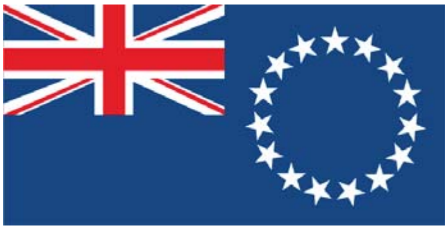
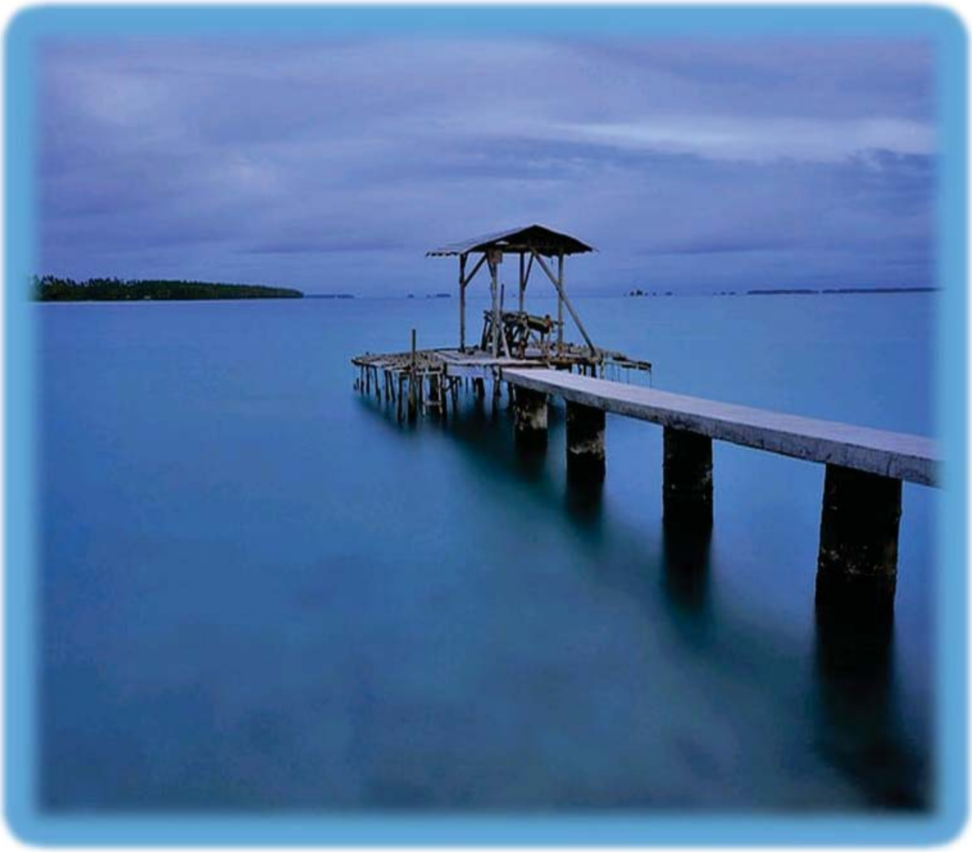
Te Atamoa o te Uira Natura



The Cook Islands Renewable Energy Chart Implementation Plan



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Executive Summary

The Cook Islands Government recognises that the full benefits of investing in renewable energy sources for generating electricity can only be realised when undertaken as part of an overall plan for the electricity sector. Such a plan will incorporate: increased efficiency both in electricity supply and use, improved access, reduced environmental impacts and enhanced energy security, while ensuring the sector remains financially viable in the long term.

In addition to identifying the least costly programme to achieve the objectives, the Implementation Plan (IP) also recommends a detailed programme of actions with indicative costs for each element. The government's IPIP will serve as a guiding document for others to action and for development partner support. As technologies, costs, demand for electricity and sources of financing change over time, it is envisioned that the IP will be periodically updated to take these factors into account.

Opportunities for renewable energy development in the Electricity Sector

Potential sources of renewable energy in the Cook Islands were considered. Each option was evaluated against screening criteria which included: maturity of technology, social and environmentally sustainable and levelised lifecycle cost.

The least cost options are solar photovoltaic (PV) and wind without storage. However for high level penetration these require storage, in the form of batteries. The levelised cost estimates for solar PV with storage are comparable to current costs of diesel generation. The data available for solar and wind will need firming up over time as experience is gained with new installations.

The IP sets out a programme of actions that will allow decisions to be made to implement the most economically practical options and the projects implemented as quickly as possible.

The t cost of Implementing the IP

The overall costs of implementing the IP is based on the following; technology requirement, upgrading of current infrastructure and project management. The total cost estimated around about NZ$257.65m.

The project is broken down into two components; Project Outer Islands – NZ$43.35m and for Project Rarotonga - NZ$214.3m.

Principles of the IP

Flexibility to update and adjust the IP is needed to ensure that it remains relevant and responds to evolving circumstances. The key principles are;

- Least costly approach to meet the national RE target;
- managing risk, with respect to the sequencing and timing of new investments and, where necessary, development of a portfolio of options;
- long term financial sustainability in the electricity sector;
- social and environmental sustainability;
- Clear, appropriate and effective definition of roles for stakeholders.

Implementation Plan Components

The IP (IP) has two major components; Project Sister Islands and Project Rarotonga.

Project Sister Islands has been initiated and includes phased deployment of PVs and battery storage with retained diesel back up. Some Sister Islands may also involve wind and other options[1] which can be evaluated in final island design. The Renewable Energy Development Division (REDD) of the Office of the Prime Minister (OPM) will be the implementing agency for this component with assistance from TAU and other stakeholders.

Project Rarotonga is substantial and involves TAU as the primary implementing agency with generation opportunities made available to the private sector.

Both components will require overall leadership, management and oversight.

Conclusions

To implement the comprehensive set of actions laid out in the IP, the Cook Islands Government will continue to exert strong leadership. The current institutional frameworks are considered appropriate for the scale of undertaking, with some minor legislative changes proposed. However it will be challenging to align all stakeholders' priorities there also needs to be a preparedness to alter roles and responsibilities should performance targets not be achieved.

[1] Biomass, Hydrogen, Pump Hydro, Gasification, Waste to Energy,

1 INTRODUCTION

The growth of the Cook Islands' economy is largely dependent upon fossil fuels as its energy source and therefore is exposed to the environment, social and economic effects that are synonymous with it. The power shift of Government in moving towards Renewable Energy not only re-confirms energy as a fundamental prerequisite to sustainable development but also: strengthens Governments' commitment to meeting it's climate change obligations; preserves the country's pristine environment and fragile ecosystems and also strengthens its level of energy security and therefore sustainable economic growth. The increased use of renewable energy in the Cook Islands will reduce their precarious reliance on importing diesel for electricity generation. The sooner the Cook Islands reduce their dependency on imported petroleum, the sooner it will have certainty in planning its economic and social future.

In harmony with the Cook Islands Renewable Energy Resources Chart (CIREC), a chart that espouses the Goal, Objectives, Principles and Pillars of this power shift, the IP will indicate the means and methods towards achieving the Goal established by the Government. It will serve to be the guiding document from which the transformation of the country to Renewable Energy is implemented.

Periodically, the IP will be updated to reflect current movements/progress and changes. Therefore, the IP is neither definite nor absolute in certain instances albeit provocative. This is an exciting time for the Government and the people of the Cook Islands.

1.1 The Cook Islands People and Economy

The Cook Islands is in the South Pacific Ocean, between Tonga to the west, Kiribati to the north and French Polynesia to the east. The Cook Islands has 15 islands with a total land area of 240 km^2, spread across 2.4 million square kilometres of ocean. It has two main groups; the north consisting of seven atolls and the southern group, comprising eight volcanic and almost atoll like islands. Of the 15 islands, 12 are inhabited and 3 uninhabited.

According to the 2011 census provisional figures indicate the total population was 17,800 people which compares to 19,350 people in 2006, and 18,000 in 2001. The 2011 census data continued to show a net flow of people from the Southern and Northern Group islands towards Rarotonga. However, the main destination of migrants was most likely to overseas locations.

Tourism is the main industry in the Cook Islands. Current tourism numbers show over a 100,000 people visited the Cook Islands in 2011, spending their time mostly on Rarotonga and Aitutaki. With an average stay of around 10 days, this boosts the population by around 3,000 each day on average and 4,000 per day during the peak tourist period, which is usually between July and September.

Real gross domestic product (GDP) per capita is now around NZ$15,000 (US$12,000). Electricity and water supply account for 2% of GDP, with the dominant components of GDP being; Wholesale and Retail Trade 20%, Restaurants and Accommodation 16%, Transport and Communication 18% and Finance and Business Services 13%. Public Administration is 9% of GDP.

The key drivers of growth are expanding tourism and rising household spending. The second largest island by population, Aitutaki, has also benefited from tourism-led growth and is now a sustainable center of private sector activity. Tourism will likely remain the driver of economic growth but is largely concentrated in Rarotonga and Aitutaki. As a country that is small in terms of both population and arable land, and as isolated as it, the Cook Islands is unlikely to develop sizable manufacturing and agriculture sectors. However, the Cook Islands is considered an ocean state and therefore development opportunities definitely exist in the Marine Sector.

1.2 The Electricity Sector

1.2.1 Background of Electricity in the Cook Islands

Rarotonga

Electricity supply in Rarotonga is primarily the responsibility of the government owned utility Te Aponga Uira (TAU), with private sector participation comprising diesel generators and increasing use of solar PV and wind. The operation of TAU is governed by the TAU Act 1991 (amended in 1999) and the Cook Islands Investment Corporation (CIIC) Act 1998, which establishes the utility as a commercially oriented Government Business Enterprise to provide reliable and economical electricity to Rarotonga.

The entire population lives in close proximity to TAU's 11 kV distribution network[2]. Electricity is generated and supplied to the whole of Rarotonga from the Avatiu Valley Power Station. The generating capacity of the station is provided by 9 generators with a total installed nameplate capacity of 12.2 MW, each aged generator, which are predominantly manual control systems, range in size from 0.6 MW to 2.600 MW. Due to ongoing de-rating of engines the actual available capacity is 9.5 MW.

TAU serves approximately 4,300 customers and generated 27.8GWh in the year to June 2010, continuing a declining trend. The peak electricity demand continues to decrease, down to 4.8 MW, with the highest ever peak being 5.1 MW in February 2008.

Aitutaki

Aitutaki is the second most popular tourist destination in the Cook Islands and has seen significant development over the last 10 years. Approximately 50% of all employment on Aitutaki is in the tourism industry. The Aitutaki Power Supply (APS) is managed by a board consisting of the CEOs of CIIC, TAU and representatives from Aitutaki. APS supplies 650 domestic and 100 commercial consumers with 24-hour/day electricity. APS currently applies a tariff that differs substantially from TAU's tariff, both in value and in structure. Domestic consumers pay a flat rate of $0.89/kWh. For commercial consumers there is a decreasing two-block tariff of $0.89/ kWh for the first 1000 units and$0.56/kWh above 1000 units. This tariff is designed to support larger commercial consumers in the tourism industry. The second block represents a substantial subsidy, as $0.56/kWh recovers only a fraction of the full cost of supply. The APS tariff can only be sustained through cross subsidies from households to commercial consumers plus additional government subsidies.

The APS power station consists of three Cummins KTA 50 G3 800kW generators including control room and high voltage switchgears.

The Sister Islands

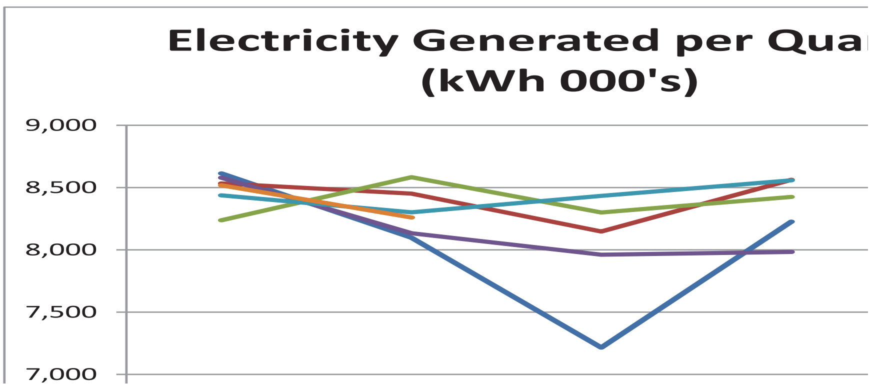
[2] TAU operates 80 km of 11 kV high voltage (HV) underground cables and 200 km of predominantly overhead 415 V low voltage (LV) lines.

With the exceptions of Pukapuka, Nassau and Suwarrow, the Sister Islands are generally fully electrified; typically with small diesel power stations and distribution networks. Smaller islands in the North and Mitiaro in the Southern Group have low voltage distribution, often a combination of both underground and overhead feeders. The larger islands of Mangaia, Mauke and Atiu have either 3.3 kV or 11 kV high voltage transmission network. The studies that have been undertaken in recent years on the Sister Islands power supply systems have recommended for the inclusion of renewable energy into the generation mix. The main problem in the Sister Islands is the lack of financial resources to effectively maintain and operate the installed equipment coupled with the lack of adequate spare parts and the high cost of delivered fuel; despite the government concession of fuel tax for the outer islands. The islands' power supplies require a continuous flow of cash support from central government. A detailed study performed for Mangaia in 2008 demonstrated that the tariff of $0.50 and $0.65/kWh for residential and commercial users respectively, needed to be adjusted to $0.93/kWh under the then current fuel price of $1.76/litre. With the current fuel price of $2.29/litre, a tariff of $1.10/kWh would be necessary. The gap between the cost of supply and revenue collected require a government subsidy of $1.5 – 2.0 million annually to keep the Sister Islands power supply systems operating.

1.2.2 The way forward for electricity

To date, the Cook Islands has not taken advantage of its own natural resources, and instead has a very heavy reliance on imported fuels for its energy needs – for electricity, transport and aviation. Electricity is supplied through diesel-powered generators, with some renewable energy resources, such as wind generation and PV installations. Imported diesel, subject to fluctuating prices, has a high delivery risk, is expensive[3] and has a destabilizing effect on businesses, households and limits growth, particularly in the more isolated Sister Islands.

Figure 1 – Electricity Generated Per Quarter



September 2006 low due to high international diesel prices

With annual electricity generated around 33GWh, this equates to an average of 3.8MW generated. Daily and hourly demands are somewhat higher which drive the peak capacity

[3]The price of diesel in the Sister Islands can be upwards of NZ$3.50/litre.

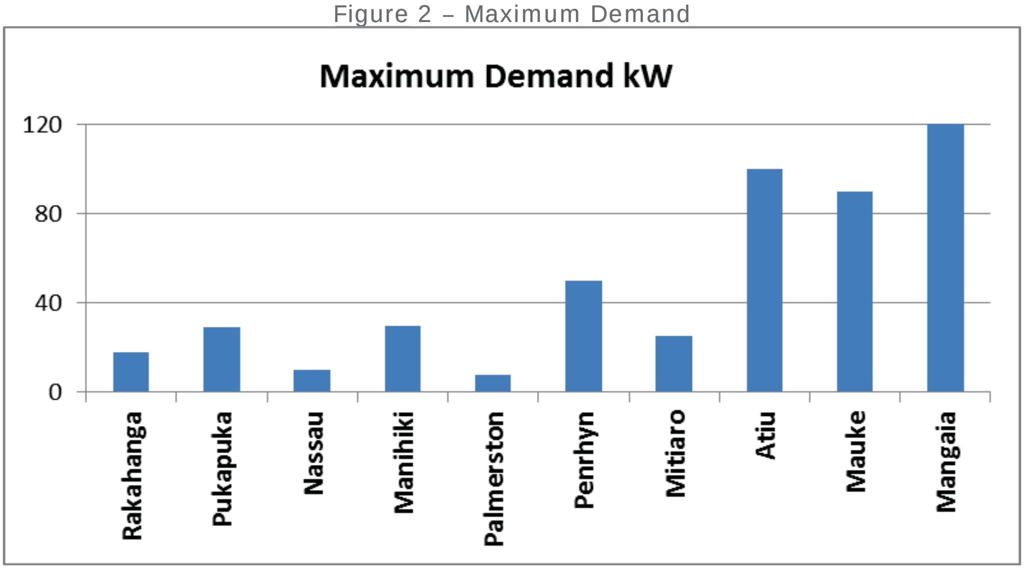
requirements for the electricity distribution networks; generation requirements; and supply from alternate sources such as; distributed private generation; batteries or demand reduction.

Electricity demand is reasonably static. Energy efficiency measures have helped reduce demand, but more can be done. The take up of air-conditioning units in Rarotonga is approaching saturation levels and increasing use of energy efficient light bulbs is making a difference. There are plans to establish standards and labelling for electrical appliances through the introduction of appropriate legislation. Growth in air conditioning has led to a midday peak, with a notable growing number of computers, TVs and other household electronics on the island.

The Cook Islands physical characteristics make it particularly vulnerable to the effects of a changing global climate. Over the past decade, this has manifested itself in the form of 18 cyclones – which have had a devastating impact on the economy, environment, homes and livelihoods of the Cook Islands people. Renewable energy is considered as one key strategy for mitigating the effects of climate change. Accordingly, moving from an economy powered by fossil-fuels to one powered by RETs makes both economic and environmental sense for the Cook Islands.

Providing reliable and adequate electricity supply to the remote, declining and dispersed population of the Sister Islands requires a different strategy than that for the main island of Rarotonga. However, some of the larger Sister Islands such as Aitutaki and Mangaia may warrant an adapted Rarotonga approach. This is reinforced by consideration of peak demands for electricity on each island showing a majority of Sister Islands less than 60kW peak. The Sister Islands of Atiu, Mauke and Mangaia are around 100 kW, Aitutaki around 600 kW and Rarotonga is significantly higher around 4800 kW.

Figure 2 – Maximum Demand



2 IMPLEMENTATION PLAN (IP)

2.1 Overview

Given that the majority of electricity generation throughout the Cook Islands is diesel fuelled and maximum demands in most islands are less than 120 kW (with the exception of Aitutaki 600 kW and Rarotonga 4800 kW), a reasonable working assumption is that renewable solutions will have certain similarities between the Northern and Southern Group but will be significantly different for Rarotonga and Aitutaki to some extent.

On Rarotonga there is currently one island network and some islands have more networks depending on locations of the communities. The network systems are generally supplied with electricity from a point source power station fuelled with diesel. This means the network is relatively simple to operate. Generally, power quality can be managed from the generating station, with the main issue being voltage drop at extremities of the system.

As distributed generation is added to networks, complexity and management issues increase.

Table 1 – Island Electrification

Island		Maximum Demand kW	Total Households (Indicative)	Population (Based on 2011 Census)
Rakahanga	N	18	50	80
Pukapuka	N	35	97	450
Nassau	N	10	32	70
Manihiki	N	30	97	240
Palmerston	N	8	18	60
Penrhyn	N	50	66	200
Mitiaro	S	39	145	190
Atiu	S	100	158	480
Mauke	S	90	106	310
Mangaia	S	120	177	570
Aitutaki	S	620	535	2,040
Rarotonga	S	5000	3009	13,100

"N" denotes Northern Group, "S" denotes Southern Group

There are important qualifications to some of this data, particularly for the Sister Islands; with declining populations, the number of households may no longer be a good reflection of those properties occupied on a permanent basis and peak demand requires specific reassessment with demand changes and proposed new systems, such as on Pukapuka where no electricity use data exists.

Based on the significantly greater peak demand of Rarotonga and the geographic locations of the Sister Islands, the options are considered separately for the Northern Group Islands, the Southern Group Islands and for Rarotonga. Consistent with the environmental and sustainability principles, analysis for each island attempts to reflect the total environmental needs of electricity users to better define future electricity needs, renewable energy resources options and possible effects of transitioning to renewable sources of electricity. The initial implementing phase for each island will use an approach similar to this to ensure adequate and comprehensive consideration of both the opportunities and the effects.

2.1.1 Objectives

The key objective of the IP is to clearly identify a series of actions with associated cost estimates to achieve the RE targets.

Implicit in this is that the IP is to provide:

1. **A co-ordinated approach**. The IP complements the CIREC and creates a common investment pathway for the Cook Islands electricity sector. The IP takes a 'whole of system' approach to the electricity sector and makes recommendations on issues such as: sector governance and management, renewable energy resources investment scheduling, project prioritisation, the impact of increasing intermittent injection of renewable energy into existing networks, network management, demand side opportunities, electricity storage, integration with the existing diesel generation and financial analysis of different renewable energy resources options for Rarotonga and the Sister Islands.

2. **Sufficient relevant activity detail**. The IP includes sufficient detail about specific activities, or activity areas, that are technically and economically viable and includes current analysis to rank and prioritise these activities.

3. **Confidence that renewable energy sources will provide reliable, quality and affordable electricity**. The people of the Cook Islands require an assurance that the renewable energy targets will be met and that their continuing electricity needs will be met in terms of reliability, quality and affordability.

The IP presents a common plan for the Cook Islands electricity sector. On many of the Sister Islands it is relatively clear what the best technical solutions are and progress can be made quickly. In Rarotonga the complete solution is more complex, and the pathway forward needs to be more dynamic.

The IP is therefore a ***how*** document, outlining the steps that need to be taken to achieve the targets. Important issues addressed in this document include:

- How security of supply will be maintained.
- How Sister Islands will be converted to renewable energy resources.
- Governance of the electricity sector.
- Enabling TAU to continue to operate profitably with increasing renewable energy resources uptake.

- Enabling TAU to increase its technical (network and generation) renewable energy resources capability and capacity to assist with development of renewable energy resources projects.
- The contribution of energy efficiency and energy conservation. How distribution networks can meet requirements of increasing penetration by renewable energy resources technologies.
- How donors and development partners can support specific activities, projects, or requirements as they are identified.

Overtime, the IP will be continuously updated by the REDD, with assistance from TAU and other parties.

2.1.2 Principles

The key principles of the IP are set out below.

Least Cost Approach to Meet the Objectives

To identify the least cost approach, the range of options must be considered and evaluated relative to one another. These include improvements in the existing electricity system; supply and demand side efficiency improvements; and options for non-diesel electricity generation for both grid and off-grid electricity supply.

Managing Risk

The introduction and implementation of technical and institutional approaches will be designed and managed to avoid inadvertently increasing supply interruption risks. The sequencing and timing of adjustments will allow sufficient time to undertake the detailed work and have in place the required specialist expertise. As a risk management tool, it would be important to develop a portfolio of options to meet the demand for electricity. The value of establishing a portfolio of supply sources will be considered when evaluating alternatives with comparable cost characteristics.

Financial Sustainability

In this context “financial sustainability” means the cost of operating the electricity sector, including regulatory, operations, maintenance, fuel and financing costs is recovered through the tariff. While the provision of a subsidy for a particular investment is not incompatible with the concept of financial viability, it should be applied in cases where there are specific objectives outside the normal commercial operation; to address specific social or equity objectives related to providing electricity services in remote areas; to address specific negative externalities including funds aimed at supporting a transition to renewable energy resources; or to support gaining experience with technologies that may be expected to become more cost effective over time. The essential feature is that the source of any subsidy required to keep the sector financially viable must be secure. Investment options must be evaluated considering the cost implications over the investment lifetime.

Social and Environmental Sustainability

Environmental and Social sustainability encompasses minimising local negative social and physical environmental impacts of the electricity sector, as well as aligning with the actual needs of communities. Special consideration will be given to those groups with specific needs including youth, women, religious groups and those with special needs. Investments that have major negative environmental or social impacts or constraints that cannot be mitigated or solved will be avoided. Social sustainability also incorporates an element of equity. Hence the scope of the IP includes the provision of sustainable and affordable electricity supply.

Clear, appropriate and effective definition of roles

It would be necessary to establish a Governance framework that supports performance, innovation and collective participation. This framework would establish between all stakeholders, clear and defined roles with polices and legislation to support it.

2.2 Options on the Outer Islands - basic system parameters

2.2.1 Northern group of islands

Electricity generation in the Northern Group islands is predominantly from using diesel fuel with the notable exception of Pukapuka which has a photovoltaic system providing 95% of the island's power needs including street lighting and household requirements. This system is 24 volt direct current (DC) but some households have gone to the extent of using inverters to achieve the conventional 240 volt alternating current (AC) system.

Table 2 – Northern Group Electricity Density/Population

	Max Demand kW	Households	Population (Based on 2011 Census provisional figures)	Population/ Household	kW/person	kW/Household
Rakahanga	18	24	77	3.2	0.23	0.36
Pukapuka	30	97	453	4.7	0.08	0.36
Nassau	10	32	73	2.3	0.14	0.31
Manihiki	30-20	97	243	2.5	0.20	0.31
Palmerston	8	18	60	3.3	0.13	0.44
Penrhyn	48-20	66	203	3.1	0.30	0.76

Manihiki and Penrhyn have two technically distinct networks.

With few commercial operations, electricity demand is largely related to the population and the persons per household. The ratios of kW per person and kW per household are therefore good indicators of; data quality and the potential for increased demand (increase take up of electric appliances). Generally, fewer people in a household lead to higher levels of use per person. There are no significant increases in demand expected and changing demographics are leading to some reductions in population. On these islands there is no charge made for electricity use by churches and for street lighting.

It is important that all data is verified and trends confirmed as an early stage of the implementation, as the cost effects could be substantial.

The need for renewable solutions are due to the remote location; the very intermittent and uncertain availability of supplies; operation or maintenance of all infrastructure; and cost recovery.

The dispersed low levels of electricity demand requires a collective solution which maximises the contribution of island resources, and a co-ordinated delivery and support of energy systems.

Electricity provision requires a breadth of expertise not available within the limited number of people on each island. Reports indicate the electricity systems on the islands are generally in a state requiring some level of upgrade and it is suspected that households wiring are in a similar state. The opportunity is to deliver a sustainable longer term solution for the total system from electricity supply through to consumer use.

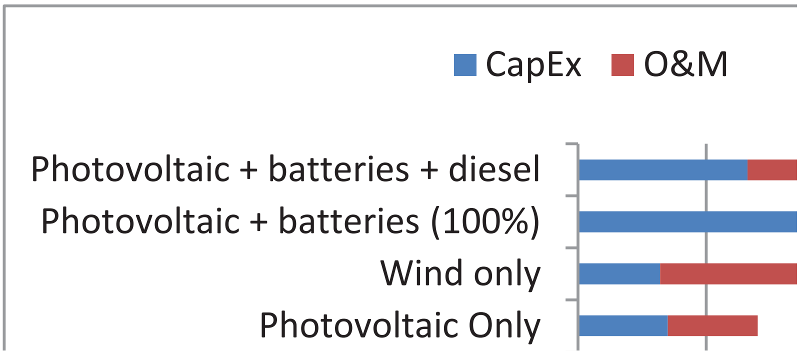
Solutions which minimise operations and maintenance requirements, and are of low technical complexity are therefore highly desirable. High levels of consistency, redundancy and resilience are warranted. Operations covering the full system (generation through to appliances, and including social elements) would be best managed as a portfolio with common management and service personnel and local input as available. The shift from diesel fuelled electricity generation will have spill-on effects to the community. There will be a dramatic reduction in diesel deliveries to the Sister Islands, which may impact on the commercial viability of total island supplies and the regularity of delivery services, and therefore this impact will require attention. There are residents with operational functions associated with the current generation installation that need to be assisted long term with adapting to the new technologies. Other energy requirements such as LPG supplies and vehicle fuel need to be considered as part of the electricity solution, to ensure effects and possible risks are identified and appropriately managed. The renewable energy technology options for the Northern Group islands include:

Table 3 – Northern Group Renewable Energy Technology Options

Technology for electricity supply	Commentary
Solar photovoltaic	Technically viable, relatively simple. Highly scalable. Likely to be near commercial.
Wind	Technically viable. Requires considerably greater maintenance. Higher risk of mechanical failure. Can be challenging to repair. Requires proactive management for cyclonic winds.
Biomass	High capital and operational costs, fuel supplies uncertain, technically complex. Piggery based biogas at small scale may be viable.
Bio-fuels	Fuel currently more expensive than diesel and would require continuation of the fuel supply infrastructure.
Battery storage	Technically viable, simple, expensive. Reliability good but needs active management.

The levelised cost of electricity generation is the cost per kilowatt hour (per unit) of electricity generated required recovering all costs including capital, operational, fuel and maintenance. The following plot presents an indication of the levelised cost of generation for the technologies considered most immediately viable on the Outer Islands.[4]

Figure 3 – Levelised Generation Cost (c/kWh)



[4]Assumes Outer Island Councils do not pay tax other than VAT.
Diesel at $2 per litre.
Based on Rakahanga Power Study Report December 2006 and other sources.
Allowances are included for both capital and operating costs for the remote locations and small scale effects.

These costs represent the lifetime costs for generation only and do not include additional costs in total system delivery such as distribution, billing and system losses which are included in later consideration of tariffs.

The Wind and Photovoltaic only options can be accommodated on systems up to low levels of penetration and therefore on their own result in very low levels of total renewable energy resources. To achieve high levels requires some form of electricity storage currently most effectively provided in the form of batteries. It is possible to meet all electricity needs with a photovoltaic/battery combination but to guarantee supply at all times requires significant scale up of the panels and batteries. Therefore photovoltaic/battery/diesel back up is the most viable renewable energy resources option at this time and is cheaper relative to the current full diesel systems. Detailed island design will reassess current peak demands and adjust installed capacity accordingly. There are situations where existing diesel generation sets require maintenance or replacement and networks need upgrading. On Pukapuka the total system including household re-wiring needs installation as it is currently based on a 24 volt DC system. Each island is considered in greater detail in *"Cook Islands Renewable Energy Chart Implementation Plan – Island Specific"* document.

For the Northern Group, the following cost estimate has been developed.

Table 4 – Northern Group Cost Estimate

Northern Group $m	**Island Total**	**7.15 $m**				
	plus	**0.72 10% Project Management**				
	Total Estimate	**7.87 $m**				
	Rakahanga	**Pukapuka**	**Nassau**	**Manihiki**	**Palmerston**	**Penrhyn**
Peak Demand kW	**18**	**35**	**10**	**30**	**8**	**50**
Households	**50**	**97**	**32**	**97**	**18**	**66**
Capital Costs TOTAL	**0.96**	**1.83**	**0.86**	**1.18**	**0.64**	**1.69**
PV/Battery	**0.46**	**0.74**	**0.26**	**0.77**	**0.26**	**1.10**
Diesels	**0.03**	**0.07**	**0.04**	**0.00**	**0.12**	**0.06**
Wind	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Power House	**0.08**	**0.08**	**0.08**	**0.00**	**0.08**	**0.16**
Network	**0.15**	**0.51**	**0.27**	**0.20**	**0.10**	**0.15**
Service Lines	**0.00**	**0.04**	**0.02**	**0.00**	**0.00**	**0.00**
Metering	**0.03**	**0.03**	**0.00**	**0.00**	**0.01**	**0.03**
House Re-wiring	**0.15**	**0.30**	**0.15**	**0.16**	**0.03**	**0.11**
Appliances	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Street Lighting	**0.04**	**0.04**	**0.02**	**0.03**	**0.02**	**0.06**
Other ?	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Training	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**

The scope of work and the estimated costs would be updated for each island as part of the *CIREC IP – Island Specific* document with the order and timing of implementation for each island.

2.2.2 Southern group of islands (excluding Rarotonga)

Electricity generation is predominantly from diesel fuelled generation.

Table 5 – Southern Group Electricity Density/Population

	Max Demand kW	Households	Population	Pop/Household	kW/person	kW/household
Mitiaro	39	145	190	1.3	0.21	0.27
Atiu	100	158	480	3.0	0.21	0.63
Mauke	90	106	300	2.9	0.29	0.85
Mangaia	120	177	570	3.2	0.21	0.68
Aitutaki	620	535	2040	3.8	0.30	1.16

Similar comments apply to this group of Islands as for the Northern Group. However the scale is much greater with peak demand ranging from 100kW to 600kW, with the sum of peak demand across the islands approximately 970kW compared with 150kW for the Northern Group. Aitutaki with maximum demand of 600kW may have sufficient critical scale to warrant some of the solutions proposed in Rarotonga.

Much of the Northern Group discussion is repeated below in order that the Southern Group can be considered in a stand-alone context.

For the lower populated islands with few commercial operations, electricity demand is largely related to the population and the persons per household. The ratios of kW per person and kW per household are therefore good indicators of; data quality and potential for increased demand (increased take up of electric appliances). Generally, fewer people in a household lead to higher levels of use per person. On the higher populated islands this relationship becomes less relevant due to more commercial operations particularly for tourism. There are no significant increases in demand expected and changing demographics are leading to some reductions in population. On these islands there is no charge made for electricity use by churches and for street lighting. It is important that all data is verified and trends confirmed at the early stage of the IP, as the cost effects could be substantial.

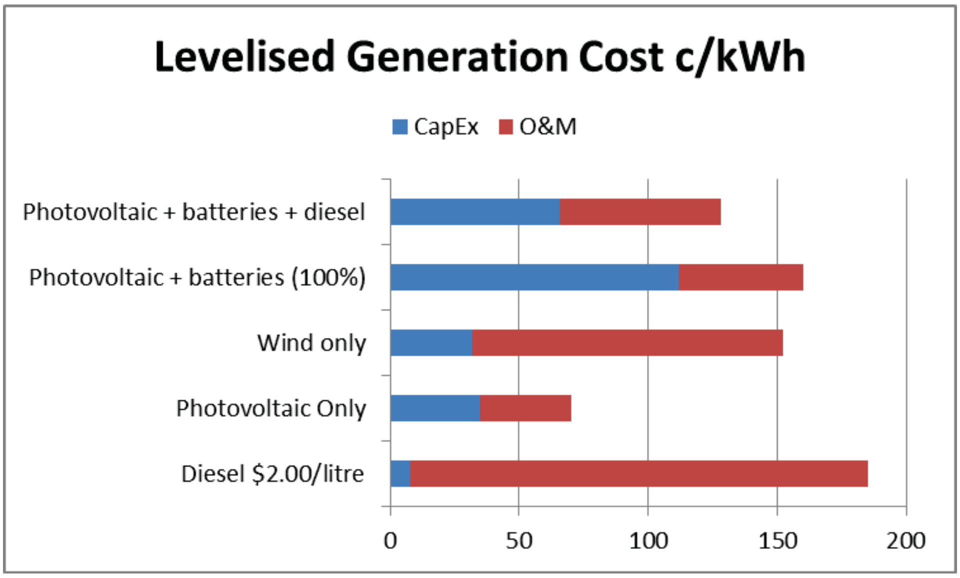
The technology options for the delivery of electricity supply in the Southern Group can be identified as follows.

Table 6 – Southern Group Renewable Energy Technology Options

Technology for electricity supply	Commentary
Solar photovoltaic	Technically viable, relatively simple. Highly scalable. Likely to be near commercial.
Wind	Technically viable. Requires considerably greater maintenance. Higher risk of mechanical failure. Can be challenging to repair. Requires proactive management for cyclonic winds.
Biomass	High capital and operational costs, fuel supplies uncertain, technically complex. Piggery based biogas at small scale may be viable.
Bio-fuels	Fuel currently more expensive than diesel and would require continuation of the fuel supply infrastructure.
Battery storage	Technically viable, simple, expensive. Reliability good but needs active management.

The levelised cost of electricity generation is the cost per kilowatt hour (per unit) of electricity generated required to recover all costs including capital costs, operational costs, fuel costs and maintenance costs.[5]

Table 7 Levelised Generation Costs for Southern Group



These costs represent the lifetime costs for generation only and do not include additional costs in total system delivery such as distribution, billing and system losses which are included in later consideration of tariffs.

Wind and photovoltaic only can be accommodated on systems up to low levels of penetration and therefore on their own result in very low levels of total renewable

[5] Assumes Outer Island Councils do not pay tax other than VAT.
Diesel at $2 per litre.
Based on Rakahanga Power Study Report December 2006 and other sources.
Allowances are included for both capital and operating costs for the remote locations and small scale effects.

electricity. To achieve high levels requires some form of electricity storage currently most effectively provided in the form of batteries. It is possible to meet all electricity needs with a photovoltaic/battery combination but to guarantee supply at all times requires significant scale up of the panels and batteries. Therefore photovoltaic/battery/diesel back up is the most viable renewable electricity option at this time and is cheaper relative to the current full diesel systems.

Detailed island design will reassess current peak demands and adjust installed capacity accordingly. There are situations where existing diesel generation sets require maintenance or replacement and networks need upgrading.

For the Southern Group the following cost estimate has been developed in conjunction with REDD. All costs should be treated as indicative.

Southern Group	**Island Total**	**28.22**	**$m**		
$m	**plus**	**2.82**	**10% Project Management**		
	Total Estimate	**31.05**	**$m**		
	Mitiaro	**Atiu**	**Mauke**	**Mangaia**	**Aitutaki**
Peak Demand kW	**39**	**100**	**90**	**120**	**620**
Households	**145**	**158**	**106**	**177**	**535**
Capital Costs TOTAL	1.67	3.04	3.19	3.43	16.89
PV	**0.00**	**0.00**	**0.15**	**0.00**	**0.00**
PV/Battery	**0.99**	**2.55**	**2.55**	**2.86**	**15.81**
Diesels	**0.06**	**0.00**	**0.00**	**0.00**	**0.06**
Wind	**0.00**	**0.00**	**0.00**	**0.20**	**0.00**
Power House	**0.08**	**0.00**	**0.00**	**0.00**	**0.20**
Network	**0.25**	**0.25**	**0.25**	**0.15**	**0.50**
Service Lines	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Metering	**0.08**	**0.07**	**0.07**	**0.05**	**0.05**
House Re-wiring	**0.09**	**0.05**	**0.05**	**0.05**	**0.05**
Appliances	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Street Lighting	**0.10**	**0.10**	**0.10**	**0.10**	**0.20**
Other ?	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Training	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**

2.2.3 Northern and Southern Group (excludes Rarotonga) Schedule

Table 8 – Northern and Southern Group Schedule

Outer Islands		TOTAL	2012				2013				2014				2015				2016				
		$m	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Package 1																							
Standard Mini-Grid Design	CapEx	0.20	0.1	0.1																			
Package 2																							
Rakahanga	CapEx	0.96		0.1	0.1	0.2	0.5	0.1															
Package 3																							
Manihiki	CapEx	1.83		0.1	0.1	0.2	0.3	0.5	0.5	0.1													
Mitiaro	CapEx	1.67			0.1	0.1	0.4	0.5	0.5	0.1													
Package 4																							
Penrhyn	CapEx	1.69				0	0	0	0.4	0.5	0.5	0.2											
Pukapuka	CapEx	1.83				0.1	0.1	0.1	0.4	0.4	0.5	0.2											
Palmerston	CapEx	0.64								0.2	0.4												
Nassau	CapEx	0.86						0	0.2	0.3	0.3	0.1											
Mangaia	CapEx	3.43				0.2	0.1	0.1	0.2	0.5	0.7	0.7	0.7	0.2									
Package 5																							
Atiu	CapEx	3.04					0.2	0.4	0.5	0.5	0.5	0.5	0.3	0.1									
Mauke	CapEx	3.19					0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.2	0.1								
Aitutaki	CapEx	16.89				0.1	0.3	0.3	0.9	2	2	2	3	2.4	2	1.5	0.3	0.1					
Project Management	CapEx	3.62	0	0	0	0.1	0.2	0.2	0.4	0.5	0.5	0.4	0.5	0.3	0.2	0.2	0	0					
Longer term	OpEx	3.50		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0
Monitoring, evaluation, reporting, training																							
Total	CapEx	39.85	0.1	0.3	0.3	1.0	2.4	2.6	4.3	5.4	5.8	4.6	5.0	3.7	2.3	1.7	0.3	0.1	0.0	0.0	0.0	0.0	0
	OpEx	3.50	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0
			2012				2013				2014				2015				2016				
	CapEx		1.7				14.7				19.0				4.4				0.0				
	OpEx		0.3				0.4				0.4				0.4				0.4				

2.3 Options on Rarotonga

2.3.1 Summaries of findings from previous feasibility studies and investigations

Rarotonga has a significantly larger electricity demand than other islands. A considerable number of reports have been completed of relevance to Rarotonga; some island specific, and others covering islands elsewhere in the Pacific. The following draws on these and also other experiences in South Pacific nations, to consider options for Rarotonga.

With current electricity generation dominated by diesel generators and a distribution system based around one source of supply this presents some unique opportunities. Consideration is first given to possible sources of renewable energy resources generation.

Biomass

A recent study by Dr Zweiller on the feasibility of using biomass as an electricity source on Atiu suggest that given its maximum demand being so low (90kW), the use of biomass is not justifiable. The study suggested that the minimum demand for a small biomass plant is

500kW and there are no indications that Atiu may reach that level of demand within the next 10 years unless it introduced major industries. He further suggested that Atiu including Mangaia and Mauke could sell their trees (acacia, pine and albisia), which are considered as pests and covering much of the land area, to Rarotonga which has significantly bigger demand for electricity at 5MW. In some Pacific islands, there is considerable potential for coconut oil from copra as a fuel. In the Cook Islands, this is unlikely due to limited supplies and the high market prices.

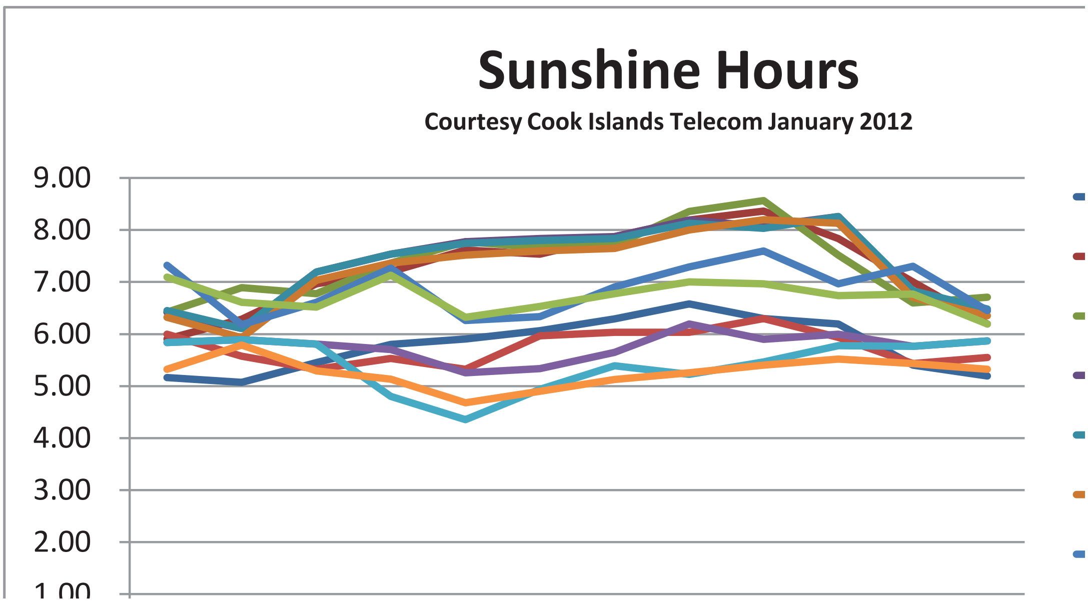
Biogas

The study by Dr Zweiller (referred to above) recommended that Atiu consider the possibility of biogas as a source of electricity given its small scale. He recommended the use of green waste together with agricultural waste to produce biogas through anaerobic digestion for electricity generation and also as cooking gas. The same comments can be applied to Rarotonga.

Solar

Solar energy is an excellent resource in the Cook Islands. The Pacific Islands Forum Secretariat collected two years (1995-1996) of horizontal, global solar radiation data through the Southern Pacific Wind and Solar Monitoring Project. This data showed that insolation, corrected for a tilted collector, averaged over 5.5kWh/m2 per day. Telecom Cook Islands have photovoltaic/battery installations throughout the Cook Islands and have made available invaluable real data of surface measurements as shown in the graph below.

Figure 4 – Sunshine Hours



Wind

The Forum Secretariat's wind and solar monitoring project is the main long term data source for Rarotonga wind energy, and is used to estimate the wind regimes of other islands. At

Ngatangiia Point, wind data recovery was 100% during two years of monitoring. The annual average wind speed was 5.5 m/s. The highest hourly and daily averages were 17.7 m/s and 14.0 m/s respectively. A Danish feasibility study in 1997 estimated annual average wind speeds in the range of 6.1–7.5 m/s (at 30m), which is suitable for economic electricity generation. The primary issue with wind generation is management practices to safeguard the turbines during extreme wind events. There also needs to be economic consideration of different hub height machines to better match available non-wind resources such as build-ability, access, operational, environmental and social aspects.

Hydro-power

There were estimates in 1990 of hydropower potential at several sites of possibly several hundred kilowatts, but development costs were considered too high. No more recent work has been identified.

2.3.2 Energy Efficiency (EE)

There is significant potential for efficient energy consumption. Although current fuel prices and electricity tariffs are strong market signals to practice energy efficiency, consumer response is slow. This can be contributed to the fact appliance stocks tend to remain fixed in the short term, high efficiency appliances tend to cost more than less efficient ones, and there are limited awareness campaigns of the potential to save costs without significantly reducing services. The current ADB Pacific Energy Efficiency Programme (PEEP) Phase 2 will implement energy efficiency (EE) measures in the Cook Islands with the main objective of achieving the overall goal of 10% reduction in average monthly energy consumption in the residential, commercial and public sectors and to establish the policy and implementation frameworks to move towards the goals of reducing fossil fuel imports by 10%.

2.3.3 Electricity Supply & Demand

Electricity demand in Rarotonga represents around 90 % of total electricity demand in the Cook Islands and is therefore critical to achieving any renewable energy resources targets and also meeting all social and economic objectives.

Detailed reporting has already been undertaken on the electricity system in Rarotonga. In particular the “Cook Islands Power System Review and Expansion Options” was prepared in 2008 and provides valuable insights into the current status and future development options. Some of the information can be updated, based on the more current information and investments being made by TAU, but the messages are clear that the existing system requires significant enhancement. Not to only maintain its current reliability but to meet future changes in demand and expectations.

In developing the IP it is very important to understand what technical changes may be required, what cost may be involved and more specifically what costs may be able to be avoided by increased use of renewable energy technologies.

Load forecasting and generating capacity

An important input into future planning for a power system is the load forecast. The load forecast determines the timing of capital works that in turn supports economic growth and identifies the risks that could have a negative impact on the economy.

The following diagram from the 2008 report illustrates the type of analysis undertaken and the need to ensure a capacity margin above expected peak demand. To illustrate also how this requires regular review, more recent events have reduced peak demand and sales by TAU delaying the need for investment in new generation plant. Increasing renewable energy resources generation is likely to be in an environment of reducing demand and incremental investment considerably in excess of business as usual for the commercial enterprise of TAU.

Figure 5 – Maximum Demand

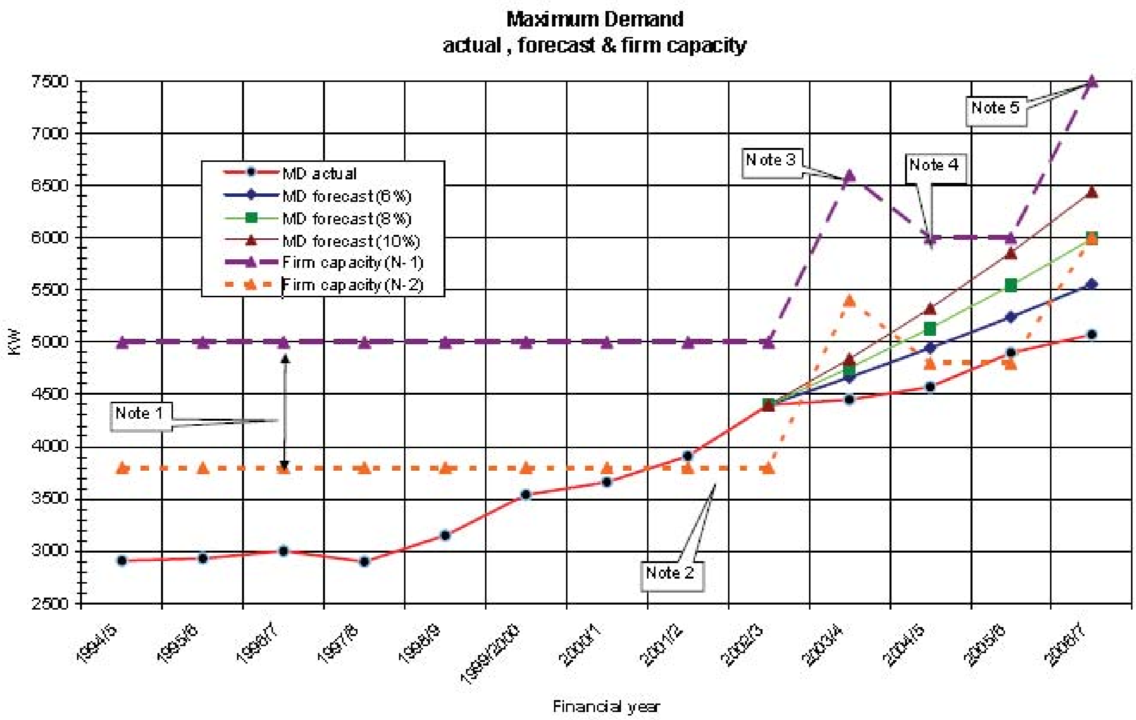


Figure 3-1 Comparison of actual and predicted MD

The firm capacity is based on the continuously rated installed generation capacity (de-rated capacity) less the largest generating set out of service for N-1 and less the largest two generating sets out of service for N-2.The installation of generating sets seven increased the firm capacity to 7.5 MW well above the maximum demand of 4.8 MW reported in 2010 (previous maximum 5.1 MW).

Fuel supply and storage

The diesel fuel is stored on the site in three 52,000 litre cylindrical surface tanks. At a consumption rate of about 22,000 litres per day, this provides enough fuel for seven days of operation. The fuel is delivered by truck to the TAU depot in either a 4,000 or 7,000 litre tanker. Engine oil is delivered in 200 litre drums and stored outside at the rear of the power station. Potential interruptions to fuel supply are a significant risk.

The rated and de-rated capacity of the generating sets at the Avatiu valley power station is recorded in the following table.

Table 9 – Capacity of Generators

GENERATOR	BRAND/Type	RATED (kW)	DE-RATED (kW)	ESTIMATED END OF LIFE
1	Duvant Crepelle/12V26N	2000	1500	2020
2	Duvant Crepelle/12V26N	2000	1500	2020
3	Mirrlees Blackstone/MB275-8	1600	1200	2019
4	Lister Blackstone/ETSL	600	400	2000
5	Lister Blackstone/ETSL	600	400	2000
6	Mirrlees Blackstone/ESL 16 Twin bank	1200	900	2010
7	MAN B and W/L9-27/38	2700	2000	2036
8	Cummins/KTA50-G3 (temporary installation)	800	800	2017
9	Cummins/KTA50-G3 (temporary installation)	800	800	2017
TOTAL		12300	9500	

The engines have an operational life determined by the manufacturer and based on the engine design. Normally the medium- or low-speed engines are able to be rebuilt more times than high-speed engines but ultimate Service Life is likely to be determined by other economic factors such as reliability, fuel efficiency, availability and cost of spare parts.

For comparison purposes, high speed engines with one major rebuild, can be expected to last for 80,000 hours or approximately 15 years before replacement. The cost of a high-speed set is about one third that of a medium-speed set and as the engine and generator are normally replaced as a generating set, this should eliminate the need for generator refurbishments.

The existing power scheme has all nine generators and six distribution feeders terminating at an 11 kV switchboard located in the power station.

For an isolated power system such as Rarotonga, it is important that the protection system is reliable and selective to ensure that any failure is rapidly detected and isolated with minimum disruption to the remaining power system.

Should wind or solar generation be introduced into the power system there will be a need for a considerably more responsive operating capability. For example, variations in wind generation will require a corresponding instantaneous response in generation capability from elsewhere, or instantaneous support from storage. This will require automated management of the generators and reliable synchronisation to quickly provide the capability. Detailed understanding of demand centres, the distribution network capabilities and the load profiles through a day and over a year are very important. With one point of electricity supply from the Avatiu Valley and radiating distribution feeders this is relatively simple to design and operate. Adding multiple injection points can be accommodated to a limited level and proactive determination of injection points on the network can help increase this level. The current system has in essence been designed to operate with flow of electricity in one direction only. The distribution system would largely prove adequate for renewable energy technologies being injected at the Avatiu Valley Power Station. However, suggestions of alternate scenarios of distributed injection points or a series of mini-grids around Rarotonga with a combination of both is possible. Mini-grids could for example be similar to the solution proposed for Aitutaki and deployed in specific locations on Rarotonga.

Figure 6 – Feeder Loads

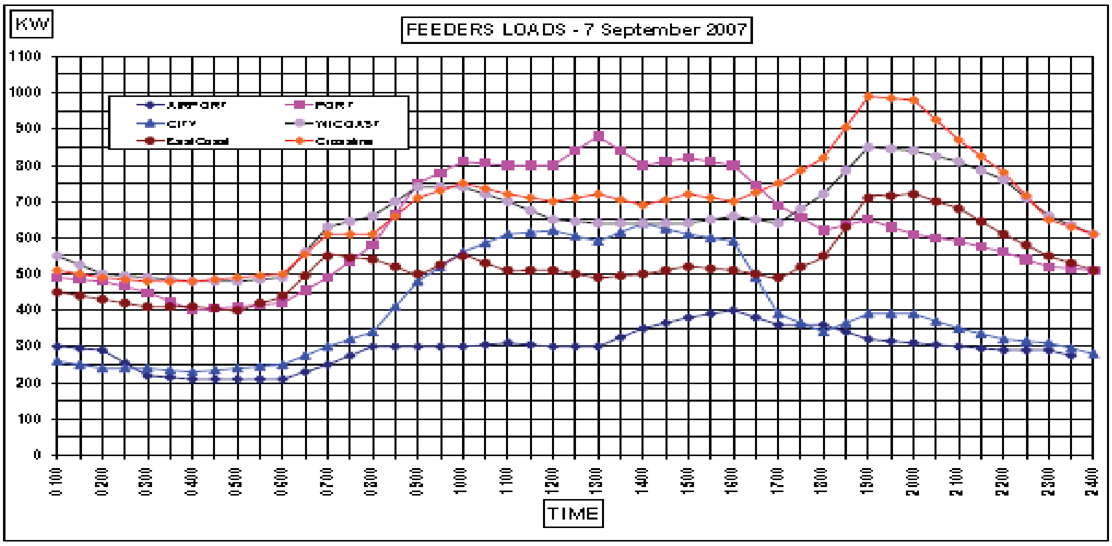


Figure 4-1 Feeder loads

The distribution feeder capacities and lengths are important indicators of both the quality of electricity supply (eg. voltage drop potential at the extremities of lines) and for capabilities to inject new generation.

Table 10 – Feeder Capacity

Distribution Feeders	Cable Lengths km	Installed Capacity kVA
Airport Feeder	7.5	1700
Sea Port Feeder	9.3	2500
Avarua City Centre	3.3	1650
West Coast	17.4	2770
Cross Line	22.5	3580
East Coast	10.7	2120
Total	**70.7**	**14320**

Detailed analysis is very important to consider all aspects of a network as points of demand and their respective characteristics are also critical. Electronic parameters such as protection systems, ramping capabilities and system harmonics require detailed assessment.

The 2008 study confirmed that a new power station in a separate location would provide excellent insurance against a total loss of the existing power station due to fire or other event. Renewable energy technology options may well add considerably to system resilience at very little incremental cost. It is therefore useful to consider the existing Avatiu Power Station as two components; one the generating sets and two the control room. A new control centre sufficiently separate from the Avatiu generating sets would add to system security and provide other benefits with the possibility of independent generators potentially coming to fruition.

Solar energy is already utilised on Rarotonga by many businesses and domestic consumers in the form of solar PV and water heaters. Some customers produce sufficient energy to supply excess electricity back into the power system, this being managed through TAU's Net Metering Policy discussed later.

Load forecast

The projected electricity demand forecasts are one of the more critical issues in the comparison of distribution system options, as they present the greatest source of risk in deciding on a development strategy.

The historic projections will need to be supported by new demographic data, but given the relatively small scale of the power supply, initial installation time for additional plant, a simplistic forecast model is adequate for comparison purposes.

TAU's current peak demand has dropped to 4.8MW with the total energy generation remained reasonably static at around 28,000 GWh per year.

Figure 7 – Rarotonga Load Cycle

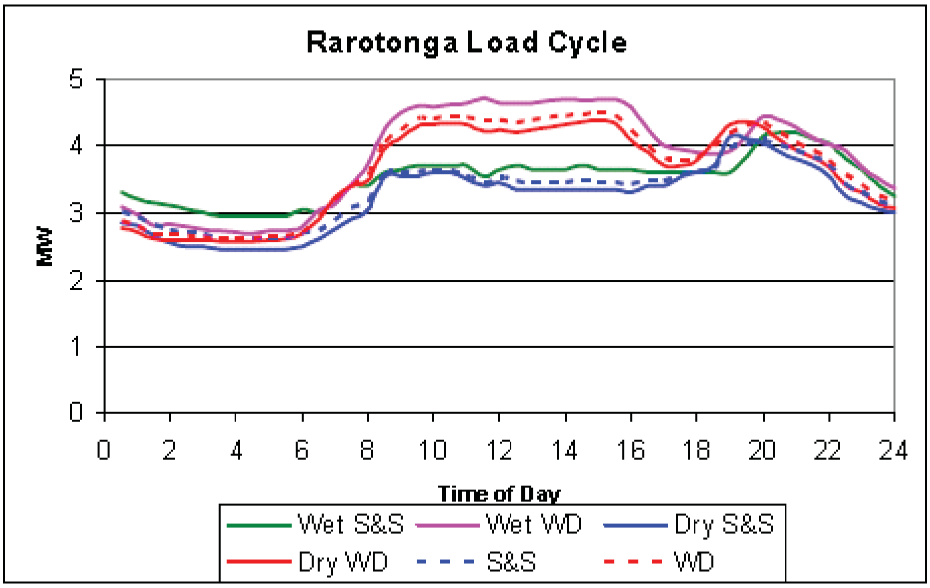


Figure 7-4 Daily Load Cycles

The commercial load with a midday peak is quite distinct as well as the evening peak of the domestic load sector. While the overall load profile is comparatively flat, the commercial peak is now higher than the evening peak and is driving the generating capacity requirement. Anecdotal evidence suggests the uptake of air conditioners is reaching a saturation point with industry activity now moving to maintaining rather than installing. The current annual load factor is about 66%, with commercial load growing at a faster rate than the total load.

Figure 8 – Load Duration Curve

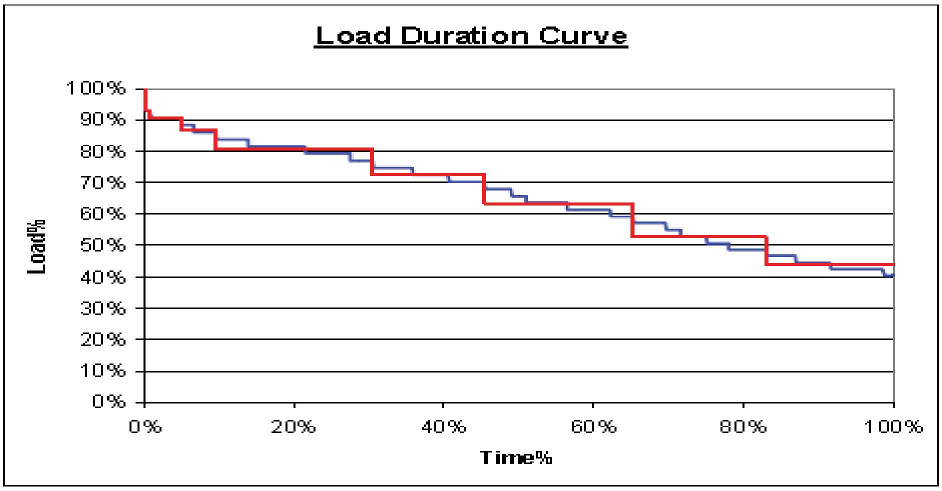


Figure 7-5 Load Duration Curve

Source:**HTC 2008**, TeApongaUira Cook Islands Power System Review and Expansion Options. Hydro Tasmania Consulting, January 2008

2.3.4 Assessment of Renewable Energy Technology Options

Although some reports[6] are a little dated, the key principles continue to apply with notable exceptions, that is, the reducing costs and increasing efficiencies trend for photovoltaic/battery systems.

On-grid renewable energy options

Potentially viable sources of renewable energy resources supply in Rarotonga have been considered to various levels.

To differentiate between them requires evaluation against criteria such as;

- *Maturity of technology*. Only mature technologies are considered options for inclusion. A technology is considered mature when the equipment is commercially available and there are reference projects where the technology has performed satisfactorily.
- *Social or environmental challenges*. Challenges would include serious environmental impacts that cannot be mitigated or major social hurdles, for example related to land use and ownership, which cannot be overcome within the timeframe of the IP.
- *Lifecycle cost*. The most important criteria to determine the least cost development path for grid connected renewable energy technology is levelised lifecycle cost for the various options. These costs, expressed in cents per kilowatt hour, accounts for discounted annual expenditure (investment and operation), divided by the sum of the discounted annual electricity production, all at the same real discount rate. For a commercial party such as TAU the discount rate is assumed to be 7%.

The options can be separated into two categories;

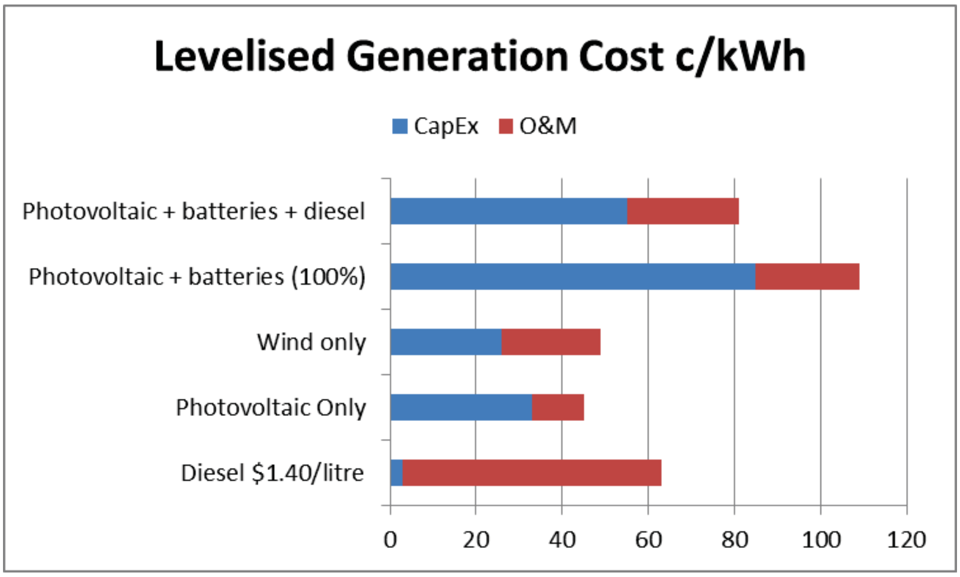
- ***Intermittent Electricity Supply.*** Solar and wind, without storage are intermittent sources of supply. An alternative source of electricity generation such as diesel generation has to quickly be brought online in order to meet customer electricity demand. The potential contribution of these sources of electricity on the grid system can be limited because above certain levels, their contributions can be very disruptive to the grid service. In some cases, electricity generated from wind or solar sources must be dumped i.e. not used, because of difficulties in quickly reducing diesel output to match a sudden increase from this generation. Solar and wind generation can reduce the fuel consumption in diesel engines, but because the firm source of supply must be ready to replace this variable electricity supply, intermittent energy cannot displace capital investment in firm capacity.

[6] "Renewable Energies in the Rarotonga Power System – An Implementation Strategy for Te Aponga Uira" dated July 2011
"Te Aponga Uira Cook Islands Power System Review and Expansion Options" dated January 2008.

- ***Firm capacity and Energy Supply*.** Firm capacity and energy is available on a continuous basis, subject to normal maintenance outages. The electricity generated can be fully used to supply the electric grid demands. Limits to the energy contributions are related to the resource availability, the development size and available funding. Of the options available in Rarotonga, the sources of firm energy that could potentially be considered include; waste to energy, biofuel or diesel in diesel engines, storage projects such as pumped hydro and batteries.

The following table ranks the levelised unit costs for the options which meet the first two screening criteria.[7] All options will benefit from improving information as projects are implemented.

Figure 9 – Levelised Generation Cost



Key assumptions have been made in the development of this graphical presentation and costs should be treated as indicative only. The wind and photovoltaic only options are viable to limited levels of penetration in a system. All costs are long run costs. The assumed cost for diesel is $1.40 per litre (approximate current cost to TAU) and for diesel generation any change in fuel costs translates very directly into the long run cost due to fuel being a high component of overall costs.

It is clear that electricity generation options other than diesel are commercially viable at current costs with wind and PV most promising. However, this is only true to levels of penetration which do not jeopardise overall electricity supplies. This level is currently determined to be 600kW total on the grid. Supplementing PV and wind with batteries adds to the costs but provides electricity storage and a more robust supply of electricity.

[7] TAU pays corporate tax.
Diesel at $1.40 per litre.

Retaining diesel generating sets as back up is commercially responsible as it minimises costs and provides good levels of system resilience.

The IP therefore quickly drives towards:

- Ability of the grid to accommodate renewable energy technology and possible cost impacts;
- Effects on diesel generation of reduced use and use at lower efficiencies; and
- Planned replacement of diesel for generation either with bio-fuels or alternate electricity storage technologies including hydro-electric.

2.3.5 Summary of the least cost options

Supply and demand efficiency improvements

TAU is responsible for the majority of diesel generation, and due to the significant fuel costs, are continually striving to gain efficiencies in generation. TAU has commissioned reports which make recommendations on efficiency improvements across generation and the network including for example automation of the generators. These are being progressively implemented.

Demand side efficiency improvements are available primarily through the use of energy efficient appliances. Various initiatives are required with a continued campaign to raise awareness. It is notable to report the initiative taken to include energy efficiency brochures with the recent census and to educate census gatherers on the topic.

Wind Turbines without storage

A number of small scale wind turbines exist around Rarotonga at present and are privately owned. The wind resource is proven with various studies having been completed. There are opportunities to immediately progress with wind generation options up to approximately 275kW in scale.

Solar PV without storage

PVs are economic to install now as demonstrated by private investments and in taking advantage of TAU's Net Metering Policy. The policy is the constraint on further penetration with a 2 kW/customer limit and the total network limit of 600 kW. These limits may be prudent but both need urgent reassessment and priority applied to grid enhancement to encourage increased take up.

Solar PV with storage

TAU's current Net Metering Policy requires PV installations above 2 kW per customer to have some form of storage for surplus energy.

Pumped hydro

Pumped hydro opportunities exist certainly at small scale and up to larger scale. These may be achieved by use of natural reservoirs but are more likely to be viable using tanks (wood, concrete or steel) as the upper and lower reservoir and possible use of the sea as the lower reservoir. Due to the very site specific nature of pumped hydro and lack of any financially assessed projects, no attempt has been made to assess their economic viability. However it is considered likely that technically and commercially viable pumped hydro projects are available.

2.3.6 Network impacts

The network and its ability to accommodate increasing levels of renewable generation are recognised by TAU as critically important to meeting the Renewable Energy Target. There are three broad conceptual options to grid development:

- Series of mini-grids around Rarotonga Distributed points of injection to the main grid.
- Single point source of generation to the main grid (current arrangement).
- Combination of these.

TAU is developing Terms of Reference for a network study to be initiated shortly to better define the range of options and possible network costs.

2.3.7 Analysis and assessment of network management and storage options

TAU has two studies underway which will significantly inform options available. One is an economic study of impacts and options, developed according to TAU from a national perspective. The second is a storage study, storage being critical to achieving high levels of renewable energy technology penetration. Both reports are due for completion in May 2012.

2.3.8 Cost curve of different options, as appropriate

At this stage no costs are available for different network development options. This topic is critical and is a priority action in the IP.

However, using the current replacement value for TAU assets of $69 million, it is reasonable to assume a total replacement cost of network assets in the vicinity of $30 million. As much of the asset can be retained, a nominal allowance of $20 million to accommodate any of the renewable scenarios would appear generous.

In order to establish a cost estimate at this time for conversion to renewable energy on Rarotonga, the opportunity has been taken to leverage the cost estimates for the Sister Islands as points of reference. To date the Sister Islands have been assessed in greater detail from a total system perspective and Rarotonga can be considered as scaled up versions with the larger Sister Islands being considered more representative. The following graphs depict the estimated capital investment in each Sister Island per peak kW and per kWh per year. Two scenarios of Rarotonga are also presented.

Figure 10 – Assessment of Rarotonga Cost ($/kW)

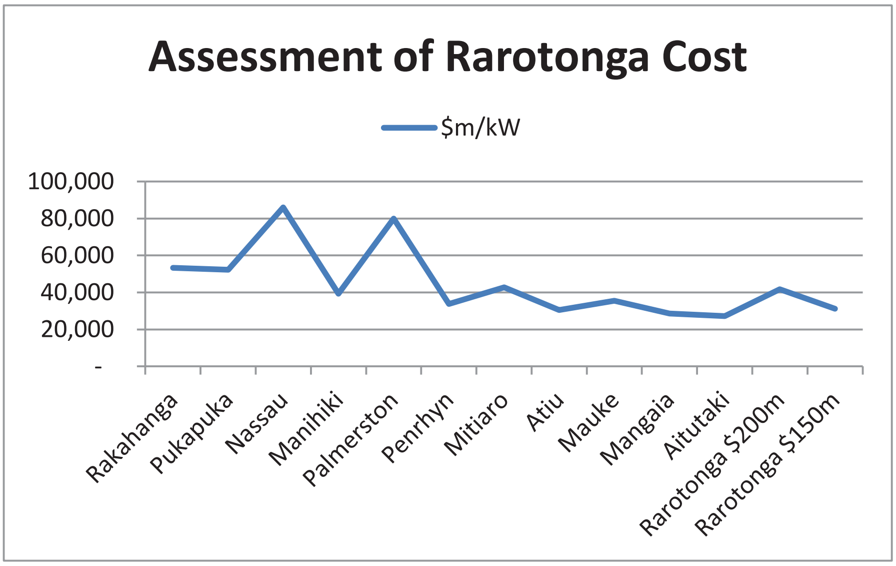
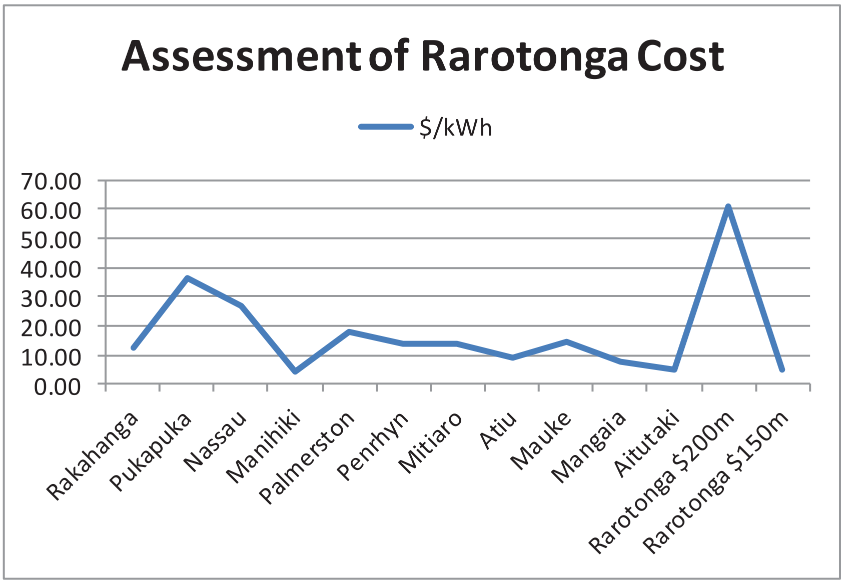


Figure 11 – Assessment of Rarotonga Cost ($/kWh)



On this basis a figure closer to $150m would appear more reasonable. However, it needs to be recognised that the cost estimates for the Sister Islands are based on achieving 100% renewable, so costs for 100% renewable on Rarotonga would be greater. As investments are made, progressive analysis will reveal the probable cost increment to get to 100%. This marginal cost may be prohibitive with the least cost option potentially being production or import of biofuel for any remaining diesel generators.

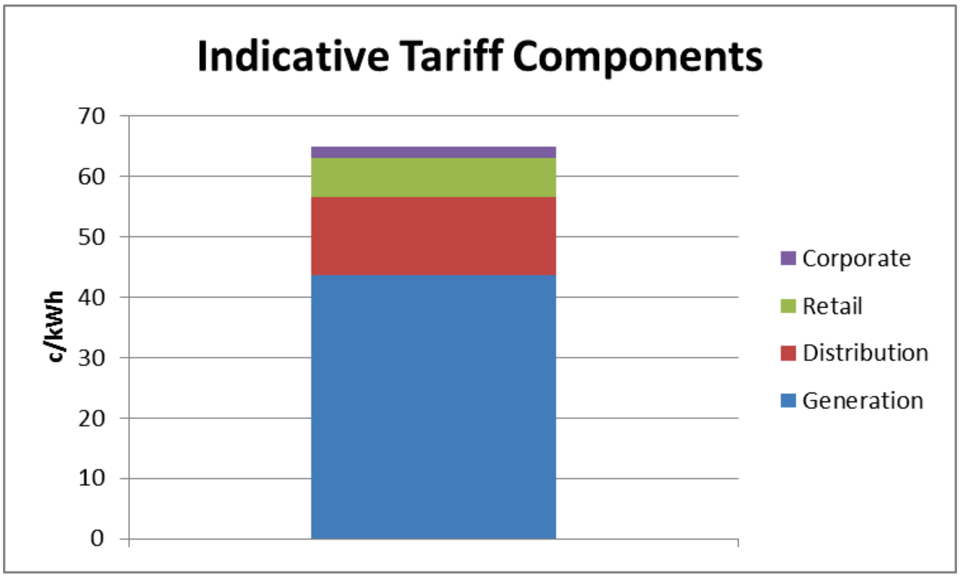
As a further point of comparison, recent commitments in the Pacific to photovoltaic/battery/diesel configurations, if implemented at the Rarotonga scale, would have a cost of approximately $185m plus any network costs. Adding network costs of say $20m leads to a figure of $205m. There would be project management costs in addition to this. The view at this stage is that this figure represents an upper bound and good investment decisions will keep costs below this level.

Based on the rationale above, a figure of $185m has been selected at this stage as a reasonable working assumption of the cost to achieve 100% renewable energy resources on Rarotonga by 2020. Due to the scale of undertaking there would be project costs in addition to this of about $20m spread over 8 years.

2.3.9 Impacts on TAU's profitability and how these can be managed

TAU's current tariff is considered fully commercial and accounts for all generation, distribution, retail and corporate costs apportioned as:

Figure 12 – Indicative Tariff Components



As generation is largely from diesel sources and considering that fuel accounts for approximately 90% of the cost of generation, any reduction in diesel use will rapidly change the business model for TAU from one with a high component of fuel costs. With the most immediately viable renewable energy technology options being those with a very high capital component and very low operating costs, the fuel component of the current business model will be replaced by a capital and financing cost component.

If TAU are to be the primary investors in renewable energy resources they will need to raise the required funds and a capital recovery factor will form a large part of the business model and the consequent tariff. At the very least TAU will be required to make substantial investment in the network above a business-as-usual rate. Alternately, mechanisms could be applied to encourage investment by others and power purchase agreements put in place. Both ways, the required levels of investment will exceed normal business as usual requirements and there will be cash-flow effects. The best example of this is with TAU as primary investor, they will need to largely continue business as usual planned investment and at the same time begin investing in further grid upgrades and generation technologies for a period prior to realising any reduction in diesel use for generation.

2.3.10 Rarotonga Schedule of Activities

Table 11 – Rarotonga Schedule of Activities

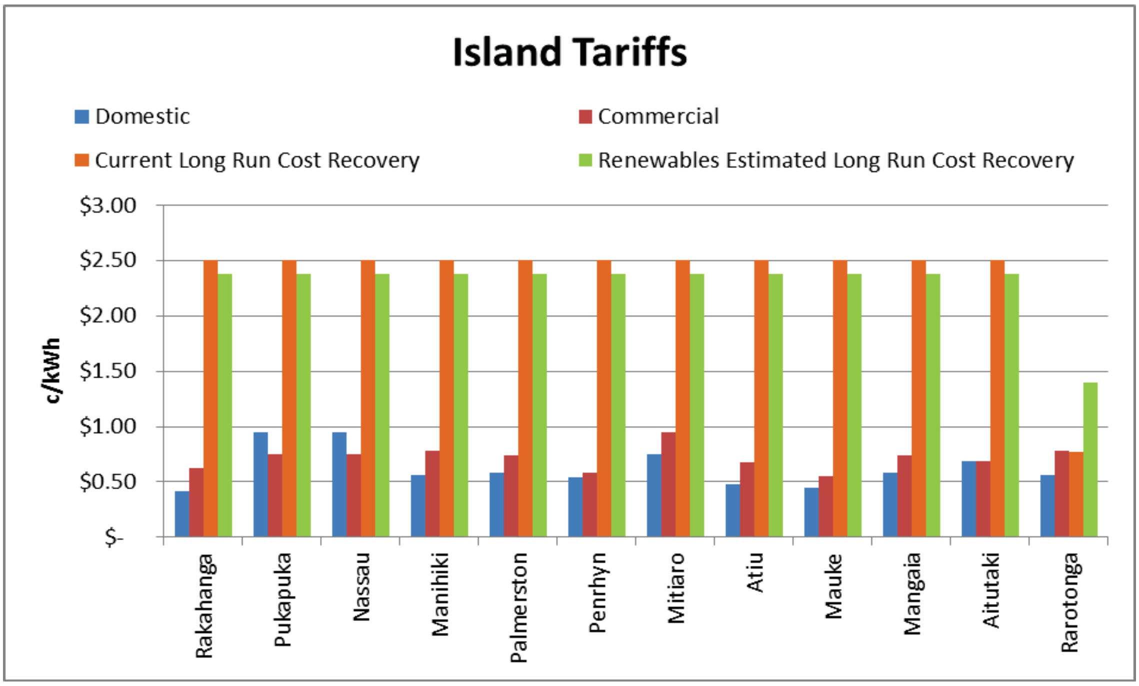
Rarotonga		TOTAL	2012				2013				2014				2015				2016				2017				2018				2019				2020			
		$m	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Waste to Energy	CapEx	0.1	0	0.1																																		
Energy Storage	CapEx	0.1	0	0.1																																		
Network Options - Renewables to 50%	CapEx	0.2		0.1	0.1																																	
Private PPA or alternate framework	CapEx	0.2		0.1	0.1																																	
Net Metering Development	CapEx	0.1		0	0.1																																	
Establish Project Team	CapEx	0.2	0	0.1	0.1																																	
Project Programme to 2020	CapEx	0.1		0.1																																		
Confirm strategy	CapEx	0.1		0.1																																		
Implement Network Stage 1	CapEx	10.0			0.2	0.5	0.5	1.5	2.5	2.5	1.5	0.5	0.3																									
Implement Private Sector Generation	CapEx	83.7			0.1	0.2	0.5	1.5	2.5	4	4	4	4	4	3.7	3.2	3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3	4	4	4	4	4	2.5	2	1	0.5			
Implement Network Stage 2	CapEx	10.0													0.5	1	2	2.5	2.2	1.5	0.3																	
Implement TAU Control & Generation	CapEx	45.2								0.1	0.5	1.2	1.5	2.0	2.0	2.0	2.0	2.0	2.0	2.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.5	1.0	0.5	0.3	0.1	0.0
To be determined	CapEx	34.7				0.3	0.3	0.3	0.5	0.5	1.2	1.5	1.4	1.2	1.0	1.0	0.2	0.2	0.5	0.8	2.5	2.8	2.8	2.8	2.8	2.3	1.3	1.3	1.3	1.3	1.1	0.9	0.5	0.1				
Project Management	CapEx	23.7		0	0.1	0.3	0.6	0.7	1	1.1	1.2	1.1	1.2	1	0.9	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.5	0.4	0	0
Longer term	OpEx	5.8		0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Monitoring, evaluation, reporting, training																																				
Total	CapEx	208.5	0.1	0.7	0.8	1.3	1.9	4.0	6.5	8.2	8.4	8.3	8.4	8.2	8.1	8.1	7.9	7.9	7.9	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.8	6.1	4.7	2.7	1.5	0.7	0.1	0.1
	OpEx	5.8	0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
			2012				2013				2014				2015				2016				2017				2018				2019				2020			
	CapEx		2.9				20.7				33.3				32.0				31.9				32.0				32.0				21.3				2.4			
	OpEx		0.3				0.5				0.8				0.8				0.8				0.8				0.8				0.6				0.4			

2.4 Indicative Tariff Impacts

The current domestic and commercial tariffs on each island are presented below. These are supplemented by estimates of the long run cost recovery in c/kWh for the two situations of a diesel generation system (as exists on most islands at present) and a renewable energy technology system comprising photovoltaic panels, batteries and diesel back up.

It is important to appreciate that these estimates include all electricity system costs to customer's meters and include costs of the distribution network and billing functions. In the case of diesel generation on Rarotonga this effectively reflects the current situation with TAU. For the Sister Islands it is assumed they do not pay corporate tax whereas TAU does.

Figure 13 – Island Tariffs



The current long run cost for the Sister Islands is significantly in excess of current tariffs and reflects the government support provided. Although the long run costs are very similar it is likely that moving to renewable energy technology will reduce the level of government support required.

For Rarotonga, the long run costs are higher than existing at present. However the cost estimate for renewable energy technology assumes a photovoltaic-based system with battery storage and Rarotonga has considerably more options available to implement renewable energy technology options which are more cost effective.

With support from donor countries these long run costs can be reduced but as replacement components are needed it will be critical that sufficient funding is available. The management of these funds need to be agreed on and carried out at the local level. As experience is gained and costs continue to reduce, these long run costs should be able to be reduced over time.

2.5 Consumer Options

This discussion covers the whole Cook Islands due to the close linkages of consumer behaviour and availability of appliances. Electricity consumption per person and per household has been analysed using the best available information.

Table 12 – Island Electrification

Island Electrification									
Island	Maximum Demand kW	Total Households	Indicative Population	Population/ Household	kWh	kW / Person	kW / Household	kWh/person	kWh/Household
Rakahanga	18	50	77	1.54	76000	0.23	0.36	987	1520
Pukapuka	35	97	453	4.67	33649	0.08	0.36	74	347
Nassau	10	32	73	2.28	39420	0.14	0.31	540	1232
Manihiki	30	97	243	2.51	300000	0.12	0.31	1235	3093
Palmerston	8	18	60	3.33	28733	0.13	0.44	479	1596
Penrhyn	50	66	203	3.08	124000	0.25	0.76	611	1879
Mitiaro	39	145	189	1.30	120000	0.21	0.27	635	828
Atiu	100	158	481	3.04	332000	0.21	0.63	690	2101
Mauke	90	106	307	2.90	220000	0.29	0.85	717	2075
Mangaia	120	177	573	3.24	441000	0.21	0.68	770	2492
Aititaki	620	535	2035	3.80	3291000	0.30	1.16	1617	6151
Rarotonga	5000	3009	13097	4.35	28828000	0.38	1.66	2201	9581

This information enables assessment of current electricity utilisation as well as providing a sanity check on available data. The rates in Aitutaki and Rarotonga reflect higher rates on consumer goods, higher levels of commerce and the very high proportion of tourists who visit these two islands.

Opportunities for efficiency gains are likely to be limited but conversely there is considerable risk that greater availability of electricity and potentially lower electricity prices may stimulate increased use of electricity.

Particular risk areas are cooking, where substantial demand is met by LPG, and air conditioning. On Rarotonga, it is understood that penetration of air conditioning is at saturation levels with limited further increase. There is anecdotal evidence that in the outer islands there is already movement to electric stoves in anticipation of cheaper electricity. This needs careful management.

Another particular risk is the increasing desire for blast freezers. These are necessary to quickly freeze fish. However, their demand for electricity is intermittent and very high relative to overall Sister Island loads. While industries such as fishing are encouraged in the Sister Islands, these demands are very difficult to accommodate in a small island system especially when the total island peak demand is 2 or 3 times more.

3 ROLES and RESPONSIBILITIES

3.1 Cook Islands Investment Corporation

The Cook Islands Investment Corporation (CIIC) is a holding company for the state-owned enterprises, and oversees and regulates the operations of Te Aponga Uira (TAU) and Aitutaki Power Supply (APS) on behalf of the Minister of State Owned Enterprises. APS and TAU perform financial planning for their respective organisations.

3.2 Te Aponga Uira

While TAU was established through a specific Act (No. 17 of 1991 and various amendments through 1999) no specific legislation exists for APS or for the outer islands. The TAU Act requires the utility to ensure efficient and reliable supply of electricity to communities on Rarotonga. Under the TAU Act 1991, a Board of Directors is given the authority to guide TAU and endorse major management decisions.

TAU is a vertically-integrated organisation, and operates the generation, distribution and retailing of electricity in Rarotonga, whilst APS provides similar services to Aitutaki, the second most populated island and tourist destination. On the Sister Islands, the respective authorities are responsible for their own energy needs, with technical support from the Ministry of Infrastructure and Planning (MOIP).

3.3 Aid Management Division

Aid Management Division is the donor co-ordinating arm of the Ministry of Finance and Economic Management. It is responsible for facilitating donor funds given to government for national projects, overseeing transparent and accountable spend of donor funds, channelling of funds to respective projects, and prudent management of funds to achieve national development priorities.

3.4 Energy Division

The Energy Division is part of the Ministry of Infrastructure and Planning. It is mandated under the Energy Act 1998 to plan, promote and develop energy strategies, establish standards, review legislation, promote conservation, encourage research, monitor electricity tariffs, and monitor and the quality of petroleum products, including compliance with fuel standards. The majority of activities of the Energy Division involve electrical inspection and standards of electrical products. It utilises expertise within MOIP for repair and maintenance of diesel generation sets in the outer islands, although it is not formally mandated to provide this service.

3.5 National Renewable Energy Committee (NREC)

In 2010, the NREC was formed to facilitate renewable energy sector policy, planning, management, and coordination. The overall objective of the NREC is to lead the renewable energy project to ensure timely achievement of government renewable energy policy targets. The NREC is also responsible for vetting various energy technologies, and to guide and oversee the planning process of renewable energy technologies.

3.6 Electricity Consumers

In response to increasing electricity tariffs and issues of security of supply, some individual investors are installing small solar and wind generators in Rarotonga primarily for own use. These schemes are based on a `net metering concept´ whereby TAU authorises its customers to generate 240V electricity via solar panels and grid-feed inverters and feed any surplus back to the grid. This concept is strongly supported by the NREC, and is suitable for the larger systems of Rarotonga, Aitutaki, including Mangaia, Mauke and Atiu as well.

Electricity consumers can install stand-alone electricity supply provided these meet any resource management requirements.

Electricity consumers are largely responsible for purchasing decisions and use of appliances using electricity. Reasonably high electricity prices tend to encourage use of more efficient appliances and to minimise use of electricity. In some cases appliances in use are strongly influenced by those available through retail outlets, but in many instances appliances are sourced from alternates such as gifting from relatives in New Zealand and elsewhere.

3.7 Health and Safety

Owners of premises or facilities using electricity are responsible for the wiring and other system components on their side of the electricity meter while TAU is responsible for the network up to the pole.

3.8 Policy, Legislation and Regulation

3.8.1 National Energy Policy (NEP)

Adopted in 2003, the NEP is a long-term vision for the nation's energy sector and needs realignment to fully complement the National Sustainable Development Plan (NSDP) 2011-2015. Its aim is "to facilitate reliable, safe, environmentally acceptable, and cost-effective sustainable energy services for the people of the Cook Islands". The guiding principles of the NEP set goals for sustainability, self-sufficiency, efficient service delivery and financial independence.

3.8.2 Regulatory Framework

The Energy Act 1998 addresses, amongst other issues, safety standards and licensing. The Cook Islands Energy Regulations of 2006 were produced and adopted as required under the Energy Act 1998. The regulations govern the licensing, technical and safety requirements for power generation, distribution and consumer premise wiring, including the qualifications and technical skill requirements for the registration and licensing of various grades of electrical workers. Although recently, both the Energy Act 1998 and the Energy Regulations

2006 take a narrow perspective of the sector, and require updating to provide for the future direction of the sector and the need for institutional overhaul.

3.8.3 Regulatory Roles

The Energy Division is mandated under the Energy Act 1998 to be responsible for many of the functions of a regulator, including the setting of standards for the provision of electrical service, as well as standards for the quality of petroleum products used in the country. The Division is also involved in the development of energy in the islands, including capacity-building measures, both in terms of human resource and knowledge of energy management.

Some of those roles have been devolved to other government agencies. The creation of the new Renewable Energy Development Division in the Office of the Prime Minister and the Energy Division's amalgamation with the Ministry of Infrastructure and Planning meant a reduction in its mandated roles in practice but not officially in legislation. The Ministry of Internal Affairs is mandated under the Dangerous Goods Act 1984 and associated regulations 1985 for licensing of petroleum suppliers in the country. In effect, the Energy Division is left with the responsibilities of compliance, setting and monitoring of standards of electrical services.

3.8.4 Regulatory Barriers

The energy sector is fragmented but presents no insurmountable barriers. The renewable energy resources targets are acting to encourage a more cohesive approach but more is required. Commitment to current renewable energy plans could be made considerably more achievable through the implementation of a strong oversight or facilitating agency. This is particularly so given the considerable investment required, likely to be greater than 10% of GDP in some years.

3.9 Cross-Cutting Issues

3.9.1 Data limitations

Sufficient data exists to make most high level decisions and most mid-range decisions, in order to facilitate immediate investment. Only in areas of detailed design and specific investment is more information required. For example sufficient local and international knowledge is available to provide confidence that the renewable energy resources targets are technically feasible and commercially achievable. However, specific investments such as a photovoltaic/battery may require further detail on the electricity demand profile and the solar regime prevailing in order to inform final decisions.

The scale of undertaking is comparable on the Sister Islands to small commercial premises in countries such as New Zealand and on Rarotonga is comparable to large hospital complexes.

The key to making investment decisions for renewable energy resources in the Cook Islands is to recognise that although current and future electricity demand are able to be estimated, inevitably demand will vary from that expected. Therefore considering a range of demand scenarios is important; these could include various daily and seasonal demand profiles and reduced demand for example.

3.9.2 Capability and capacity to implement renewable energy projects

The Cook Islands have limited experience implementing renewable energy resources projects. Various initiatives are underway to address this but considerably more capability and capacity building is required.

3.9.3 Meeting on-going maintenance requirements and costs

For both existing and future investments in electricity supply infrastructure it is most important to recognise from the outset all on-going costs to ensure required health, safety and quality standards are met.

Competent asset management programmes are a key dimension to this. Evidence suggests that TAU undertake this very competently with less certainty in the Sister Islands.

For all islands these activities and costs would currently include:

- Operation and maintenance of electricity generation and distribution facilities
- Fuel supply
- Administrative requirements

3.9.4 Institutional Responsibilities

Institutional responsibilities have over time become increasingly complicated and confused. This is partly a reflection of increasing technological options and the increasing interdependency of infrastructure provision. For example electricity supply had previously been constrained to diesel fuelled generation and distribution networks. Apart from individually owned small generators distributed generation on to networks did not exist and monitoring and control systems relied heavily on operator intervention.

There may be opportunities to benefit from multiple uses of infrastructure. For example there may be opportunities to interface provision of water supplies with electricity generation and waste water may be able to be utilised. A stronger interface between telecommunication provider and electricity providers may reap benefits.

Donors and development partners are invaluable to making progress towards the renewable energy resources targets. Opportunities to accelerate these processes and perhaps package a series of projects need to be considered in conjunction with donors.

3.9.5 Regulatory and Oversight Processes.

An early action is to review and update the policy, legal, regulatory and institutional arrangements as required implementing sector oversight and investments, including appropriate financing resources allocated through normal Government budgetary process.

The key areas to be specifically addressed in the review and updating process are set out below.

3.10 Primary areas for policy revision

3.10.1 Independent Power Production (IPP)

Policies need to be developed, emphasising competition and transparency, for the process of procuring electricity through a Power Purchase Agreement (PPA) from an Independent Power Provider (IPP). This is an important option for mobilising private capital. These processes need development and clarity as soon as possible before large scale private investments in renewable energy can occur and achieve the desired efficiencies and risk transfers.

3.10.2 Treatment of Donor-funded Renewable energy resources Investments

Specific policies need to be in place regarding the treatment of investment in renewable energy resources systems that are paid for in part or in full by donors. A clear policy is required to cover donor-funded renewable energy resources investment when calculating return on investment. A policy such as this is required to gain the confidence of Donors that their funds will be managed using robust management procedures.

3.10.3 Consumer-owned Renewable energy resources Systems

Consumer-owned renewable energy systems are an important part of the renewable energy based electricity supply system. For substantial consumer investment to take place, clear policies need to be promulgated relating to consumer owned installations of renewable energy for use at the consumer's own premises or in mini-grids which may be connected to the main grid.

3.10.4 Development and maintenance of renewable energy resources database

Renewable energy resources projects will need to be retired in due course and replaced with other options. It is a reasonable expectation that future renewable energy resources projects will be greater in number and variety and that they will be built using more cost effective technology. However, fundamental databases on potential resources will need to be continuously maintained. This is of utmost importance to assure government and donors that objectives are being efficiently and effectively achieved. The requirement for such a system and mechanisms to continuously fund it needs to be recognised.

3.10.5 Energy Efficiency Standards and Regulations

Energy conservation and efficiency improvements are an important priority for reducing electricity capital investment and diesel consumption. Appropriate, cost-effective end-use equipment energy efficiency programmes are crucial in overcoming existing market barriers such as high initial investment costs, split incentives, lack of information, as well as the ingrained habits of producers and consumers.

3.10.6 Integrating livelihoods, biodiversity and environmental considerations in the NEP

The IP is promoting the widespread use of low carbon electricity systems. It is important that the impacts of these systems on the environment are well understood. Equally important is a thorough understanding of the changing climate conditions and the impacts on the environment and how they can affect the sustainability of the energy systems of their choice. Revision of policies, laws and regulations should include consideration of the importance of conserving the integrity and diversity of nature and to ensure that any use of natural resources is equitable, efficient and ecologically sustainable.

3.10.7 Primary legal revision areas

Explicit recognition of private sector participation in electricity supply to the grid

The current legislative structures allows for, IPPs, consumer-owned, and grid connected renewable energy resources installations to be utilised. However, amendments would be advised to the TAU Act 1991 and the Energy Act 1998 to allow for the participation of the private sector to generate electricity and sell to TAU for example, through a PPA. This will provide investors with a stronger sense of stability and reduced risk of policy changes causing problems in the future.

Establishment of a Mechanism to use Subsidy in support of private sector provision of electricity from renewable sources

A policy decision is required on the means by which provision of private sector incentives for renewable energy resources investment or for the long term finance of consumer owned renewable energy resources installations is best managed, for example by TAU entering into fully commercial arrangements in a PPA and support being provided to TAU or by support directly to the private sector. For large scale private sector investment in renewable energy resources to occur, incentives may be required and the regulatory and appropriate tariff structures for consumer owned, grid connected renewable energy resources installations need to be clearly defined.

3.10.8 Primary regulatory revision areas

The tariff structure and level will need to be revised for the sector to accommodate alternatives to diesel-fired generation and emphasise efficiency in supply and use of electricity. Internationally, it is considered good practice to undertake a review of energy regulations on a regular basis and particularly at an interval following significant change. A recommended early action in the IP implementation is a review of the regulatory processes in the electricity sector.

As part of this review, the following electricity sector issues should be explicitly considered:

- Regulations relating to both technical and non-technical components for IPPs selling power to TAU need to be developed if necessary and put in place. Technical components include such things as quality of power, the specific interface components to be used, the quantity of power that can be accepted under different service conditions and any other issues that relate to the technical design of an installation of an IPP generation system. Non-technical issues include the how regulatory decisions on the pass-through of power purchase costs will be made (e.g. through specifying competitive process of selection), the methodology used for the payment for purchased power, provision for penalties should an IPP fail to provide the agreed upon level of energy, verification of energy provision by the IPP, etc.

- For on-grid installations, regulations relating to grid connected, consumer owned renewable energy systems must be re-confirmed. These need to regulate both the technical and non-technical aspects of these installations. In the technical area components of the installation – in particular the components that comprise the interface between the renewable energy installation and the grid – must comply with international standards for such equipment and provide for the safety and quality of power of the grid system. For the non-technical component, the structuring of feed-in tariffs must be clearly defined as well as any requirements for licensing, inspections or other interactions between the consumer and TAU.

3.10.9 Proposed Primary Institutional revision areas

The current institutional frameworks, although a little fragmented, appear fit for purpose. However, the risk is that there is uncoordinated activity and steps are inadvertently taken which frustrate achievement of the targets. In addition, the task is considered to require considerable professionally focused impetus. With planned expenditure above 10% of GDP in some years this warrants an overarching position of an Energy Commissioner with delegated powers from the Minister of Renewable Energy.

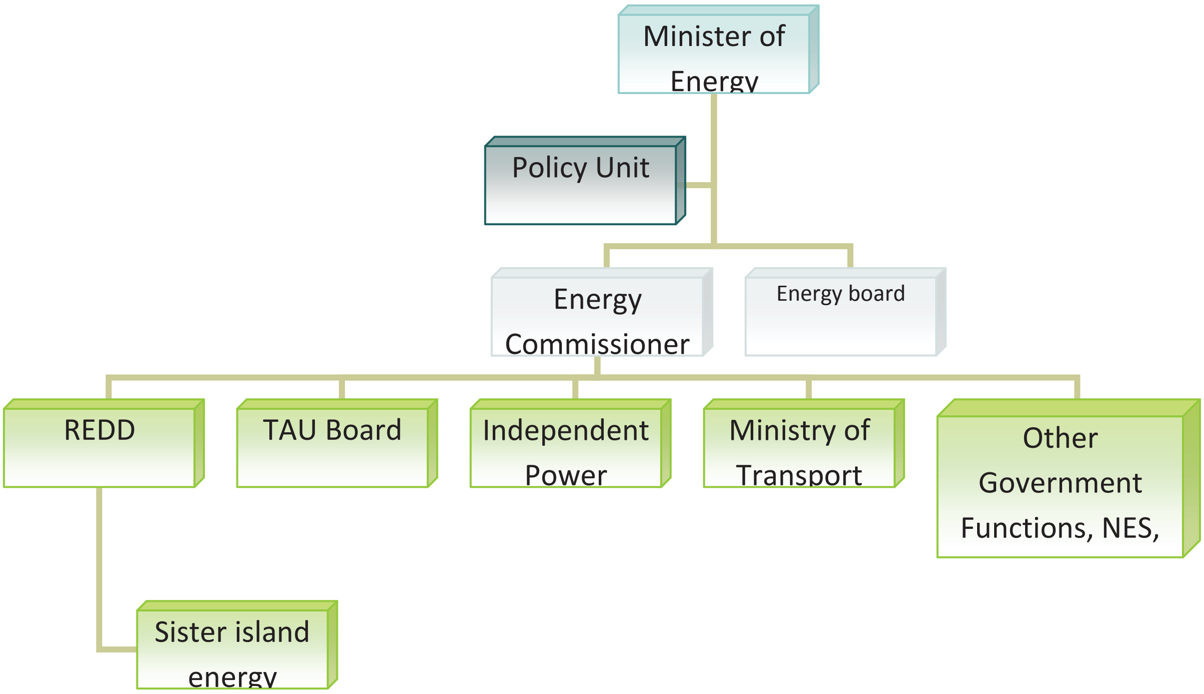
This new role of Energy Commissioner will ensure concerted and coordinated effort across all public and private sector involvement to ensure robust progress.

The Energy Commissioner would:

- Review and approve all energy sector related decisions
- Provide a central “clearing house” for energy matters
- Direct oversight of emerging obstacles
- Directly report and take directions from the Minister of Renewable Energy
- Advise the Minister on interventions necessary to achieve objectives
- Enable rapid response and pro-active co-ordinated effort
- Safeguard donor investments
- Act in anticipation of renewable energy initiatives across the total energy sector
- Address infrastructure interdependency opportunities

The proposed reporting lines would be:

Figure 14 – Proposed Governance Structure



The role of Government

The Cook Islands Government is responsible for strategic direction in the electricity sector (policy, planning and legal framework), sector oversight (regulation), creating an enabling environment for Cook Islands people, monitoring of progress to achieve the strategic goals, and facilitating where possible the direction of financial assistance to the sector in accordance with the principles listed above. This implies a strong role in actively managing the IP and actions to revise policy, legal and regulatory arrangements.
An Energy Commissioner would be dedicated to this role and report to the Minister for Renewable Energy.

The role of TAU

TAU is a critical implementing agency for IP activities, including improved network and efficiency gains. TAU will have responsibility for maintaining reliable supply of electricity to customers on the grid. TAU is a key source of technical expertise in the electricity sector and this role will be strengthened through training, capacity enhancement and strong application of resources to achieve the IP. TAU's role will focus increasingly on the network and demand aspects of the electricity sector including enhanced customer service. TAU will participate as a developer of new generation projects only to the extent that there are clear benefits and when private sector options have been demonstrated to be technically or financially unworkable, or in the absence of sufficient investment.

New proof-of-concept projects may still proceed but will not be the first order of priority. Private sector competition for new generation will play a key role in maintaining downward pressure on prices and limiting the commercial and operational risk borne by electricity consumers. It is imperative that TAU remain financially viable into the long term.

The role of the private sector

The private sector has an opportunity to invest and it must be clearly recognised that the imperative is to have confidence that the target of 50% of electricity from renewable sources by 2015 is met. To achieve this will require commitment to known and proven technologies at least in the first instance. It also needs to be recognised that TAU have an imperative to continue to manage the main grid prudently and not jeopardise reliability standards.

The role of consumers

Consumers have opportunities to themselves invest in renewable energy resources and to be conscious of efficiency opportunities in purchasing decisions.

4 SEQUENCING, MONITORING and EVALUATION

The activities identified for each island have been aggregated into the following overall schedule with cost estimates included.

Allowances have been made for overall project management costs and also long term costs primarily associated with deployment in the Sister Islands and the on-going necessity for evaluation, monitoring, training and support.

4.1 Sequencing of all activities on a quarterly basis

Table 13 – All Activities Schedule

Cook Islands		TOTAL	2012				2013				2014				2015				2016				2017				2018				2019				2020			
		$m	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Standard Mini-Grid Design	CapEx	0.2	0.1	0.1																																		
Rakahanga	CapEx	1.0		0.1	0.1	0.2	0.5	0.1																														
Manihiki	CapEx	1.8		0.1	0.1	0.2	0.3	0.5	0.5	0.1																												
Mitiaro	CapEx	1.7			0.1	0.1	0.4	0.5	0.5	0.1																												
Penrhyn	CapEx	1.7				0.0	0.0	0.0	0.4	0.5	0.5	0.2																										
Pukapuka	CapEx	1.8				0.1	0.1	0.1	0.4	0.4	0.5	0.2																										
Palmerston	CapEx	0.6								0.2	0.4																											
Nassau	CapEx	0.9						0.0	0.2	0.3	0.3	0.1																										
Mangaia	CapEx	3.4				0.2	0.1	0.1	0.2	0.5	0.7	0.7	0.7	0.2																								
Atiu	CapEx	3.0					0.2	0.4	0.5	0.5	0.5	0.5	0.3	0.1																								
Mauke	CapEx	3.2					0.2	0.3	0.4	0.5	0.5	0.5	0.5	0.2	0.1																							
Aitutaki	CapEx	16.9				0.1	0.3	0.3	0.9	2.0	2.0	2.0	3.0	2.4	2.0	1.5	0.3	0.1																				
Rarotonga	CapEx	184.9	0.1	0.7	0.7	1.0	1.3	3.3	5.5	7.1	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.1	5.4	4.0	2.1	1.0	0.3	0.1	0.0
Project Management	CapEx	27.3	0.0	0.1	0.1	0.4	0.8	1.0	1.4	1.6	1.8	1.5	1.6	1.3	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.5	0.4	0.0	0.0
Longer term	OpEx	9.3		0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Monitoring, evaluation, reporting, training																																				
Total	CapEx	248.4	0.2	1.0	1.1	2.3	4.2	6.6	10.9	13.9	14.4	12.9	13.3	11.4	10.4	9.7	8.3	8.0	7.9	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.8	6.1	4.7	2.7	1.5	0.7	0.1	0.1
	OpEx	9.3	0	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2

	2012	2013	2014	2015	2016	2017	2018	2019	2020
CapEx	4.7	35.7	52.0	36.4	31.9	32.0	32.0	21.3	2.4
OpEx	0.6	0.9	1.2	1.2	1.2	1.2	1.2	1.0	0.8

4.2 Indicative Costs, sources of Funding, key indicators

The following table provides an initial indication of the anticipated sources of financing for the key IP activities. All financing would be subject to the normal project preparation and due diligence activities of the funding agencies. Amounts of available funding are still under discussion and inclusion in the table does not imply that the indicated funding sources are committing to cover the full estimated cost of the activity.

Table 14 – RE Investment $m

Island	Rakahanga	Manihiki	Penrhyn	Palmerston	Pukapuka	Nassau	Mangaia	Atiu	Mitiaro	Mauke	Aitutaki	Rarotonga
RE Investment $m	1.0	1.8	1.7	0.6	1.8	0.9	3.4	3.0	1.7	3.2	16.9	208.5

Analysis for the Sister Islands indicates that substantial donor funding would enable current tariffs to remain constant. The level of Cook Islands Government support to on-going activities would also remain constant.

For Rarotonga specific activities and costs are uncertain and will be progressively improved. An upper bound estimate of $209m and a lower bound of $130m over the years to 2020 provide good guidance. TAU with its strong commercial footing will be able to manage renewable energy technologies in the longer term but over the years to 2020 will require substantial cash-flow support. An indicative profile of cash-flow requirements for Rarotonga is being developed in conjunction with TAU.

4.3 Monitoring progress and evaluating outcomes

Standard project management metrics can be applied to report on progress of activities and expenditure relative to a spend profile for each island. The key performance indicator will be the level of renewable energy capacity installed in relation to our RE target.

It will also be necessary to ensure appropriate asset management practices are followed and reported on to ensure learning and experiences inform future decision making.

5 RECOMMENDATIONS

There are a number of policies, legal, regulatory and institutional updates required to be put in place to drive towards the RE targets. Time and finance are the primary risk areas in achieving the RE targets.

The IP recommends the highest priority actions as:

- **REDD** - Implement the roll out of the Sister Islands RE Project, Energy database collection, Energy Efficiency, monitoring and evaluation programme.
- **TAU** – Implement the roll out of the RE Project on Rarotonga with all the necessary resources and capabilities to considerably accelerate progress in Rarotonga.
- **Private sector generation Investment** – Participate in the development of renewable energy projects in Rarotonga.

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