

Pacific Lighthouses

Renewable energy opportunities and challenges in the Pacific Islands region

Niue



Copyright © IRENA 2013

Unless otherwise indicated, material in this publication may be used freely, shared or reprinted, so long as IRENA is acknowledged as the source.

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

www.irena.org

Acknowledgements

The work and data for the preparation of this paper was carried out by Herb Wade (Consultant). The kind assistance and support provided by Speedo Hetutu (Niue Power Corporation), Paul Johnson (Niue Power Corporation), Apisake Soakai (Consultant) and Frank Vukiloloma (Secretariat of the Pacific Community) are gratefully acknowledged. This report could not have been completed without their generous assistance.

Authors: Mirei Isaka (IRENA), Linus Mofor (IRENA) and Herb Wade (Consultant)

For further information or to provide feedback, please contact: Linus Mofor, IRENA Innovation and Technology Centre. E-mail: LMofor@irena.org or secretariat@irena.org.

Disclaimer

The designations employed and the presentation of materials herein do not imply the expression of any opinion whatsoever on the part of the International Renewable Energy Agency concerning the legal status of any country, territory, city or area, or concerning their authorities or the delimitation of their frontiers or boundaries.

Pacific lighthouses

Renewable energy opportunities and challenges in the Pacific Islands region

Niue

August 2013

TABLE OF CONTENTS

Preface	III
Acronyms	IV
1. Country context	1
Physical description	1
Population.....	2
Environment.....	2
Political development.....	2
Economic overview	2
2. Energy landscape	3
Institutional and regulatory arrangements for energy	3
Niue Power Corporation (NPC).....	3
Niue Energy Policy and Energy Action Plan (2005)	3
Energy supply and demand.....	3
Petroleum.....	3
Electricity generation and demand	4
Electricity tariffs	5
3. Renewable energy opportunities	6
Biomass.....	6
Biogas.....	6
Solar energy	6
Wind power.....	6
Wave and OTEC.....	6
4. Experiences with renewable energy technologies	7
Solar photovoltaics.....	7
Solar Thermal	7
Biofuels and biomass	7
5. Challenges for renewable energy deployment	8
References	9

Note on currency:

On 23 October, 2012, the exchange rate was New Zealand Dollars (NZD) 1.223 per United States dollar (USD).

Preface

In the Abu Dhabi Communiqué on accelerating renewable energy uptake for the Pacific Islands (of 13 January 2012), leaders from the Pacific Island Countries and Territories (PICTs) called on the International Renewable Energy Agency (IRENA) to “...map the Renewable Energy Readiness of the Pacific Islands Countries and Territories to ascertain the status of renewable energy opportunities and identify pathways to close gaps” and to integrate all IRENA activities in the region “...into a coherent roadmap for the Pacific Islands”. In response, IRENA has carried out a wide range of activities of specific relevance and application to the PICTs as well as other Small Island Developing States (SIDS). This work has now been integrated into the IRENA report: ***Pacific Lighthouses: Renewable Energy Roadmapping for Islands***.

The report consists of an overview roadmap framework and 15 island-specific studies on the respective energy

situations, and the challenges and opportunities for renewable energy deployment, around the region. These studies are available for the Cook Islands, the Federated States of Micronesia, the Republic of Fiji, Kiribati, the Republic of the Marshall Islands, the Republic of Nauru, Niue, the Republic of Palau, Papua New Guinea, Samoa, the Solomon Islands, the Kingdom of Tonga, Tokelau, Tuvalu and the Republic of Vanuatu. The IRENA Pacific Lighthouses report draws on those studies, as well as an additional study on a diesel-renewable energy hybrid power system, intended as a transition measure to a renewables-based energy future for the PICTs, which is also part of the series.

IRENA, in collaboration with its members and other key development partners, will continue to support the development national roadmaps and strategies aimed at enhanced deployment of renewables in the Pacific and other island states and territories.

Acronyms

BFC	Bulk Fuel Corporation
EDF	European Development Fund
EU	European Union
GDP	Gross Domestic Product
kph	Kilometres per hour
KW	Kilowatts (Thousands of Watts)
LPG	Liquefied Petroleum Gas
ML	Megalitres (millions of litres)
MW	Megawatts (Millions of Watts)
NPC	Niue Power Corporation
NZD	New Zealand Dollar (Currency)
OTEC	Ocean Thermal Energy Conversion
PEC	Pacific Environment Community Fund (Japan)
PV	Photovoltaics
USD	United States Dollar

1. Country context



Figure 1. Map of Niue

Source: Government of Niue.

The boundaries and names shown on this map do not imply official acceptance or endorsement by the International Renewable Energy Agency.

Physical description. Niue is a single raised coral island of 259 km² located roughly in the centre of a triangle consisting of Tonga, Samoa and the Cook Islands. The island, which has a closed-in reef and no lagoon, rises nearly vertically from the sea to a perimeter elevation of around 25–30 metres, then slowly rises to a central plateau with a maximum elevation of 68 metres. There are some beaches and steep footpaths down the cliff that provide access to the sea. A continuous reef around

the island means that ships must use open anchorage and transfer goods by lighter and small boats though a channel blasted into the coral reef to provide passage to the island's single wharf; however, ships with limited weight can anchor at the wharf. About 20% of the land area is considered arable although only a fraction of that area is cultivated regularly. Most of the forests, which cover over 60% of the land, are protected against cutting through a system of legal and traditional sanctions.

Niue has no surface water sources. Its primary water source is a large aquifer accessed through artesian boreholes for domestic, commercial and agricultural water supply.

Population. Niue is an independent country in free association with New Zealand. After the establishment of free association in 1974, Niue's population declined rapidly due to emigration. The current population of ethnic Niueans in New Zealand is about 20 000 while the population on Niue is only around 1400. Although there has been some effort to encourage repatriation, there continues to be a slow loss of population to New Zealand and Australia.

The population lives in 14 villages spread around the coast of the island and well connected by good roads. The capital village is Alofi. Most of the population is bilingual, speaking both English and Niuean. Education is compulsory from age 5 to 17 years. The Niue High School covers forms 1-7, with form 7 teaching provided in New Zealand. The population of Niue is mainly of Christian faith.

Environment. Environmental issues have a high priority Niue where the people have taken positive action to maintain their environment for future generations. A low population density has allowed large areas of the island's interior to remain as natural forests which have become tourist attractions along with the exotic coral formations, caves and other natural features of the island. Water and air quality are generally very good.

Rainfall is distributed fairly evenly over the year, although higher than average from December to March. The annual average temperature is close to 25°C with a range of about 21°C to 32°C.

Tropical cyclones are a serious risk for Niue. On the 5th of January 2004, Cyclone Heta struck Niue. With winds in excess of 270 kilometres per hour and an estimated sea surge of 50 metres, which rose above the island's 30-metre cliffs, the storm wreaked havoc along the western coast, destroying most of the government buildings and facilities and many homes. Recovery was slow in the aftermath of the cyclone, and it took many years for Niue to fully recover from the event.

Economic overview. Niue's GDP in 2009 was approximately NZD 15.9 million (USD 1.55 million). The remainder of the island's economic needs came from donor funding with most of this coming from New Zealand and the EU. Remittances from family members overseas are also an important input to the economy.

Niue has no mineral or fertiliser resources, and its soil is thin and rocky, although generally fertile. Taro, the predominant crop, is a staple food and holds cultural sig-

nificance to Niueans. Other crops include cassava, sweet potatoes and yams, some of which are exported to New Zealand. Honey has also become a significant export earner for Niue. Passion fruit was a major export until it was wiped out by Cyclone Ofa in 1990. Small quantities of coconut, fruit and vegetables are also cultivated, mainly for domestic use, along with chickens, pigs and a small number of cattle. Fishing is also done mainly at a subsistence level, requiring strong artisanal fishing skills to deal with difficult sea access around the rugged steep coastline. This subsistence fishing – including reef gleaning, spear fishing, reef rod fishing and canoe fishing – accounts for 90% of the island's catch, which is used for family consumption, community functions and local restaurants, or is sold at the Alofi market. The exposed and unprotected nature of the coastline to the open and sometimes very rough seas, combined with the absence of natural harbours or lagoon systems are added obstacles to fishing. Small quantities of frozen fish are exported, though mostly to Niuean relatives in New Zealand and not in any significant amounts. There were once efforts to establish a substantial frozen fish export business with the formation of a joint venture between Reef Shipping (an ocean shipping company) and the Government that included a large flash freezer and cold storage facility. However that facility is closed today owing to insufficient demand to maintain economic operation, coupled with high electricity prices caused by fuel price increases.

Cyclone Ofa in 1990 turned Niue from a food-exporting country to one dependent on food imports for nearly two years. Cyclone Heta in 2004 was even worse, with several years needed before food exports reached previous levels.

Niue's road system is very good with around 125 km of paved roads and another 100 km unpaved but in good condition. Access is easy to all populated areas. Air access has been a long-standing problem despite the presence of excellent airport facilities. In 2012, there was only one flight a week – to and from Auckland on Air New Zealand.

Tourism is seen as offering good economic potential for Niue. However, since Cyclone Heta only one full service hotel has been operating on the island, though there are several guest houses. Primary tourist attractions include Niue's sculpted coral coast, interior caves, forest preserves and wildlife, the seasonal presence of whales and the unusually clear ocean water for diving.

Niue's principal employer is the Government, with about half of the labour force working in the civil service. Small shops, tourism and other services provide work in the private sector for the remainder of the population.

2. Energy landscape

Institutional and regulatory arrangements for energy

Niue Power Corporation (NPC). NPC is the nationally-owned power utility and reports to the Secretary for Government. Currently, all electrical generation and energy efficiency programmes, both for renewables and fossil fuels, comes under the NPC, which has 19 employees. Petroleum tenders, however, are managed by the Department of Bulk Fuel.

Niue Energy Policy and Energy Action Plan (2005). The plan, which was written to support the Niue Strategic Plan (2003-2008), includes a commitment to energy efficiency and renewable energy. Under the plan Niue is committed to convert 30% of all electrical generation to renewable energy by 2013 and 100% by 2020.

Energy supply and demand

Petroleum. The Bulk Fuel Corporation (BFC) has the exclusive authority to import petroleum products, with the exception of liquefied petroleum gas (LPG) which is privately imported. BFC manages all aspects of fuel

import, storage and distribution and uses New Zealand procedures and standards. Fuel is delivered about once every three months. The retail price is set by the Government, while a tax of NZD 0.10 (USD 0.082) per litre is applied to diesel fuel, petrol (gasoline) and jet fuel. Imports have risen rapidly over the past decade despite the declining population, although slower growth is expected in the future as appliance ownership approaches saturation.

Most of the homes in Niue use LPG for cooking as a result of the 9th European Development Fund (EDF-9) supported Energy Sector in Five ACP Pacific Islands (REP-5) project that included conversion of over 300 household electric cooking facilities to LPG in 2008¹. Additional LPG stoves are also tentatively included in the EDF-10 initiative and, if implemented, will result in almost 100% of homes using LPG for cooking.

Table 1 shows the imports of petroleum products to Niue. Domestic kerosene is supplied from jet fuel stores. The kerosene sales to households is quite low relative to most other Pacific islands, since all homes are electrified and cooking is mostly with LPG. About 69% of diesel

¹ Further details available at the REP-5 website pages for Niue: http://www.rep5.eu/Project_Countries/Niue

Table 1. Petroleum imports 2005-2010 (in millions of litres)

Year	Diesel Fuel	Diesel used for Electricity	Petrol (Gasoline)	Jet Fuel	Total Imports
2005	1.377	0.895510	0.564	0.573	2.514
2006	1.377	0.822629	0.610	0.493	2.480
2007	1.161	0.833736	0.573	0.544	2.278
2008	1.224	0.846520	1.463*	1.021*	3.708
2009	1.260	0.778522	0.551	0.304	2.115
2010	1.170	0.805216	0.627	0.475	2.272

* Forum Secretariat Regional Meeting on Niue caused the increase in petrol and jet fuel

Source: Provided through communication by Government of Niue (2012).

fuel, i.e. approximately 0.8 megalitres (ML) per year, is used for electricity generation while 90% of petrol goes for land transport and the rest is used by outboard-powered boats.

Electricity generation and demand. Electricity generation capacity is 2.4 MW, using four 508 kW Caterpillar C18 engines for a total of 2 032 kW, but this figure is de-rated to around 1400 kW. All the residences and businesses (except for one household in the interior of the island which has chosen to use solar power) have access to grid power. Power is available 24 hours a day to supply customers through 1510 electricity meters, mostly on government facilities. The government is the largest user of power, representing about half of the total consumption in Niue. The Matavai Resort and Swanson Supermarket are presently the largest commercial customers.

The NPC serves 720 residential customers, 50 commercial customers and 90 government customers with sales as shown in Table 2. Unmetered loads include 208 streetlights and 40 sea track lights. The cost of diesel fuel to the NPC as of November 2011 was NZD 1.40 (USD 1.14) per litre.

Total annual electricity sales are shown in Table 2. Individual sector data were unavailable. Energy production from renewable sources is around 3% of the total, with around 1% coming from biomass for household use and the rest from solar.

Load curves (Figure 2) do not differ much between the week and weekend. As there is little air-conditioning of offices to increase the daytime power demand, the peak of the load curve is in the evening, except on the days when the existing rock crusher is in use and dramatically increases the load – as apparently is the case on the Friday curve shown in Figure 2.



Source: Provided through communication by NPC (2012).

Figure 2. Electricity load curves

Table 2. Electricity sales

Year	Sales (MWh)
2005	2 007.285
2006	3 175.951
2007	3 276.696
2008	2 886.581
2009	2 725.794
2010	2 673.732*

*Not confirmed.

Source: Provided through communication by NPC (2012).

The expected growth in use for petrol and jet fuel is 2% per year, 2% for diesel for electricity generation and 3% for diesel for transport. LPG is expected to grow very little since the market is already almost saturated. If renewable energy and energy efficiency measures are aggressively applied, about 15% of the diesel fuel used for electricity generation can be cost-effectively saved and about 25% of the diesel fuel for electricity generation can be economically saved through solar and wind systems connected to the grid. About 5% of ground

transport fuel use can also be saved through energy efficiency measures.

Electricity tariffs. All sectors have the same tariffs as shown in Table 3. Each metered customer is also charged NZD 15 (USD 12.26) per month as a supply charge. Full cost recovery is not possible with this tariff scheme and so considerable government subsidies are required.

Table 3. NPC electricity tariffs (as of July 2013)

Consumption	Tariff (NZD/kWh)	Tariff (USD/kWh)
0-100 kWh/month	0.50	0.41
101-300 kWh/month	0.60	0.49
over 300 kWh/month	0.70	0.57

Source: Provided through communication by NPC.

3. Renewable energy opportunities

Biomass. Given the protected status of forests, land tenure issues and the lack of large plantations of economically useful tree crops on Niue, it appears unlikely that biomass can be economically developed for power generation. The only biomass that has so far been found to be economic for electricity generation throughout the Pacific has been concentrated waste from agricultural processing or forestry industries, none of which operate on Niue. While a relatively large proportion of land could be made available for growing fuel crops, production on the island would be constrained by scale. Harvesting can be labour-intensive, and transport and handling costs for bulky fuel stock could be prohibitively expensive unless Niue were to develop its own processing centre for combustion or gasification.

Biogas. Niue's population is dispersed over the entire area of the island and there are no distinctive urban and rural areas. Collecting manure for economically feasible biogas-based power generation is not attractive to households, and the quantity of waste that could be used for digestion is small. Biogas is therefore unlikely to be developed as a significant fuel source for electricity production.

Solar energy. Niue has a good solar resource and so using solar thermal energy for water heating and solar photovoltaics for electricity generation are both practical. Integrating more than 15% of the energy delivered by the NPC grid from solar PV would require the addition of energy storage facilities.

Currently, 52 kWp of solar is grid-connected and 3 kWp is installed as a large solar home system on the only home that is not on the grid. Approximately 2% of NPC's generation comes from solar PV systems, with the rest from diesel generators.

Large-scale solar PV development should not create any environmental or social problems if installations are geographically distributed around the island and placed on roofs. Existing PV projects in the pipeline will already exceed current "safe" limits for solar penetration on the grid, and all future grid-connected solar projects will need to include storage facilities to ensure grid stability. Off-grid solar for water pumping or solar mini-grids for

smaller villages are viable alternatives to offset electricity use without affecting the quality of the grid power.

If solar installations include storage batteries, provision for the recycling of spent batteries is essential if environmental damage caused by the lead compounds in the batteries is to be avoided.

Wind power. A study funded by the Secretariat of the Pacific Islands Forum (an inter-governmental organisation that aims to enhance cooperation between the independent countries of the Pacific region) using a 30-metre wind measurement mast was carried out from 1995–1997. It determined that the wind resource in Niue is moderate but could be economically developed. Ten years of data (1997 to 2007) from Hannan Airport indicates that the average monthly wind speeds are reasonably constant but are highest in September and October and lowest during March. A study in 2007 by Garrad Hassan, a wind energy consulting company, recommended wind installation using tilt-down towers, up to a maximum of 300 kW to limit cyclone risks. Larger installations with complex load-shifting control systems would be necessary for wind energy to deliver more than 20% of the total energy delivered by the NPC grid. A wind turbine installation was initially proposed for EDF-10, but concerns about complexity of control systems required to manage the variability of the wind turbine's output led the NPC to shift to adding more solar for now.

Large-scale wind development for Niue does not entail allocating large land areas for wind farms. Niue's modest power requirements could be met by three or four turbines to supplement diesel generation. No significant negative impacts on the environment or social problems seem likely from the use of wind power. However, any turbines installed must be designed to survive cyclone passages and must be carefully integrated into the grid to avoid stability problems.

Wave and OTEC. Niue's wave and ocean thermal resources are good. If commercially produced, well-tested systems become available, these energy sources could eventually help to meet Niue's energy needs. There are no known tidal, hydro or geothermal resources that could be developed in Niue.

4. Experiences with renewable energy technologies

Solar photovoltaics. Prior to 2009 installations of solar PV were limited to lighting for a canoe access stairway, lighting for a community centre and power for its refrigerator and a village solar pump that was installed in the 1980s. The canoe stairway lighting system failed after five years and the community centre was partially working until it was damaged by Cyclone Heta in 2004.

In 2009 the first grid-connected PV installations were implemented under the EU's REP-5 programme. They included 20 kWp installed on the roof of the high school, 2 kWp on the roof of the NPC office and 30kWp of ground-mounted arrays at the hospital. This project represents around 15% penetration for the Sunday noon-time load and "hunting" of the generators to keep up with the changing solar input has been observed. These installations provide around 2% of the total energy produced by NPC.

Currently EDF-10 plans to provide 70 kW of roof-mounted grid-connected installations and the Japanese Pacific Environment Community (PEC) Fund proposes to install 200 kWp of ground-mounted solar near the power house that will include sufficient battery storage

and controls to allow input to the grid without stability problems.

In 2011 a farm in the interior of Niue – the one residence not connected to the grid – installed about 3 kWp of solar PV with batteries and an inverter to provide its power needs.

Solar Thermal. Solar water heating has been used for over 20 years on Niue, and most government housing has included imported units of the Solahart type of design. Tourist accommodation also typically use solar water heaters. The remaining market for such systems is small and can easily be served by the existing private importers. A programme by the EU in 2004-2006 under EDF-9 included incentives for the installation of solar water heaters in residences, resulting in about 290 households benefitting from installations. It is now planned to install water heaters for all households in Niue.

Biofuels and biomass. There has been no experience with biofuels and biomass has only been used for cooking and crop drying.

5. Challenges for renewable energy deployment

Challenges to be overcome for effective renewable energy deployment include the following:

- Complex requirements by financing institutions for project proposals and project management.
- High cost of access to the island.
- Land tenure issues, particularly for bioenergy technologies.
- Difficult environment for electrical and mechanical equipment.
- Lack of adequate technical capacity for maintenance and repair.
- Lack of economies of scale.
- Limited knowledge of renewable energy.
- Lack of a realistic and well-defined action plan to achieve fuel import reduction targets.
- A small utility, requiring care in integrating renewable to maintain grid stability. Perceived risks to grid stability when a high share of variable renewable energy, such as solar or wind, is integrated.

IRENA can suggest pathways to overcome these challenges through its Global Renewable Energy Islands Network (GREIN) and believes that regional and national roadmaps should reflect these pathways. IRENA will continue to work with existing regional and national stakeholders to achieve the transition to renewable energy for a secure and sustainable energy supply.

References

In the preparation of this report, primary sources were used as much as possible. Some information was obtained through written questionnaires, some through interviews and some through email correspondence. Where primary sources were not available, the following secondary and tertiary sources were used.

Publication References

Asian Development Bank (2012), Newsletter: Pacific Economic Monitor.

Johnston, Peter (2008), Expanding and Updating the Pacific Islands Renewable Energy Project (UNDP/GEF/SPREP/PIREP) Reports and Data.

Pacific Power Association (2011), Performance Benchmarking for Pacific Power Utilities.

Pacific Power Association-KEMA (2012), Quantification of the Power System Energy Losses in Southern Pacific Utilities.

Pacific Regional Infrastructure Facility (2011), Pacific Infrastructure Performance Indicators.

Resources and Logistics-EU (2011), Support to the Energy Sector in 5 Pacific Island States, REP-5. Final Evaluation Report Vol 1-Main Report.

Secretariat of the Pacific Community (SPC) (2011), Towards an energy secure Pacific, Framework for Action on Energy Security in the Pacific.

United States Central Intelligence Agency, (2012), The World Fact Book 2012-2013.

Wade, Herbert - SPC Regional Environment Programme/Pacific Islands Renewable Energy Project (2005), Pacific Regional Energy Assessment 2004 Volume 8 - Niue.

World Bank, East Asia and Pacific Region, Pacific Islands Country Management Unit (2006), A review of obstacles and opportunities for improving performance in the Pacific Islands.

Internet Reference Sources

Secretariat of the Pacific Community, Pacific Regional Information System, Statistics for Development Programme (2012), <http://www.spc.int/nmdi/MdiHome.aspx>

Secretariat of the Pacific Regional Environment Programme, Pacific Regional Energy Assessment: Country Reports (PIREP) (2012), <http://www.sprep.org/Pacific-Environment-Information-Network/country-profiles-directory>

The World Bank, Indicators (2012), <http://data.worldbank.org/indicator/all>

United States National Aeronautics and Space Administration (2012), solar and wind data website URL: <http://eosweb.larc.nasa.gov/cgi-bin/sse/sse.cgi?>



IRENA
C67 Office Building, Khalidiyah (32nd) Street
P.O. Box 236, Abu Dhabi,
United Arab Emirates
www.irena.org

Copyright © IRENA 2013