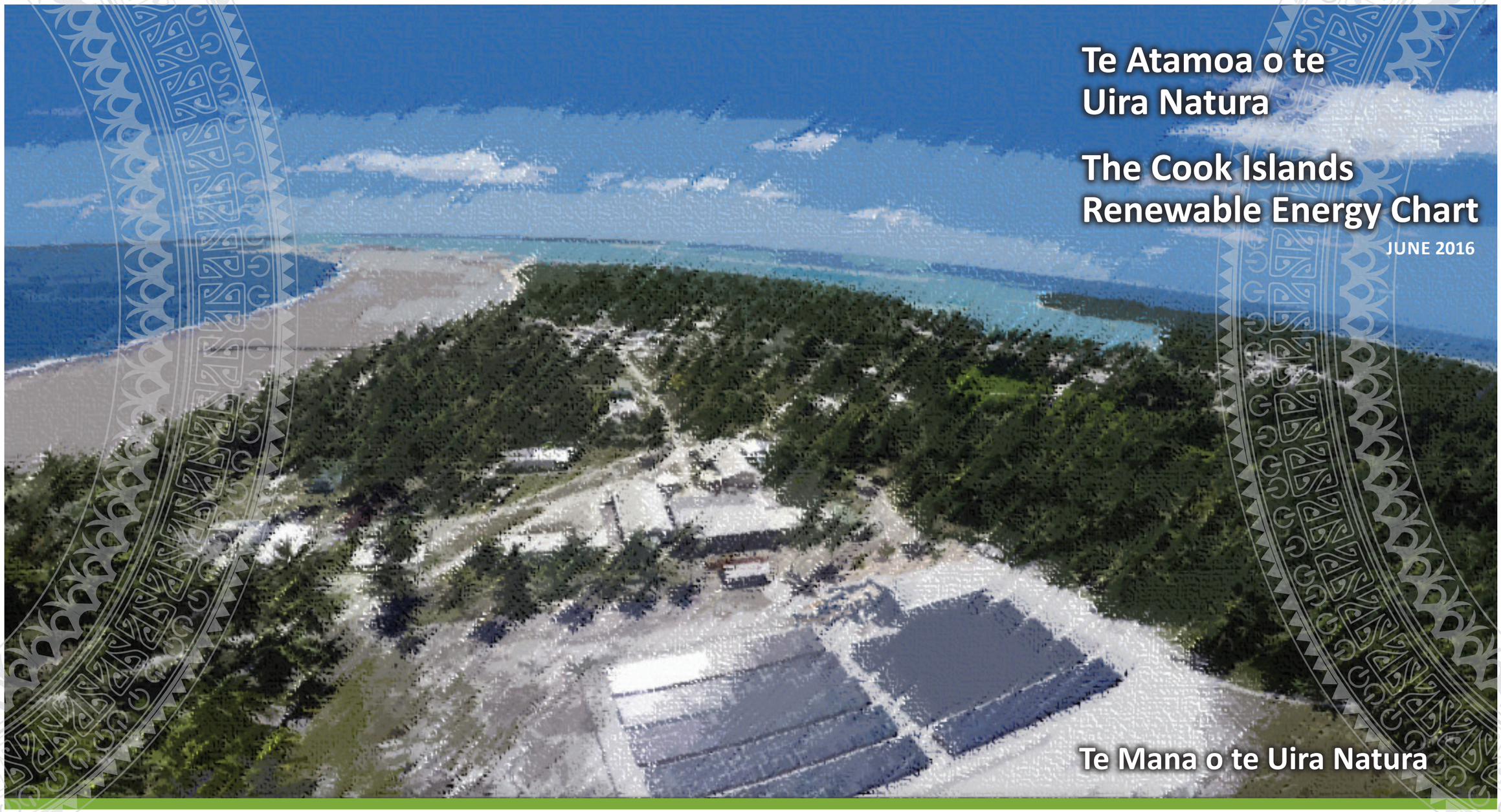
UPDATED SUMMARY OF

Te Atamoa o te Uira Natura

The Cook Islands Renewable Energy Chart

JUNE 2016



Te Mana o te Uira Natura

UPDATED SUMMARY OF TE ATAMOA O TE UIRA NATURA

Contents

1. Introduction

This Plan updates the Te Atamoa o te Uira Natura (The Cook Islands Renewable Electricity Chart (CIREC), 2012) and is a guiding document for all stakeholders.[1] While responsibility for the implementation of the CIREC rests with the Energy Commissioner, the Renewable Energy Development Division (REDD) will have the overarching role in developing strategic directions and approval for proposed renewable energy plans, ensuring funding and resources to complete the programme, and responsibility for monitoring and oversight. Te Aponga Uira (TAU) will perform a substantial role in the detailed planning and practical implementation. Further support will be required from Cook Islands other key agencies such as Cook Islands Investment Corporation (CIIC), Infrastructure Cook Islands, Aitutaki Power Supply, Ministry of Finance and Economic Management, Development Coordination Division, Island Councils, and others (including support of the public, which is central to this task). Each of these agencies has reviewed and committed to the approach set out in this update, including providing continuous input and improvement for the plan. Achieving coordination and alignment of programmes and policies will ensure the most efficient and effective implementation pathway.

The renewable energy policy goal is focused on measuring progress on the accessibility, use and composition of energy and transport. Our country has been at the forefront of international efforts to harness renewable energy to meet its electricity needs, and have set electricity targets to be 100% renewable energy by 2020.

Beyond this plan, there is still much work that needs to be done to ensure that all Cook Islanders have affordable, reliable and sustainable energy to power our future. Transport is a crucial issue in our remote and widely dispersed island nation. There is a need for frequent and reliable linkages between islands and internationally. This is central to the concept of nationhood and impacts the livelihoods of our people.

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1 This document provides an overview of the Plan, suitable for policy makers and investors. A companion technical document is available that provides details, explanations, and background data for the information in this overview.

2. The Cook Islands

Located in the South Pacific Ocean, the Cook Islands is sandwiched 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 square kilometres, spread across 1.8 million square kilometres of ocean. It has two main groups; the north consisting of six true atolls and the southern group of nine volcanic or almost atoll islands. The Cook Islands is home to about 13,000 permanent residents. Most live on the largest island, Rarotonga. In comparison, the outer islands are sparsely populated, and there is a slight trend of internal migration from the outer islands to Rarotonga, and an external migration from the Cook Islands to New Zealand, Australia and further afield.

Figure 2-1: Cook Islands map[2]

Tourism is the main industry in the Cook Islands, contributing 68 percent towards GDP. Approximately 120,000 tourists visit the Cook Islands each year, spending their time mostly on Rarotonga and Aitutaki.

Gross domestic product (GDP) per capita is approximately NZD$25,000 (2015 est.), and the Cook Islands has enjoyed an average growth of 3.0 percent per annum since the mid-1990s, though this has declined slightly in the past few years with estimated 2.1 percent growth in 2015 [3]. Like many countries in the Pacific, the Cook Islands face challenges based on its geographic isolation and small population.

Though a draw card for tourists, the country's isolation exposes it to vulnerabilities, in particular higher costs associated with importing and exporting goods. All petroleum fuel is imported for transport, aviation and electricity at high and often volatile prices.

2 The World Factbook, Central Intelligence Agency, https://www.cia.gov/library/publications/the-world-factbook/geos/cw.html (accessed 5/9/2015)

3 ADB estimate, http://www.adb.org/countries/cook-islands/economy.

3. Cook Islands electricity sector overview

All inhabited islands of the Cook Islands currently have centralised power supplies, providing single phase (230 V) or three phase (415 V) through a distribution grid to most residential and commercial and industrial customers [4]. Historically, diesel generators powered all of these systems. Since around 2011, increasing solar PV generation on Rarotonga has changed this situation. And in 2014-15, installation of solar-hybrid systems on Northern Group Islands further altered the mix.

Figure 3-1 Image of renewable energy system installed at Rakahanga (Photo provided by Renewable Energy Development Division)

TAU operates electricity supply on Rarotonga, a company wholly owned by the CIIC, of the Cook Islands Government. 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.

In Aitutaki, the electricity supply is operated by Aitutaki Power Supply (APS), a part of the Aitutaki Island Council administration. On other islands, Island Councils are responsible for electricity supply.

Largely due to the mild climate, per capita electricity use is relatively low by international standards (about 2,200 kWh/person on Rarotonga, and less on the other islands). The other major factor affecting electricity consumption is the cost of electricity relative to income. While central government subsidies to outer islands have meant that electricity prices paid by consumers are similar on all islands, income on the outer islands is typically lower than on Rarotonga and Aitutaki, resulting in lower per-capita consumption. Electricity supply is not capacity constrained, as the existing generation capacity on all islands far exceeds current demand.

4 A few customers operate stand-alone systems.

4. Renewable energy policy goals 2016 – 2020

The National Sustainable Development Plan (NSDP) 2016-2020 establishes the Cook Islands aspirations for sustainable development. This plan aligns with the NSDP, and specifically addresses the first three target areas of the NSDP Goal 6 - ensure access to affordable, reliable, sustainable, modern energy and transport. These target areas and the associated performance metrics are:

- **Increase use of renewable sources**
  - Indicator 6.1: - Percentage of electrical generation from renewable energy

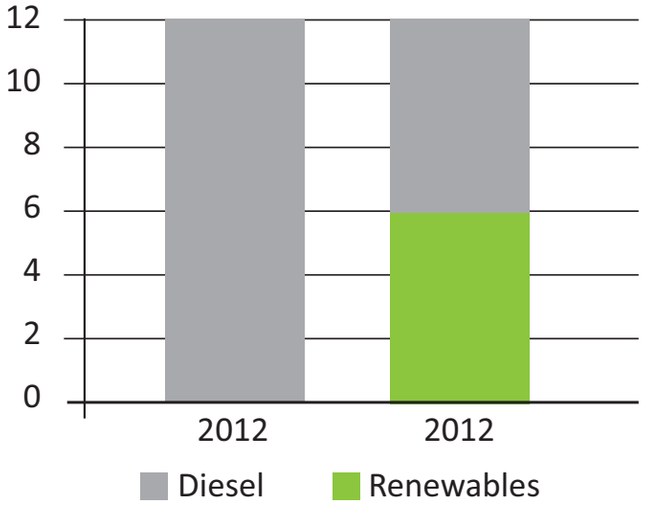

Figure 4-1 Number of islands powered by renewables since the previous, 2012 CIRECIP [5]

This indicator looks at the percentage of all electrical generation from renewable energy sources. Over the last five years the Cook Islands have made huge strides to reach its national electricity target of 50% of islands converted to renewable energy sources by 2015, with the remaining 50% to be achieved by 2020. The electricity needs of all islands of the Northern Group are now met by renewable sources (Solar PV). Efforts to transform the Southern Group as of early 2016 are well underway. This indicator follows up on the

5 Also, while not being fully powered by renewables, Rarotonga has increased renewable contribution from about 1% to 14% over the past three years.

commitment made to complete these efforts by 2020 with the most significant area of conversion expected on Rarotonga where most of our population and businesses are based.

This will be determined through the metering across the country and the assessment of kWh that is generated through the different systems. TAU and REDD will collect data. The aim is to have 100% renewable generation by 2020.

Table 4-1 NSDP Goal 6: Total electricity generation from renewable resources

Sources of data: Annual Statistics Report (NSO - MFEM)

Total electricity generation from renewable sources	Traffic light	Status
90%	Green	On track
70-90%	Yellow	Of concern
<70%	Red	Off track

- **Reduced reliance on fossil fuels**
  - Indicator 6.2: – Annual amount of fossil fuels imported

Efforts to promote renewable energy are designed to eventually decouple the country from its reliance on fossil fuels and provide a buffer to the external shocks in global oil prices. This will have both economic and environmental benefits. Reducing the use of fossil fuels should indicate not only greater use of renewable resources, but also more efficient energy use and conservation.

There are a number of potential sources for this data including Internal Affairs and Statistics (Customs). Measurement for this indicator includes petrol, diesel and LPG but excludes aviation fuel. At present, the performance of the Implementation Plan under this measure will consider only fuel used for electricity generation.

Annual change in fossil fuel imports (excluding aviation fuel)	Traffic light	Status
> - 2%	Green	On track
0 - 2%	Yellow	Of concern
> 0%	Red	Off track

Table 4-2 NSDP Goal 6: Annual change in fossil fuel imports (excluding aviation fuel)

Sources of data: National Accounts (NSO - MFEM), Customs Data (Customs - MFEM).:

- **Affordable electricity**
  - Indicator 6.3: – percentage of median income spent on electricity

This indicator looks at the proportion of income that is spent on electricity needs at the household level. While we look to convert energy generation from fossil fuels to renewable energy, we also want to ensure that electricity is affordable to all, given the challenge of maintaining and replacing renewable energy systems in future. This measure also includes the per capita amount of Government subsidisation of energy production, distribution and consumption.

This indicator compares electricity costs to median income. It considers the cost of average usage of electricity by a household based on monthly average energy consumption of 200 kWh.

Median income spent on electricity	Traffic light	Status
< 5%	Green	On track
5 - 9%	Yellow	Of concern
> 9%	Red	Off track

Table 4-3 NSDP Goal 6: Median income spent on electricity

These benchmarks are based on international, and the Forum of Island Countries (FIC), benchmarks and averages. Sources of data: Income tax data (RMD - MFEM), Power audits, metering and reports (TAU, Island Administrations).

5. Implementation strategies

To achieve these policy goals, this plan sets out different solutions based on the relevant characteristics of different islands within the Cook Islands and sets out actions over the next 5 years, to 2020. These actions are:

Table 5-1 Implementation strategies for each island

Islands	Characteristics	Implementation strategy	Scheduled	Indicative Cost[6]
Northern group	Relatively small population (<600 per island). Low electrical load with flat load growth. Remote locations.	Centralised solar PV-battery-diesel hybrid system, imple-mented in a single stage.	2014-15 Completed	20M
Southern group, excluding Rarotonga and Aitutaki		Centralised operation and maintenance (O&M) and asset management support. Requires selection of asset manager and implemen-tation of structural changes to facilitate their role.	2016-17	17M
Aitutaki	Higher population (over 1,000 residents). Strong tourist industry. Moderate electrical load with some load growth. Good access and facilities	Centralised solar PV-battery-diesel hybrid system, with specific enabling technology for grid stability, and options for wind generation. Three stage implementation		
		• Stage 1 –approximately 30% renewable energy using solar PV generation, a 300 kW diesel generator, control and integration.	Stage 1: 2017	Stage 1: 4.3M
		• Stage 2 – additional 1 MW solar PV generation (or wind) and adding grid stabilisation including a flywheel and small battery, increasing renewable energy to approximately 50%.	Stage 2: 2018 - 2019	Stage 2: 6M
		• Stage 3 – additional solar PV generation (or wind) and battery storage for load shifting to provide in excess of 90% renewable energy.	Stage 3: 2019 - 2020	Stage 3: 13M

Islands	Characteristics	Implementation strategy	Scheduled	Indicative Cost[6]

Rarotonga	Higher population (over 10,000 residents).
	Strong tourist industry.
	Moderate population growth but load offset by energy efficiency and embedded generation.
	Complex network.
	Good access and facilities.
		To meet the 2020 policy targets, Rarotonga will require:
		• in excess of 24 MWp of renewable energy generation capacity
		• in excess of 60 MWh of storage
		• grid stability enabling technology. Detailed implementation to be formed during 2016, by undertaking the following:
		• dynamic load and generation data collection
		• preparation of a network model
		• comprehensive network study, including:
		  • Establish agreed assumptions and standards
		  • System modelling and optimisation
		  • Evaluation of commercial structures and metrics
		  • Assessment of smart grid technology to enable structural and technical reform
		  • Determine likely funding sources
		  • Comprehensive assessment and due diligence of proposed technology options, including trials as necessary
		  • Evaluation of opportunities for demand side management, including energy efficiency.
		Interim arrangements should be considered including:
		• Limiting commitments to independent power producers for new generation
		• Implementing storage under the Global Environment Fund project to increase the renewable energy generation limit of the grid
		• Manage expectations of the community and stakeholders, to provide sufficient planning opportunity.
			2011 - 2020	200 - 300M

6 New Zealand dollars

6. Policy principles and drivers

The implementation strategies presented in the previous section integrate the following practical requirements:

- The targets relate specifically to stationary electricity needs (i.e. this excludes electricity that may be required for electric vehicles, mobile plant or equipment).
- To achieve the target, stationary electricity should be predominantly generated from renewable energy resources. It is desirable that 100% of electricity on each island be generated from renewable energy sources, however this will be contingent on practical constraints as set out in the next point.
- Achieving these targets should not compromise quality or reliability of supply, safety, affordability of electricity, or the environment:
  - Supply should be available 24hours a day, 365 days per year, to all current grid connected residents and businesses, and should meet existing power quality standards.
  - Safety requirements should be to existing New Zealand standards applied in the Cook Islands grid.
  - Affordability of electricity should be maintained, with national expenditure on electricity to be no more than without renewable energy.
  - Cook Islands environmental standards should be maintained, and implementation of the targets should use environmentally friendly technology.
- It is understood that the affordability issue in particular may limit the contribution of energy from renewable energy sources on any given island to 60-95% of the total for that island (islands with higher diesel costs are at the upper end of this range). However, provision should be made in the Implementation Plan for this to increase to 100% as technology and price factors improve (potentially beyond 2020). The Plan addresses the following policy drivers and key considerations:
- proven and commercial renewable electricity technical options
- one-go approach and phased approach as suited to different islands
- tariff reviews
- institutional restructuring
- policy and regulatory adjustments
- community education, awareness and advocacy
- capacity building
- financing and partnerships
- compatibility and sustainability.

7. Implementation to date

Table 7-1 Implementation programme

	Islands	Completed (50% Target)	Scheduled (Remaining 50%)				
		2015	2016	2017	2018	2019	2020
Northern Cook Islands	Manihiki	✓					
	Nassau	✓					
	Palmerston	✓					
	Penrhyn	✓					
	Pukapuka	✓					
	Rakahanga	✓					
Southern Cook Islands	Atiu		✓	✓			
	Mangaia		✓	✓			
	Mauke		✓	✓			
	Mitiaro		✓	✓			
	Aitutaki		⊙	⊙			⊙
	Rarotonga	⊙	⊙	⊙	⊙	⊙	⊙
Legend	✓	One-stage implementation					
	⊙	Multi-stage implementation					

Projects completed on the Northern group include over 850 kW of solar PV. With battery storage, these projects supply 95%-100% of electricity from renewable sources.

On Rarotonga, there is currently over 3 MW of renewable energy generation installed, contributing about 13% of Rarotonga's electricity needs. Most of this is solar PV, including a 1 MW array (Te Mana Ra) at the Rarotonga Airport. TAU has also undertaken a range of other steps to progress the Implementation Plan, including installing high-efficiency, high-speed diesel generators, which have the capability to respond to rapid changes in solar generation.

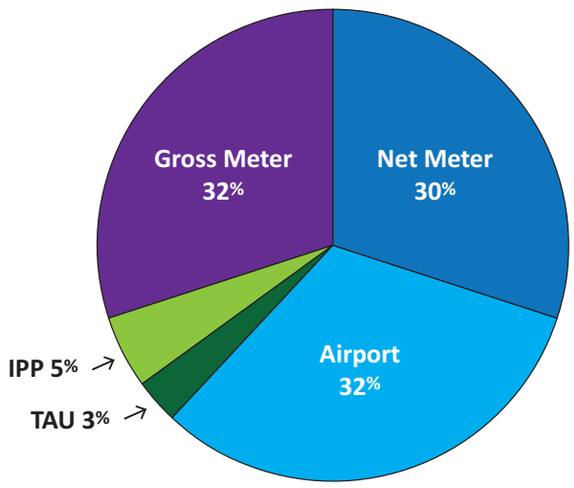

Figure 7-1 Renewable energy mix on Rarotonga

8. Challenges

This plan is based on overall economic efficiency by identifying the least cost programme to achieve the objectives outlined in Section 4 and incorporating enhanced energy security, increased energy efficiency both in supply and demand, and reduced environmental impacts, whilst ensuring the sector remains financially viable. The least cost approach varies across the different islands / island groups because of the scale and complexity entailed. For Rarotonga, the complexity means that the least cost path is not a set of physical investments, but rather a programme of actions that grows capability and confidence; moving forward with progressive renewable energy integration while planning appropriate technical, commercial and regulatory measures for larger integration, storage and generation opportunities.

High contribution renewable electricity systems, where most of the energy used to meet load comes from renewable energy sources, are substantially more complex than more typical diesel based island electricity systems, and even more so where distributed generation is involved. For small, centralised systems that are relatively self-contained, 'off- the-shelf' solutions that make use of sophisticated power electronics to manage all necessary grid functions are available, and examples of these have been installed in the Northern group (with similar functionality expected for the Southern group, excluding Rarotonga and Aitutaki). For the systems on Aitutaki and Rarotonga, such solutions are not currently available (nor would they likely represent least cost), and a customised approach is necessary.

Challenges specific to Aitutaki and Rarotonga are outlined on the following pages.

Aitutaki

For Aitutaki, the situation is somewhat simplified by the modest load, and availability of land to provide a centralised generation system. The Implementation Plan still requires a mix of technologies (control system, solar PV generation, battery storage for separate functions of load shifting and grid stability, and additional system inertia) and non-technical steps (energy efficiency, tariff re-structuring). However, with careful detailed planning, there is ample time to implement this solution in a three stage process, in line with the policy timeframe.

For Aitutaki, historical generation data shows a trend for increasing generation, indicative of increased per-capita consumption. There are few distributed generators on Aitutaki, hence the generation data is reflective of consumption. The expected growth in generation is shown below.

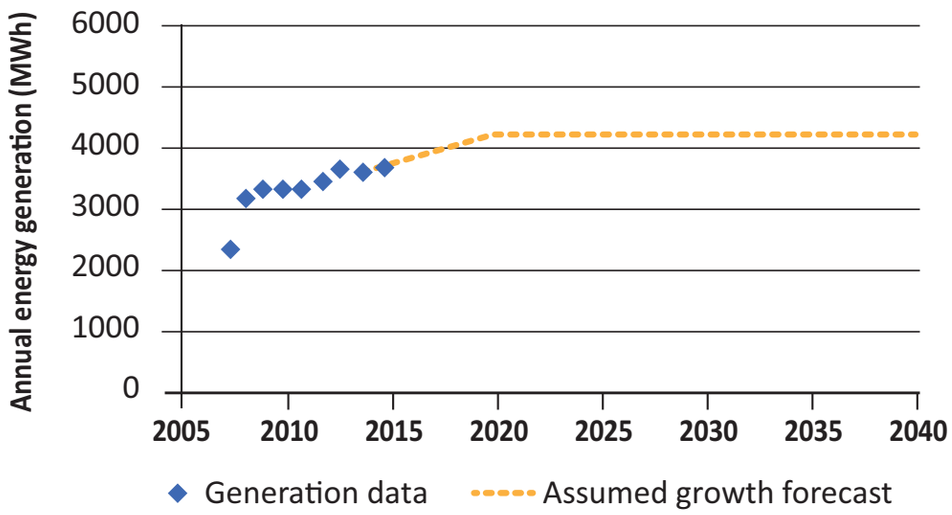

Figure 8-1 Aitutaki electricity generation requirements

Rarotonga

For Rarotonga, the situation is considerably more challenging. The significance of this challenge should not be underestimated, and will require substantial support, training and capacity building for TAU, and rapid, detailed planning on an ongoing basis.

It will require a complex mix of technical and non-technical solutions, including policy and institutional reform. Key to this challenge is land constraints, which limit siting options for renewable energy generation (particularly for wind power, which could otherwise provide night-time generation and significantly reduce load shifting requirements). Because the generation mix, network configuration and enablers are contingent upon siting options, these interrelated factors need to be addressed and solved simultaneously. While there is a range of important background information available to inform this work, further work is required to align these studies, integrate current operational data, and develop a comprehensive technical, commercial, and regulatory plan for Rarotonga. As such, this is the focus of the Implementation Plan for Rarotonga for the next 6-12 months.

For Rarotonga, the trend in total generation must account for centralised generation and widespread distributed generation. The resulting combined generation data is shown below. This shows a very modest decline in consumption likely associated with increased energy efficiency. In the longer term, the forecast allows for a return to growth in consumption in line with long term population trends. The Implementation Plan includes some flexibility and requires monitoring of demand trends and adjustments as necessary.

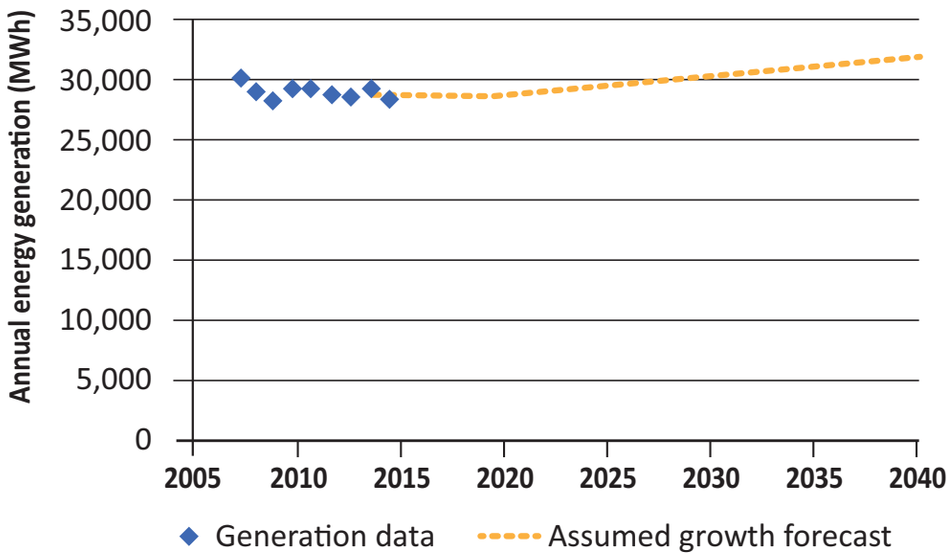

Figure 8-2 Rarotonga electricity generation requirements

Existing information available for Rarotonga highlights a number of challenging complexities and constraints, which require time and additional expenditure to resolve. As such, the possibility should be considered that a prudent Implementation Plan for Rarotonga may require limiting renewable generation contribution from local renewable resources to levels below that currently envisaged (i.e. biodiesel could still bridge the gap to high renewable contribution) within the timeframe of this Implementation Plan.

OVERARCHING ISSUES FOR RAROTONGA:

Commercial: Maintaining cost of energy in line with, or below diesel costs will be dependent on the costs of diesel and renewable energy technology. As the contribution from renewable energy increases, the requirement for enablers increases (typically as step changes), so it is important that a least cost strategy is used to maximise the renewable energy contribution. However, there are a wide variety of diverse scenarios to consider in determining the least cost plan. Central to this issue is the fact that the relatively low cost of solar PV generation on its own, does not reflect the full cost of the additional technologies, including storage, required to integrate high levels into the grid (which is very different to having low levels of solar PV in the grid, which can be done with practically no additional costs). Commercial decisions with regards to least cost investment must be fully reflected in tariffs and power purchase agreements to avoid perverse incentives.

Technical: Wind and solar generation do not provide all of the functions required of power systems that diesel generators do. 100% renewable energy generation (even for short periods)

requires other technologies to provide inertia, fault current, frequency control, spinning reserve, and voltage control[7]. This may include sophisticated control systems, battery energy storage systems, flywheels, dynamic resistors, and others. High frequency data and power systems modelling is required to determine the requirements. Various options need to be evaluated for their commercial merit.

Practical: Identification of areas suitable for siting of renewable energy generation is a major issue. Sites for wind power are quite limited though it can offer value by reducing night time storage requirements. Solar is likely to dominate the renewable energy generation mix but has fare more possible siting scenarios, from a fully distributed system to a centralised generation and/or storage system and all variants in between. These will have different commercial implications and require a good understanding of the appetite to make available larger areas of land for generation.

Equally important is the capacity for works. Distributed generation (and storage) will require progressive implementation, using local expertise and capability. Rapid fluctuations in the rate of installation will have potentially destabilising impacts to local industry.

Funding: With such a large investment required, this is unlikely to be directly within the capacity of TAU and/or Cook Islands Government, and will rely heavily on grants/concessionary loans, or private investment. Where private funding is used (e.g. Independent Power Producers (IPP)), the terms and conditions, and tariff structure, included in the Power Purchase Agreement (and the feed-in tariffs) must be carefully constructed to avoid over-commitment (effectively purchasing power that can't be used or at an unsustainable price), yet giving due consideration to the risks and business case of the IPP. Typically, this means focussing IPP involvement on generating assets, rather than enabling technology like grid stabilisation and energy storage.

7 Some of these are required when the diesel generators are operating, but close to minimum load, in order to address rapid fluctuations in renewable energy generation.

9. Agency responsibility

Table 9-1 Agencies currently responsible for carrying out RE activities

Actions	Responsibility	Supporting roles	TA required
Rarotonga			
Network Study for Rarotonga *A detailed grid integration and business model, providing commercial, technical and regulatory assessment, and recommendations of actions required for Rarotonga*	TAU	REDD	Y
Actions for Rarotonga arising from Network Study	It is expected that there will be a broad range of actions arising from the Network Study requiring implementation. First and most important will be Government endorsement of the detailed plan. Actions arising will include seeking funding for specific enabling technology projects, implementing commercial changes, implementing regulatory changes, and communications with private investors and the public. While it is anticipated that much of the practical responsibility will necessarily be taken on by TAU, REDD will have an overarching role in developing strategic directions and approval for proposed renewable energy plans, as well as to ensure funding and resources to complete the programme, monitoring and oversight. A separate action table similar to this one should be prepared on the outcome of the Network Study.		
Energy storage on Rarotonga (under the Global Environment Facility project)	REDD & TAU	MFEM	Y
Manage interim limits on distributed PV to maintain grid stability on Rarotonga	TAU	OPM	N
Aitutaki			
Implementation of Aitutaki Stage 1 project	REDD & APS	MFEM	Y
Source funding for Aitutaki Stage 2 & 3	REDD	APS, DCD	N
Implementation of Aitutaki Stage 2 & 3	REDD & APS	MFEM	Y

Actions	Responsibility	Supporting roles	TA required
Outer islands			
Selection of asset manager for outer islands	REDD	MFEM, ICI, CIIC	Y
Implementation of Southern Group projects, excluding Aitutaki and Rarotonga	REDD	MFEM	Y
Regulatory reform as required to support outcomes of outer islands asset manager	REDD	MFEM, TAU	Y

10. Further considerations

For solutions, on all islands, to achieve their potential, will require additional planning, policy setting, institutional strengthening, and reform beyond the scope of this Implementation Plan. In the longer term, O&M requirements will form a critical component of this plan. While O&M costs for renewable energy systems are typically substantially less than for diesel systems (due to reduction in fuel costs), O&M is critical to these systems achieving their planned performance and meeting or surpassing their design life, and hence investment returns. Thus, while this Implementation Plan currently focuses on the policy implementation timeframe of 2020, it incorporates flexibility for a range of options and requirements beyond this target date.

Beyond 2020, in addition to detailed ongoing asset management, O&M requirements, there is great potential for more innovative programmes that will derive additional value from the nature of the system. In particular, this can include advanced smart grid capability to better manage power and energy flows and asset performance. Specifically, electric vehicle to grid capability may be an important consideration, which could utilise excess generation during the day to offset vehicle fuel usage.

This Plan will continue to serve as a guiding government document for actions and for development partners to support. As technologies, costs and demand for electricity, and sources of financing change over time, it is envisioned that the Implementation Plan will be periodically updated to take these factors into account. The Implementation Plan is aligned with the policy targets and metrics articulated in the National Sustainability Development Plan (NSDP), and in particular, Goal 6: Ensure access to affordable, reliable, sustainable, modern energy and transport. Updates to the Implementation Plan will ensure continuing alignment with the NSDP. It is intended that the Implementation Plan be reviewed every six months during 2016 and 2017, and updated at least annually through to 2020.