Nauru Energy Sector Summary Report

Prepared as an input to the development of the Nauru Energy Road Map

May 2013

TABLE OF CONTENTS

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LIST OF FIGURES

LIST OF TABLES

Acknowledgements and data collection

This report was prepared by Dr. Herb Wade (IRENA and GIZ Energy Road Map Consultant), with inputs from Katerina Syngellakis (SPC-GIZ Sustainable Energy Management Adviser) and Apisake Soakai (IRENA Pacific Coordinator) on the request of the Government of Nauru.

The authors would like to acknowledge the inputs of Ms. Mavis Depaune, the Pacific Adaptation to Climate Change Project Coordinator for the Nauru Government, who spent considerable time in locating, providing and reviewing much of the requested information as well as assisting in locating additional sources.

In the preparation of this report, primary sources were used as much as possible. Where primary sources were not available, a large number of secondary and tertiary sources were checked with each source typically providing a small but useful part of the overall picture.

The authors of the report would also like to gratefully acknowledge the contribution of the International Renewable Energy Agency (IRENA) in providing information for this report. IRENA provided the information on renewable energy which is based on the IRENA report "Renewable Energy Opportunities and Challenges in the Pacific Islands Region: Nauru".

The authors would also like to thank the Pacific Power Association and the Pacific Regional Infrastructure Programme (through the Pacific Investment Advisory Centre) for their cooperation during the preparation of this report.

Acronyms

ADO .... Automotive Diesel Oil
AOSIS .... Alliance of Small Island States
AUD .... Australian Dollars (currency)
CIE .... Department of Commerce, Industry and Environment
EEZ .... Exclusive Economic Zone
EU .... European Union
GHG .... Greenhouse gas
GIZ .... German Technical Cooperation
GoN .... Government of Nauru
IRENA .... International Renewable Energy Agency
JICA .... Japanese International Cooperation Agency
km^2 .... Square kilometres
kV .... Kilo Volt (thousands of Volts)
kwh .... Kilowatt hours (thousands of Watt hours)
kWp .... Kilowatts peak (rated output of solar panels)
LED .... Light Emitting Diode
LPG .... Liquid Petroleum Gas
ML .... Megalitres (millions of litres)
MW .... Megawatts (millions of Watts)
MWp .... Megawatt peak (rated output of solar panels)
NASA .... National Aeronautics and Space Administration
NUC .... Nauru Utilities Corporation
OTEC .... Ocean Thermal Energy Conversion
PPA .... Pacific Power Association
SIDS .... Small Island Developing States
SPC .... Secretariat of the Pacific Community
TEPCO .... Tokyo Electric Power Corporation
UN .... United Nations
UNFCCC .... United Nations Framework Convention on Climate Change
USD .... United States Dollar

As of March 9, 2013, the exchange rate was AUD 0.9715 per USD

Executive Summary

In order to achieve Nauru's ambitious goal of reducing the country's high reliance on imported fossil fuel by meeting 50% of its energy needs from renewable energy sources by 2015,[1] the Nauru Government requested technical support from GIZ, SPC and IRENA in the development of a Nauru Energy Road Map in early 2012. The aim of the present report is to provide a stocktake of the current situation in the energy sector of Nauru and therefore inform a baseline which can subsequently be used in the development of the Road Map.

With the decline of its phosphate resource, Nauru remains in a difficult transitional stage between extraordinary national wealth and a return to the resource-poor situation faced by so many small Pacific island nations. In the energy sector, Nauru is moving along in a process of shifting from what amounted to a system of free electricity to tariffs that recover the real cost of power. At the same time the power system comprises a power station dating back to the early 1950's with diesel generators ranging in age from 10 to 37 years old and a distribution system also dating back many decades, all of which urgently need overhaul and replacement. Donor inputs, particularly from Australia, the European Union and Japan, have been generous and the power system is back to a reasonable standard though there is still much to be done.

Petroleum imports

The average amount of petrol purchased by the government for its own use and for distribution is around 1.5 ML a year. Automotive diesel oil (ADO) is around 8.8 ML and jet fuel around 1.3 ML. Liquid Petroleum Gas and kerosene. The Government has frequently relied on grant funding from Australia for the purchase of petroleum imports for the power sector. RONPHOS also do their own purchasing of petroleum products. Liquified petroleum gas (LPG) and kerosene are imported and distributed by the private sector. Diesel fuel and petrol are stored and distributed by NUC to all users except RONPHOS who maintains a separate diesel fuel storage facility for their industrial use. Jet fuel is handled by the national airline Our Airline though NUC does manage its storage along with that of other petroleum products.

Electricity

Nauru's electricity supply comes from a single power station operated by NUC. The generation, transmission and distribution equipment is old, with much of it urgently needing repair or outright replacement. The existing diesel engines have enough capacity to meet demand but if any one engine breaks down, load shedding is necessary. NUC has recently commenced a program of replacing the steel poles with wooden ones as well as the replacement of faulty line fuses to reduce the extended outages. 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 dominated by domestic usage. The weekday baseload is around 2MW with an evening peak of around 3.2MW. The weekend load varies from around 2.5 to 3MW with the peak again in the evening. There is little demand for water heating but a substantial demand for cooking is still present though often electric cooking has been replaced by LPG or kerosene cooking.

[1] Part of the goal set in the National Sustainable Development Strategy (NSDS) 2005-2025

Prepayment meters have been installed since 2009 for most domestic and commercial customers with some (but not all) government offices, including RONPHOS and the NRC, also on prepaid meters.

The tariff is still heavily subsidised, with a residential rate of AUD 0.10/kWh (USD 0.10) up to 300 kWh and $0.20 (USD0.21) per kWh for additional energy. Commercial customers pay a flat rate of AUD 0.25/kWh (USD 0.26). The industrial (phosphate) rate is AUD 0.50 (USD 51.5) per kWh and the government is now being charged a flat rate per month of AUD 0.20 (USD 0.21) per kWh. Full cost recovery is calculated to be AUD 0.49 (USD 51.4) per kwh at the AUD 0.85 (USD 87.6) per litre price in November 2011.

Due to the major structural changes taking place in the Nauru economy, accuracy is very low for forecasting future energy use.

Energy security

In 2012, SPC released 36 energy security indicators for Nauru using baseline data from 2009. While Nauru ranked high in some indicators such as electrification (100%, compared to a SIS average of 68%) and affordable tariffs (14USc/kWh compared to a SIS average of 36USc/kWh), it had low scores for renewable energy share in the overall energy mix at 0.05% and only an estimated 73 days of fuel supply security. No significant programmes have been put in place to improve demand side energy efficiency.

Institutional, regulatory and legal arrangements for energy

The NUC currently provides all electricity services to Nauru except for the Australian refugee camp and the main processing plant of RONPHOS. The status of the utility as a corporation was formalised with the passing of the Nauru Utilities Corporation (NUC) Act which states the legal obligations of the utility. Under the Act, the CEO of NUC reports directly to the Minister of Infrastructure, Communications and Utilities. There are presently no subsidiary legislations or regulations to guide the day to day operations of the utility.

In 2012 NUC developed a Corporate Strategy with technical assistance from the Asian Development Bank including vision, objectives and performance indicators. Priority areas identified in the strategy include: power generation and distribution systems, research and implementation of renewable energy projects, energy efficiency, improved tank farm management and overarching financial management and control and capacity building.

With regard to the institutional framework for energy policy-making, planning and regulation within government, there have been very limited resources dedicated to the energy sector to date with energy placed as one of the portfolios of the Environment Division of the Department of Commerce, Industry and Environment (CIE). There is no single staff with responsibility for the energy sector and this has been managed by CIE staff largely on an “as needed” basis under the direction of the Secretary of CIE.

Renewable energy

The 2005 National Sustainable Development Strategy (NSDS) and the 2009 Energy Policy Framework both state Nauru's aim to make 50% of energy provided through renewable energy by 2015. It is now clear that this cannot be achieved in this time frame as has been acknowledged by Government.

Solar. Measurements show an average of over 6 kWhr/m^2/day with a seasonal variation of around 10-15%. Currently more than 1 MWp of solar PV could be installed although this would be a large infrastructure investment, even without storage. In terms of energy production, a 30% midday demand penetration represents around a 5% energy penetration for the conditions in Nauru.

Wind. Nauru's wind resource is poorly known although, based on airport and NASA wind data, it is probably only marginally cost-effective at present fuel prices.. Measurements already made indicate an annual average wind resource of 4.22 m/sec at 30 meters (about 4.7 m/sec if extrapolated to 50 meters) for 2009-2011.

Biomass. With little or no biomass present at topside, there are currently insufficient biomass resources for either combustion or significant production of biofuels.

Wave. Wave energy in the equatorial region is low with around 10-15 kW/m estimated from satellite observations. Even if wave conversion systems become commercially available, the low resource will make it difficult for Nauru to economically develop wave power.

Ocean Thermal Energy Conversion. There is an opportunity for OTEC energy development once engineering and commercial trials are completed elsewhere. However, it does not appear likely that OTEC can be a part of the Nauru energy economy within the next 10 years, since there still are no OTEC plants anywhere in the world currently producing electricity.

Currently less than 1% of Nauru's electricity is currently generated from renewable resources. The only project in the pipeline for renewable energy generation is a grid-connected solar installation of 132 kWp planned for 2013. Challenges for renewable energy deployment include:

- Low human capacity to meet the requirements for complex project proposals and project management by potential renewable energy financing institutions.
- No single agency has responsibility for renewable energy in the government.
- High cost of access to the island.
- Land tenure issues may be a problem for large-scale installations.
- Nauru's high ambient temperatures, moisture, UV exposure, coral dust and high levels of atmospheric salt create a difficult environment equipment
- Lack of adequate technical capacity for maintenance and repair.
- Small population, with few resulting economies of scale.
- Limited knowledge of renewable energy at high levels of government.
- Lack of a realistic and well-defined action plan to achieve fuel import reduction targets.
- The utility (NUC) is in transition and future load demand is uncertain.

Supply Side Energy Efficiency

NUC has a relatively low internal energy use of 2.27%, a somewhat high 4.43% for technical losses and a very high 15.77% non-technical loss which includes unbilled usage. Non-technical losses are primarily financial losses and though their reduction will improve the financial condition of NUC, they have little effect on actual energy production or use though of course in the long term the utility will be unable to maintain a high quality of service if it cannot maintain an adequate financial return.

Losses in un-billed usage, notably streetlights, can be significantly reduced by replacing existing equipment with energy efficient units. NUC's electricity transmission system is old and overall distribution losses could also be reduced by simple replacement of worn out equipment. The EU are currently funding a distribution network rehabilitation project. NUC management would like to see a complete rebuild of the system moving the overhead system to below ground.

A general survey of the existing distribution system should be carried out and, if shown to be economically reasonable, a plan prepared for upgrading and/or changing to an underground system. This would allow better management of energy flows in the distribution system through centralized controls at the power house and reduce basic losses in the system components.

More fuel efficient engines are available and fuel efficiency should be a high priority when replacing existing engines or adding capacity. The NUC generators are aged and in poor condition, as indicated by the high level of de-rating of all the units. The average fuel efficiency of the diesel generators is 3.6 kWh/l, which is considerably lower than the Pacific average of 3.8kWh/l (PPA, 2012).

The primary challenge for implementation of supply side energy efficiency measures appears to be access to funds for the needed capital investments and management of contracts to bring in overseas contractors to carry out much of the maintenance, repair and replacement work.

In general it is clear that NUC management has a good understanding of how to improve supply side efficiency but does not have access to the funds and human resources needed to carry out the actions. Benefits from supply side energy efficiency should be highlighted where they are cost-effective and put forward for support alongside renewable and demand side energy efficiency.

Demand Side Energy Efficiency

Decades of very low (or no) electricity costs for energy consumers has resulted in a much higher per-capita energy usage than is seen in most island countries. Therefore, there are many opportunities for energy efficiency improvements, particularly in the residential and government sectors. However, until there is a better understanding of the actual energy use patterns and the energy using equipment's characteristics, well targeted programmes to reduce energy consumption cannot be confidently prepared. Surveys and audits should precede the design of programmes for demand side management (DSM).

From 2007 to 2010 various demand-side activities were undertaken in Nauru under the auspices of the REP-5 project, funded by the European Union. These included in 2009 the installation of over 1800 pre-payment meters in homes and businesses. A demand-side energy efficiency action plan was also drafted and two energy efficiency officers were hired. The two officers carried out an awareness campaign on energy efficiency and conservation that targeted homes and small businesses. However, after the end of the project in 2010, the energy efficiency officer contracts were not renewed and the campaigns were not sustained. This shows the kind of long-term continuous measures required for DSM cannot be dependent only on external short-term project funding.

A major driver of demand side energy efficiency is the energy price. So long as energy costs remain artificially low, as has long been the case in Nauru, programmes to improve demand side efficiency will tend to have only a short term effect with energy usage soon rising back to pre-programme levels after the programme concludes. For demand side energy efficiency programmes to have the longest lasting benefit, the energy using hardware needs to be upgraded with low maintenance, long lived, high efficiency equipment and consumers must expect substantial price hikes for energy in the future (e.g. a government plan to reduce subsidies on electricity).

Data collection needs

In order to plan future programmes and projects in Nauru's energy sector and monitor progress toward the goal of providing 50% of Nauru's energy with renewable energy, it is essential that good data is collected.

Unambiguous, accurate and reliable records of the quantity of fuel imports, their timing and the specific type of fuel imported are needed. Fossil fuel usage for land transport, sea transport and air transport should be accurately collected along with the patterns of usage of energy for each type of transport. Fossil fuel use for electricity generation and the pattern of electricity usage are essential data. Diurnal electricity load patterns, load patterns on different days of the week are also very important data needed.

Data regarding the electricity generation, transport and other services that are provided by renewable energy must also be collected. As new renewable energy projects are installed, the energy they provide and information on the use made of it should be collected.

In order to be able to design renewable energy systems and predict their performance, a good understanding of the renewable energy resource on Nauru is required over long periods of time. There is currently collection of some solar resource data on Nauru. However, the wind resource monitoring equipment has been damaged and the reliability of the data it is collecting is questionable. There are no other resource monitoring programmes currently underway.

In order to be able design effective DSM programmes there is a need for NUC to be able to synthesise monthly energy usage for individual customers and businesses. The necessary software will need to be obtained through the supplier of the prepayment meters. A detailed survey of household and small business energy use will be needed and energy audits of commercial entities, RONPHOS and Government offices.

Since roughly 30% of electrical energy supplied by NUC is used for water desalination, a detailed audit of the entire water system from connection to the grid through end use is required.

A general survey of the vehicles and boats in Nauru and their patterns of use is needed to properly design energy efficiency improvement programmes for Nauru transport.

1 Introduction

1.1 Nauru Energy Road Map

In order to achieve Nauru's ambitious goal of reducing the country's high reliance on imported fossil fuel by meeting 50% of its energy needs from renewable energy sources by 2015,[2] the Nauru Government requested technical support from GIZ, SPC and IRENA in the development of a Nauru Energy Road Map in early 2012. In response to the request, GIZ, SPC and IRENA agreed to offer a joint technical assistance to develop the Nauru Energy Road Map.

The first kick-off workshop held in May 2012 confirmed that it is critical to introduce more reliable and sustainable energy in order to reduce high dependency on imported fossil fuel. The key drivers of the road map were identified as:

- Reduce dependence on fossil fuels
- Improve planning and coordination (within the energy sector)
- Improve Energy Efficiency
- Improve cost-effectiveness of energy
- Provide more reliable, sustainable and clean energy
- Attract funding to the energy sector

It was agreed that the Energy Roadmap should take a "whole-of-sector approach" including both energy efficiency and renewable energy assessments.

In July 2012, GIZ, SPC and IRENA established a Technical Assistance (TA) team to support the development of the Roadmap. In November, the Nauru Government organized a second national consultation workshop to define the framework of the development of the Energy Roadmap including the vision, approach and methodology and to discuss the key strategies, activities and timelines in various sectors to reduce the dependency on imported fossil fuel. There was a general consensus that the Energy Roadmap should serve as an implementation plan for the 2009 National Energy Policy Framework (NEPF) and the 2005 (revised 2009) National Sustainable Development Strategy (NSDS). The vision of these policies is to provide a reliable, affordable, secure and sustainable energy supply to meet socio-economic development needs of Nauru.

1.2 Aims of the report

The aim of the present report is to provide a stocktake of the current situation in the energy sector of Nauru and therefore inform a baseline which can subsequently be used in the development of the Nauru Energy Road Map. As such, this report will present:

- General country context (geography, economy, population, etc.)
- Energy sector landscape covering supply and demand and institutional arrangements
- Experience, potential and challenges in the use of renewable energy and energy efficiency
- Data needs for the energy road map and beyond

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[2] Part of the goal set in the National Sustainable Development Strategy (NSDS) 2005-2025

2 Country context

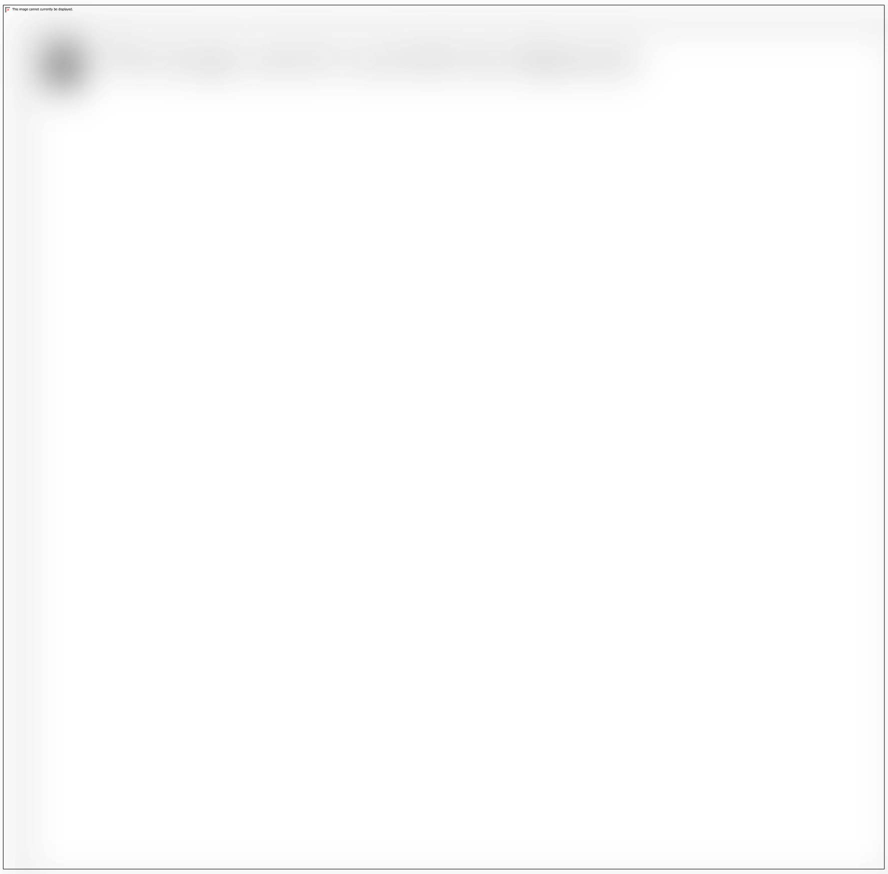

Figure 1 - Map of Nauru and its location

Source: Government of Nauru

2.1 Physical Description

Consisting of a single, isolated raised coral equatorial island, Nauru lies about halfway between Sydney and Honolulu. Its total land area is 21 km^2 with an Exclusive Economic Zone (EEZ) of 320 000 km^2. The island is divided into two separate 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. Fresh water is a serious problem on Nauru with potable water coming only from rainwater collection and reverse osmosis desalination plants. These plants used around 30% of the electricity generated by Nauru Utility Corporation (NUC) in 2008.

2.2 Population

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

2.3 Environment

The climate is equatorial and marine in nature. There are no cyclones, although rainfall is cyclic and periodic droughts are a serious problem. On average, Nauru experiences a drought period every 5.2 years and each drought has an average length of 19 months. There has been a recorded period of drought that has lasted up to three years (GoN, 2012). Rainfall averages 2080 mm per year but one year recorded only 280 mm of rainfall. 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. Leakage from the petroleum tank farm and tanks at Aiwo district also is an environmental problem. Sewage is dumped into the ocean just beyond the reef causing while the island's many poorly maintained septic tanks have further contaminated the groundwater. As with other small island developing State (SIDS), Nauru is highly vulnerable to the impacts of climate change. Nauru already suffers from the effects of inter-annual variability in climate and sea-level and any long-term mean changes in temperature and rainfall will further exacerbate the problems being experienced.

2.4 History and culture

There are both Polynesian and Melanesian influences in Nauru's historical and social make-up, but the local language is unique and not clearly related to any other single language. The first recorded sighting of the island was by a British ship in 1798. From 1888 Nauru was administered by Germany but Australia took possession in 1914 and, after World War I, the League of Nations made Nauru a co-trusteeship of Australia, New Zealand and Britain. In 1942, the island was taken over by Japan and occupied for the duration of World War II. After the war, the United Nations re-established Nauru's trusteeship relationship with Australia, New Zealand and Britain with Australia as administrator. On January 31, 1968, Nauru became politically independent.

The Nauruan culture as we know it today is a combination of traditions adopted from other pacific island states such as Kiribati and other Micronesian states as well as Tuvalu. Efforts now are being made to research and revive the Nauruan cultural and traditional practices including preserving the language in written form.

2.5 Political development

Nauru has a Westminster parliamentary system with a single chamber of 19 members elected for a three-year term. The parliament elects one of its members as President who acts as both Head of State and Head of Government. Nauru has had frequent changes of government in recent years, usually directly or indirectly due to problems associated with its failing economy. Nauru is a member of most Pacific Island economic and environment associations and a signatory to most of the economic and environment treaties that affect the Pacific. Nauru became a member of the

Commonwealth and the United Nations (UN) in 1999. Nauru ratified the UNFCCC and the Kyoto Protocol and currently is the chair of the Alliance of Small Island States (AOSIS), a coalition of small island and low-lying coastal countries that share similar development challenges and concerns about the environment, especially their vulnerability to the adverse effects of climate change. AOSIS functions primarily as a lobbying and negotiating voice for SIDS within the UN system.

2.6 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. Although a Nauru Phosphate Royalties Trust was established to provide income after the phosphate was mined out, poor management of the trust resulted in its rapid depletion, making Nauru essentially bankrupt.

In 2005, through a managerial restructuring, the Nauru Phosphate Corporation became the Republic of Nauru Phosphate Corporation (RONPHOS) and began plans to access the remaining pockets of phosphate. In 2006 work began on accessing the leftovers from earlier mining and shipments again began, though at a low level. Some income flow resumed in 2007 and production in 2009 was a modest, but welcome, 41 549 tonnes. There is thought to be a second layer of phosphate bearing rock below the existing mined out area and if that is correct, some income from phosphate shipments could continue for several decades.

Although Japan has assisted in 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 the Nauru's operating funds in recent years have come from Australia as payment for damages to the environment during the years of mining; through payments to Nauru for hosting refugee populations that Australia was unwilling to host on its own soil; 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 and Nauru is dependent on Australia to keep most of its public services operating. Essentially, all fuel for transport and power generation is provided by Australia.

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. Under the Nauru-Australia Compact of Settlement (NACOS) which ended litigation by Nauru against Australia in the International Court of Justice over rehabilitation of phosphate land mined before independence, Australia paid Nauru $57 million in cash and agreed to provide $50 million over a period of twenty years (paid in annual installments of $2.5 million indexed at 1993 values, e.g. $3.7 million in 2008-09). The expenditure of these funds is governed by the Rehabilitation and Development Cooperation Agreement (RADCA). Australia and Nauru are cooperating closely on using NACOS funds to facilitate the mining of residual primary and, later, secondary phosphate reserves, followed by the rehabilitation of mined-out lands. However, there has been little visible progress in rehabilitation of mined areas to date.

3 Energy landscape

3.1 Introduction

With the decline of its phosphate resource, Nauru remains in a difficult transitional stage between extraordinary national wealth and a return to the resource-poor situation faced by so many small Pacific island nations.

In the energy sector, Nauru is moving along in a process of shifting from what amounted to a system of free electricity to tariffs that recover the real cost of power. At the same time the power system comprises a power station dating back to the early 1950's with diesel generators ranging in age from 10 to 37 years old and a distribution system also dating back many decades, all of which urgently need overhaul and replacement.

Donor inputs, particularly from Australia, the European Union and Japan, have been generous and the power system is back to a reasonable standard[3] though there is still much to be done.

A National Energy Policy has been in place since 2009 and the government has established goals for the increased use of renewable energy (with a target to reach 50% of the overall supply) and improved efficiency on the part of both the utility and energy customers.

To help coordinate this transition and help relieve Nauru from its almost total dependence on fossil fuels, the government has asked IRENA, GIZ and SPC for assistance in developing a road map, or action plan, to set and achieve renewable energy and energy efficiency goals. An initial draft is expected in the second half of 2013.

3.2 Energy Supply and Demand

3.2.1 Petroleum

The average amount of petrol purchased by the government for its own use and for distribution is around 1.5 ML a year. Automotive diesel oil (ADO) is around 8.8 ML and jet fuel around 1.3 ML. The government regulates the resale price of fuels with revisions every shipment. Government does not charge throughput fees. Shortages have occurred due to a lack of funds in the government budget to make timely purchases, resulting in times of voluntary petrol rationing and rolling blackouts of electricity.

Table 1 – Fuel imports 2006-2010

Fuel Type	2006	2007	2008	2009	2010
Actual Diesel	8 144 167	5 334 340	8 074 821	8 671 864	8 842 138
Actual Petrol	1 092 549	1 164 518	1 409 669	1 447 507	1 467 753
Actual Jet Fuel	520 245	954 996	963 200	N/A	N/A

Source: NUC, 2012

[3] From circa 2005 to 2009 Nauru experienced scheduled rolling black-outs. From late 2009 a 24 hour electricity service was restored, although brown-outs and black-outs are still regular occurrences.

3.2.2 Liquid Petroleum Gas and kerosene

Liquified petroleum gas (LPG) is used by many households for cooking. It is also reportedly being used for cooking by restaurant businesses. It is provided by two private importers, Central Meridian (CMI) and Capelle & Partner (LAVA GAS). Retail prices were observed to be in region of 60 AUD for an 11kg cylinder. Information about kerosene use for cooking was not available but its cost is high, with the retail price observed as AUD 7 per litre[4].

3.2.3 Electricity

3.2.3.1 Electricity supply

Nauru's electricity supply comes from a single power station operated by NUC. Most of the power now comes from four ageing medium-speed Ruston stationary engines with a high-speed Cummins generator providing essential supplementary capacity. Table 2~~Table 2~~ below provides information on the generators.

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Table 2 - Installed Diesel Capacity

Generator Type	Rating (MW)	Speed (RPM)	Year Installed	Running Hours	De-rated Capacity (MW)
#1 Ruston	2.6	750	1989	29,841	1.0
#4 Cummins	1	1,500	2008	6,650	0.35
#5 Ruston	2.0	750	1976	19,629	Out of Service
#6 Ruston	2.0	750	1977	22,102	1.6
#7 Ruston	2.8	750	2008	22,633	1.2
Total	10.4				4.15

Source: PPA, SPC-GIZ CCCPIR, 2013

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 existing diesel engines have a nameplate total of 10.4 MW power generation capacity, but have been de-rated to 4.15 MW. This is enough to meet demand but if any one engine breaks down, load shedding is necessary. This also means that NUC does not currently have sufficient capacity to carry out planned or scheduled generator maintenance without causing load shedding.

The Nauru Economic Infrastructure strategic Investment Plan (NIESIP) prepared in January 2012 called for the establishment of an O&M spare parts store and workshop for NUC to enable more regular and timely maintenance of its gensets and reduce lead time for spare parts. However, there has been no progress on this project to date and AusAID is providing spare parts and equipment on an ad hoc basis.

The distribution system is in a ring main configuration and includes 11 kV, 3.3 kV and 415 V sections. There are three (3) 11 kV radial feeders; Ringmain North, Ringmain South and Ringmain East; with inter-tie points and two (2) 3.3 kV feeders.

[4] Observation made in retail outlets during SPC-GIZ CCCPIR technical mission, November 2012

The overhead transmission/distribution network is ageing and large parts are in need of overhaul and/or complete replacement. NUC has recently commenced a program of replacing the steel poles with wooden ones as well as the replacement of faulty line fuses to reduce the extended outages. NUC also plans to look at replacing and upgrading various transmission/distribution equipments with funding from the EU to cater for future load growth and future renewable energy generation that is connected to the grid.

At present NUC has a number of important positions in power generation and transmission and distribution which are vacant. This is having an impact on the performance of the utility.

3.2.3.2 Electricity demand

Currently maximum demand is around 3.3 MW. 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 3 – Total generation and fuel use 2008-2010

Year	Actual generation MWh	Fuel used (litres)
2008	19 382	5 929 740
2009	21 174	6 299 460
2010	22 462	7 181 100

Source: NUC, 2012

Daily load curves for 2010, as shown in Figure 2 below, indicate a weekday baseload of around 2MW and an evening peak of around 3.2MW, probably due to cooking using electric ovens. The weekend load varies from around 2.5 to 3MW with the peak again in the evening. There is little demand for water heating but a substantial demand for cooking is still present though often electric cooking has been replaced by LPG or kerosene cooking.

Figure 2 – Load curves for 2010

Source: NUC, 2011

3.2.3.3 Electricity tariffs

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 (although there is likely a significant variation between households). Home ownership of multiple air-conditioners is common (though often unused due to their high cost), as are electric cookers, freezers and refrigerators.

To gradually shift the population to paying for electricity, prepaid meters have been installed since 2009 for most domestic and commercial customers with some (but not all) government offices, including RONPHOS and the NRC, also on prepaid meters.

The tariff is still heavily subsidised, with a residential rate of AUD 0.10/kWh (USD 0.10) up to 300 kWh (lifeline threshold) and $0.20 (USD0.21) per kWh for additional energy. It should be noted that 300kWh is very high a lifeline allocation. Commercial customers pay a flat rate of AUD 0.25/kWh (USD 0.26). The industrial (phosphate) rate is AUD 0.50 (USD 51.5) per kWh and the government is now being charged a flat rate per month of AUD 0.20 (USD 0.21) per kWh.

Full cost recovery is calculated to be AUD 0.49 (USD 51.4) per kwh at the AUD 0.85 (USD 87.6) per litre price in November 2011, so the subsidy to residential customers is well in excess of 50%. Currently RHONPHOS is the only entity paying for electricity at a cost-recovery tariff. The total overall subsidy could be gradually reduced as customers become more energy-efficient and fewer kWh have to be subsidised even if tariffs and energy costs remain unchanged.

Table 4 – Customer Meters 2011

Sector	Number of prepaid customers	Number of billed customers
Residential	1980	42
Commercial	124	48
Industrial	0	2
Government	0	32

Source: NUC, 2012

Even though there are only 20 public streetlights on Nauru and their consumption is very small, conversion to high-efficiency LED lights is being considered. These lights are not metered and the cost for running them is born by NUC.

3.2.4 Future growth in energy demand

Due to the major structural changes taking place in the Nauru economy, accuracy is very low for forecasting future energy use. It is possible that fuel use will not increase, and may even decrease, over the next decade as electricity prices are increased 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. It appears that only the use of jet fuel may have any significant growth over the next 10 years and that is not likely if Our Airline (the national airline of Nauru) cannot expand its operations.

3.2.5 Energy security

A UN ESCAP report released 2012 stated that "*The dependence of Pacific countries on fossil fuels for their energy needs presents a major threat to energy security and economic stability*."[5] This statement holds true for Nauru which is currently extremely depended on imports for all its energy use and as has very high exposure to fuel price rises. With its very limited land area and mining out of a large part of this, traditional use of biomass for cooking is limited. Alternatives such as kerosene and LPG are expensive imports. Electricity generation is also 99% dependent on imported fuel. Solar energy is the only proven renewable energy resource which could be utilised in short to medium term to reduce dependency on fuel imports for electricity generation. The country's vulnerability is also increased by its isolation from other islands, making shipping of any product more expensive than other Pacific Island Countries.

In 2012, SPC released an energy profile of Nauru based on 36 energy security indicators using baseline data from 2009. While Nauru ranked high compared with other Pacific Small Island States (SIS) in some indicators such as electrification (100%, compared to a SIS average of 68%) and affordable tariffs (14USc/kWh compared to a SIS average of 36USc/kWh), it had low scores for renewable energy share in the overall energy mix at 0.05% and only an estimated 73 days of fuel supply security. No significant programmes have been put in place to improve demand side energy efficiency (SPC, 2012).

3.3 Institutional, regulatory and legal arrangements for energy

3.3.1 Nauru Utilities Corporation

Until 2005, the Nauru Phosphate Corporation provided all the island's electricity and water 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 corporatize NUA and the Nauru Utilities Corporation (NUC) was created.

In June 2011, the status of the utility as a corporation was formalised with the passing of the Nauru Utilities Corporation (NUC) Act which states the legal obligations of the utility. Under the Act, the CEO of NUC reports directly to the Minister of Infrastructure, Communications and Utilities. The current organizational structure of NUC is shown in Figure 3~~Figure 3~~ below.

Whilst the structure is straightforward, it does not provide a buffer between the management of the operations of the utility and the elected government. The direction of the utility is directly exposed to changes in governments which could lead to difficulties in medium and long term planning.

[5] Green Economy in a Blue World: Pacific Perspectives, ESCAP, September 2012

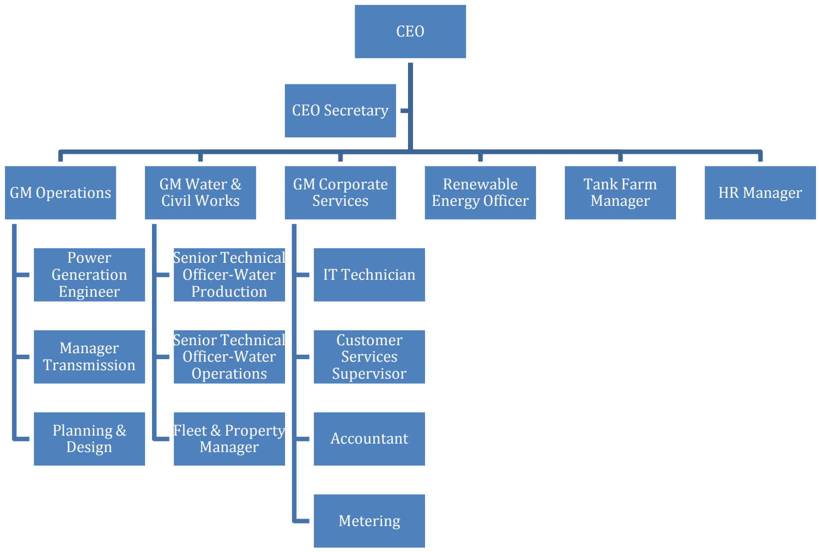

Figure 3 - Organizational structure of NUC

It should also be noted that although the NUC Act sets up the aims and responsibilities of the utilities corporation, there are presently no subsidiary legislations or regulations to guide the day to day operations of the utility.

In 2012 NUC developed a Corporate Strategy with technical assistance from the Asian Development Bank including vision, objectives and performance indicators. Priority areas identified in the strategy include: power generation and distribution systems, research and implementation of renewable energy projects, energy efficiency, improved tank farm management and overarching financial management and control and capacity building.

The NUC currently provides all electricity 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 all customers except RONPHOS who do their own purchasing. Diesel fuel and petrol are stored and distributed by NUC to all users except RONPHOS who maintains a separate diesel fuel storage facility for their industrial use. Jet fuel is handled by the national airline Our Airline though NUC does manage its storage along with that of other petroleum products. LPG and kerosene are privately imported and distributed.

3.3.2 Government institutional arrangements

With regard to the institutional framework for energy policy-making, planning and regulation within government, there have been very limited resources dedicated to the energy sector to date with energy placed as one of the portfolios of the Environment Division of the Department of Commerce, Industry and Environment (CIE). There is no single staff with responsibility for the energy sector and this has been managed by CIE staff largely on an "as needed" basis under the direction of the Secretary of CIE. An approximate institutional mapping of the energy sector is given in Figure below.

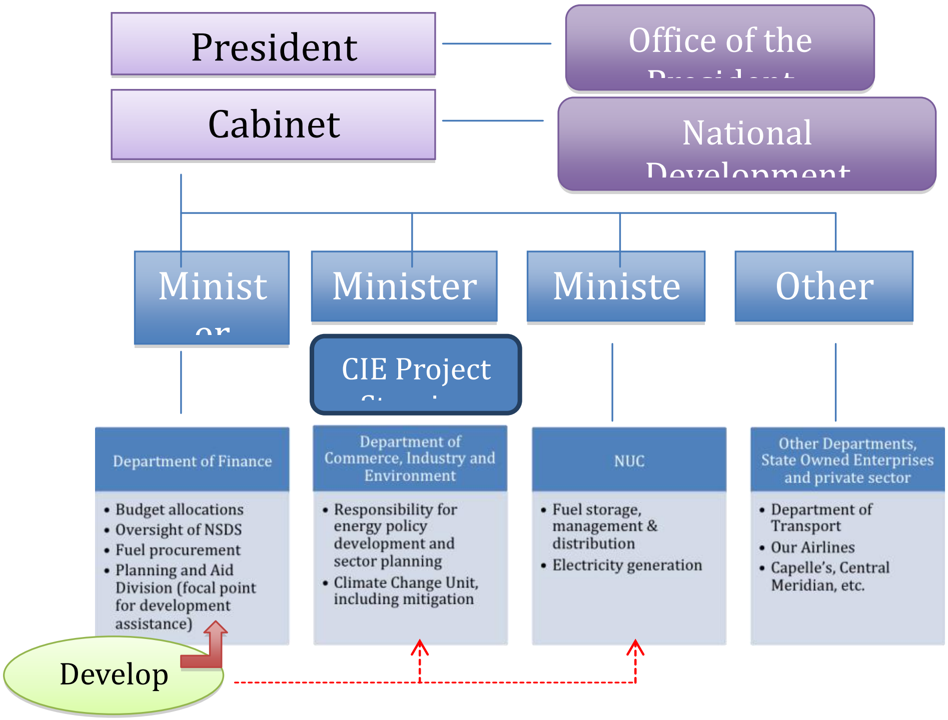

Figure 4 - Energy institutional map

Since 2004, development partners have made significant contributions to the energy sector. Funding for equipment, technical assistance and fuel procurement is channelled through the Ministry of Finance but as the diagram shows there is also some technical assistance channelled to other sectoral departments such as energy which does not always go directly through the Department of Finance. A non-exhaustive list of development partner assistance to the Nauru energy sector is given in Annex 1 to this report.

Although CIE has the responsibility for energy policy and planning, there is no dedicated staff at present. A Renewable Energy Officer is accommodated at NUC and is primarily responsible for renewable energy project implementation and for energy efficiency campaigns. There is also an Assistant Renewable Energy Officer, although this position does not seem to be formalised.

Prior to the 2009 Nauru Energy Policy Framework, renewable energy was not 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 essentially no use of renewable energy until 2008 when the European Union REP-5 project installed 40 kWp of grid-connected solar panels on Nauru College. Since then a 30kWp solar PV system was installed on the government buildings in Yaren district, bringing the total grid-connected renewable energy generation capacity to 70kWp. Recently, there have been installations of solar home systems donated by Chinese Taipei institutions and distribution to households of solar powered torches.

A list of key energy-sector related policies and legislations is given in Table X below.

Table 5 - Key policy, legislation and strategic planning documents

Year	Legislation, policy, strategic planning document
2005 (rev. 2009)	National Sustainable Development Strategy 2005-2025
2006	Nauru's Utilities Sector – A Strategy for Reform
2008 (draft)	Nauru Energy Efficiency Action Plan 2008-2015
2009	National Energy Policy Framework
2011	Nauru Utilities Corporation Act
2012	Nauru Economic Infrastructure Strategic Investment Plan
2012	Nauru Utilities Corporate Strategy

Today Nauru is working on an energy road map, including action plans for the development of renewable energy and energy efficiency sufficient to significantly lower imports of diesel fuel for electricity generation.

3.4 Monitoring framework

There is a very limited framework for monitoring and evaluation of progress in the energy sector. This is based on dispersed documents and ad hoc assessments often funded by development partners on request from the Government of Nauru.

The NUC Corporate Strategy developed in 2012 summarizes the major strategic directions NUC will pursue over the coming three to five years. It includes specific objectives and Key Performance Indicators (KPIs) with the aim to achieve outcomes related to each objective within set timeframes.

Some monitoring is also done indirectly as part of the NSDS review, which includes energy under the section on Infrastructure. The NSDS was launched in 2005 and is meant to be reviewed every 3 years. There was a review in 2009; however, the next review has been postponed to 2014.

There is also some monitoring and evaluation of the energy sector through the annual process of planning and budgeting which is undertaken with AusAID.

4 Renewable energy

4.1 Renewable energy opportunities

The 2005 National Sustainable Development Strategy (NSDS) and the 2009 Energy Policy Framework both state Nauru's aim to make 50% of energy provided through renewable energy by 2015. It is now clear that this cannot be achieved in this time frame as has been acknowledged by Government.

The development of an Energy Road Map was included in the 2012 Nauru Economic Infrastructure Strategic Investment Plan (NEISIP) with the aim to progressively replace the use of fossil fuels with renewable energy.

Solar. 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, due to the intermittency of the resource, expensive electrical storage systems will~~would~~ be required for it to be included into 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 the midday demand. Above this threshold, storage and control systems will probably have to be introduced to ensure grid stability. This still means that currently as much as~~more than~~ 1 MWp of solar PV could be installed although this would be a large infrastructure investment, even without storage. In terms of energy production, a 30% midday demand penetration represents around a 5% energy penetration for the conditions in Nauru.

Wind. Nauru's wind resource is poorly known although, based on airport and NASA wind data, it is probably only marginally cost-effective at present fuel prices. Data collection, funded by PIGGAREP[6] and the EU, has been carried out for more than three years at a telecommunications tower at Anabar District on the northern part of the island where the wind resource is expected to be greatest but tower components near the measurement instruments that may change both the speed and direction of the wind seen at the instruments lowers the confidence in the collected data. ~~is currently in progress at a telecommunications tower at Anabar District on the northern part of the island.~~ Measurements already made indicate an annual average wind resource of 4.22 m/sec at 30 meters (about 4.7 m/sec if extrapolated to 50 meters) for 2009-2011. These figures are at the low end of practicality for wind energy generation. A resource assessment using a more suitable 50 metre guyed mast is underway and is intended to determine the appropriateness of further wind energy development and to assess the quality of the data already collected from the nearby telecommunications tower.~~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 at topside, there are insufficient biomass resources for either combustion for electricity or significant production of biofuels. Land rehabilitation may eventually result in topside biofuel plantations if suitable fast growing plants can be grown in the rehabilitated area, but certainly no production will be seen within the next decade.

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[6] PIGGAREP funded the first 12 months (2009-2010) of the wind data collection. The EU funded an additional two years (2010-2011).

Wave. Wave energy in the equatorial region is low with around 10-15 kW/m estimated from satellite observations. Wave devices are being tested at the prototype stage around the world, however, none are yet commercially proven. Even if wave conversion systems become commercially available, the low resource will make it difficult for Nauru to economically develop wave power.

Ocean Thermal Energy Conversion. With the very rapid drop-off that occurs beyond the reef, there is an opportunity for OTEC energy development once engineering and commercial trials are completed elsewhere. However, it does not appear likely that OTEC can be a part of the Nauru energy economy within the next 10 years, since there still are no OTEC plants anywhere in the world currently producing electricity.

4.2 Experiences with Renewable Energy Technologies

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

- Solar water heating was used to some extent in the 1980s but most of the systems failed after a few years of use and were not repaired. Currently there is little demand for water heating systems. However those few households presently using electric tank type electric water heaters should be encouraged to replace them with either demand type electric water heaters or, preferably, solar water heaters.
- The Japanese utilities company TEPCO undertook a technical trial of OTEC in 1981 with an experimental plant on the west coast of Nauru that produced a net power of 15 kW for a short time before being damaged by a storm. The trial was mainly designed as a proof of concept to gain experience with the technology and it has not resulted in further development of OTEC in Nauru.
- In 2008, the REP-5 project of the EU installed a 40 kWp grid-connected installation on the roof of Nauru College. NUC states that the installation produced 157,336 kWh from June through October 2011.
- Sixty solar home systems of 130 Wp capacity, which included LED lights, have been provided by Taiwan though their operational status is not known. All were installed on homes already connected to the grid so only the lighting load is affected.
- ~~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 and smaller units installed in less travelled residential areas. .
- Although some 160 Wp arrays for solar-powered district water pumps have been installed through JICA funding, details of their number or their status are not available.
- A few households have private solar water pumping systems, although the number and capacity of these is not known.

- Solar PV and small-wind turbines with batteries were installed on power poles sometime in 2009 with the intention to power the telecommunications system. However, the project was not completed as intended and some of the batteries were used for alternative purposes, while some of the solar PV panels remain unused.
- In 2013, a grid-connected solar installation of 132 kWp was installed across two roofs on government buildings near the power plant to offset the electrical energy needed to operate the reverse osmosis plant that was installed through the PEC fund of Japan in early 2013. Operational data is not yet available.
- Solar powered torches with LED lights donated by Taiwan 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 and installed at the government offices building in 2012. In late 2012 this was expanded to a total of 30kWp.
- Twenty solar stills for water purification were purchased and installed on private residences in areas with a particular vulnerability to water shortages.

Looking to future installations, the only current project in the pipeline for renewable energy generation which has funding secured is a grid-connected solar installation of 132 kWp planned for 2013 to offset the fossil fuel cost of powering an additional reverse osmosis plant to be installed through the PEC fund of Japan. This system would be installed within the NUC compound. AA summary of renewable energy projects in Nauru is given in Table 6 below.

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Table 6 – Summary of past, current and proposed renewable energy projects

Technology	Installation Date	Capacity	Implementing Entity	Funding Entity	Operating in 2013
Solar Water Heaters	1980s	Unknown	GoN	GoN	No
OTEC	1981	150 kW gross, ~15kW net	TEPCO	Japan	No
Grid Connected solar PV	2008	40 kWp	GoN/NUC/IT Power	European Union	Yes
Solar PV and small wind turbine system	2009	Unknown	GoN	Unknown	No
Solar home systems	Unknown	7.8 kWp (60 SHS at 130 Wp each)	GoN/NUC	Chinese Taipei Inst.	Yes
Solar street lights	Unknown	155 units (130Wp)	GoN/NUC	Chinese Taipei Inst.	Some
Solar water pumps	Unknown	160Wp (quantity unknown)	GoN/NUC/ private	JICA/private	Yes
Solar LED lights	Unknown	Unknown	GoN/NUC	Chinese Taipei Inst.	Unknown

Solar stills	2011	20 units with 4 panels per unit	GoN/PACC project	AusAID	Yes
Grid connected solar PV	2012	30 kWp	GoN/NUC	Chinese Taipei Inst.	Yes
Grid connected solar PV	2013~~Planned~~	132 kWp	GoN/NUC	PEC Fund	n/a
Grid connected solar PV	Proposed	1.78 MWp	GoN/NUC	Unknown	n/a

4.3 Challenges for renewable energy deployment

As evidenced by the slow progress in development of renewable energy in Nauru over the past 30 years, there are a number of challenges to deploying renewable on the island. Some of these challenges are typical of Pacific Small Island States and other small islands around the world; others are specific to the context of Nauru. Below some of the challenges that are more specific to Nauru are listed although this is not an exhaustive list:

- There is a low human capacity to meet the requirements for complex project proposals and project management by potential renewable energy financing institutions.
- No single agency has responsibility for renewable energy in the government.
- High cost of access to the island.
- Land tenure issues may be a problem for large-scale installations.
- Nauru’s high ambient temperatures, moisture, UV exposure, 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 high levels of government.
- Lack of a realistic and well-defined action plan to achieve fuel import reduction targets.
- The utility (NUC) is in transition and a declining load is possible as industrial use declines while tariffs rise and users adopt energy-efficiency measures. Any renewable energy that is added now should consider this possibility and be capable of being upgraded to include either advanced controls or storage that reduces the rate of variation even though it may not be needed at present.

5 Supply Side Energy Efficiency

For a power station, supply side energy efficiency is determined by the ratio of kWh delivered to loads to kWh generated at the alternator. It includes all station usage such as energy to operate fuel transfer pumps, control systems, cooling fans and other equipment in the power house. It also includes all losses that occur in transformers, switchgear and the transmission and distribution wiring. Two main classes of supply side losses are usually measured, technical and non-technical system losses.

Technical losses are those that relate to the difference between energy generated and energy actually delivered to a load somewhere on the system. Non-technical losses relate to the difference between energy delivered to loads on the grid and energy actually paid for by customers on the grid (energy sales). Technical losses directly affect the import of fuel needed for generation on a per kWh basis. Non-technical losses affect the financial return to the utility and the tariff required to be charged to paying customers in order to recover the overall cost of energy delivery.

In the case of Nauru and the development of the Energy Road Map, engine fuel efficiency – the number of kWh generated per litre of fuel – is also a measure of supply side efficiency that must be included in the analysis.

5.1 Supply side energy efficiency opportunities

In 2012, a PPA sponsored study determined that NUC has a relatively low internal energy use of 2.27%, a somewhat high 4.43% for technical losses and a very high 15.77% non-technical loss which includes unbilled usage. Non-technical losses are primarily financial losses and though their reduction will improve the financial condition of NUC, they have little effect on actual energy production or use though of course in the long term the utility will be unable to maintain a high quality of service if it cannot maintain an adequate financial return.

Losses in un-billed usage, notably streetlights, can be significantly reduced by replacing existing equipment with energy efficient units. NUC's electricity transmission system is old and overall distribution losses could also be reduced by simple replacement of worn out equipment (high-voltage transmission switches, circuit breakers, etc.) but the large investment required needs to be economically justified by the energy savings that will result. The EU are funding a rehabilitation project, which includes procurement and installation of equipment to the value of 1.3m Euros. NUC management would like to see a complete rebuild of the system moving the overhead system to below ground.

A general survey of the existing distribution system should be carried out and, if shown to be economically reasonable, a plan prepared for upgrading and/or changing to an underground system. This would allow better management of energy flows in the distribution system through centralized controls at the power house and reduce basic losses in the system components.

More fuel efficient engines are available and fuel efficiency should be a high priority when replacing existing engines or adding capacity. The NUC generators are aged and in poor condition, as indicated by the high level of de-rating of all the units. The average fuel efficiency of the diesel generators is 3.6 kWh/l, which is considerably lower than the Pacific average of 3.8kWh/l (PPA, 2012).

Non-technical losses in NUA are considered excessive and need to be addressed by management but though a reduction of those losses will provide benefits with regards to the tariff that needs to be set to break even, it will have little or no effect on the quantity of fuel used per kWh generated.

Table 5 – Summary of initial supply-side energy efficiency opportunities

Area	Item	Description

Unbilled usage	Street lights	Replace existing street lights with energy efficient street lights, bill communities or GoN for street lighting, investigate and stop electricity theft.
Non-technical losses other than unbilled usage	Unpaid or extraordinarily late payments of bills	Install prepaid meters for all customers on standard meters who are not paying bills on time.
Technical losses	Distribution system	A general survey of the existing distribution system should be carried out and, if shown to be economically reasonable, a plan prepared for upgrading.
Technical losses	Generation	Selection of more fuel efficient engines when replacing existing engines or adding capacity

5.2 Experience with supply side energy efficiency

In general, supply side efficiency improvements have been found to have a longer life and more predictable results than those attempted on the demand side. With supply side efficiency actions, the utility has full control over the improvements and their maintenance and has specialized staff available to install and maintain the gains in efficiency provided by the improvements. Demand side improvements require significant actions by a large and diverse group of customers who all must have the persistence and skills needed to maintain the gains made, else the efficiency initially gained will be slowly lost over time.

After the sudden fuel price spike of 2008, the managements of most Pacific utilities have become increasingly interested in pursuing supply side efficiency improvements. For a number of years, the Pacific Utilities have been supported by the Pacific Power Association (PPA) through the provision of the training and technical support needed to improve supply side efficiency.

The Nauru utility has made great strides over the past 10 years in improving generation efficiency and as shown by the 2012 PPA study has a level of technical losses that is comparable to that of other Pacific utilities of a similar size – though improvement is certainly still possible. A programme of repairs and equipment replacement for the distribution network has commenced with funding from the EU although there is still a lot of work to be completed. Overall fuel use per kWh delivered to customers probably could be reduced a few per cent without engine replacements. As that reduction in losses will affect every kWh generated, the savings provided by even a few per cent in supply side efficiency improvements will be substantial.

5.3 Challenges for implementation of supply side energy efficiency

The primary challenge for implementation of supply side energy efficiency measures appears to be access to funds for the needed capital investments and management of contracts to bring in overseas contractors to carry out much of the maintenance, repair and replacement work.

In general it is clear that NUC management has a good understanding of how to improve supply side efficiency but does not have access to the funds and human resources needed to carry out the actions. In recent years, funds from development partners have focussed on renewable energy infrastructure, rather than traditional power generation. However, benefits from supply side energy efficiency should be highlighted where they are cost-effective and put forward for support alongside renewable and demand side energy efficiency.

6 Demand Side Energy Efficiency

6.1 Demand side energy efficiency opportunities

Decades of very low (or no) electricity costs for energy consumers has resulted in a much higher per-capita energy usage than is seen in most island countries. In a general sense, it can therefore be expected that there are many opportunities for energy efficiency improvements, particularly in the residential and government sectors. However, until there is a better understanding of the actual energy use patterns and the energy using equipment's characteristics, well targeted programmes to help electricity consumers reduce energy cannot be confidently prepared. Surveys and audits should precede the design of programmes for demand side management (DSM) and these should be some of the priority actions of the Road Map for demand side energy efficiency.

6.2 Experience with demand side energy efficiency

From 2007 to 2010 various demand-side activities were undertaken in Nauru under the auspices of the REP-5 project, funded by the European Union. These included in 2009 the installation of over 1800 pre-payment meters in homes and businesses. A demand-side energy efficiency action plan was also drafted and two energy efficiency officers were hired. The two officers carried out an awareness campaign on energy efficiency and conservation that targeted homes and small businesses. This included school and community energy efficiency competitions. However, after the end of the project in 2010, the energy efficiency officer contracts were not renewed and the campaigns were not sustained. This shows the kind of long-term continuous measures required for DSM cannot be dependent only on external short-term project funding.

A major driver of demand side energy efficiency is the energy price. So long as energy costs remain artificially low, as has long been the case in Nauru, programmes to improve demand side efficiency have tended to have only a short term effect with energy usage soon rising back to pre-programme levels after the programme concludes. For demand side energy efficiency programmes to have the longest lasting benefit, the energy using hardware needs to be upgraded with low maintenance, long lived, high efficiency equipment (e.g. replacement of standard fluorescent fixtures with long-life high efficiency LED units) and it is best if consumers expect substantial price hikes for energy in the future (e.g. a well publicized government plan to gradually reduce subsidies on electricity).

6.3 Challenges for implementation of demand side energy efficiency

Demand side energy efficiency improvements in residences probably can do more to reduce fuel imports than any other energy efficiency action. However, residential DSM is also the hardest to implement and to maintain so long as electricity tariffs are heavily subsidized. To implement and maintain energy efficiency actions in the residential sector will require constant interaction with communities explaining why DSM is important to them and to Nauru and for educating individual households as to how to lower their electricity usage without any loss of quality of life. Since supporting investment in energy efficiency measures is less costly over the long term than the current subsidies to electricity customers, it makes good sense for Government to work with donors and internally to provide incentives to households to install more efficient lighting and appliances and to improve their homes in ways that reduce the need for fans and air-conditioning. To design effective incentives, a good knowledge of how households in Nauru use electrical energy is needed as well as a good knowledge of the characteristics of the energy using equipment in households.

Because of the tendency for households to slowly drift back to lower energy efficiency patterns, so long as electricity tariffs are kept artificially low, customers will need to be constantly reminded of the need for staying energy efficient and measures will need to be taken to encourage households to purchase high efficiency lights and appliances rather than the normally lower initial cost, lower efficiency devices.

7 Data collection needs

7.1 Data collection relating to the Nauru energy balance

In order to monitor progress toward the goal of providing 50% of Nauru's energy with renewable energy, it is essential that good data be collected regarding energy imports, energy used in Nauru and energy exports.

7.1.1 Energy import data

Imported energy for Nauru means fossil fuel imports. Unambiguous records of the quantity of fuel imports, their timing and the specific type of fuel imported are vital to the determination of the Nauru energy balance. These data should be quantity based, not value based, and should accurately reflect the timing and type of energy that is imported to Nauru, its source and its storage location.

7.1.2 Energy Use Data

Fossil fuel usage for land transport, sea transport and air transport should be accurately collected along with the patterns of usage of energy for each type of transport. These data then can be used to help determine opportunities for energy efficiency improvements and for replacement of imported fossil fuels with renewable energy. For example, if a major use of imported fuel is for land transport, analysis of the use patterns can indicate if electric vehicles charged by renewable energy may be attractive, if incentives for car pooling are likely to work or if mass transport systems can be expected to reduce transport energy use.

Fossil fuel use for electricity generation and the pattern of electricity usage are essential data for the formulation of programmes for supply side and demand side energy efficiency programmes. Diurnal electricity load patterns, load patterns on different days of the week are also very important data needed for the analysis of the ability of solar and wind energy inputs to offset fossil fuels for electricity generation. Collection and analysis of energy use data relating to both quantity of energy used what the energy is used for and the time of day of the energy use is necessary for the preparation of comprehensive and effective DSM programmes.

Data regarding the electricity generation, transport and other activities that affect the national energy balance and are provided by renewable energy must also be collected in order to determine the overall percentage of total energy use that is provided by renewable energy. As new renewable energy projects are installed, the energy they provide and information on the use made of it should be collected in order to enable monitoring of progress towards Nauru’s renewable energy targets and planning of future renewable energy projects.

7.2 Data collection for Renewable Energy Implementation

In order to be able to design renewable energy systems and predict their performance, a good understanding of the renewable energy resource is required. Because many renewable resources, such as wind, solar energy and wave energy, vary in multi-year cycles, it is important to maintain long term data collection for all renewable energy sources in use and expected to be used in the future. There is currently collection of some solar resource data on Nauru. However, after the first year of installation, the wind resource monitoring equipment was damaged and the reliability of the data it is collecting is questionable. There are no other resource monitoring programmes currently underway.

7.3 Data collection for preparing energy efficiency programmes

Given that the primary data needed for supply side energy efficiency improvements were determined through the PPA funded NUC study in 2012, energy efficiency data collection needs to concentrate on the demand side.

7.3.1 Residential energy use data requirements

The use of prepaid meters with their random timing for energy purchases makes it more complicated to determine periodic energy use by NUC residential customers. Although monthly meter readings are no longer made, there remains a need for NUC to make use of software that can synthesize monthly energy usage for individual customers in order to determine actual patterns of household and small business energy use. This is needed both to provide a baseline for the monitoring and evaluation of energy efficiency efforts and for classifying customers into usage groups to aid in delivery of the appropriate energy efficiency programmes. If not already available in Nauru, this software will need to be obtained through the supplier of the prepayment meters.

To develop effective, properly targeted energy efficiency programmes, a detailed survey of household and small business energy use will be needed. The survey should include a detailed inventory of the energy using devices that are in use, their power requirements, their age and conditions and their typical period of usage per day/week. For sites using air-conditioning, details of the building and its characteristics also need to be included.

7.3.2 Commercial/Industrial DSM data requirements

For all commercial facilities other than RONPHOS, energy use is largely confined to office machines, lighting, refrigeration and air-conditioning. Energy audits focusing on these areas in the buildings occupied by the commercial entities should be adequate to provide the data needed to develop energy efficiency programmes for that sector. As with residential audits, construction characteristics of the buildings that include air-conditioning should be included in the audits.

For RONPHOS, energy audits of the type to be used in the commercial sector will be appropriate for office and warehousing buildings but specialized audits will be needed for gathering data on the phosphate processing and handling energy use.

7.3.3 Government Buildings DSM data requirements

For all government buildings, detailed energy audits and data regarding building construction characteristics will need to be carried out. Where government buildings are not on prepayment meters, monthly meter reading should take place to record electricity usage.

7.3.4 Water Supply DSM data requirements

Since roughly 30% of electrical energy supplied by NUC is used for water desalination, a detailed audit of the entire water system from connection to the grid through end use will be an important part of the data gathering requirement for developing actions to improve demand side energy efficiency and to prepare a baseline for measuring the effect of those actions.

7.3.5 Transport data requirements

A general survey of the vehicles and boats in Nauru and their patterns of use is needed to properly design energy efficiency improvement programmes for Nauru transport. In particular, patterns of use of personal vehicles, including motorcycles which are increasingly being used on Nauru, needs to be better understood in order to design mass transit or transport sharing programmes.

Annex 1 – Non-exhaustive list of estimated energy sector investments in Nauru 2004 – 2017