Report

IRENA
International Renewable Energy Agency

Pacific Lighthouses

Renewable energy opportunities and challenges in the Pacific Islands region

Nauru

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.
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Note on currency:
On October 23, 2012, the exchange rate was Australian Dollars (AUD) 0.9715 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

AUD	Australian Dollar (currency)
EEZ	Exclusive Economic Zone
EU	European Union
km²	Square kilometres
kV	Kilovolt (thousands of Volts)
kwh	Kilowatt hours (thousands of Watt hours)
kWp	Kilowatts peak (rated output of solar panels)
LED	Light Emitting Diode
LPG	Liquefied Petroleum Gas
ML	Megalitres (millions of litres)
MVA	Megavolt-Amperes (Same as MW at a power factor of 1.0)
MW	Megawatts (millions of Watts)
MWp	Megawatt peak (rated output of solar panels)
NUC	Nauru Utilities Corporation
OTEC	Ocean Thermal Energy Conversion

1. Country context

Figure 1. Map of Nauru and its location

Source: Perry-Castañeda Library Map Collection University of Texas.

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

Physical description. Nauru is a small single oval-shaped and raised coral equatorial island, locate about 40 kilometres (km) south of the Equator at 0° 32' 0" S, 166° 55' 0" E. Its total land area is 21 square kilometres (km^2) with an Exclusive Economic Zone (EEZ) of 320 000 km^2. The island is divided into two plateau areas – "bottomside" a few metres above sea level, and "topside" typically 30 metres higher. The topside area is dominated by pinnacles and outcrops of limestone, the result of nearly a century of mining of the high-grade tricalcic phosphate rock. There are no natural harbours and the island is surrounded by a fringing reef 120–400 metres wide. However, the reef falls off very rapidly, allowing deep-water ships to moor within a short distance of its edge.

Population. The 2012 census shows a population of 9 945 persons of whom 90.8% are ethnic Nauruan. The population has fallen since 2002 mainly due to a fall in the number of expatriate workers, mostly from Kiribati and Tuvalu, who began leaving Nauru as the island's phosphate production dwindled.

Environment. The climate is equatorial and maritime in nature. There have been no cyclones on record. Al-

though rainfall averages 2 080 mm per year, periodic droughts are a serious problem with only 280 mm of rainfall in the driest year recorded. Land biodiversity is limited, with only 60 species of indigenous vascular plants. A century of mining activity in the interior has resulted in the drainage of large quantities of silt and soil onto the reef, which has greatly reduced the productivity and diversity of reef life. Sewage is dumped into the ocean just beyond the reef, causing further environmental problems, while the island's many poorly maintained septic tanks have contaminated the ground water. Access to fresh water is thus a serious problem on Nauru with potable water coming only from rainwater collection and reverse osmosis desalination plants. These desalination plants used around 30% of the energy generated by Nauru Utility Corporation (NUC) in 2008.

Economic overview. The basis for Nauru's economy since the early 1900s has been phosphate exports. At the peak of Nauru's phosphate industry in 1975, more than 1.5 million tonnes of phosphate was exported at a price of USD 68 per tonne. After the mid-1990s, production gradually fell. By 2001, Nauru exported just 250 000 tonnes and the price per tonne had halved. Shipments fell to almost zero by 2004 but exports resumed in 2005. The falling exports and failure of the Nauru Phosphate Royalties Trust (which was established to provide income after the phosphate was mined out) brought Nauru to the brink of economic collapse by 2004. In 2005, through a process of rehabilitation, restoration and renewal that followed the crisis, the Nauru Phosphate Corporation became the Republic of Nauru Phosphate Corporation (RONPHOS) and began plans to extract the remaining pockets of phosphate. In 2006 work began on extracting the leftovers from earlier mining, and shipments began again, though at a low level. Some income flow resumed in 2007 and production in 2009 was a modest 41 549 tonnes.

Although Japan has provided assistance for the creation of a local fishery industry, fishing is not a major source of export income and is unlikely to be expanded in the near future.

Most of Nauru's operating funds in recent years have come from Australia as payment for rehabilitating the damage to the environment during the years of mining; through payments to Nauru for hosting refugee populations; or through outright grants. A substantial income also comes from licensing foreign fishing boats to operate within the EEZ. However the near-term economic outlook is poor.

The most pressing issue for Nauru's future development is the rehabilitation of the more than 70% of the island's land area that has been mined. In 1993, an AUD 107 million (about USD 71 million in 1993) Compact of Settlement was agreed by Australia and Nauru for the purpose of rehabilitating the topside area. The Nauru Rehabilitation Corporation (NRC) was formed in 2007 but little progress has been made to date. Besides rehabilitation, today the NRC is also engaged in mining the phosphate to send to RONPHOS for processing and marketing.

2. Energy landscape

Institutional and regulatory arrangement for energy

Nauru Utility Corporation (NUC). Until 2005, the Nauru Phosphate Corporation provided all the island's utility services. In 2005, the Nauru Utility Authority (NUA) was formed to separate the water and electricity utilities function from the Phosphate Corporation. It was later decided to corporatise NUA, and Nauru Utilities Corporation (NUC) was created. In June 2011, the status of the utility as a corporation was formalised with the passing of the NUC Act, which states the legal obligations of the utility. The NUC provides all energy services to Nauru except for the Australian refugee camp and the main processing plant of RONPHOS, which both generate their own power. Petroleum is purchased by the Government for supply to all customers except RONPHOS, which does its own purchasing. Diesel fuel, petrol and jet fuel are stored and distributed by NUC to all users except RONPHOS, which maintains a separate diesel fuel storage facility for industrial use. LPG and kerosene are privately imported and distributed.

National Sustainable Development Strategy (2005-2025). National Sustainable Development Strategy (NSDS) as revised in 2009 outlines a development strategy for Nauru with the "...vision of a future where individual, community, business and government partnerships contribute to a sustainable quality of life for all Nauruans". The strategy has four revised sectors goals. The infrastructure sectors cover energy, water and sanitation, waste and sewerage, transport and communications and media. The strategy for energy goal is the implementation of a national energy policy framework.

National Energy Policy Framework. The Nauru National Energy Policy Framework (NEPF) was developed, under the Nauru integrated planning approach and in consultation with various stakeholders. It aims to provide a guideline for the development of the energy sector of Nauru. The policy framework was adopted in 2009 with the vision of providing reliable, affordable and sustainable energy for enabling the socio-economic development of Nauru. It includes a target to supply 50% of the total energy use in Nauru from renewable sources by 2015.

Nauru National Energy Roadmap. Nauru, together with various development partners (ADB, AusAID, EU, GIZ, IRENA, IUCN and UNDP), is currently developing its energy roadmap to assist with the implementation of the NEPF. The roadmap and its implementation will have a strong focus on renewable energy and energy efficiency as a key enabler for reducing heavy dependence on imported fossil fuels.

Energy supply and demand

Petroleum. The average amount of petrol purchased by the Government for its own use and for distribution is around 1.5 million litres (ML) a year (Table 1). Automotive diesel oil import is around 8.8 ML and jet fuel is estimated at around 1.3 ML. The Government regulates the resale price of these fuels. Shortages have occurred due to a lack of funds in the government budget to make timely purchases, resulting in occasional voluntary petrol rationing and rolling blackouts of electricity.

About 9.5 tonnes of liquefied petroleum gas (LPG) are used by households each year for cooking. LPG is provided by two private importers. Information about

Table 1. Fuel imports 2006–2010

Fuel type	2006	2007	2008	2009	2010
Diesel	8144167	5334340	8074821	8671864	8842138
Petrol	1092549	1164518	1409669	1447507	1467753
Jet Fuel	520245	954996	963200	N/A	N/A

Source: Provided through communication by NUC (2012).

Table 2. Installed Diesel Capacity

Engine	Deliverable MW Maximum	Rated (MW)
Ruston #1	1.40	2.6
Cummins	0.5	1.0
Ruston #4	Not installed	2.0
Ruston #5	0.8[1]	1.0
Ruston #6	1.7	2.0
Ruston #7	1.7	2.7
Cat genset	Not installed	2.0
TOTAL	**5.3**	**12.3**

Source: Provided through communication by NUC (2013)

1: currently out of service.

kerosene use was not available, but the level is reportedly low relative to electricity and LPG.

Electricity generation and demand. Nauru's electricity supply comes from a single power station operated by NUC (Table 2). Most of the power now comes from four ageing medium-speed Ruston stationary engines with a high-speed Cummins generator which also available to provide stand-by capacity. The engines have a total nameplate generation capacity of 12.3 MW, but have been de-rated to 5.3 MW. If an engine breaks down, load shedding is necessary. The distribution system is in a ring main configuration and includes 11 kV, 3.3 kV and 415 V sections. Maximum demand was once in excess of 7 MW but has dropped, largely due to the loss of industrial demand, to around 3.3 MW. The electricity generation between 2008 and 2012 is given in Table 3

During the years of high phosphate production, industrial use dominated the Nauru energy economy. That use has diminished and the domestic sector is now the dominant user (Table 4).

Because electricity tariffs have been kept artificially low and bill collection was not enforced, the average household use of electricity is very high, estimated at around 400 kWh/month. Electric cookers, freezers and refrigerators are common, as is home ownership of multiple air-conditioners (though units are often unused due to their high operating cost). To gradually shift the population to paying for electricity, prepaid meters have been installed for most domestic and commercial customers (Table 4).

Even though there are only 20 public streetlights on Nauru and their consumption is very small, conversion to high-efficiency Light Emitting Diode (LED) lights is being considered. A number of LED-type street lights powered directly by solar energy have been provided by a donor but some are no longer operating due to vandalism and technical problems.

Daily load curves for 2010, as shown in Figure 2 below, indicate a weekday baseload of around 2 MW and an evening peak of around 3.2 MW, probably due to cook-

Table 3. Total generation and fuel use 2008–2010

Year	Actual generation (MWh)	Fuel used (litres)
2008	19 382	5 929 740
2009	21174	6 299 460
2010	22 462	7 181 100
2011	23 024	7 360 628
2012	23 600	7 544 644

Source: Provided through communication by NUC (2013).

Table 4. Customer meters (2011)

Sector	Number of prepaid customers	Number of billed customers
Residential	1 980	42
Commercial	124	48
Industrial	0	2
Government	0	32

Source: Provided through communication by NUC (2012).

ing using electric ovens. The weekend load varies from around 2.5 to 3 MW with the peak again in the evening. There is little demand for water heating.

Due to major structural changes taking place in the Nauru economy, forecasts of future energy use cannot be made very precisely. It is possible that fuel use will not increase, and may even decrease, over the next decade as a result of energy efficiency drives and electricity prices rising from the heavily subsidised levels of today to a tariff that recovers full cost. Also, industrial fuel use is closely tied to phosphate production, which has a long-term downward trend. Only the use of jet fuel is expected to rise much over the next 10 years, and even that looks unlikely if Our Airline (the national carrier of Nauru) cannot expand its operations.

Electricity tariffs. The tariff is still heavily subsidised, with a residential rate of AUD 0.10/kWh for up to 300 kWh/month[1] and AUD 0.20/kWh for consumption greater than 300 kWh/month. Commercial customers pay a flat rate of AUD 0.25/kWh. The industrial rate is AUD 0.50/kWh. The Government is now being charged a flat rate per month of AUD 0.20/kWh. Full cost recovery is estimated to be AUD 0.49/kWh at the AUD 0.85 per litre diesel price in November 2011, so the subsidy is well in excess of 50% although the need for a subsidy should be gradually reduced as customers become more energy-efficient.

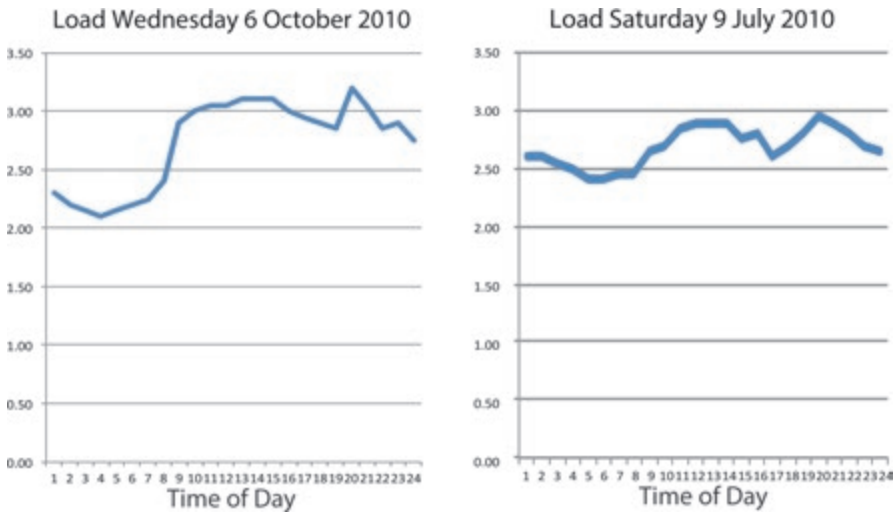

Figure 2. Load curves for 2010 (MW)

Source: Provided through communication by NUC (2011).

1 *Lifeline tariff limit*

3. Renewable energy opportunities

The 2009 Energy Policy Framework supports a 50% reduction of fossil fuel use through the use of renewable energy and energy efficiency measures by 2015, although the Government has indicated that a longer timeframe will be required. The development of an Energy Road Map is included in the 2012 Nauru Economic Infrastructure Strategic Investment Plan (NEISIP) with the aim of progressively addressing the possible replacement of fossil fuels with renewable energy.

Solar energy. Measurements show an average of over 6 kWhr/m^2/day (with solar panels tilted to the angle that maximises energy input) with a seasonal variation of around 10–15%. Although solar PV offers electricity generation that can supplement the existing diesel generation, the variable nature of solar energy will require energy storage systems for it to be connected to the grid at high levels of penetration. A dynamic model has not yet confirmed the maximum possible level of solar penetration before grid stability issues occur, but it is likely to be limited to around 20–30% of midday demand. Above this threshold, storage and control systems will have to be introduced to ensure grid stability.

Wind power. Nauru's wind resource is not well known although, based on airport and National Aeronautics and Space Administration wind data, it is probably only marginally cost-effective at present fuel prices. Data collection, funded by PIGGAREP and the EU indicates an annual average wind resource of 4.22 m/s at 30 metres (about 4.7 m/s if extrapolated to 50 metres) for 2009–2011. These figures are at the low end of practicality for wind energy generation. A resource assessment using a more suitable pipe-type guyed tower is planned to determine the appropriateness of further development, and to confirm the quality of the data already collected from the telecommunications tower.

Biomass. With little or no biomass present in topside, there are insufficient biomass resources for either combustion or significant production of biofuels. Land rehabilitation in the distant future might eventually result in a topside biofuel resource, but certainly no production will be seen within the next decade since secondary mining is expected to continue for up to another 30 years.

Wave energy. Wave energy in the equatorial region is low with around 10–15 kW/m estimated from satellite observations. Wave energy systems are not yet commercially available though they are being tested at the prototype stage around the world. Even if wave conversion systems become commercially available, low resource availability will make it difficult for Nauru to develop economical wave power.

Ocean thermal energy conversion (OTEC). With the very rapid increase in depth that occurs beyond the reef, there is an opportunity for OTEC energy development once engineering and commercial trials are completed elsewhere in the region.

4. Experiences with renewable energy technologies

There is a Renewable Energy Officer in the NUC who is primarily responsible for renewable energy project implementation and for energy efficiency campaigns. Prior to the acceptance of the Nauru Energy Policy Framework in 2009, renewable energy was never considered in any legislation, regulations or corporate actions, except for a small number of solar water heaters installed on government housing by the Public Works Department in the 1980s. There is little use of biomass for cooking, and for all practical purposes, there was no use of renewable energy until 2006 when the European Union (EU) Support to the Energy Sector in Five ACP Pacific Island Countries (REP-5) project installed 40 kWp of grid-connected solar panels on Nauru College. Since then a 30 kWp solar PV system was installed on the government buildings in Yaren district, bringing the total grid-connected renewable energy generation capacity to 70kWp. Today Nauru is working on an action plan for the development of renewable energy and energy efficiency sufficient to significantly lower imports of diesel fuel for electricity generation.

Less than 1% of Nauru's electricity is currently generated from renewable resources. Installations over the years have included the following:

- Solar energy was used to some extent in the 1980s for water heating but most of the systems that were installed failed after a few years of use and were not repaired. Currently there is little demand for water heating systems of any type.
- The Japanese utility company, Tokyo Electric Power Corporation, undertook a technical trial of OTEC in 1981 with an experimental plant on the west coast of Nauru that produced a net power of around 15 kW for a short time before a storm damaged the intake pipe and the system was disassembled. Despite over 30 years of development, that trial remains the only time electricity has been delivered to a commercial grid by an OTEC plant. The trials were mainly designed as engineering tests for TEPCO to gain experience with the technology and have not resulted in further development of OTEC in Nauru.
- In 2006, the REP-5 project of the EU installed a 40 kWp grid-connected PV system on the roof of Nauru College.
- Sixty solar home systems of 130 Wp capacity, which included LED lights, have been funded by Chinese Taipei institutions.
- Chinese Taipei institutions also funded a solar street lighting project which included 155 units installed around the island following the main road, with some of the larger units installed in community areas and government buildings.
- Some 160 Wp arrays for solar-powered district water pumps have been installed through Japan International Cooperation Agency (JICA) funding, although details are not available.
- Solar-powered LED torches donated by Chinese Taipei institutions were recently distributed to households. Further information was not available at the time of writing.
- A grid-connected PV system with an installed capacity of 15.84 kWp was provided by Chinese Taipei institutions and installed at the government offices building in 2012. In late 2012 this was expanded to a total of 30 kWp
- A pipeline project for grid-connected solar PV installation of 132 kWp is to be funded by Japan to offset the electricity use of an additional reverse osmosis plant funded through the PEC Fund of Japan.

5. Challenges for renewable energy deployment

The challenges and barriers that need to be addressed for enhanced deployment of renewable energy technologies in Nauru include the following:

- Limited capacity to prepare and carry out complex project proposals and provide project management for renewable energy projects.
- No single agency has renewable energy responsibility in the government.
- High logistics cost to access to the island.
- Land tenure issues may be a problem for large-scale installations.
- Nauru's high ambient temperatures, moisture, coral dust and high levels of atmospheric salt create a difficult environment for electrical and mechanical equipment.
- Lack of adequate technical capacity for maintenance and repair.
- Small population, with few resulting economies of scale.
- Limited knowledge of renewable energy at decision-making levels of government.
- Lack of a realistic and well-defined action plan to achieve fuel import reduction targets.
- The national utility, NUC, is in transition as industrial use declines, tariffs rise, and users adopt energy-efficiency measures, all of which make energy usage and cost difficult to predict. This also makes it difficult to readily determine how much renewable energy should be added to meet government goals.

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.

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

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