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The Secretariat of the Pacific Regional Environment Programme

Pacific Regional Energy Assessment 2004

An Assessment of the Key Energy Issues, Barriers to the Development of Renewable Energy to Mitigate Climate Change, and Capacity Development Needs for Removing the Barriers

NIUE National Report Volume 8

SPREP IRC Cataloguing-in-Publication Data

Wade, Herbert
Pacific Regional Energy Assessment 2004 :
an assessment of the key energy issues, barriers
to the development of renewable energy to
mitigate climate change, and capacity development
needs to removing the barriers : Niue National
Report / Herbert Wade. – Apia, Samoa : SPREP, 2005.

xi, 38 p. : figs., tables ; 29 cm. – (Pacific Islands Renewable
Energy Project. Technical report ; no. 08)

"This report is based on data gathered by a
PIREP team consisting of Sionetasi Pulehetoa,
Bradley Punu and Herbert Wade".

ISBN: 982-04-0288-3

1. Energy development – Niue. 2. Energy sources, Renewable –
Niue. 3. Energy research – Niue.4. Conservation of energy
resources - Niue. 5. Conservation of natural resources – Niue.
6. Energy consumption – Climate factors – Niue. I. Pulehetoa,
Sionetasi. II. Punu, Bradley. III. Pacific Islands Renewable
Energy Project (PIREP). IV. Secretariat of the Pacific
Regional Environment Programme (SPREP). V. Title.
VI. Series.

333.794159626

Currency Equivalent: 1.0 NZ$ (NZD) ≈ 0.64 US$ (November 2003)

Fiscal Year: January – December

Time Zone: GMT / UTC plus 10 hours

This report is based on data gathered by a PIREP team consisting of:

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The international consultant visited Niue on 21-28 November, 2003. Information for the report was gathered by the national consultant both during and after the visit of the international consultant. The national coordinator provided generous support and assistance during the several visits.

An earlier draft of this report was reviewed by the Niue National PIREP Coordinating Committee, Secretariat of the Pacific Regional Environment Programme (SPREP), the United Nations Development Programme (UNDP) and others. However, the contents are the responsibility of the undersigned and do not necessarily represent the views of the Government of Niue, the national PIREP committee, SPREP, UNDP, the Global Environment Facility or the many individuals who kindly provided information on which the study is based.

Herbert Wade

July 2004

ACRONYMS

AAGR	Average Annual Growth Rate
AC	Alternating Current
ACP	African, Caribbean, Pacific countries
ADB	Asian Development Bank
ADO	Automotive Diesel Oil
BFC	Bulk Fuel Corporation
BP	British Petroleum
CIF	Cost+insurance+freight
CPI	Consumer Price Index
CROP	Council of Regional Organisations of the Pacific
DC	Direct Current
DPK	Dual Purpose Kerosene
DSM	Demand Side Management for efficient electricity use
EC	European Community
EDF	European Development Fund
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENSO	El Niño/El Niña oceanic climate cycle
EU	European Union
EWG	Energy Working Group of CROP
FSM	Federated States of Micronesia
FY	Fiscal Year
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GMT/UTC	Greenwich Mean Time/Universal Time Coordinate
GNP	Gross National Product
kV	Kilo-Volts (thousands of volts)
kVA	Kilo-Volt-Amperes (Thousands of Volt Amperes of power)
kW	Kilo-Watt (Thousands of Watts of power)
kWh	Kilo-Watt-Hour (Thousands of Watt Hours of energy)
kWp	Kilo-Watts peak power (at standard conditions) from PV panels
LPG	Liquefied Petroleum Gas
MOU	Memorandum of Understanding
NASA	US National Aeronautics and Space Administration
NPC	Niue Power Corporation
OTEC	Ocean Thermal Energy Conversion
PACER	Pacific Agreement on Closer Economic Relations
PEDP	Pacific Energy Development Programme (UN 1982-1993)
PIC	Pacific Island Countries
PICCAP	Pacific Islands Climate Change Assistance Programme (GEF/UNDP)
PICTA	Pacific Island Countries Trade Agreement
PIEPSAP	Pacific Islands Energy Policies and Strategic Action Planning
PIFS	Pacific Islands Forum Secretariat
PIREP	Pacific Island Renewable Energy Project (GEF/UNDP)
PPA	Pacific Power Association
PREA	Pacific Regional Energy Assessment (1992)
PV	Photovoltaic
PWD	Public Works Department
RMI	Republic of the Marshall Islands
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SWH	Solar Water Heater
SWOT	Strengths, Weaknesses, Opportunities and Threats
ULP	Unleaded Petrol
UN	United Nations
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USP	University of the South Pacific
V	Volts
Wh	Watt hours of energy

Energy Conversions, CO_2 Emissions and Measurements

The following conventions are used in all volumes of the PIREP country reports unless otherwise noted.

Fuel	Unit	Typical Density kg / litre	Typical Density l / tonne	Gross Energy MJ / kg	Gross Energy MJ / litre	Oil Equiv.: toe / unit (net)	Kg CO_2 equivalent [c]	
							per GJ	per litre
Biomass Fuels:								
Fuel wood (5% mcwb)	tonne			18.0		0.42	94.0	
Coconut residues (air dry) [a]								
Shell (15% mcwb) harvested	tonne			14.6		0.34		
Husk (30% mcwb harvested	tonne			12.0		0.28		
Average (air dry) [b]	tonne			14.0		0.33		
Coconut palm (air dry)	tonne			11.5		0.27		
Charcoal	tonne			30.0		0.70		
Bagasse	tonne			9.6			96.8	
Vegetable & Mineral Fuels:								
Crude oil	tonne			42.6		1.00		
Coconut oil	tonne	0.920	1,100	38.4		0.90		
LPG	tonne	0.510	1,960	49.6	25.5	1.17	59.4	1.6
Ethanol	tonne			27.0		0.63		
Gasoline (super)	tonne	0.730	1,370	46.5	34.0	1.09	73.9	2.5
Gasoline (unleaded)	tonne	0.735	1,360	46.5	34.2	1.09	73.9	2.5
Aviation gasoline (Avgas)	tonne	0.695	1,440	47.5	33.0	1.12	69.5	2.3
Lighting Kerosene	tonne	0.790	1,270	46.4	36.6	1.09	77.4	2.8
Aviation turbine fuel (jet fuel)	tonne	0.795	1,260	46.4	36.9	1.09	70.4	2.6
Automotive diesel (ADO)	tonne	0.840	1,190	46.0	38.6	1.08	70.4	2.7
High sulphur fuel oil (IFO)	tonne	0.980	1,020	42.9	42.0	1.01	81.5	3.4
Low sulphur fuel oil (IFO)	tonne	0.900	1,110	44.5	40.1	1.04	81.5	3.4

Diesel Conversion Efficiency:

	litres / kWh:	Efficiency:
Actual efficiencies are used where known. Otherwise:		
Average efficiency for small diesel engine (< 100kW output)	0.46	22%
Average efficiency of large modern diesel engine(> 1000 kW output)	0.284	36%
Average efficiency of low speed, base load diesel (Pacific region)	0.30 - 0.33	28% - 32%

Area: 1.0 km^2 = 100 hectares = 0.386 $mile^2$ 1.0 acre = 0.41 hectares
Volume 1 US gallon = 0.833 Imperial (UK) gallons = 3.785 litres 1.0 Imperial gallon = 4.546 litres
Mass: 1.0 long tons = 1.016 tonnes
Energy: 1 kWh = 3.6 MJ = 860 kcal = 3,412 Btu = 0.86 kgoe (kg of oil equivalent)
1 toe = 11.83 MWh = 42.6 GJ = 10 million kcal = 39.68 million Btu
1 MJ = 238.8 kcal = 947.8 Btu = 0.024 kgoe = 0.28 kWh
GHGs 1 Gg (one gigagramme) = 1000 million grammes (10^9 grammes) = one million kg = 1,000 tonnes
CO_2 equiv CH_4 has 21 times the GHG warming potential of the same amount of CO_2; N_2O 310 times

Notes: a) Average yield of 2.93 air dry tonnes residues per tonne of copra produced (Average NCV 14.0 MJ/kg)
b) Proportion: kernel 33%, shell 23%, husk 44% (by dry weight).
c) Assumes conversion efficiency of 30% (i.e., equivalent of diesel at 30%).
d) Assumes conversion efficiency of 9% (biomass - fuelled boiler).
e) Point source emissions

Sources:
1) Petroleum values from Australian Institute of Petroleum (undated) except bagasse from AGO below
2) CO_2 emissions from AGO Factors and Methods Workbook version 3 (Australian Greenhouse Office; March 2003)
3) Diesel conversion efficiencies are mission estimates.
` 4) CO_2 greenhouse equivalent for CH_4 and N_2O from CO_2 Calculator (Natural Resources Canada,

EXECUTIVE SUMMARY

1. Country Context

Physical Description. Niue is a single raised coral island of 259²km located about the centre of a triangle consisting of Tonga, Samoa and the Cook Islands. With a close in reef and no lagoon, it rises nearly vertically from the sea to a perimeter elevation of around 25-30 metres then slowly rises to a central plateau having a maximum elevation of 68 metres. There are no beaches and access to the sea is by way of steep foot paths down the cliff. Shipping must use open anchorage and transfer goods to the single wharf by lighters and small boats. About 20% of the land is considered arable though only a fraction of that is continually in crops. Forests cover over 60% of the land and through a system of legal and traditional sanctions are mostly protected against cutting.

Social and Cultural. The original settlers appear to have been from Tonga, Samoa and later Pukapuka (Cook Islands) with most of the cultural heritage traceable to Samoa and Tonga. Niue is an independent country in free association with New Zealand. After establishment of free association, Niue's population declined rapidly due to emigration. The current population of ethnic Niueans in New Zealand is about 20,000 while the population on Niue is around 1,700. There has been some effort to encourage repatriation though there continues to be a slow loss of families to New Zealand.

Most of the population is bilingual, speaking both English and Niuean well. Education is compulsory from age 5 - 14. The Niue High School covers forms one to six with form seven provided in New Zealand. The population is almost all Christian with about 75% belonging to the Ekalesia Niue, a faith developed from the London Missionary Society, and 10% are associated with the Latter Day Saints. The remaining 15% are mostly Roman Catholic, Jehova's Witnesses and Seventh Day Adventists.

Environmental. Environmental issues have a high priority. The people of Niue have taken positive action to maintain the environment for future generations. The low population density has allowed large areas of the island's interior to remain as natural forests and this natural state has become a tourist attraction along with the exotic coral formations, caves and other natural attractions of the island. In general water quality and air quality are very good. Periods of drought occur that can cause loss of crops and hardship for residents.

Rains are distributed fairly evenly over the year though December to March is somewhat higher than the average. The annual temperature is near to 25°C with a range of about 21°C - 32°C.

Tropical cyclones are a serious risk for Niue with a major passage about once every 10 years. On Monday, 5 January 2004, Cyclone Heta struck Niue head on. With winds in excess of 270 kph and a sea surge estimated at 50 metres, rising above the 30 metre cliffs and wreaking havoc along the western coast destroying most of the government buildings and facilities. Waves in some cases pushed inland 100 metres. In the aftermath of the cyclone, recovery is slow and years will be needed for full recovery.

Political Development. Protectorate status was obtained in 1900. In 1901 Niue was annexed by New Zealand. In 1974 Niue gained independence in free association with New Zealand. Government follows a Westminster structure with a 14 member

assembly elected as village representatives and six members elected from the common roll. The premier is elected by the assembly and then selects three other assembly members for cabinet posts.

There is a Niue High Court though serious cases and reviews of decisions are heard by the Chief Justice of Niue located in New Zealand.

Economic Overview. GDP in 2000 was about $14.2 million with $3m dollars from agriculture, $311,000 from tourism and $204,000 from manufacturing. The remainder came from donor funding with about $6m dollars from New Zealand. Remittances from family members overseas are also an important input to the economy.

Niue has no mineral or fertilizer resources, the soil is thin and rocky though generally fertile. Commercial export crops include coconuts, taro bananas and vanilla that are grown along with subsistence gardens on the 40% of land that has been cleared for agriculture. Passion fruit was a major export until wiped out by Cyclone Ofa in 1990. Honey has also become a significant export item. Small quantities of frozen fish are exported, though mostly to relatives in New Zealand and not in significant quantity. However, there are hopes of establishing a substantial frozen fish export business with the formation of a joint venture between Reef Shipping and the government that includes a large flash freezer and cold storage facility for fish. In order to get a license to fish in Niue's EEZ, fishing boats will have to ship their fish through the Niue freezer facility.

Cyclone Ofa in 1990 turned Niue from a food exporting country to one dependent on food imports for nearly two years and Cyclone Heta's effect was even worse so it will be years before food exports reach 2003 levels.

The road system is very good with around 125km paved and another 100km unpaved but in good condition. Access is easy to all populated areas. Air access has been a long -term problem despite the presence of an excellent airport facility. Recently Polynesian Airlines has added Niue to its twice a week Apia-Auckland-Apia flight significantly increasing passenger and freight movements.

Tourism is perceived as having good economic potential and its development is encouraged though there is now only one full service hotel operational on the island. Primary attractions include the sculpted coral coast, the interior caves, the forest preserves and wildlife, the seasonal presence of whales and the unusually clear water for diving.

The principal employer is the government and about half of all employed persons work as part of the civil service. Small shops, tourist services and other services provide work in the private sector for the remaining half.

Institutional and Legal Arrangements for Energy. There is no energy officer in government. PWD has the only experience with renewables and that is limited to a small solar pump. Petroleum tenders are managed by Finance and NPC handles electricity supply.

2. Energy Supply, Demand and the GHG Inventory

Energy Supply. The Bulk Fuel Corporation (BFC) has the exclusive authority to import petroleum except for LPG which is privately imported. BFC manages all aspects of fuel import storage and distribution. New Zealand procedures and standards are used. The supply contract is with Shell Fiji, Ltd. and has been for many years. Fuel is delivered about once every three months. The retail price is set by government

and a $0.10 per litre tax applied to ADO, petrol and jet fuel. Imports have risen rapidly over the past decade despite a declining population though a slower growth is expected for the future as appliance usage approaches saturation.

Liquefied petroleum gas (LPG) use has grown rapidly for cooking, replacing kerosene as the fuel of choice. Over half of Niue homes use LPG.

Electricity is generated and delivered by the Niue Power Corporation, a government corporation reporting to the Secretary for Government. It has 16 employees with five in technical jobs, two as meter readers and nine in management and administration. Capacity is 2.4 MW using three 800 kW Caterpillar engines but have to be derated to 1.6 MW. There is 180 km of distribution with 11kV primaries. All residences and businesses (except for one new house in the interior) have access to power. Power is available 24-hours a day for the 960 customers, mostly residential. The Matavai Resort is presently the largest commercial customer though when the fish freezer comes on line its usage will dwarf all others. Government is the largest user sector, representing about half the sales. The tariff has been constant for the past six years at $0.30 per kWh. This is a heavily subsidized rate.

Energy Demand. In FY2002-2003, about 1.5 ML of ADO, 570 KL of petrol, 540 KL of Jet Fuel, and 14,800 kg of LPG were imported. The bulk of diesel fuel is used for electricity generation, nearly 1 ML per year. 90% of petrol goes for land transport. Electricity sales were 3.37 GWhr in FY2002-2003. Energy production from renewable sources is less than 1% of the total, all in biomass for household use.

Future Growth in Energy Demand and GHG Emissions The expected growth in fuel use for petrol and jet fuel is 2% per year, 2% for ADO use for electricity and 3% for ADO used for transport. LPG is expected to grow rapidly at 6%. The 2002 baseline estimation of petroleum based GHG emissions is 6.9 GG and the 2012 forecast is 8.7 Gg. If renewable energy and energy efficiency measures are aggressively applied, about 15% of ADO used for electricity can be saved through efficiency measures, about 15% of ADO for electricity can be saved through solar and wind systems connected to the grid. About 5% of ground transport fuel use can be saved through energy efficiency measures. The total savings would be around .96 Gg in 2012 or about 11% of total CO_2 emissions.

3. Potential for Renewable Energy Technologies

Biomass. Given the protected status of forests and the lack of large plantations of economically useful tree crops, there is little opportunity for biomass to be a significant energy source over the next decade.

Biogas. The population is dispersed over the area of the island, there is no distinctive urban and rural area. Collecting manure for economically reasonable biogas generation is not reasonable and the quantity of urban waste that could be used for digestion is small. Biogas is therefore not considered a significant potential for GHG reduction.

Solar. Niue has a good solar resource and both solar thermal for water heating and solar photovoltaics for electricity generation are practical. However, the maximum impact that is practical to attain is unlikely to exceed five percent of the energy delivered by the NPC grid.

Wind The wind resource is moderate and considered to be economically developable. However unless complex load shifting control systems are included, wind energy is

not likely to deliver more than about 10% of the total energy delivered by the NPC grid.

Wave and OTEC. Both wave and ocean thermal resources are good, but at this time there are no commercially available systems that can be used in Niue to convert these energy sources to useable power.

There are no known tidal, hydro or geothermal resources developable in Niue.

4. Experiences with Renewable Energy Technologies

Solar Photovoltaics. There has been little experience with solar PV systems. A small light was installed for lighting a canoe access stairway, a refrigerator and lights was powered for a community centre and a solar pump was installed for a village. All three projects failed after a short time and none are currently working.

Solar Thermal. Solar water heating has been used for over 20 years and most government housing has included imported units of the Solahart type of design. Tourist accommodations also typically use solar water heaters for the guests. The remaining market is small and can easily be met by the existing private importers.

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

5. Barriers to Development and Commercialisation of RETs and Energy Efficiency Measures

Known Barriers to Renewable Energy Development

- Dependence on donor funding for energy projects
- Lack of national energy policy
- Lack of energy officials in government.
- There are no technical training facilities on Niue
- Niue has a difficult environment for electrical and mechanical equipment
- There is limited technical capacity on Niue
- Almost no prior experience with renewable energy for power production
- Susceptibility to cyclones
- Small population limits the market
- Lack of confidence in renewable energy due to prior project failures.
- Renewable energy cost is not clearly competitive with conventional generation.
- Petroleum is cheap and convenient as a source of energy
- There is a lack of information about renewable energy at NPC and government
- Understanding of renewable energy technologies is poor
-

6. Capacity Development Needs for Removing the Barriers

Barriers can be reduced through:

- project development support;
- assistance for renewable energy related fiscal policy development;
- support for energy policy development;

- develop some local capacity for technical training to meet the needs for renewable energy and energy efficiency utilisation;
- provide technical training for NPC personnel for installation, operation and maintenance of appropriate renewable energy systems;
- training and information provision to NPC;
- support local companies with training and information;
- information programmes about renewable energy and energy efficiency for all sectors; and
- Decision maker information delivery.

7. Other Implications of Large Scale Use of Renewable Energy

Large scale development of biomass or biofuels would either require taking large tracts from existing agricultural land or replacing natural forests with plantations. Neither option appears to be acceptable in Niue. The economic and social advantages for rural development that would be present in other countries with the promotion of biomass and biofuels would not occur in Niue since there is no "rural" population at a lower economic level than an "urban" population.

Large scale wind development does not imply large land areas for the modest power requirements of Niue. Three or four turbines are likely all that will be practical to put to use. There do not appear to be significant negative impacts on the environment nor social problems resulting from the use of wind power to supplement the diesel generation. Benefits include lowered GHG production and improved economics of power generation.

Large scale solar PV development for supplying the grid should not create environmental or social problems if installations are distributed around the island as many roof top installations instead of installed as very large arrays that require a large land area. Lowered GHG production and improved economics for power production are expected to be the positive aspects of large scale, grid connected solar photovoltaics.

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

The largest technically and economically practical wind and solar generators installed on Niue can only be expected to offset around 15% of the diesel fuel used for power generation. Energy efficiency measures should also be employed for the most cost effective use of the installed renewable energy systems and to achieve the maximum GHG reduction over the next decade.

8. Implementation of the Capacity Development Needs and Co-financing Opportunities

The €1.8 million EU project that tentatively will support the installation of wind turbines on Niue is the only renewable energy related project currently in the pipeline for Niue that appears practical for the provision of co-financing.

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Niue Map and locator

1. PHYSICAL, SOCIAL, ENVIRONMENTAL, POLITICAL, ECONOMIC AND INSTITUTIONAL CONTEXT

1.1 Physical

Located at 20°S and 175°W near the centre of a triangle consisting of Tonga (480 km to the east), Samoa (550 km to the north-west) and the Cook Islands (900 km to the west), Niue is one of only two Pacific Island Countries (PICs) consisting of a single island. With a land area of 259 km^2, Niue has about four times the land area of Rarotonga in the Cook Islands but has a population of only about 1700 people. It is reputedly the world's largest upraised coral atoll. With a close in reef and no lagoon, it rises nearly vertically to a perimeter elevation of around 25-40 metres. From the perimeter cliffs the land rises slowly to a central plateau having a maximum elevation of about 68 metres. There are no beaches and access to the sea is limited, difficult and often hazardous with no protected harbours. Most access to the sea is by way of steep footpaths from the plateau. Shipping must use the open anchorage at the main village of Alofi with goods and passengers transferred to the concrete dock by lighters and small boats.

There are numerous caves and the rugged, water sculpted rock formations around the coast are a major tourist attraction. The maze of underground caves and channels carry the 2050 mm of average annual rainfall to the sea so there are no lakes or streams though fresh water pools in caves and rock formations are sometimes present. Lined boreholes with electric pumps are generally used for obtaining fresh water. Currently, all fresh water comes from the 50 meter thick fresh water lens and is extracted through 15 boreholes for distribution to households. Water quality is good and can be tapped at a depth typically in the range 25-100 metres below the surface.

Figure 1-1 – Niue's west coast at Alofi

Herb Wade 2003

About 20% of the island is considered to be arable land though only a fraction of that is continually in crops. Large forest tracts exist with a total cover of over 60% of the island and through a system of traditional and legal sanctions are mostly protected against serious encroachment. There is no significant forest products industry and the number of trees are taken is well below the natural rate of forest regeneration. The creation of the Huvalu Conservation Area by the cooperative efforts of the Liku and Hakupu villages is an example of the dedication of residents to preserving the flora and fauna of Niue for future generations and as an eco-tourist attraction.

1.2 Social and Cultural

Tradition has it that the first canoe landed in Niue at Awaiki over a thousand years ago. The original settlers appear to have been from Tonga, Samoa and later Pukapuka (Cook Islands) and the Niuean language is a blend of the three with closest correspondence with Tongan and Samoan. Early settlers named the island Motusefua (island on its own) and Captain James Cook, who visited in 1774, called it "Savage Island" since his attempt to land was repulsed resulting in Cook being wounded by a spear.

The culture is therefore typically Polynesian with modifications to fit the unique Niuean environment. One adaptation to the Niue conditions is the design of the local canoe. Though of the typical Polynesian single outrigger design, the Niuean canoe is exceptionally well crafted and rugged yet lightweight, typically only 30-40 kg, since the canoe must be hand carried up and down the steep accesses to the sea. The added weight of a sail is not required since the reef comes up to the cliff line and deep water is only a short distance from shore. Though the outboard engine equipped aluminium dinghy is now the standard personal fishing boat, around 30 traditional canoes remain in regular use and the skills for their construction have been maintained.

With very few exceptions, houses are located around the perimeter of the island and there are no interior villages though agricultural tracts are largely in the interior.

After establishment of free association with New Zealand, Niue's population declined rapidly, some 6.6% annually at its highest rate in the 1980s. The current population of ethnic Niueans in New Zealand is approximately 20,000, mostly living in the Auckland area. In recent years the population appears to have stabilized at around 1,700 persons. There has been some effort to encourage repatriation to Niue though there remains the annual loss of a few families to New Zealand. Due to the mass migrations of the 70s and 80s, about 60%of the housing stock is vacant with absentee owners.

Table 1-1 – Population 1997-2001

Year	1997	2001
Population	2088	1788
Households	n/a	508
Persons/HH		3.4

Source – Niue 2001 Census

Niueans are typically bilingual, speaking both Niuean and English. Education is compulsory and free for ages five to fourteen. The National Primary School in Alofi provides classes one to six. English is introduced at class three and its use in teaching gradually increased as the student progresses. The Niue High School, also near Alofi, covers forms one to six. Form seven is taken in New Zealand by students selected under a government scholarship scheme.

The University of the South Pacific has a facility at the Niue High School with resident and distance learning programmes. There is no vocational or trades school on Niue.

Though the famous Pacific missionary, John Williams, was not allowed to land Christian island teachers in 1830, the Christian religion was introduced by a Niuean Christian teacher, Nukai Peniamina, from the London Missionary Society in 1846. About 75% of the population are associated with the Ekalesia Niue, which was developed from the LMS teachings, and 10% are associated with the Latter-Day Saints. The remaining 15% are mostly Roman Catholic, Jehovah's Witnesses and Seventh-Day Adventists.

1.3 Environmental

As a matter of public policy, environmental issues have high priority. The people of Niue are obviously proud of the fact that the environment has not been seriously degraded and have taken positive action to maintain both the marine and the terrestrial environment in a manner that minimises the degradation often associated with economic development. The low population density has allowed large areas of the island's interior to remain as natural forests and both local and national governments closely control activities in the natural areas so that their natural state is preserved.

Rains are fairly evenly distributed over the year though there is a wet season (December to March) with greater than average cloud cover. The annual average temperature is close to 25°C with a seasonal range for daily average temperature from about 21°C to 32°C. Winds are prevailing from the east-south-east.

Tropical cyclones are a serious risk for Niue with a major passage averaging about once every 10 years. On Monday 5 January 2004, Tropical Cyclone Heta struck Niue head on. Winds in excess of 270 km and a mountainous storm surge battered the west coast causing great destruction largely due to a sea surge estimated at 50m that rose well above the cliffs and in some cases pushed 100m inland. Alofi and the villages of Makefu, Tuapa, Namukulu and Hikutavake and serious damage elsewhere on the island. The Niue Hotel was destroyed and most government and private structures near the west coast were severely damaged or destroyed. The severity of the cyclone was the greatest on record and resulted in disruption of many services for an extended period. The economy of Niue has been hit hard by the need to rebuild and full recovery is not expected for several years. In addition, the population may fall further as people choose to migrate to New Zealand rather than rebuild damaged homes.

Air quality, ocean quality and fresh water quality are excellent, though there are concerns that increasing use of pesticides and fertilizer may damage the fresh water supply.

About 40% of the land area has been cleared for subsistence gardening and, more recently, for commercial crops, notably taro and vanilla. Passion fruit was a major economic crop but it was wiped out by Cyclone Ofa in 1990 and was not replanted.

More than 60% of Niue is forested but there is no significant forest industry. There are a number of small coconut plantations but they are not well maintained as the product no longer is important economically.

1.4 Political

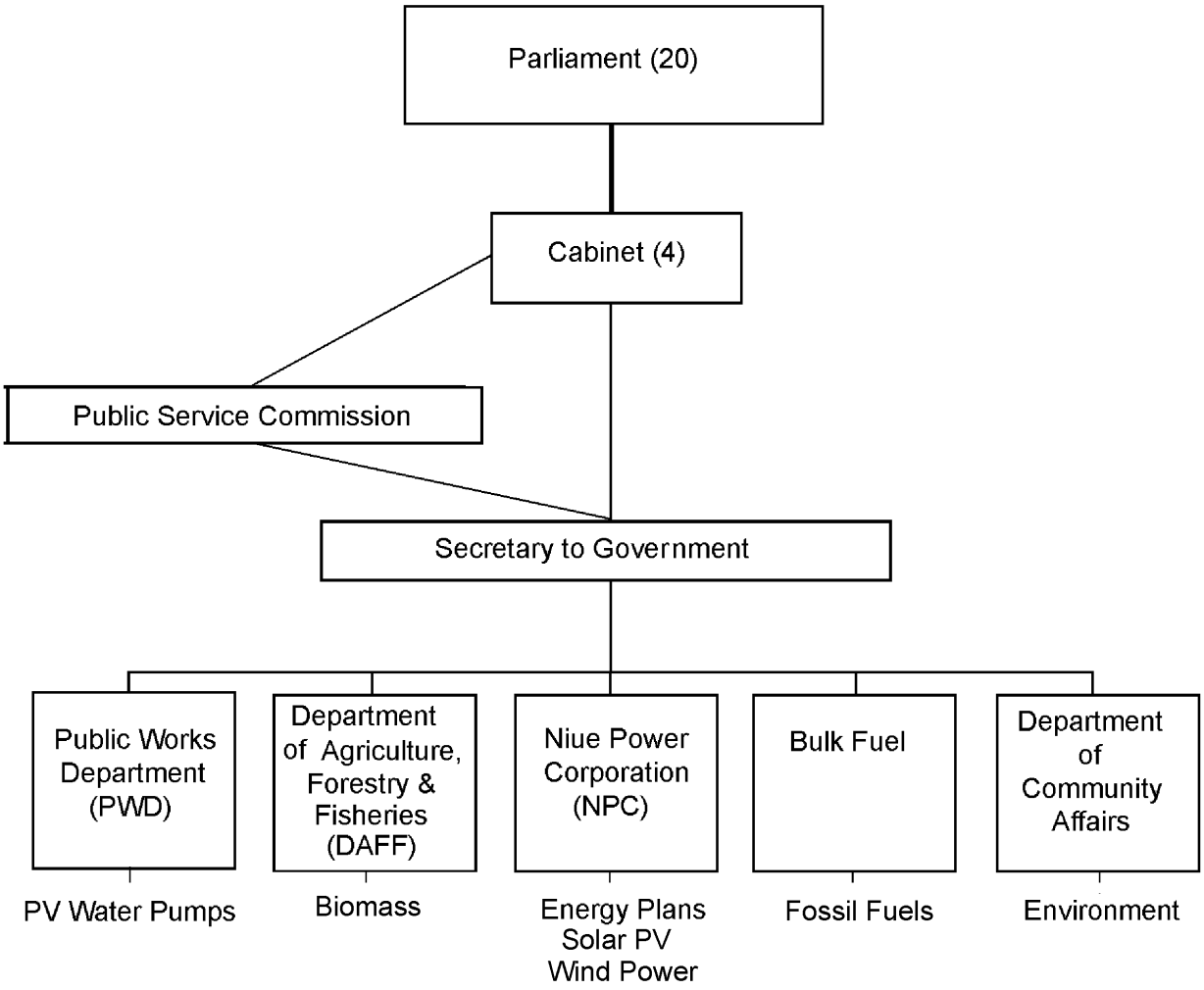
In 1900, after repeated requests by Niue chiefs, protectorate status was granted by Britain. In 1901 Niue was annexed to New Zealand. Through the Constitution Act of 1974, Niue gained independence in free association with New Zealand on 10 October, 1974 making Niue the smallest self-governing nation in the world. New Zealand accepts most of the responsibilities for foreign relations and defence and is the major contributor to the Niuean economy.

Government follows a Westminster style structure with an assembly consisting of 14 members elected as village representatives and six elected from the common roll by universal suffrage for citizens 18 and older. The premier is selected by the assembly. He

then selects three other assembly members for cabinet posts. The government is headquartered in Alofi though after Cyclone Heta destroyed most of the government buildings, the centre may move further inland to a new location.

The Judiciary consists of the Niue High Court that has three jurisdictions. They are Criminal, Civil and Land. Serious cases and reviews of decisions are heard by the Chief Justice of Niue located in New Zealand.

The last election was in 2002 when the present Premier, Hon. Young M. Vivian, formed a new government. This change in party for the government is not viewed as marking major changes in policy. In particular, attitudes toward renewable energy, climate change and maintaining the environment remain very positive.



LPG provided through the private sector only (Alis Giftware & Jefferson's Workshop)

1.5 Economic

Essentially a single, massive coral rock, Niue has no mineral or fertilizer resources and the soil is sparse, rocky and thin though generally fertile. Agricultural and fishery

products dominate the export economy. There is an active programme to develop new agricultural exports but though several new crops have been promoted over the years, the principal agricultural exports remain the traditional crops of coconut, taro and bananas. New Zealand is the primary recipient of exports. Coconuts appear throughout the island though only sparsely in the interior. There are some small coconut plantations along the perimeter. Taro and bananas are primarily interior crops. Currently vanilla is undergoing commercial trials for export. Honey also has become a significant export item through the efforts of one commercial developer. Small quantities of frozen or processed fish is exported, typically to relatives in New Zealand, but at this time it is not a significant economic activity. The government hopes that will change when the new fish freezing and storage facility is operational. The facility will be a joint venture between Reef Shipping and the government. It will have two chillers, two blast freezers, and two storage freezers requiring about 300-350 kWh. A 1.2 MW generator will be installed at the facility. Water will be supplied from three tanks with holding capacity of 20,000 litres for fresh water per day, and 100,000 litres of salt water per day. Up to 20 fishing vessels are expected to be fishing in the EEZ and therefore expected to use up to five tonnes of fuel per visit. In order to get a license to fish in the EEZ, fishing boats will have to ship their fish through the Niue freezer.

Due to the dependence on agricultural products for export, cyclones can seriously damage the economy for a year or more. Cyclone Ofa in 1990 turned Niue from a food exporting country to one that had to import produce normally exported. It was nearly two years before local food production recovered completely. The passion fruit industry that had become a major exporter was destroyed and was never re-established. In January 2004, Cyclone Heta, the worst on record, decimated the western coast and the urban area of Alofi, seriously damaged structures elsewhere and destroyed most crops. The economy will take several years to recover and then only with the support of New Zealand and other countries.

Table 1-2 – Agricultural land use

Crops	Land use Ha
Taro	613
Coconuts	290
Kava	49
Nonu	65
Tapioca	5.6
Vanilla	3.7
Total	1026.3

Source – 2001 Census

Although Niue usually has frequent rains throughout the year, periods of drought do occur that may seriously damage the export of agricultural products. During times of drought, taro and other produce normally exported from Niue must be imported.

With the limited resources and small population it is clear that Niue cannot be economically independent and maintain the standard of living that the population takes for granted. Though most funding comes from New Zealand, Niue's free association status allows it to directly apply for funding from multilateral donors such as UNDP and the EU. Niue is an associate member of the Asian Development Bank (ADB), and aspires to full Member status in the near future, but cannot presently negotiate funding with the bank..

The principal employer remains government though the size of the civil service was dramatically reduced in the 1990s. Currently about half of employed persons work for the government. The private sector (including self-employed persons) provides employment for most of the other half.

Most families have a "bush" garden for household food supply and most families have access to a boat for fishing. There is no organized market for either produce or fish though there are opportunistic sales of both and local shops sometimes accept household surpluses for resale.

Table 1-3 – Economic Indicators 1998-2003

Type	1998/1999	1999/2000	2000/2001	2001/2002	2002/2003
GDP total	14,199,000	14,210,000	Not avail.	Not avail.	Not avail.
GDP tourism	326,000	311,000	na	na	na
GDP manufactures	191,000	204,000	na	na	na
GDP agriculture	3,089,000	2,934,000	na	na	na
Inflation rate	0.6%	2.3%	1.5%	0.7%	na
Revenue income	$19.173m	$19.226m	$21.100m	$16.68m	$15.134m
Aid income source NZODA	$6,460,939.	$5,765,120.	$6,000,000.	$6,625,000.	$6,250,000.
AID income Source AusAID.	$800,000.	$875,000.	$$900,000.	$900,000.	$900,000
AID income source 3 UNDP	US$12,253.	US$162,088.	US$80,943.	US$90,365.	US$215,081.
Import total	$5.568m	$4.911m	$1.974m	$3.245m	Not Avail.
Fuel import	$1,094,304.	$744,080.	$1,224,701.	$1,535,572.	$1,876,677.
Exports	$274,000	$353,000	$349,000	$135,000	Not avail.

Source – Bradley Punu

Around 125km of the perimeter and cross-island roads are paved with numerous unpaved spurs and interior "bush" roads making a total of 230 km of roads. Access is easy to all populated and most unpopulated areas. All roads of the island are useable during all seasons. There is no public transport though buses are operated to transport school children and those government employees without private transport.

Despite the well developed Hanan airport facility near Alofi, air access has been a long term problem with many different air carriers providing only limited services over the years. Recently, Polynesian Airlines has added Niue to its Apia to Auckland Boeing 737 service providing a significant increase in available seats and air freight capacity. With two to three flights a week, access for tourists, family and freight is no longer the limiting factor that it has been in the past.

Tourism is perceived as having considerable economic potential and its development is being actively pursued by government and private enterprise. Approximately 100 rooms are available for visitors with about half in the private guest house category and half in the mid-range, international hotel class. Dining facilities outside the main hotels remain limited with snack bars providing only a basic lunch offering catering mostly to government employees and typically no evening meal provision at all. Primary attractions include the sculpted coral coast, the interior caves, the forest preserves and wildlife, the seasonal presence of whales and the unusually clear water for diving.

1.6 Institutional Context for Energy

The Niue Integrated Strategic Plan 2003-2008, in the Energy Sector under infrastructure development, states a goal is to provide a reliable energy supply to all residents and to complete the European Union energy project. There is no Energy Department or government energy planner and each government department participating in the energy sector is independent with no overall coordination or regulation. Petroleum tenders are managed by Finance and NPC handles electricity supply.

Figure 1-2 – Hotel Niue November 2003

Herb Wade 2003

Figure 1-3 – Hotel Niue January 2004

Tapu Magazine (2004)

2 ENERGY SUPPLY, DEMAND AND THE GHG INVENTORY

2.1 Energy Supply

2.1.1 Introduction

Most energy issues controllable in Niue relate to grid delivered electricity. The Niue Power Corporation (NPC) handles the planning, development and implementation of both conventional and renewable energy sources for electricity production. The fish freezing facility that is being constructed will have its own electrical generator though it will be connected to the grid as well.

The Public Works Department (PWD) has a small amount of experience with renewable energy for water heating and water pumping but has no specific interest in renewables or in energy planning or development.

2.1.2 Petroleum

The Bulk Fuel Corporation (BFC) has the exclusive authority to import petroleum products except for LPG. BFC handles the import, storage and distribution of diesel fuel, petrol and kerosene petroleum products using New Zealand procedures and standards. There is no capacity or mandate to develop fuel conservation measures and none have been put into effect. BFC in effect only responds to market demands.

Institutional structure

BFC reports to the Secretary of Government. It is responsible for the import of diesel, gasoline and aviation fuel but not LPG. Local businesses are not permitted to import these products to sell to the local market.

Source and delivery mechanisms

The supply contract is with Shell Fiji Ltd and has been for many years. The inter-island tanker originating in Fiji (the *Pacific Venture*) comes to Niue every three months though sometimes it is significantly delayed due to bad weather. After the vessel is anchored a fuel line is connected to the pipeline on shore leading to the main storage tanks.

Pricing

Due to the very small market and Niue's isolation, there can be little control over either pricing or sourcing of petroleum. The wholesale price is set by BFC based on the purchase price from Shell. The retail price is set by the Niue Government which was $1.50 per litre for diesel and $1.45 unleaded gasoline in December 2003. This price level includes the mark up for the retailer. The aviation fuel is stored at the Hanan (Niue) International Airport and controlled by the Bulk Fuel Corporation. The price includes $0.10/liter tax for ADO, petrol and jet fuel.

Storage

The three bulk fuel storage tanks are about 7.6 meters above sea level at the Alofi wharf. This site is vulnerable to wave surges during strong winds or cyclones from the west or northwest and the tanks were severely damaged by cyclone Heta in 2004 and will be

moved to another location as a part of rebuilding efforts. At the time of the November 2003 visit, the tank farm had three storage tanks: unleaded petrol 244,235 litres (180 tonnes), jet fuel 244,630 litres (180 tonnes) and diesel 407,436 litres (330 tonnes) with a total holding capacity of 896,301 litres. Diesel fuel is also stored at NPC in two 25,000 litre tanks. Jet fuel is stored at the Hanan airport in two tanks.

Table 2-1 – Petroleum imports and sales

Item	1998/1999	1999/2000	2000/2001	2001/2002	2002/2003
ADO litres	1,212,370	1,158,994	1,233,853	1,178,340	1,508,749
Gasoline litre	618,685	602,758	618,399	551,872	568,294
Jet Fuel litres	340,677	346,915	387,474	326,992	542,050
LPG kg	n/a	n/a	n/a	13,068	14,810
Diesel sold to NPC	866,280 ltrs	880,050 litrs	889,350 ltrs.	938,350 ltrs.	963,800 ltrs.
Jet Fuel Sold	11,905ltrs	10,087ltrs	5,600ltrs	7,600ltrs	9,102ltrs
Petrol sold in gas stations.	617,490 ltrs.	616,605 ltrs.	583,275litrs.	564,490 ltrs.	605,720 ltrs.
Diesel sold in gas stations	378,100 ltrs	399,815 ltrs.	753,630 ltrs.	355,400 ltrs.	367,100 ltrs.
Petrol sold for dinghies.	Not avail.	Not avail.	Not avail.	84,000 ltrs.	98,000 ltrs.
Diesel for large boats	2458	2,624	10,341	10,458	10,300

Source – Bradley Punu

Despite the slightly declining population, fuel imports have increased rapidly, more than 150% in six years. However, automobile and appliance use is approaching saturation and growth of the domestic sector is not expected to be rapid. Increased tourism is being sought but a number of factors such as the cost of access, limited tourism attractions and limited accommodation makes it unlikely that there will be a major increase in tourism without very high investment.

Distribution

Deliveries of diesel fuel and gasoline to the two service stations are by tanker truck two times a week, Monday and Thursday. A blue colour is added to jet fuel and it is sold as domestic kerosene. Kerosene is delivered to retailers in 200 litre drums.

Regulation

The primary operating and safety regulatory structure is provided by Shell. For operational and safety areas not covered by Shell regulation, New Zealand regulations apply. Shell regularly inspects the bulk fuel facility and examines operating methodology to ensure that their regulations are followed. There is no regulatory oversight by government other than the setting of retail fuel prices.

LPG

LPG use has grown rapidly in recent years with more than half of Niue homes using LPG for cooking. Though LPG was at one time imported in large bulk cylinders with smaller personal cylinders refilled at retailer sites, the two private companies importing LPG have found it to be more economical to import pre-charged 10 kilogram and 100 pound cylinders and exchange them for empty ones at the two retail outlets. Data on actual imports are limited to customs information. In 2002-2003, 346 items listed as LPG were imported with a total value of $17,386 and a 10% duty was applied. Unfortunately, there is no distinction between 10 kg and 100kg cylinders. No records were available for any year except 2002 when 4,250 kg of LPG was imported. The retail price in 2003 is $45.00 per 10 kg cylinder at Jefferson's ($4.50per kg) and $190.00 for a 100 1b cylinder at Ali's Giftware ($4.20 per kg).

2.1.3 Electricity

Institutional Structure

NPC is a government corporation reporting to the Secretary for Government. It has 16 employees with nine in management and administration, five in technical jobs and two meter readers. Currently all positions are local though AusAID is expected to fund an Australian engineer in the future.

The NPC in its Corporate Plan for 2001-2002 has stated among its goals to:

- identify and act on opportunities to maximize revenue and minimize operational and administrative expenses;
- encourage and promote staff development in line with the skills requirements of the organization; strive for recognized unit standards where appropriate; and
- investigate, formulate, develop and implement strategies to exploit Niue's national resources and minimize dependency on imported energy products, i.e. wind and solar generation; generation efficiency and demand management.

Generation, transmission and distribution system

There is a single powerhouse at Tuila near Alofi. Diesel engines provide the power source for all generation. Three air cooled Caterpillar 1500 RPM engines with generators rated at 800 kW each are the primary power producers. As these are rated for standby service at 60 Hz and 1800 RPM, their continuous power production capability is less at 50 Hz and 1500 RPM making the total useable capacity 1.6 MW. The engines operate with a fuel use rate of 3.4 kWh/litre and lube oil use is 420 litres per month. A smaller, older fourth unit is being rebuilt for standby status.

The 180 km distribution system is almost all underground with two 11kV high voltage feeders located in the right-of-way of the perimeter road. Connection between the north feeder terminating at Liku and the south feeder terminating at Hakupu is nearing completion which will make the system into a ring main configuration. Local distribution is at 415V 50Hz three phase providing single phase power to users at 240V. Distribution transformers for the underground feeders number 45 and there are six pole transformers

on the overhead distribution comprised of 228 HV and 17 LV poles. Transmission capacity is 900 kVA, well above current demand levels so losses are low at 9.31 per cent.

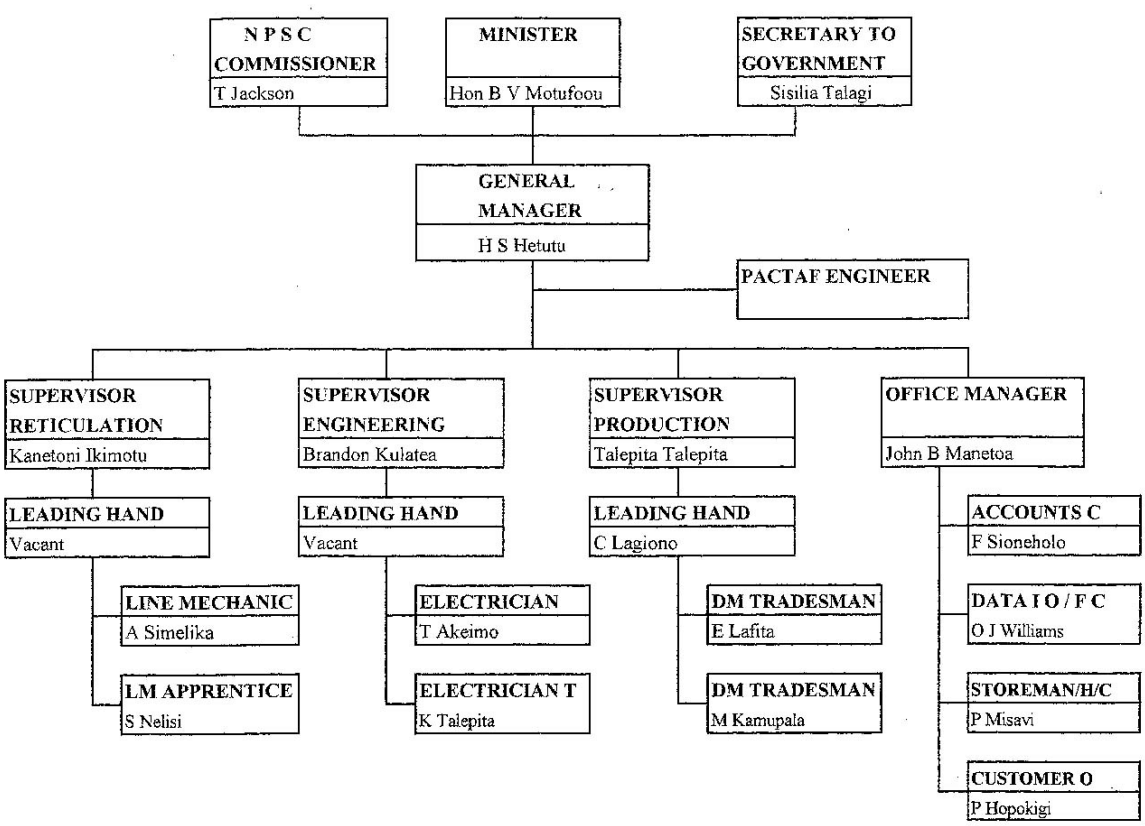


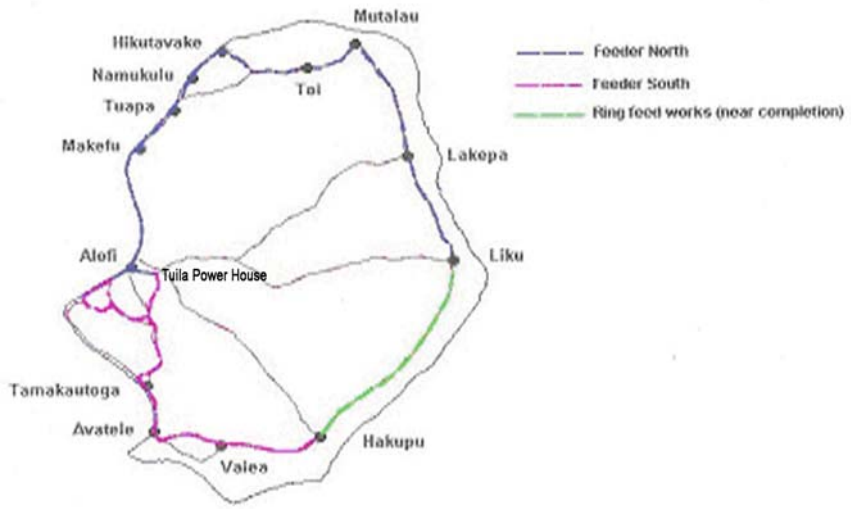
Chart 1. NPC Organization chart, 2002

All residences and businesses have access to mains power except one house recently constructed in the interior of the island. The system is operated 24- hours a day with one generator running except at peak demand time which is typically about 1800-2000. There are currently 1030 meters serving 960 separate customers, mostly residential. There are 176 streetlights in the system.

The present peak load is 667 kW with an average load around 480 kW. Customers outside of the Alofi business centre are restricted from using electric cookers that require three phase power causing the shift from wood and kerosene for cooking to LPG instead of to electricity.

Government is the dominant customer with nearly half of electricity production going to the various government facilities. The Matavai Resort is presently the largest commercial customer though the new fish freezing facility is expected to exceed their energy use when fully operational.

Figure 1: Map of the 11kW distribution system



Source: NPC

Approximately 10 days of fuel storage is maintained at the powerhouse. Replenishment is by truck from bulk fuel stocks. The price paid for fuel is currently $0.61 per litre (December '03). NPC purchases fuel on the same terms as other users, they do not receive tax or duty concessions.

Table 2-2 – NPC operational statistics 1998-2003

Type	1998/1999	1999/2000	2000/2001	2001/2002	2002/2003
Number of customers domestic	743	745	756	930	984
Number of customers commercial	121	120	117	346	374
Number of customers government	124	93	93	95	95
Total units sold.	2,889,224	2,903,917	2,945,136	3,052,452	3,368,888
Units sold domestically	1,307,763	1,190,606	1,387,260	1,242,792	1,381,244
Sold commercial	636,774	609,823	611,796	627,672	707,466
Sold government	944,687	1,103,488	946,080	1,181,988	1,280,178
Diesel used litres	n/a	893,536	887,700	924,450	949,150
Max demand	680 kW	719 kW	629 kW	653 kW	667 kW

Source – NPC 2004

Pricing

The tariff charged for electricity use has been constant for at least the past six years. The flat tariff for all users except for air conditioner use is $0.30 per kWh. Air conditioning units are charged $.48 per kWh. This is a heavily subsidized rate with losses made up from aid and through the government budget. All customers are metered and disconnection for non-payment does occur.

Regulation

Other than acting on direct orders of cabinet, there is no external regulation. Technical standards are those of New Zealand and operational procedures also follow those of New Zealand.

2.2 Energy Demand

2.2.1 Petroleum

Transport

As sales do not differentiate between sales for automobiles and sales for boat use there is no way to determine the relative use of petroleum for land and marine transport. With 84 outboard motors in Niue and more than 600 motorcycles, cars, trucks and vans powered by petrol and over 170 diesel powered vehicles on the road[1], land transport clearly dominates both diesel and petrol use for transport.

Air Transport

Polynesian Airlines is the sole scheduled air transport and is by far the major purchaser of jet fuel. A few charter aircraft and military aircraft sometimes purchase fuel at the airport.

Electricity Generation

The bulk of diesel fuel imports are used for electricity generation. A few land vehicles use diesel as do a few boats but the percentage of sales for transport is small.

Household Lighting and cooking

Since all Niue households but one are connected to the grid so there is little use of kerosene for lighting. Only 4.3% of households in 2001 used kerosene for cooking so there is little use of petroleum by households other than for transport.

LPG

LPG is imported in bulk and cylinders refilled at two retail centres. The use of LPG has reportedly been rising but actual long-term data was not available. All LPG is imported privately. In 2001 27.8% of households used some gas for cooking and 19.3% used it as the main cooking fuel.

[1] 2001 Census

2.2.2 Electricity

Domestic

Domestic use of electricity is primarily for refrigeration (78% of households), freezers (67%) and cooking (32.1% of households). Air conditioning is little used (1.6% of households) except in offices. The average household use in 2002 was a 1403 kWh/year per domestic meter and there were nearly twice as many meters (943 meters at 122kWh/mo/meter) as the census counted as households (508 households at 227kWh/mo/household).

Table 2-3 – 10 largest electricity customers – typical month in 2003

Customer	Units/month (typical 2003)
PWD Water Pumps	22,122
Telecom.	18,090.
Health Dept.	15,993
Cullin's Food Shop.	8,077
Burt's Supermarket.	7,156
Matavai Resort.	6,607
Education Dept.	5,815
Niue Airport.	5,587
Mitaki's Café.	2,774
NZ Office	2,675

Source – NPC 2004

Commercial

Hotels and food shops are the larger users in the commercial category. The average use per commercial meter was 1892 kWhr.

Government

Government use in 2002 was almost as large as domestic use though it only included 95 customers. As Table 2-3 shows, government users represent six out of the ten largest electricity users.

Industrial

There is no industrial use of electricity.

2.3 GHG Inventory

2.3.1 Introduction

Inasmuch as there has been little change in energy use, economic activity or forest cover since the PICCAP greenhouse gas inventory was completed in June 2000, the data provided by that study is still considered valid and no updating has been attempted.

2.3.2 Carbon Dioxide

Estimates of energy growth from 2002 to 2003 are very uncertain due to the fact that a single investment project such as a large hotel or the fish freezers scheduled for completion in 2005 can dramatically increase energy use. A modest growth is expected partly due to the likelihood that the population will not grow and partly because appliance and vehicle ownership are approaching market saturation. Any growth is likely to be in the commercial and government sectors.

The primary opportunity for GHG reduction lies in increasing the efficiency of energy use in transport and electrical consumption. Renewables do not offer a great opportunity for transport reduction since the development of biofuels is unlikely due to the high labour cost in Niue and the need for large scale coconut plantations that would be very difficult to develop under the land tenure system on Niue.

Table 2-4 -Petroleum imports for 2002 and projections for 2012									
		2002						2012	
Fuel	**KL**	**KT**	**TOE**	**GHG (tonnes)**	**GHG (Gg)**	**% of GHG**	**AAGR**	**GHG**	**% of GHG**
Motor Spirit	568	415	452	1,420	1.4	*20.4%*	2%	1.7	*19.9%*
Jet fuel	542	430	469	1,409	1.4	*20.3%*	2%	1.7	*19.8%*
Electricity use of ADO	964	810	875	2,603	2.6	*37.5%*	2%	3.2	*36.5%*
Transport use of ADO	545	458	495	1,472	1.5	*21.2%*	3%	2.0	*22.8%*
LP Gas	29	14.8	17.3	46.4	0.0	*0.7%*	6%	0.1	*1.0%*
Total	*2,648*	*2,128*	*2,308*	*6,950*	*6.9*	*100.0%*		*8.7*	*100.0%*

For reduction in diesel fuel use, wind and solar power offers some offset of diesel fuel use but only if installed without complex load management systems since such systems are unlikely to be reliable in Niue due to an environment that is hard on electronic equipment and to Niue's limited technical capacity. Unless expensive large scale energy storage, such as hydrogen or batteries, is included with the wind or solar power, it is unlikely that more than 15% of Niue's electrical energy can reliably be provided by renewables unless the problems preventing the development of biofuels on Niue are solved. That represents about a 9% reduction in 2012 projected GHG emissions.

Energy efficiency measures that reduce non-aviation transport fuel by five percent could be applied by 2012 and a 15% reduction in electricity use appears possible as well.

Table 2-5 - Indicative Maximum Fuel Savings & GHG Reductions, 2012				
Resource or technology		**Potential CO_2 savings (Gg / year)**	**% of total savings**	**Comments**
Solar and wind		.48	50 %	15% of ADO used for electricity
Energy efficiency Electricity Transport		 .4 .08	 42 % 8 %	 15% of ADO for electricity 5% of ground transport fuel
Total		*.96*	*100 %*	
Source: mission estimates				
Note: Efficiency measures only reduce GHG for the non-renewable component of electricity generation.				

3 POTENTIAL FOR RENEWABLES

3.1 Resources

Niue has potential for wave energy, OTEC, biomass, biogas, solar and wind. There is no significant tidal or geothermal energy resource. Given Niue's small population and limited technical capacity, only commercially available, mainstream renewable energy technologies are appropriate for use. Therefore solar, wind, biomass and biogas represent the technologies that have reasonable potential for development as energy sources. The only significant renewable energy sources currently used in Niue are wood for cooking (about 13% of households) and solar thermal energy for water heating (16.9% in 2001).

3.1.1 Solar and wind resources

Although solar radiation and wind data has been gathered by the Niue weather service, their data has been collected for climate study and is not of a type that provides good insight into energy potential. To date the only measurements of energy potential of solar and wind come from the Southern Pacific Wind and Solar Monitoring Project sponsored by the Forum Secretariat Energy Division and carried out by Environment Meteorological Consultants, Australia. A tower was installed at Hakupu in 1994 (Figure 3-1). The measurements began in November 1994 and continued until February 1997 providing two full years of data. Wind direction and velocity were measured at a 30 meter height and, from photographs, the thermopile type pyranometer appears to have been mounted on an arm extending to the side of the tower somewhat below the 30 meter level. The pyranometer was mounted to measure horizontal radiation, not tilted as would be the case with solar energy collectors. All data is provided on an hourly basis.

Figure 3-1 - Tower

Herb Wade 2003

The data was collected almost continuously over the two year period though there were some gaps early in the series apparently due to data logger problems since the gaps appeared both in the wind and in the solar data.

Table 1: Monthly average wind speed at 30 metres AGL in m/s at Hakupu, Niue.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	7.65	5.1	4.5	6.6	5.5	5.8	6.2	7.7	7.7	5.8	6.7	4.5
1996	3.8	3.9	4.2	6.9	4.7	6.6	5.4	5.4	7.2	5.0	6.5	5.9
Avg	5.7	4.5	4.35	6.75	5.1	6.2	5.8	6.55	7.45	5.4	6.6	5.2

Source – *Southern Pacific Wind and Solar Monitoring Project*, FSED, 1997

Directional data shows that there is a very strong easterly and south-easterly dominance over the entire year and there is only modest seasonal variation in direction and speed.

This data indicates that there probably is an economically developable wind resource at the measurement site provided equipment suitable for the site can be installed and arrangements can be made for operating and maintaining the system at an acceptable cost. One serious problem is the recurrence of tropical cyclones of hurricane strength about once every 10 years on average though there have been periods with much higher frequency during the past 30 years. For example, between January 1941 and January 1947 there were four storms of hurricane force that passed over Niue. Cyclone Heta in January 2004 was the worst on record and clearly would have destroyed any wind power systems in its path.

Table 2. Horizontal solar radiation monthly averages in kW/m^2/day

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	5.93	4.97	5.10	4.18	3.34	3.08	3.19	3.33	4.71	5.52	5.05	6.20
1996	4.40	5.56	4.83	4.69	3.21	2.76	3.63	4.21	4.97	5.00	5.94	5.59
Avg	5.17	4.82	4.97	4.44	3.28	2.92	3.41	3.77	4.84	5.26	5.50	5.90

Source - *Southern Pacific Wind and Solar Monitoring Project*, FSED, 1997

Since this data is measured on a horizontal plane, the energy available on a tilted collector will have much less seasonal variation and will on average be higher. The data indicates a solar resource that is good but not excellent and implies that solar electrification projects may be difficult to justify economically though solar water heating and drying applications are likely to be cost effective. It is noted that this data, with its two year average of 4.52 kWh/m^2/day, is much lower than that measured in French Polynesia at the same latitude (5.5 kWh/m^2/day) and lower than that predicted from NASA satellite data (5.33 kWh/m^2/day) for Niue. Confirmation of the data seems justified. It is recommended that a good quality thermopile type pyranometer be located at the Niue weather station to continue hourly solar resource measurements for at least five years.

3.1.2 Biomass

Biomass resources are significant but given the poor soils and the resulting slow growth, the fuel farms for large scale energy development would have to be very large with accompanying land use problems. Currently, efforts are directed toward conservation of existing forest resources and mass removal of biomass for fuel would not be acceptable. Coconut oil for biofuel is possible but unlikely to be cost effective because of high labour costs and the difficulty of creating large scale coconut plantations under the Niue land tenure system.

There are no hydro, geothermal or tidal resources available for development. Theoretically wave energy could be developed for energy but energy conversion equipment is not yet commercially available.

3.2 Biogas

The population is dispersed, there is no urban / rural division. Collecting manure for economically reasonable biogas generation is not reasonable and the quantity of urban

waste that could be used for digestion is small. Biogas is therefore not considered a significant potential for GHG reduction.

3.3 Regulation

There are no standards or regulations for renewable energy other than those generally applicable to electricity supplies.

Home with solar water heating

HerbWade 2003

Figure 3-2 - View of Sir Roberts Wharf, Alofi, during Cyclone Heta's approach

Niue Police, 2004

4 RENEWABLE ENERGY EXPERIENCE

Niue has had few renewable energy projects. In the late 1980s, PEDP provided training assistance to PWD for the construction and installation of solar water heaters. Though PWD decided not to construct the heaters, they did include commercial thermosiphon solar water heaters on new government housing and solar water heaters were installed on the Niue Hotel, then owned by Government.

Also in the 1980s, single panel solar systems were installed at several canoe access trails (Figure 4-3) to both help locate the landings from the sea and to provide light for carrying canoes to and from the plateau. The systems worked for several years but were poorly maintained and ultimately ceased operatinga. In 1996, a two panel system for access lighting at the Tautu canoe access was funded by SPC but the local installation contractor was so slow that funding was cancelled and the installation never was completed.

Figure 4-1 - Panels for Namukulu Community Hall (note corrosion and delamination of the lower panels)

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Though records are not available, discussions with villagers indicates that SPC installed a solar refrigerator and lights in the Namukulu village community hall in the late 1980s. The PIREP team visited the site and found the system still in place but not working. It included a 12VDC refrigerator constructed in Tahiti and at least four fluorescent tube lights that appear to be 18 Watt units. There were 14 Photowatt single crystal panels of 36 cells each. Panels were rated at 47 Watts each for a total of 658Wp rating. Battery specifications could not be read but appear to be six 2V cells of about 250Ah capacity at C_{10}. The villagers complained that what they really needed was a freezer, not a refrigerator. So to keep fish for more than a week, it was necessary to freeze them in a

conventional freezer, then transfer them to the solar refrigerator. By doing that they could be kept longer. The villagers also complained that though the lights worked in the community hall, they were not nearly as bright as the ones operated from the generator. In general the village felt they found the system to be useful but not really what they needed. Though PWD technicians were supposed to maintain the system, there were no regular checks of the batteries and they soon failed. The solar array is mostly in good shape, though the bottom most two panels of each of the two arrays has serious perimeter corrosion and delamination of cells.

Figure 4-2 - Sun tracking PV panels for solar pump (inoperative)

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In 1996, a solar water pump was installed for the village of Makefu with funding from AusAID (Figure 4-2). Two pumps were originally slated for installation, the other to be at Vaiea, but as the Vaiea well was not far from the perimeter road, a spur to the perimeter grid was run and the pump powered by NPC. The Makefu borehole was too far to economically run a grid extension so the solar pump was installed. The Suntron pump was operational in 1997. It included 21 Solarex polycrystalline panels each rated at 65Wp for a total of 1,365Wp capacity. The panels were mounted on three one axis trackers made by Suntron Power Products Pty. Ltd. of Australia. Suntron Power Products ceased trading in 1996 and repair parts have not been available. The pump never reached the manufacturer's design value in pumped volume and the output was insufficient to meet the village needs. The 90,000 litre tank was almost never full and as village use is on the order of 30,000 litres/day, there were often shortages. In 1999 the tracking system failed and though parts were sent overseas for repair, they were never returned. Without the tracking, the pump output fell further. Since 2002 the pump has not worked at all and the system is out of service.

There have been a few private purchases of solar water heaters and solar PV systems but there are no dealers or service personnel in Niue.

There has been no past experience with electrical generation using wind power. The classic Australian windmills for water pumping were used at one time but as they wore out, they were damaged by hurricanes or corroded due to the salt laden atmosphere, they

were not replaced. Where water wells are in the interior areas where the grid does not reach, they are serviced by small diesel pumps.

Although biomass has been used in the past for cooking and for copra drying, neither is a major use today. No copra is shipped from Niue any longer and most homes are moving away from wood as a cooking fuel with LPG rapidly becoming the fuel of choice.

Although coconuts are a significant export from Niue, they are "drinking" coconuts or whole coconuts, not copra. With the high personal income levels present in Niue, there has been no interest in cutting copra or developing low cost coconut oil as a fuel. Coconut oil is produced in small quantities as a body lotion and for cosmetic uses but the selling price is very high on a per litre basis.

4.1 Lessons learned from past projects

- **Keep it simple.** Given the isolation of Niue and the very limited technical support available on island, the use of complicated designs is unwise. The tracking system used for the PV water pump was much too complex to survive for long in Niue. Much better would have been the use of a larger area of fixed collectors with no moving parts to fail and minimal electronic gadgetry to break down. While the initial cost may have been somewhat higher, the life expectancy of the project would have been much longer.
- **Provide systems that do what people want.** Maintenance efforts will only be made if the system is doing what the users want. In the case of the solar refrigeration system, it provided neither the freezing capability desired nor the brightness of lighting needed. Therefore there was little incentive to keep the system running by demanding that PWD follow through on their maintenance promises.

4.2 Projects in the pipeline that will affect energy in Niue

Two projects dominate the energy picture in Niue. The first is the construction of a blast freezer and cold storage facility as a joint venture between Reef Shipping and the government. The facility is expected to have around a 100kW demand and the starting power for the blast freezer is so high that there must be a separate generator at the freezer to handle the load. Once running, the load could be shifted to the grid (with prior notification to the power plant) or kept on the local generator. Construction has begun, near the PWD facility in Alofi and should be completed in 2004. While there is some question about the economic utility of the facility, if its use proceeds as planned it will be the highest single demand on the Niue grid. Currently the main motor at the rock quarry is large enough to make it necessary for them to call the power plant prior to start up but it is substantially smaller than that to be installed at the freezer.

The second project is the European Union (EU) renewable energy and energy efficiency project still in the planning stage. With a total budget of €1.8 million, the project is one of the largest energy projects ever to be undertaken in Niue. It is a part of the €11.41 million EU regional project targeting Niue, Nauru, Federated States of Micronesia Palau and Republic of the Marshall Islands.

The present proposal is that much of the budget go to the installation of three grid connected 150 kW wind machines, associated dummy loads and controls. Additionally

small energy efficiency, energy information and training components are proposed. As the financing agreement is not expected to be signed until March 2004 and the inception phase not scheduled to be completed until June 2005, there remains considerable opportunity for changes in direction for the project.

The PIREP team suggests that the reconstruction of many government facilities after their damage or destruction by Cyclone Heta in 2004, is an opportunity to rebuild with highly energy efficient designs at minimal added cost. It is suggested that government consider requesting that the EU allocate at least part of the designated funding to further that concept.

Figure 4-3 - Lihu Canoe Access Stairway

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5 BARRIERS IDENTIFIED FOR THE USE OF RENEWABLE ENERGY TECHNOLOGIES

5.1 SWOT Workshop

A S.W.O.T. workshop was conducted on the morning of Monday 24 November in the Hotel Niue. The opening speech by the Acting Minister for Environment, the Honourable John Tiakia conveyed the purpose of this workshop and why it is important for government to support this undertaking. Part of his speech emphasized the fact that:

"Niue's main energy source comes from the production of fossil fuel for transport, industrial energy, and electricity production. This is costly and contributes to the global environmental problems. This contribution may be minimal compared to other developing and developed countries…However, under circumstances such as the increasing cost of fuel and Niue being a signatory to the Kyoto Protocol, Niue would have to do its best in carrying out what is beneficial for the country and its people."

The workshop participants concluded with the list of strengths, weaknesses, opportunities and threats shown in Table 2.

Table 2 – SWOT workshop results

Strengths	Weaknesses	Opportunities	Threats
Good wind and sun	Small population	To develop eco tourism	Cyclones
Uses NZ currency	Isolation of Niue	To improve trade balance by reducing fossil fuel imports	Reduction in external aid finance
No problems with access on the island	Small proportion of young people	To show internationally that Niue does what it says about the environment	Continuing fall in population
Modest requirements for energy	Limited private sector	To increase technical capabilities on island	The EU project does not work as intended
Well educated populace	Market small so little interest by outside investors	To decrease energy dependence on outside sources	
Ease of communications to populace	Technical training not available on island		
Political stability	Was unable to keep earlier renewable energy projects working		
Low corruption			
General commitment to protecting the environment			

SWOT Workshop held at the Niue Hotel on 24 November, 2003

5.2 Known barriers

The following specific barriers to the sustainable development of renewable energy and energy efficiency systems were identified in Niue.

5.2.1 Fiscal and Financial Barriers

At the top of the list of barriers must be those relating to the relative cost of renewable energy, both in terms of its actual financial cost and the cost of shifting from familiar and convenient fossil fuels to unfamiliar technologies. Fiscal policies include import duties that unfairly tax renewable energy systems, taxes applied to renewable energy systems

that are biased against renewable energy and inadequate government budgets for renewable energy development.

Taxes and import duties for renewable energy in Niue are much less of an issue than in larger countries since virtually all renewable energy development of any capacity will have to be developed by government. The NPC will necessarily have to take the lead role and private sector activities are expected to be limited to solar water heating, a market that has yet to develop strongly.

Dependence on aid funding for projects. With such a small economic base to work from, there is almost no opportunity for local generation of the funds necessary for significant renewable energy development. Funds from New Zealand and other donor sources will be required. That limits opportunities for access to funding and also imposes limits on the types and sources of renewable energy technologies that can be used to those considered acceptable by the donor agencies.

5.2.2 Legislative, Regulatory and Policy Barriers

The legislation establishing the NPC does not appear to penalise renewable energy, though it does not encourage its use either. If the government considers renewable energy to have a high priority, providing NPC with a mandate to incorporate it into its power systems would be beneficial. Such a mandate would have to include provision for the government to cover any added cost of investment and energy production that exceeds that found with fossil fuels. A significant weakness, largely due to the small size of the country, is the lack of structures in government specifically for the regulation of NPC tariffs.

Lack of national energy policy. No energy policy is in place to help focus on energy problems and rational energy development. Because there is no surplus capacity available to develop and operate renewable energy systems, if they are to become an important part of the energy production in Niue, then government must have a clear focus for developing that capacity. It will be a long term process that will require a directed effort that is unlikely to exist without a well defined policy that is genuinely treated as a guiding concept for government over the long term.

Lack of Government energy specialists. Development of energy development skills, for both conventional and renewable technologies, is needed in government to ensure that donor funded energy projects are in fact appropriate for Niue. While NPC is presently the only public agency active in the energy sector, it has a narrow focus: the delivery of electricity through the grid. That accounts for less than half the energy demand of Niue and if government is serious about reducing dependence on petroleum for energy, then transport energy must also be addressed and capacity developed for its management and regulation.

5.2.3 Institutional Barriers

Throughout the Pacific, one of the main points of failure in renewable energy projects has been institutions that are inadequate to provide sustainable operations. Each form of renewable energy has specific technical and institutional structures that must be in place for receiving payment for energy services, maintenance of equipment and installation of

new components. In Niue the only existing institution likely to fulfil the requirements is NPC. Since renewables that impact GHG production will be grid-connected, integrating the renewable energy management into the NPC structure appears to be necessary.

Technical training. There is no technical training available in Niue. Any technical training must be obtained overseas at high cost and with total absence of the trainee from work. Training that combines work and study is impossible though often that is the most effective since theory learned in the classroom can be immediately applied on the job and there is no loss of staff for long periods to attend training.

5.2.4 Technical Barriers

Although wind power, solar photovoltaics and solar water heating are all technically mature, there remain technical barriers that must be overcome that are related to the special conditions present in Niue.

Difficult environment for electrical and mechanical equipment. The tropical marine environment of Niue is difficult for mechanical and electronic equipment. Electronic control systems and DC to AC converters are particularly vulnerable and must be designed specifically with the salt laden air, high ambient temperature and moist conditions in mind.

Limited Technical Capacity. Niue has a small population with few persons having technical competence applicable to energy development. Renewable energy will need to be developed in conjunction with the existing energy systems. Technical personnel are already in short supply on Niue and the additional development of renewable energy in parallel with existing energy systems will require additional personnel that will have to be trained from the ground up. The addition of either wind or solar to the existing diesel generation system does not reduce the load on existing staff; it could even increase their work load because of the increased variability of the load on the diesels.

Lack of renewables experience. There is minimal prior experience with renewable energy systems. There is no experience at all with successful renewable energy systems for grid based electricity generation. The few PV installations that have been made have all failed and there are no persons on Niue who can be considered to have experience that would be related to renewable energy.

5.2.5 Physical Barriers

Physical barriers are not directly amenable to barrier reduction. They must be figured into any renewable energy system design and effort made to reduce their harmful effect.

Susceptibility to cyclones. Niue lies in the zone where tropical cyclones are a barrier. Because renewable energy equipment by definition must interact with the natural environment, that equipment is necessarily more vulnerable to local natural disasters than equipment dependent on imported fuels.

5.2.6 Market Barriers

Market barriers are those that reduce opportunity for private enterprise to participate in developing renewable energy. The primary market barrier of small size is basic and not amenable to externally delivered barrier reduction programmes.

Small population. The small size of the market is not attractive to private enterprise interested in providing renewable energy systems. The market for technical skills and products is simply too small in Niue for the profitable development of a private sector technical services or sales industry.

Lack of confidence in renewable energy due to prior project failures. With several highly visible failures of renewable energy installations as the local experience, it is difficult to generate enthusiasm at either the public or private level for new renewable energy efforts.

Cost not clearly competitive. To be economically reasonable, renewable energy systems must produce power at a cost comparable to existing grid power since the country is fully electrified from the grid. Many of the PICs find renewable energy to be cost effective in unelectrified rural areas because the cost of extending conventional power systems to those areas is very high. Niue has all areas already served by the national grid. Therefore in Niue renewable energy must directly compete with diesel based grid power if long term operational subsidies are to be avoided.

Petroleum is cheap and convenient. For power generation, diesel fuel is less expensive and more convenient to use than available renewable energy sources making acceptance of renewable energy to replace petroleum fuels for power generation and transport difficult.

5.2.7 Informational and Public Awareness Barriers

For renewable energy technology to be accepted, it is important that people at all levels understand its benefits and its problems and become familiar with the idea of replacing fossil fuels with renewable technologies. Various public awareness programmes have been established in the region but Niue has none presently in place.

Lack of information about renewable energy at NPC and in Government. Although there have been discussions regarding renewable energy, particularly wind energy, development, that have involved NPC and government personnel, the information available remains quite limited and appears insufficient for NPC or government to be able to make a truly informed decision as to the proper course to take.

Lack of understanding of renewable energy and energy efficiency technologies. Although there have been small projects using PV, they have been poor examples and have not reduced information barriers. In general there needs to be a better understanding by decision makers, the general public and businesses regarding the advantages, disadvantages and costs of renewable energy and energy efficiency technologies.

6 CAPACITY DEVELOPMENT NEEDS FOR REMOVING THE BARRIERS

Capacity development is required to offset barriers of inadequate capacity in the NPC, lack of clear policies and strategies for energy development, and maintenance issues resulting from the difficult environment of Niue relative to mechanical and electrical systems. While projects can be developed to specifically address these issues on a regional basis, as is now the case for policy development through PIEPSAP, the issues are broad and generally cannot be tied to a specific project or barrier reduction effort. ESCAP is developing a regional training concept intended to address these issues and, if implemented, should provide the majority of the capacity development needs of Niue other than training and capacity development support specifically focused on individual projects, such as the upcoming EU project, which should be carried out as an integral part of those projects.

6.1 Barrier Reduction Through Capacity Development

6.1.1 Reducing Fiscal and Financial Barriers

Project development support. Although there do not appear to be problems of locating finance for renewable energy development, there is some problem accessing it due to problems with the development of project documentation acceptable by financing institutions. As part of regional capacity building efforts, specific programmes in project development, project document preparation, economic analysis and interfacing with international finance agencies should be developed and delivered to Niue. These need to focus not only on the NPC but also on any other agency, public or private, that has a need to access international finance for renewable energy or energy efficiency projects.

Fiscal Policy development. Taxes, import duties, electricity tariffs and government purchasing policies have an impact on the cost of renewable energy relative to fossil fuels. Government officials responsible for these policies should be made aware of the effect these policies have on the development of renewable energy and energy efficiency measures. This can be done through a regional capacity building programme that provides informational materials and training for the appropriate officials.

6.1.2 Reducing Legislative, Regulatory and Policy Barriers

Energy policy development. Assistance is needed in the development of a well formulated, country specific energy policy document that addresses issues of energy efficiency, renewable energy and conventional energy and can be accepted by all political factions as a genuine long term guiding policy for government. The PIEPSAP project under SOPAC is expected to focus on these issues.

6.1.3 Reducing Institutional Barriers

Technical Training. In order to operate and maintain renewable energy systems, technicians must be trained and that training must be available on demand, not just at the initiation of a project. ESCAP is in the process of developing a regional training concept that would include training for operating, maintenance and repair technicians. Also, it is expected that the EU project will include specialist training for the equipment being

installed. Arrangements should be made for that training to be provided by a training facility in the Pacific Region so that it can continue to be made available after the EU project closes.

6.1.4 Reducing Technical Barriers

NPC training. Capacity needs to be developed at NPC for the integration of renewable energy into the power system. The technical requirements for large scale wind or solar PV implementation are significant and NPC will almost certainly need to place a specialist on staff that has been well trained in the operation and maintenance of the renewable energy equipment. Significant capacity development will be needed with any large scale integration of renewable energy into the grid. Given the specialist nature of the expected grid connected system, capacity development should include participation by the equipment manufacturer or vendor as well as skilled trainers and should be funded by the EU as part of the project.

6.1.5 Reducing Market Barriers

Market development. The basic problem of the market being too small and dispersed to support private development cannot be addressed by capacity development measures. However, any training programmes that are provided relating to installation, maintenance, troubleshooting and repair should be opened to private individuals or companies who may aspire to contract their services to the NPC or other public agency implementing renewable energy in Niue.

6.1.6 Reducing Informational and Public Awareness Barriers

Decison maker information delivery. Through in country programmes, sessions at international assemblies of decision makers, PPA annual meetings, SOPAC meetings, Forum meetings and other opportunities, information needs to be provided decision makers regarding the appropriate technologies for Niue and problem areas that need to be avoided. NPC staff and cabinet advisory staff should receive specific information packages and, where possible, actual training on the manner that RETs can aid national development and on the best approaches to energy strategies using energy efficiency and renewable energy methods. This is a need common to most of the smaller PICs and can be developed into a regional programme.

Public information programmes. What knowledge there is of solar PV is largely based on failed projects. There is little public knowledge about wind power or hybrid systems. As this is a need for most of the PICs, the necessary public information materials can be developed regionally and delivered to countries along with short term training and advice in their proper delivery.

7 Implications of a Large Scale Use of Renewable Energy

7.1 Large scale use of biofuels or biomass for energy production

Biofuel and biomass resources are present on a modest scale and there is sufficient cleared land available to dramatically increase their availability. But their growth and harvesting on a large scale is made difficult by land use issues and the lack of a labour force to grow and harvest the fuel crops. Large-scale development of biomass for combustion or biofuels for engine operation both would involve the use of very large areas of the country for growing the resource and would require a relatively high percentage of the labour force to participate in fuel production activities. The economic, social and environmental effects would be significant and generally negative in relation to other options for land use and labour utilisation. Because of its small size, the lack of an industrial/commercial establishment concentrating wealth and energy use in urban areas and the prevalence of government employment even in rural areas, there is not the large gap between "rural" and "urban" incomes in Niue that are seen in many PICs. So the growing of fuel crops would not provide either the economic or social benefits that would be found where those large income gaps do exist. Major development of fuel crops could also limit the possibilities for the development of high value agricultural exports, such as vanilla, since both land and labour would have to be concentrated on fuel production to attain large scale biofuel or biomass use for energy.

7.2 Implications of large scale wind energy development

The renewable energy technology closest to commercial viability is wind turbines directly connected to the grid to offset fuel use. However, in order to assure grid stability the kW input from the wind installations should not generally be more than about 15% to 20% of the existing kW daytime demand where a single turbine location is in service. Higher percentages are possible but involve increasingly complex energy management systems, more widely dispersed wind turbine locations or a very expensive energy storage system. All these approaches generally result in significantly higher cost per kWh delivered from wind and increased difficulty in technical maintenance in the Niue context.

Adding a wind component does not reduce the requirement for conventional generation capacity since (at least without energy storage) wind power cannot be assured to be available when needed. Since the peak load in Niue is less than 1 MW, a large scale wind farm will not be needed even at the relatively modest wind speeds found in Niue so a single site is proposed for development with no more than three turbines. Although power penetration can be 15% to 20% of system power demand, in terms of energy delivery that will result in less than 15% of the existing energy demand of Niue being offset by wind unless very expensive energy storage such as batteries or hydrogen generation is included or excess turbine capacity with complex generation management systems are installed. While wind plus storage could become economically practical if there are very large increases in fuel prices and/or a fall in wind turbine or energy storage system prices, it is unlikely that wind power with massive energy storage will be economically feasible for Niue within the next decade.

With the less than 1 MW maximum demand of Niue, more than three or four medium sized wind turbines is all that can be accommodated. Therefore there is not likely to be serious negative environmental effects or significant social effects that result from their installations. There would, however, be economic benefits resulting from lowered dependence on fossil fuels and environmental effects due to reduced GHG production for electrical generation.

7.3 Implications of large scale solar energy development

The problems that exist with wind systems are more acute for solar since the resource is only available part of each day. Though the power penetration can be made similar to that of wind, 15%-20% according to the complexity of the control or storage system, the energy penetration will be much less and probably not greater than 5% of total grid delivered energy. Further, large land areas are required for largescale solar power systems, much larger than for wind power systems of similar power generation capacity. Solar power systems do have the advantage of being less vulnerable to damage by tropical cyclones than wind turbines.

Social and economic advantages of a distributed network of solar energy generators feeding into the grid would be mostly concentrated in the benefits associated with a reduction in dependence on external petroleum supplies: reduced economic trauma resulting from fluctuations of petroleum prices and increased local control of the national energy supply. Since the solar energy would not be seen as a separate energy source by users, there would be no social benefits at the household or village level nor would there be any likelihood of grid connected solar reducing energy costs to consumers. There could be somewhat higher system reliability made possible by having multiple generators and lower distribution losses may be seen through the injection of power at many points along the distribution system.

7.4 Implications of energy storage using lead-acid batteries

Introduction of wind or solar energy sources to the grid at levels greater than can be absorbed directly without grid instability will require the use of energy storage systems, typically high capacity lead-acid storage batteries. Environmentally appropriate disposal of failed batteries will be necessary. Fortunately the recycling of lead-acid batteries is provided by most battery manufacturers and arrangements for disposal consists only of shipping spent batteries to the recycling centre. With the industrial class of battery that would need to be used for large scale solar development, recycling is not a large issue because the life is long, typically 10 years or more, and the number of batteries small though individual batteries would be fairly large. Long term indoor storage of spent batteries does not create environmental problems (Figure 7-1)nor does it reduce the recycling value for the batteries so it is reasonable to store spent batteries until a sufficient number can be gathered together to make an economically efficient shipment to the recycling centre.

7.5 Summary

For the period ending 2013, it appears improbable that renewables can technically provide more than about 20% of the electricity used in Niue and virtually none of the

transport energy use. When economics is considered, it is unlikely that renewables can substitute much more than around fifteen percent..

For the period 2003-2013, there appears to be as much or more potential for the reduction of petroleum use – and greenhouse gas emissions – by improving the efficiency of energy use in transport and through electricity demand side management than by implementing renewable energy systems. However, renewable energy development certainly should not be ignored but should be developed hand-in-hand with energy efficiency measures. The longer term (10+ years) potential is greater for renewables than energy efficiency measures and the NPC needs to gradually gain experience in integrating renewable energy into its system for there to be successful development of large scale use over the long term.

Figure 7-1 - Failed batteries at Namukulu village still good for recycling after 10 years of storage

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8 Implementation of the Capacity Development Needs and Co-Financing Opportunities

1. Immediate capacity building is needed for renewable energy and energy efficiency measures with a concentration on grid-connected renewable energy and energy efficiency for electricity and transport. Capacity building for wind power will be required particularly as regards proper operation and maintenance. If grid connected photovoltaics are to be provided, training should be provided from Germany, the U.S or Japan since only those countries have extensive experience with grid connected PV systems.
2. There will need to be continuing technical training for personnel to operate and maintain renewable energy and energy efficiency equipment. The EU funded renewable energy project being considered for Niue will probably include a training component for installation and maintenance of the project but, if past projects are an indication, it is unlikely to provide for long range training and technical support for NPC in renewable energy system operation and maintenance. Given the high turnover of technical personnel, particularly at the lower levels, continuing availability of specialized training in the maintenance and repair of the renewable energy systems is an issue that needs to be addressed. As it is an issue throughout the Pacific, the opportunity exists for the GEF or other multi-lateral agencies to fund development of a regional training capability that can bridge the gap between the focused trainings provided with donor projects.
3. There have been no significant public information efforts relating to renewable energy and energy efficiency. Neither the general public nor businesses have a good understanding of the methodology and benefits of renewable energy and energy efficiency technologies. Developing a quality public information program is an opportunity for co-financing by an external organization in association with the Niue Government and local sources.
4. Management capacity for renewable energy and energy efficiency project implementation at the NPC and within the government needs further development using external resources. It is also an area of training and education that represents a regional need and is an opportunity for GEF or other multi-lateral organization to provide valuable input.

8.1 Existing co-financing opportunities

Co-financing for the foreseeable future is limited to the EU renewable energy project scheduled for implementation beginning in late 2004. There appears to be an opportunity for development of capacity building activities within both the government and NPC in association with the EU project. Specific co-financing concepts cannot be developed until the activities to be funded under the EU project are clearly defined, probably early in 2005.

9 ENERGY EFFICIENCY

The economics of integrating renewable energy into the existing energy supply systems are greatly dependent on the total energy requirement. It does not make economic sense to develop programmes for the implementation of new sources of energy without including programmes to improve the efficiency of energy use. Savings through energy efficiency measures in Niue are expected to be equally if not more effective in reducing petroleum imports (and therefore GHG production) as would be practical through large scale renewable energy implementation. For the addition of renewable energy to the Niue energy supply to be most effective, energy efficiency improvement programmes should be implemented simultaneously.

9.1 Government

With the rebuilding of many government facilities after the February 2004 cyclone, comes the opportunity to rebuild using energy efficient architecture and energy efficient lighting and air conditioning systems. The added capital cost will be modest for most energy efficiency improvements with a full payback through energy savings in less than five years.

9.2 Domestic

There are clearly opportunities for energy efficiency improvements in the domestic sector. A programme of public information and education plus making energy efficient lights and appliances available in local shops could result in substantial savings in fuel for electricity production. Consideration should be given to arranging for special financing for energy efficient freezers and refrigerators to replace existing appliances and to programs to provide household audits of air conditioners, refrigerators and freezers to propose maintenance activities (door seal replacement, cleaning, etc.) and home upgrades (better seals for windows in air conditioned rooms, insulation in the ceiling of air conditioned rooms, awnings to block the sun from windows, etc.)

9.3 Transport

The opportunities for improvement in transport fuel efficiencies include actions to penalise purchasers of large inefficient vehicles for personal transport, to educate drivers and boatmen in techniques for improving fuel efficiency, engine tune up service provision and investigating public transport opportunities. Since a significant number of vehicles in use are operated by government, when present vehicles are to be replaced government should consider fuel efficiency as one of the primary specifications for the purchase of replacement vehicles.

10 ANNEXES

Annex A - Persons Interviewed by the Local and International Consultants

Speedo Hetutu, General Manager, Niue Power Corporation (NPC) gm.npc@mail.gov.nu

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Ofalosa Williams, Records and Accounts Officer, NPC.

Pita Talepita, Engineering Division, NPC.

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Christine Ioane, External Affairs Officer, Fala Fono, Alofi South, Niue Is.

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Desmond Tukutama, Manager Airport Bulk Fuel, Fonuakula, Niue Is.

Colleen Kulatea, Records and Accounts Officer, Airport Bulk Fuel.

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Brendon Pasisi, Principal Fisheries Officer, Fisheries Division, Department of Agriculture and Fisheries, Sir Robert's Wharf, Alofi, Niue Island.

Paul Pasisi, Monitoring, Surveillance and Coordination Officer. Fax (683) 4079.

Leonard Tukuitonga, Financial Secretary, Treasury Department, Utuko, Alofi, Niue Is.

Sue St. Clair, Records and Accounts Officer, Treasury Department. Fax (683) 4350.

André Siohane, Manager Water Supply Division, PWD, Alofi. Waterworks@mail.gov.nu or pwd@mail.gov.nu

Colin Leslie Posimani, Manager Niue Hotel, PO Box 80, Alofi, Niue, 683-4091 Fax 683-4372.

Hon Sandra Lee-Vercoe, NZ High Commissioner

Ida Talagi-Hekesi, Information Centre Manager, Niue Tourism Office

Kimray Vaha, Assistant Statistician, Economic Planning and Development Division andStatistics Unit, Premier's Department.

Bryonne Nichols, Broadcasting Corporation Niue

Pacil Pasisi, Police

Morris Tafatu – Homeowner

Hon Michael Jackson, MP (common roll) and publisher of the Niue Star

Hon Bill V. Motufoou, Cabinet Minister (acting Premier). Minister of Public Works, Water, Civil Constructions and Port Facilities, Bulk Fuel, Economic Planning Development and statistics, Niue Development Bank, Agriculture Forestry and Fisheries,

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David Poihega, Climate Change Officer

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Paul Pasisi, Monitoring, Surveillance Control Officer

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J.Berry Sofaea, Supervisor, Bulk Fuel

Sunlou Freddie, Acting Manger, Economic and Planning

Stan Kalauni, Marketing Officer

Togia Sioneholo, Secretary of Justice, Lands and Survey

Ahohiva Levi, Registrar, Lands and Survey

Fapoi Akesi, Department of Community Affairs

Tagaloa Cooper, Environment Officer

Hon. Jack Willie Lipitoa, Member of Parliament (Namukulu Village)

Falani Mokoia, Manager Swanson Ltd Supermarket

Maria Togatule, Acting Chief of Police

Desmond Hipa, Manager of Ali Giftware

Misa Kulatea, Hakupu Heritage And Cultural Park

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