA as required</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

#### 2. Project demand development of all PRUC operational grids

- Analyse historic trends in demand development separated into: Development in main island and Babaribelo Islands Development in three outer island grids operated by PRUC
- Assess price elasticity of demand for PRUC networks
- Provide a range of demand development scenarios based on economic growth assumptions

#### 4. Estimate investment requirements to meet demand

- Calculate optimal capital expenditure programs (net cost of supply) based on a 20 year period for scenarios identified in task 3 above and categorised into categories: generation, distribution and administration/human resource development
- Consider alternative supply options if viable and assess impacts of conservation efforts

#### 5. Calculate LMP of supply

- Calculate LMP for all major electricity supply systems broken down into: LMP capital LMP operating cost
- Propose a LMP based base tariff (excluding fuel and/or lubricants)

#### 6. Estimate revenue requirements based on a variety of financing and ownership scenarios

- Develop a 10-year discounted cash flow model to determine PRUC revenue requirements (including commercial financing and concessional loans supported by donors)
- Revise revenue requirements based on operational performance review and compare with benchmark values from other Pacific power utilities
- Present and discuss cash flow models for different ownership/financing scenarios and discuss issues arising from pure LMP based pricing and the revenue requirements of PRUC
- Propose appropriate model incorporating revenue requirements and LMP calculations for the financially sustainable operation of PRUC
- Present models to PRUC management and train financial staff to use model

#### 7. Develop retail adjustment mechanisms

- Develop retail adjustment mechanism to incentivise operating efficiency, increase use of new PMH and alternative generating options
- Propose a useful and durable adjustment formula and schedule for application

#### 8. Assess minimum electricity requirements of low income households

- Identify a baseline tariff for low-income households following analysis of low-income households electricity consumption and affordability to pay by low-income urban and rural households
- Discuss financing options for the implementation of subsidies, government support, donor funding and other models
- Compare the opportunity cost for lifetime tariff subsidies vs alternatives to ensure equitable development

#### 9. Propose a tariff structure including adjustment provisions

- Propose a tariff structure for all PRUC customer classes incorporating adjustment mechanisms
- Consider secondary objectives such as price signals, tariff structure and reactive power networking
- Analyse other issues including incorporating meter rental in tariff structure, define criteria for commercial vs. private customer and need of uniform tariff structure and direct-consumption fees for overage accounts
- Prepare Tariff Setting Guidelines document (see Task 10)

#### 10. Develop educational material for tariff consultations

- Develop education material in consultation with GPEF, PRUC and SEDEIA (cost of design or printing not included in budget)
- Assist in preparing briefing materials and recommendations at stakeholder workshop (see Task 12)

#### 11. Development and Presentation of Findings

- Prepare Final Report detailing Consultant’s approach and assignment methodology
- Prepare draft report providing preliminary documentation and recommendations
- Prepare LMP and financial models
- Prepare presentation of findings and recommendations to stakeholder workshop
- Prepare Tariff Setting Guidelines document
- Prepare Final report

* Primary Role
* Secondary Role
### Attachment 5 – Personnel Schedule

<table>
<thead>
<tr>
<th>Position</th>
<th>Full-time</th>
<th>Part-time</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>President/CEO</td>
<td>1.00</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>Executive Vice President</td>
<td>0.50</td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>Senior Operating Engineer</td>
<td>0.50</td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>Operating Engineer</td>
<td>0.50</td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>Assistant Operating Engineer</td>
<td>0.25</td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>Combined</td>
<td>2.25</td>
<td></td>
<td>2.25</td>
</tr>
</tbody>
</table>

**Figure 2 - Personnel Schedule (Person-Days)**
Attachment 6 – NDBP Energy Efficiency Outline

12 November 2009

Mr Kaleb Udui Jr.
President
National Development Bank of Palau

DRAFT OUTLINE OF INDICATIVE ENERGY EFFICIENCY FINANCING PLAN

An opportunity has been identified to:

1) Create a new lending portfolio for the NDBP;
2) Increase the energy efficiency of Palauan residential households and therefore reduce electricity bills; and,
3) Decrease the operating expenditure of PPUC through reduced diesel consumption.

During our site visits in Palau it was observed that a large number of households are currently using refrigeration which is severely corroded and as a result, poorly insulated/lacking airtight seals. The impact of these conditions is that the motors run longer than necessary in order to try and maintain a cool temperature. This was evident in both upright fridges and chest freezers.

If consumers were able to replace their existing chest freezers/fridges with new appliances it is expected that their electricity usage would drop substantially. However, it is recognized that many Palauan consumers may struggle to be able to pay the outright purchase price of a new chest freezer/fridge. Based on these two factors, an opportunity has been identified for the NDBP to work with PPUC and the PEO to achieve mutually beneficial goals.

Benefits to the Consumer

If we were to assume a household had a chest freezer that had rusted and degraded significantly and as such it never reached its target cooling level it is likely it may run for 24 hours a day (a common occurrence in the Pacific Island).

On this basis a 150 watt chest freezer would use 1,314 units of electricity per annum (0.15kW x 24 hours per day x 365 days per year). If this level of electricity is being consumed the household will be exposed to at least the mid-rate residential tariff (27.21¢ per kWh) if not the highest tariff of 31.7¢ per kWh. At the mid-rate the appliance would cost the consumer $358 per annum.

A new chest freezer with adequate seals and insulation should run for approximately 8 hours per day in Palauan temperatures. Comparing the two options, a new chest freezer would decrease the consumer’s electricity bill by 876 kWh per annum or (at least) $238.
It is perceived that the problem lies with a household raising the funds to pay for the new chest freezer (approximately USD 700).

If the NDBP was to issue loans to consumers to fully fund the purchase of a new chest freezer at a rate of (for example) 7.00% per annum, the repayment of the loan would cost $171 per annum over a five year term.

For the first five years the consumer would save $67 per annum after it had made the $171 loan repayment. The benefit to the consumer rises to $238 per annum for the remainder of the chest freezers operational life (assumed to be ten years in Palauan conditions) after the loan has been repaid.

On this basis, the consumer’s power would will decrease by over $2,380 over the next ten years. If electricity tariffs rise over the next ten years (very probable with a diesel based system) this saving will be even higher.

The cost of servicing the loan over the five year term would be $853, resulting in a net benefit to the consumer of over $1,500. The net present value of the benefits of this investment is $817 with an IRR of over 50%.

If an annual tariff increase to keep in line with inflation is considered, these benefits are significantly higher. If the price of diesel increases at a rate greater than that of inflation over the next ten years then the savings will be higher still.

Benefits to PPUC
Potentially, benefits also flow to PPUC. As residential tariffs are subsidized by commercial and government tariffs, every residential kWh that PPUC can offset represents a decrease in the total subsidy required. This equates to downward pressure on the commercial and governmental tariff.

If the short-run marginal cost of PPUC is 29¢, then PPUC would save 1.8¢ for each kWh not required through this energy efficiency measure. If 876 kWh are saved through each new chest freezer this equates to approximately $16 per annum or $158 over the life of the chest freezer (NPV of $99).

If this scheme is rolled out across 1000 homes, PPUC would save 876MWh per annum or $15,768. This assumes that the fuel price stays constant. If it increases over the next ten years the savings will be greater.

Benefits to the NDBP
The NDBP would also benefit from this scheme. At an interest rate of 7%, each loan will derive $154 of revenue to the NDBP over the five year term. If 1,000 loans are established this equates to over $150,000.

If the NDBP sources its funds at 3%, this equates to a gross profit of over $86,000. There is the possibility that the certain funders may offer lower concessionary interest rates to the NDBP in light of the energy efficiency nature of the loans. If 1% terms were obtained (EIB rates) then the gross profit to the NDBP would be over $130,000.
One important aspect to note is that the scheme should mirror that of the recent American/German “cash for clunkers” automobile subsidies. There is no benefit to be gained by any party if the old chest freezers/refrigerators are not collected and scrapped. The inefficient appliances need to be removed from the household upon delivery of the new appliance. As such, this scheme could only apply to those households who currently own an old chest freezer/fridge, not those looking to purchase their first.

This collection and disposal would bring additional expense – which could potentially borne by the PEO if they were to be involved.
<table>
<thead>
<tr>
<th>INDICATIVE ENERGY EFFICIENCY FINANCING PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Freezer Purchase Price (USD)</td>
</tr>
<tr>
<td>Interest Rate - NPDB</td>
</tr>
<tr>
<td>Tenor (years)</td>
</tr>
<tr>
<td>Chest Freezer Size (watts)</td>
</tr>
<tr>
<td>Previous running time (hours per day)</td>
</tr>
<tr>
<td>New running time (hours per day)</td>
</tr>
<tr>
<td>Residential Rate (mid) (US¢ per kWh)</td>
</tr>
<tr>
<td>Commercial Rate (US¢ per kWh)</td>
</tr>
<tr>
<td>PPUC SRMC (US¢ per kWh)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Saving (kWh per annum)</td>
<td>876.00</td>
<td>876.00</td>
<td>876.00</td>
<td>876.00</td>
<td>876.00</td>
<td>876.00</td>
<td>876.00</td>
<td>876.00</td>
<td>876.00</td>
<td>876.00</td>
</tr>
<tr>
<td>Saving to Consumer</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
</tr>
<tr>
<td>Saving to PPUC</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
</tr>
<tr>
<td>Total Benefit</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
</tr>
<tr>
<td>Cost to Finance Chest Freezer</td>
<td>170.72</td>
<td>170.72</td>
<td>170.72</td>
<td>170.72</td>
<td>170.72</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Net Benefit</td>
<td>83.32</td>
<td>83.32</td>
<td>83.32</td>
<td>83.32</td>
<td>83.32</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
<td>254.04</td>
</tr>
<tr>
<td>Net Benefit to Consumer</td>
<td>67.55</td>
<td>67.55</td>
<td>67.55</td>
<td>67.55</td>
<td>67.55</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
<td>238.27</td>
</tr>
<tr>
<td>Net Benefit to PPUC</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
<td>15.77</td>
</tr>
<tr>
<td>Total Nominal Benefit to Consumer</td>
<td>1,529.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPV of Value to Consumer</td>
<td>816.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Nominal Benefit to PPUC</td>
<td>157.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NPV of Value to PPUC</td>
<td>96.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>