SPREP

Pacific Islands Renewable Energy Project

A climate change partnership of GEF, UNDP, SPREP and the Pacific Islands

GEF

UNDP

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

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National Report

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PIREP

our islands, our lives...

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

Joseph Cain, National PIREP Coordinator

Lockley Denuga local consultant

and

Herbert Wade, International PIREP Consultant

The international consultant visited Nauru from 26 March – 1 April, 2004

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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
ARM	Atmospheric Radiation Measurement Programme (USA)
BPC	British Phosphate Commission
CIF	Cost+insurance+freight
CPI	Consumer Price Index
CROP	Council of Regional Organisations of the Pacific
DC	Direct Current
DPK	Dual Purpose Kerosene (Jet fuel and Domestic 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
ESCAP	Economic and Social Commission for Asia and the Pacific (UN)
EU	European Union
EWG	Energy Working Group of CROP
FATF	Financial Action Task Force on Money Laundering (OECD)
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
GoN	Government of Nauru
JICA	Japan International Cooperation Agency
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
MDG	Millennium Development Goals
NPC	Nauru Phosphate Corporation
NPRT	Nauru Phosphate Royalties Trust
OECD	Organization for Economic Cooperation and Development
OTEC	Ocean Thermal Energy Conversion
PACER	Pacific Agreement on Closer Economic Relations
PIC	Pacific Island Country
PICCAP	Pacific Islands Climate Change Assistance Programme (GEF/UNDP)
PICTA	Pacific Island Countries Trade Agreement
PIFS	Pacific Islands Forum Secretariat
PIREP	Pacific Island Renewable Energy Project (GEF/UNDP)
PV	Photovoltaic
RET	Renewable Energy Technology
SHS	Solar Home System
SOPAC	South Pacific Applied Geoscience Commission
SPREP	Secretariat of the Pacific Regional Environment Programme
SWH	Solar Water Heater
TEPCO	Tokyo Electric Power Company
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization

USA	United States
USP	University of the South Pacific
V	Volts
WB	World Bank
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 [e]	
							per GJ	per litre
Biomass Fuels:								
Fuelwood (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. Consisting of a single, isolated raised coral equatorial island, Nauru is about half way between Sydney and Honolulu. Total land area is 21 km^2 with an EEZ of 320,000 km^2. There are two separate plateau areas: "bottom side" that is a few metres above sea level and "topside" that is typically 30 metres higher. Topside is dominated by pinnacles and outcrops of limestone, the result of nearly a century of mining of the high grade tricalcic phosphate rock that lay between those formations. There are no natural harbours and the island is surrounded by a fringing reef 120-400 metres wide. The reef falls off very rapidly and deep-water ships can moor within a short distance of the reef edge. Fresh water is a serious problem with potable water coming only from rainwater collection and desalination plants.

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

Population. The 2002 census shows a population of 10,065 persons of which about 75% are ethnic Nauruan. The annual growth of the population since 1992 has been only 0.15% per year due mainly to a reduction in the number of expatriate workers staying in Nauru as the phosphate production dwindled.

Environment. The climate is equatorial marine in nature. There are no cyclones though rainfall is cyclic and periodic droughts are a serious problem with one year having a recorded rainfall of only 280 mm. The land biodiversity is limited with only 60 species of indigenous vascular plants. The century of interior mining has resulted in the drainage of large quantities of silt and soil onto the reef. That has greatly reduced the productivity and diversity of reef life from an earlier era. Sewage is dumped into the ocean just beyond the reef causing further environmental problems and many septic tanks place ground water at risk of contamination.

Political Development. Nauru has a Westminster parliamentary system with a single chamber parliament of 18 members that are elected to a three year term. The parliament elects one of its members to act as President who is both Head of State and Head of Government. Nauru has had frequent changes of government in recent years, usually directly or indirectly due to problems associated with the failing economy. Nauru is a member of most Pacific Island economic and environment associations and a signatory on most economic and environment treaties that affect the region. Nauru became a member of the Commonwealth and the United Nations in 1999.

Economic Overview. The basis for the economy of Nauru since the early 1900s has been the export of phosphate. In the 1990s, the peak of phosphate production was reached at around $120 million per year but since the mid-1990s exports have fallen to a fraction of the 1980s peak. Though a Nauru Phosphate Royalties Trust was established to provide income after the phosphate was mined out, poor management of the trust has resulted in its serious depletion making Nauru essentially bankrupt today.

Though there has been assistance from Japan in the creation of a local fishery industry, it is not a major source of export income and is unlikely to be expanded in the near future.

Most of the operating funds in recent years have come from Australia as payment for damages to the Nauru environment during its years of mining, through payment to Nauru for hosting refugee populations that Australia is unwilling to host on its own soil and through outright grants. Substantial income also comes from licensing foreign fishing boats to operate within the EEZ. The economic outlook for the near-term is poor and Nauru is dependent on Australia for the continuance of most public services.

The most pressing issue for future development is the rehabilitation of the more than 70% of Nauru's land area that has been mined. $107 million Compact of Settlement was agreed upon by Australia and Nauru in 1993 for the purpose of topside rehabilitation but there is no visible progress.

Institutional and Legal Arrangements for Energy. The Nauru Phosphate Corporation (NPC) provides all energy services to Nauru. Petroleum is purchased by, stored by and distributed by NPC. All water and waste disposal services are handled by NPC as is all electricity generation. There is no government energy office. Renewable energy is not considered at all in any legislation, regulations or corporate actions except for a small number of solar water heaters installed on government housing by the PWD in the 1980s. There is little use of biomass for cooking and for all practical purposes, there is essentially no use for renewable energy.

2. Energy Supply, Demand and the GHG Inventory

Energy Supply. Petroleum is purchased for cash by NPC since credit is no longer extended by oil suppliers. The average annual petrol purchased by NPC is around 3.5 ML, ADO is around 9.5 ML and jet fuel around 1.6 ML. Pricing for resale is based on CIF cost plus a mark up sufficient to cover handling and storage. There is no price regulation. Shortages have occurred due to a lack of cash at NPC to make a timely purchase and there have been times where voluntary rationing of petrol and rolling blackouts of electricity were the result.

The electricity supply is from a single power station operated by NPC. Most of the power now comes from containerised diesel generators with only one of the eight stationary engines still in service. The distribution system is in a ring main configuration and includes 11kV, 3.3kV and 415V sections. Maximum demand was in excess of 7 MW but is dropping due to the loss of industrial demand with the remaining demand around 4 - 5 megawatts.

Energy Demand. During the high phosphate production years, industrial use dominated the Nauru energy economy. That use has diminished to the point where the domestic sector is now, or soon will be the dominant user. Electricity data to determine the present use patterns was not available though it is clear that there are major shifts underway in the patterns of use of all energy.

Because electricity tariffs have been kept artificially low and collection of bills is not enforced, household use of electricity is very high at around 915 kWh/month per household. Multiple air-conditioners are common as are electric cookers, freezers and refrigerators.

Future Growth in Energy Demand and GHG Emissions The current GHG production is estimated at 45.3 Gg/year. Due to the major structural changes taking place in the Nauru economy, accuracy is very low for forecasting future energy use. It is likely that fuel use will not increase and may even decrease over the next decade. In any case it is highly unlikely that usage will increase significantly. The PIREP team believes that only the use of jet fuel appears likely to have any growth over the next 10 years and that only if plans are carried out to expand Air Nauru regional services though agreements with other national carriers.

The addition of renewable energy and energy efficiency measures has an estimated potential of reduction of 35% of the 2013 GHG predicted values. The great majority of these savings are projected to come from energy efficiency measures since more than half of energy used in Nauru can be saved with little change in quality of life for the residents. Solar energy is only likely to save a maximum of 5% of the ADO used for power generation.

3. Potential for Renewable Energy Technologies

Solar As an equatorial country, Nauru has a very good solar resource. Measurements show an average of about 5.8 kWhr/m^2/day with only small seasonal variation. Solar PV offers electricity generation that can supplement the existing diesel generation. However, unless very expensive electrical storage systems are included, the penetration of solar power into the grid is limited to around 15%-20% of noon time demand. This still represents more than 1MWp of solar PV and would be a large investment even without storage. In terms of energy production, a 15% demand penetration represents around a five percent energy penetration for the conditions in Nauru.

Wind. The wind resource is poorly known though probably not economically useful. A resource assessment for topside would be worth carrying out to determine the appropriateness of further development.

Biomass. With little or no biomass present topside, there are insufficient biomass resources for either combustion or significant production of biofuels. Rehabilitation efforts may result in topside biofuel plantations but certainly no production will be seen within the next decade.

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

OTEC. With the very rapid drop off that occurs beyond the reef, there is opportunity for OTEC energy development once engineering and commercial trials are completed elsewhere. Within the next 10 years, it does not appear likely that OTEC can be a part of the Nauru energy economy.

4. Experiences with Renewable Energy Technologies

No significant commercial development of renewable energy has been recorded. Only solar water heating has been used to any extent and most of the systems failed after a few years of use and were not repaired.

The Japanese did a technical trial of OTEC in 1981 with an experimental plant on the west coat of Nauru that produced a net power of 15kW. The trials were mainly as engineering trials to gain experience with the technology and have not resulted in further development in Nauru.

5. Energy Efficiency Activities

There have been no organized attempts to improve energy efficiency. Both supply side and demand side efficiencies are quite poor.

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

Barriers to Renewable Energy Development.

- The collapse of the economy makes it impossible to even plan for investment.
- No banking services are available in Nauru making it difficult for private enterprise to participate in energy development
- No local finance for energy development is available since the public sector is effectively bankrupt.
- There is no national energy policy.
- No energy agency structure is present in government to provide direction and regulation.
- Small size and population places limits on capacity and resources for development.
- There is a lack of technical training facilities that could support renewable energy capacity development.
- Land tenure issues make it difficult to develop large scale renewable energy systems using biomass or biofuels.
- There is a difficult environment for electrical and mechanical equipment.
- Few developable renewable energy resources exist in Nauru.
- There is a lack of experience with grid connected renewable energy systems in the region.
- High energy use per household makes it difficult to economically replace conventional sources with renewable energy.
- There is a lack of experience with renewable energy in Nauru.
- Limited knowledge of renewable energy at high levels in government makes decision making difficult.
- Limited public awareness of renewable energy options makes acceptance more difficult.

Barrier to Energy Efficiency Development.

- The primary barrier to energy efficiency development is the low tariff for electricity and non-collection of bills.
- Limited public awareness of energy efficiency possibilities is also a barrier.

7. Capacity Development Needs for Removing the Barriers

A number of barrier reduction actions that focus on capacity development are needed.

- Assistance in improving capacity for renewable energy and energy efficiency project development.

- NPC tariff development support to ensure that the tariff structure that is selected best fits the needs of the country.
- Energy policy development support.
- Training for NPC and government officers involved with energy planning and project execution.
- Support for renewable energy and energy efficiency information delivery to decisions makers.
- Renewable energy and energy efficiency public information programmes.

8. Other Implications of Large Scale Use of Renewable Energy

For the foreseeable future, only solar energy and possibly wind energy can offset significant amounts of fossil fuel in Nauru. Both would use grid connected technologies and would therefore not have any clear social effect. There is also no known negative environmental impact resulting from the use of either technology in Nauru.

9. Implementation of the Capacity Development Opportunities

A €1.5 million renewable energy and energy efficiency programme is to be financed by the EU starting late in 2004 or early 2005. The content of the programme has yet to be determined though it is likely there will be a significant solar PV component. This project provides the main opportunity for co-financing of capacity building efforts for Nauru. Co-financing associated with Australian investment in the power sector also appear to be an opportunity. Other donors, notably Japan and New Zealand, have small projects in Nauru but nothing that relates to energy.

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Map of Nauru

Source: Government of Nauru

1. COUNTRY CONTEXT

1.1 Physical

Located 41 km south of the Equator at longitude 166º 56´ east and about half way between Sydney and Honolulu, Nauru is a country consisting of a single, isolated, equatorial island. Although only 21 km^2 in land area, Nauru commands an Exclusive Economic Zone (EEZ) of 320,000 km^2.

Figure 1-1 – Nauru Coastal Area

Herb Wade 2004

The fringing reef of 120-400 metres width falls rapidly at about a 40º angle to 4000 metres. The land has two separate plateau areas called "bottom-side" or coconut land and "topside" or pandanus land. Virtually all the population lives on the bottom-side plateau that is 100-300 metres wide all around the 19km of coast and is typically 1-15 metres above sea level. Topside is a central plateau typically 30 metres higher than bottom-side with the tallest point 71 metres above sea level. Often the 30 metre elevation difference between bottom-side and topside is a sheer cliff although there is easy natural access with several roads leading to topside. Originally, topside consisted of pinnacles and outcrops of limestone with the spaces between filled with soil and high grade tricalcic phosphate rock that is the result of Nauru having been a resting place for Pacific migratory birds for thousands of years. This formation originally covered about 70% of the island and the 1888 discovery of the phosphate resulted in phosphate mining being the primary economic activity since 1906. Unlike Niue, the only other Pacific country consisting of a single raised coral island, the lower plateau offers easy access to the sea typically with long white sand coral beaches leading down to a very rough reef area liberally studded with 1-4 meter tall limestone pinnacles and large rocks (Figure 1

There are no natural harbours but deep water exists a short distance outside the reef, so large ships, in particular the freighter owned by Nauru that travels between Brisbane and Nauru via Port Vila and Honaria, can anchor less than 100 metres off shore and a small artificial harbour allows the safe movement of containers and other goods to shore. Fuel can be offloaded from tankers using a flexible pipeline included in the offshore facilities used for loading phosphate ships. A second small artificial harbour was constructed by the Japanese Fisheries Department in 1998 at Anibare and provides protection for the unloading of fishing boats up to about 10 metres in length.

A freshwater lens exists in the porous coral rock and most families tap it for washing and sanitation through wells and small electric pumps. The bottom-side lens water is brackish and not suitable for drinking. Water obtained through boreholes topside is probably fresher but has not been significantly tapped as yet although there are plans to do so. Unfortunately there is evidence of both biological and chemical contamination of the freshwater lens so water withdrawn may require substantial treatment before it can be deemed safe for public use. Also there is little knowledge of either the extent of the freshwater lens or of the effect significant pumping may have on the remaining vegetation, particularly on bottom-side. A somewhat brackish water lake exists five metres above seal level in the bottom-side. Buada residential area and a few smaller brackish ponds, including one in a cave underground, exist but do not solve the fresh water problem. Nearly all houses and commercial buildings have rainwater catchments but the volume of storage is insufficient for true drought conditions, maintenance is often poor and the production and loading of phosphate for export results in huge dust plumes that can contaminate water catchments in some areas of the island.

The Nauru Phosphate Corporation (NPC) is responsible for the public water supply. Due to drought conditions, several times in the past fresh water has had to be brought to Nauru by sea at high cost. Since 1994, a multi-effect desalination unit operated by the NPC and powered by steam generated from the NPC power plant exhaust heat, has provided a capacity of 1200 tonnes of fresh water per day when it is working and when the power plant stationary engines are producing at least 4.5 MW. The plant also requires an electrical input of around 240kW plus the power needed for pumping in the salt water. The fresh water is delivered by truck to users' storage tanks for a charge of $8.00 for six tonnes of water. The desalination unit had not been functioning for about 30 months at the time of the April 2004 visit partly because of functional problems related to its age and state of maintenance and partly because NPC uses containerised rental generators that exhaust to the air and cannot provide exhaust heat to the desalination unit. For the desalination unit to function, 6 MW must be on line for starting the desalinator and at least 4.5 MW of generation must be on line continuously feeding the diesel exhaust heat to the desalination unit for its continued operation. Presently only two 1.5 MW engines are functioning in the power house; the rest of the 7 MW of operational capacity is provided by five containerised rented generators that exhaust their waste heat to the air.

Two 125 tonne/day reverse osmosis desalinator units are currently being used to supplement rainfall for potable water supply but one has some functional problems and there is concern for its continued reliable operation. The cost of their operation is also considerably more than the $1.67/tonne charged for delivered fresh water. Fortunately, rainfall has been generally adequate to keep local catchments sufficient for needs and water delivery from the NPC has been modest. The 210 room, government owned Meneñ hotel, currently filled nearly to capacity by expatriate contract workers, has its own reverse osmosis desalinator, removing that demand from the NPC fresh water supply. NPC hopes that the waste heat powered desalinator can be back in operation before a drought period creates a major demand for fresh water.

1.2 Historical and Social

Estimates vary but Nauru has probably been occupied for at least 3000 years. Although the people are considered Micronesians, the island was probably discovered by different ethnic groups at different times – there are indications of both Melanesian and Polynesian influences – and their descendents combined to form today's ethnic Nauruans. The language of Nauru is unique and gives few hints of its origins. Traditional Nauru society is matrilineal and is based on 12 tribal groupings.

The first recorded European sighting of Nauru was by the British ship *Hunter* in 1798 when it was given the name 'Pleasant Island'.

Figure 1-2 – WWII Japanese fortification

Herb Wade 2004

Nauru was included in Germany's Marshall Island protectorate in 1888 but in November 1914 at the commencement of WWI, Australia took possession of the island. After Germany's defeat, the island was placed by the League of Nations under the trusteeship of Great Britain, Australia and New Zealand with Australia as administrator. Those countries then soon formed the British Phosphate Commission (BPC) and shared the revenues from phosphate mining.

Nauru was taken over by Japan in August 1942. The Pacific war years found Nauru drawn into the conflict with Japanese aerial attacks and occupation early in the war. In 1943, the Japanese built an airstrip on the island and deported 1200 Nauruans to the island of Chuuk, now a part of the Federated States of Micronesia. Some war relics remain: in 2004 an unexploded Japanese bomb was uncovered while excavating for building foundations and the coastal area has several concrete bunkers remaining as evidence of wartime activity. As a result of the war, phosphate was not exported from 1942 to 1947. At the end of World War II, Nauru was made a United Nations Trust Territory under Britain, New Zealand and Australia, again with Australia as administrator, and it became independent on January 31, 1968.

Table 1-1 – 1992-2002 Population Statistics (percentages)

	1992				2002			
	Nauruan		Non-Nauruan		Nauruan		Non-Nauruan	
	Males	Females	Males	Females	Males	Females	Males	Females
0-14	16.60	15.84	4.88	4.51	16.06	14.86	3.87	3.34
15-64	17.07	16.93	11.22	9.99	20.85	21.52	9.07	8.05
65+	0.40	0.68	0.13	0.17	0.44	0.59	0.14	0.12
N.S.	0.72	0.64	0.14	0.09	0.49	0.45	0.11	0.05
TOTAL	**34.79**	**34.08**	**16.37**	**14.76**	**37.83**	**37.42**	**13.19**	**11.56**

Source: Nauru Bureau of Statistics, 2002 Census pre-release data

Although the 2002 census is not yet fully tabulated beyond basic population statistics, these those show a 2002 population of 10,065 persons of whom 75.25% are ethnic Nauruan. The 1992 census counted 9919 persons on Nauru with about 68.87% ethnic Nauruan. This represents an overall annual growth of only 0.15 percent.

Table 1-2 - Nauru Population 1992-2002						
	1992 population	1992 households	2002 population	2002 households	Average HH Size	AAGR %
Nauru	9919	1394	10065	1677	6.0	0.15
Source – 1992 and 2002 Census						

The very low rate of increase is largely due to the decreasing number of expatriate contract worker households since 1992 as the rate of phosphate extraction has fallen. Nauru continues to have a very young population with 38.13% of the 2002 population 14 or younger as compared with 41.83% in 1992.

Health problems, particularly diabetes and associated degenerative diseases, are a major problem. Nauru maintains five kidney dialysis machines, more than any other Pacific Island Country (PIC), as they are needed to handle the unusual number of persons with renal failure on Nauru. In the late 1980s, around one-third of the adult population were diabetics. Foods intended for diabetics occupy significant shelf space in grocery shops. Nauru has consistently been low in Pacific rankings regarding life span and high in frequency of lifestyle related diseases. Health officials attribute these problems to a diet consisting almost entirely of imported processed foods, heavy use of soft drinks and alcohol all combined with low levels of exercise.

Education facilities are available through high school and scholarships have been available for some students to attend secondary school in Fiji and other Pacific Islands. For example, the Hammer de Roburt Scholarship Scheme receives about A$250,000 annually from AusAID for five regional scholarships[1]. Until recently, many teachers have been foreign contract workers but problems with housing and with finances has reduced their numbers dramatically. The education system has had problems maintaining a good student/teacher ratio and in maintaining an acceptable standard of instruction.

USP has a centre in Nauru that can be used for short courses and focused technical training as well as USP credit studies. There is a vocational-technical school on Nauru although its facilities were greatly reduced by a major fire in 2003. Lost in the fire were all electrical trades teaching facilities. Most trades training in technical fields is through informal apprenticeships at NPC and on-the-job training although some personnel receive overseas training, mostly in Fiji, Samoa, New Zealand and Australia.

1.3 Environmental

Until quite recently, there has been no formal gathering of climate data on Nauru. Basic temperature and rainfall data has been collected by NPC since 1916, however, and provides a good picture of the general climate. Fortunately, in late 1998, the Atmospheric Radiation Measurement Programme (ARM) funded by the USA began taking detailed measurements of solar radiation, atmospheric radiation and primary meteorological data. Although the purpose of ARM is basic climatological research, as a by-product Nauru now has the highest quality solar radiation data in the Northern Pacific that includes not only data on global, but also direct and diffuse, radiation.

[1] AusAID Country Brief, Nauru (2003)

The Australia sponsored SEAFRAME sea level measurement program has had a station on Nauru since 1993 but many more years of data will need to be collected and analysed before genuine long term sea level trends can be determined.

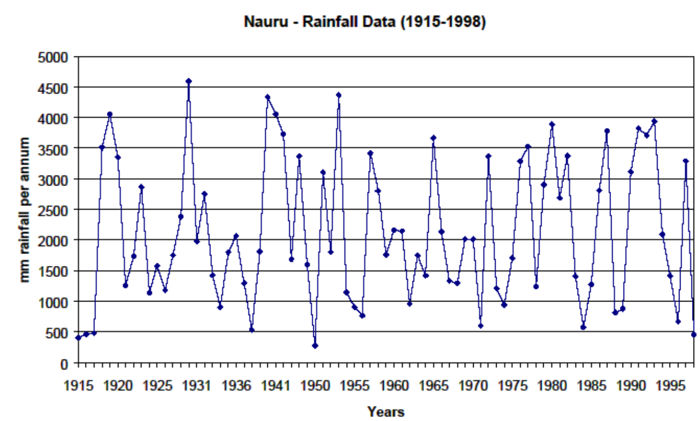
Annual rainfall averages a relatively wet 2125 mm per year but over a 77 year period annual precipitation has ranged from severe drought at 280 mm to very wet at 4590 mm making water supply a particularly difficult problem. The occurrence of severe droughts also has resulted limited biodiversity making Nauru one of the poorest terrestrial ecologies in the world, less diverse than some of the world's great deserts with only 60 species of indigenous vascular plants on record. Imported economic plants, particularly fruit trees such as breadfruit, often do not survive the severe drought periods. The rainfall cycles are related to the El Niño/El Niña cycle in the Pacific. Figure 1-3 – Rainfall data for Nauru, 1915-1996shows the rainfall variations from 1915-1998 indicating their clearly cyclic nature and the disturbing downward slope of the trend line.

Figure 1-4 – Solar Instruments at ARM

Herb Wade 2004

Not surprisingly considering its equatorial location and oceanic setting, temperatures remain quite constant the year around averaging about 28° with typically a ±3° diurnal variation.

Figure 1-3 – Rainfall data for Nauru, 1915-1996



Source – Climate Change Response, Nauru – 1st National Communication 1999

Wind data has not been gathered with energy production in mind. However the data indicate that there is a low probability of the wind resource being economically useful for power production. May to November winds are typically easterly from 2.5-5 m/s. December to April winds are typically 5-9 m/s but westerly. Although higher winds are to be expected at some sites, their seasonal nature greatly reduces their economic importance and their seasonal reversal makes locating a suitable site more difficult. One advantage that Nauru has is that cyclones are not a hazard at the Equator although winds up to about 18 m/s can occur.

The interior mining has resulted in drainage of large quantities of silt and soil onto the reef following heavy rains. That has in turn resulted in a reef that is much less productive and diverse in life than the undisturbed reefs of other island countries. The processing and loading of the phosphate also results in plumes of phosphate dust that contaminates rain catchments causing the rain water resource to be reduced in value in some areas of the island.

Coastal erosion is an issue and significant costal change has been recorded as a result of the creation of boat channels and foreshore development.

Table 1-3 - Status of Ratification of Environmental Treaties and Conventions by Nauru

Status in Nauru	SPREP Convention	Hazardous wastes (Waigani Convention)	Nuclear free Pacific (Rarotonga Treaty)	GHG reductions (Kyoto Protocol)	Ozone depleting substances (Montreal Protocol, et al.)
Signed Ratified Entered into force	16 Jun 93 16 Mar 94	16 Sep 95	17 Jul 86 13 Apr 87 13 Apr 87	– 16 Aug 01	Ac: 12 Nov 00

Notes: Treaties & conventions are briefly described in Volume 1, the PIREP Regional Overview report

* The Kyoto Protocol is in force from 15 February 2004 for European Union members only.

Sources: Websites for conventions, PIFS & SPREP (Jan. – March 2004).

Another coastal issue is that of sewage dumping. Household sewage is held in cesspools and septic tanks for pumping into tank trucks. The collected raw sewage is then dumped through a pipeline to a site just beyond the edge of the reef. While this avoids the contamination of the ground water by sewage, it does cause modification of the reef environment and is a potential health hazard.

1.4 Political

The primary political division of Nauru is into 14 districts. Independence was gained in 1968 forming a republic based on the Westminster parliamentary system. There is a single chamber parliament with 18 members elected for three-year terms. The parliament elects one of its members to be president who acts both as head of government and head of state. Elections are held every three years with all resident Nauru citizens 20 years and older required to vote. There are no permanent formal political parties but a loose multi-party system.

Nauru has had frequent changes in leadership brought about by election reversals, resignations, and votes of no confidence, usually following allegations of poor financial management.[2]

Nauru is a member of the Pacific Islands Forum, Forum Fisheries Agency, SPREP, SOPAC and USP, the Pacific Community, the Asian Development Bank (ADB), ESCAP, ICAO, Intelsat (non-signatory user), Interpol, IOC, ITU, OPCW, Sparteca, SPC, SPF, UNESCO, UPU, and the WHO. Nauru is also a member of the newly formed sub-regional group of Micronesian countries which formed to co-operate on transport and trade links. Nauru became a full member of both the Commonwealth and the United Nations in 1999.[3]

[2] *Nauru Country Report*, Commonwealth Business Council 2002.

[3] *Nauru Country Report*, New Zealand Ministry of Foreign Affairs and Trade, 2003

1.5 Economic

1.5.1 Phosphate

Nauru is one of the three islands of the Pacific having large quantities of phosphate left behind by migrating birds. The others are Banaba in Kiribati and Makatea in French Polynesia. Phosphate mining has been the mainstay of the Nauru economy throughout the 20th Century.

Phosphate was discovered on the island around 1900 and by 1906 mining operations had begun under an agreement signed by the Sydney-based Pacific Phosphate Company and the German government that administered Nauru as a protectorate.

Figure 1-5 – Phosphate Shipments 1996-2003

Fiscal Year	Tonnes Shipped	A$ value shipped	A$ per Tonne
1996	551,320	$38,003,000	$68.93
1997	541,050	$35,527,000	$65.66
1998	456,800	$30,302,000	$66.34
1999	648,500	$47,762,076	$73.65
2000	650,791	$48,298,191	$74.37
2001	449,190	$31,333,556	$69.76
2002	161,950	$11,007,445	$67.99
2003	112,900	$7,704,900	$68.25

Source – NPC 2004

After independence, Nauru bought the phosphate industry from BPC for $21 million and formed the Nauru Phosphate Corporation (NPC) in 1970 although most of NPC management and technical personnel remained Australian. At the time of independence about 30% of topside had been mined. In the ensuing years as much as $120 million a year in phosphate was exported. This high rate of export was maintained during the 1970s through to the mid-1980s but then began to decline.

The Nauru Phosphate Royalties Trust (NPRT) was set up to invest the profits from the phosphate industry as a source of income for Nauru after the phosphate was depleted. However the NPRT has been a far from transparent operation. Numerous bad investments and unsecured borrowing by the government to pay budgetary deficits has decimated the fund.

Ronwan payments are the returns to landowners on profits made by the NPRT. In recent years, there have been no Ronwan payments or if cheques were provided as payment, the Bank of Nauru sometimes has not had sufficient cash available to pay the amount.

Figure 1-6 – Phosphate Cantilevers for Ship Loading

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Land tenure issues and land owner compensation has been a difficult problem in Nauru as in most of the Pacific. Land owners feel that they have been poorly compensated in the past and have retaliated by failing to renew government leases on properties and land that expired in the early 2000s. As a result government has lost access to housing for expatriate teachers, health workers and technical personnel causing their relocation to the Meneñ Hotel or non-renewal of contracts. Projects requiring land owner cooperation will not be likely to be easy to implement.

1.5.2 The 'Pacific Solution'

In 2001 a Memorandum of Understanding (MOU) between Australia and Nauru was signed allowing Australia to move up to 1,200 asylum seekers who had attempted illegal entry to Australia to camps in Nauru located topside. The MOU provided Nauru $10 million with promises to improve health care, education, waste management and other public infrastructure for Nauru. By 2004 about $20 million had been provided by Australia to Nauru for accommodating the two refugee camps.

1.5.3 Other economic activity

Agriculture is limited by land availability and the high labour cost. Also, imported insect pests, notably fruit flies and white flies, attack pandanus, guava, mango, papaya, breadfruit and other fruit bearing plants. Although an eradication programme assisted by Australia has apparently succeeded in eradicating three species of fruit fly, the eradication program has slowed and the quarantine procedures used to prevent reinfestation are considered inadequate by Australian experts. Presently there are no agricultural exports and production is almost purely for personal consumption. Attempts have been made to develop commercial egg production soon exceeded demand for what were perceived by the market as a low-quality product because of the pale yellow colour of the local egg yolks.

Coconuts are not a commercial crop and are only gathered for household use. There has been no census of coconut trees but given that the tree cover is very limited, their number is small by Pacific standards. With the cyclic drought conditions, coconut production can be expected to also be cyclic. Many breadfruit trees died as a result of the 1997 drought and caution is needed in the selection of imported economic tree species due to the wide variation in annual rainfall seen in Nauru.

Table 1-4 - Nauru and Regional Economic Treaties

Status	SPARTECA	PACER	PICTA
Signed		18 Aug 2001	18 Aug 2001
Ratified	08 Aug 1982	14 Mar 2003	14 Mar 2003
Entered into force	07 Sept 1982	3 Oct 2002	13 Apr 2003

Source: Discussions with Pacific Islands Forum Secretariat (early 2004)

Trials for commercial fishing are now operating with one 18 metre catamaran and one 15 metre catamaran for long line fishing in the Nauru EEZ. Presently the 18 metre boat is undergoing major repairs. The strategy is to provide high quality sashimi grade tuna (big eye and yellow fin) to Japan at a premium price. Each boat has a crew of six with a three person support crew on shore. The small boat goes out on three-day cruises and the larger boat can stay out about a week. The larger boat carries 7000 litres and the smaller boat has 6000 litres of diesel fuel to power their twin 210 hp Cummins engines. About 75% of the available fuel is used per trip. Trials thus far appear successful with around 1.5 tonnes of fish shipped to Japan per trip at a value of between $10,000 and $20,000 per shipment. Although the boats were purchased under local budgets, maintenance is assisted by Japan with on-the-job training for local staff provided since 1999. Increasing the number of operating boats is being considered but budgetary restrictions make it unlikely for the near future.

Except for the modest long line tuna fishing, there is no significant sea based economic activity. Many families have traditional canoes or small outboard powered boats that are used for subsistence fishing. The reef continues to provide households with a source of shellfish and other marine foods but damage due to silt and phosphate runoff has kept productivity low – some estimates put reef productivity at less than 40% of normal.

Figure 1-7 – The Japanese funded harbour at Anibare

Herb Wade 2004

Although local fishing contributes little to the economy, licenses for fishing in the Nauru EEZ have provided substantial income. Bilateral fishing agreements exist with Japan, the Philippines and Vanuatu, In December 1999 the country signed a three year agreement with the Taiwan Tuna Fishing Association which allows up to 42 boats to fish in Nauru's EEZ at a fee of $28,000 per boat[4].

Although in the 1980s, Air Nauru was losing as much as $20 million a year, in recent years the airline has had revenues higher than expenses. The trimming of the airline from seven jets in the early 1980s to the single 737 now being operated plus operations only on routes where there is no competition or where there is high traffic has turned the finances around. The zero credit available to the airline hampers its operations and from 2000 – 2003 the plane was out of service a number of times due to insufficient cash to pay fuel and maintenance bills. To raise cash (and also to fend off creditors seeking to take possession of the aircraft) the 737 was sold, then leased back to Air Nauru. The airline is considering restoring the north-south Pacific link between Fiji and Majuro, an action that would make travel between the northern PICs and those in the south much more convenient and less costly.

In the hope of increasing income, offshore banking operations were undertaken in the 1990s. According to the 2003 Nauru Country Paper of the New Zealand Ministry of Foreign Affairs and Trade *"Nauru has in recent times received criticism for its offshore banking arrangements. Problems are being worked through with the OECD's Financial Action Task Force on Money Laundering (FATF). FATF listed Nauru as one of the World's three most uncooperative money laundering jurisdictions. The recent passing of anti-money laundering legislation which closed Nauru's off-shore banks [2003] has eased the threat of further counter measures."*

Nauru still maintains a foreign companies register acting as a tax haven and offers a "one stop shop" for foreign investors to establish and register companies in Nauru. Activities in this area appear to be secret and information could not be obtained regarding the number of companies or the value to Nauru of the maintenance of this registry.

[4] [4] *Nauru Country Report*, Commonwealth Business Council 2002.

1.5.4 Current fiscal problems

Starting in 1989, Nauru entered into an era of consistent budget deficits. Initially the NPRT was used as collateral for government borrowing but those assets were largely mortgages. By 1995 massive borrowing from the Bank of Nauru began resulted in the banks collapse. Huge debt servicing costs of over $13m dollars a year on the estimated $280m dollars government debt have caused a further spiral into debt and the loss of collateral to creditors. In 1998 the ADB began a technical assistance program focused on improving financial management in government. The programme got off to a good start with an across the board reduction in government budgets and a general restructuring of the civil service but the reforms soon lost headway and further progress has been minimal.

According to Asian Development Outlook 2003:

> Attempts to achieve sound economic management are severely hampered by poor-quality planning and budget systems. Budget planning and implementation are haphazard, basic administration is impeded by the breakdown in computing capacity and public accountability is extremely weak.
>
> Budget documents are usually treated as confidential and are not made available to the general public, while the accounts of public enterprises and trusts are typically out of date or nonexistent.
>
> Immediate priorities for the new government include 1) reducing the large budget deficits, principally be restructuring the public sector wage bill and containing the high cost of overseas representations; 2) establishing a mechanism to reorganize the Nauru Phosphate Corporation, achieve the company's financial viability, and extract its remaining resources; (3) improving management and restructuring the portfolio of the NPRT; 4) introducing appropriate legislation to encourage the operation of a reputable commercial bank and to restructure Air Nauru; and 5) repaying existing arrears to government suppliers and tenders.

Nauru has no import tariffs except duties on imported alcoholic drinks and vehicles. There are no trade restrictions or foreign exchange controls. There is no income tax and no direct tax. After independence, government budgets were initially met by exports of phosphate but when phosphate shipments began to slow in the 1990s, government failed to control spending and began borrowing against the Phosphate Royalty Trust, the Bank of Nauru and other assets. By 2003, little was left in the way of liquid assets and Nauru had gone from a nation with huge per-capita cash surpluses to a debtor state dependent on AusAID for meeting basic infrastructure costs.

Since the late 1990s, Nauru has effectively had no credit. Shipping, NPC, Air Nauru and Nauru Telecom have seriously abused their credit and have had services curtailed as a result. The income from the ‘Pacific Solution’ – roughly $20 million in payments for maintaining refugee camps on behalf of Australia – has been helpful in meeting immediate cash requirements as has Australia’s topside rehabilitation payments and other bilateral aid including financial support of public services.

The GoN and its businesses on Nauru, notably NPC, have not paid full salaries since July 2003. Every two weeks on “payday” crowds form around the Bank of Nauru office in Aiwo, each person hoping to receive at least something in cash against their pay. To help offset this problem, bills for public services such as water, sewage and electricity are not being collected by NPC but as few households have gardens, there remain significant household expenditures for food and transport. No one seems to be going hungry and the many air conditioners are still running, but the financial problems are great and are not going to go away without major structural changes that will strongly affect the life style of all Nauru citizens.

1.5.5 Donor assistance

In 2001-03 Australia provided around $3.0 million annually in bilateral assistance. Also in August 1993, after years of litigation in the International Court of Justice revolving around a suit brought by Nauru for the cost of rehabilitating mined out areas, an out-of-court settlement, the Compact of Settlement, totalling $107 million was signed between Australia and Nauru (of which $12 million comes from New Zealand and $12 million from the UK). In the settlement Australia provided a one time payment of $57 million into a trust fund for Nauru and is to provide a further $2.5 million a year (indexed for inflation) for 20 years to fund a Rehabilitation and Development Cooperation Program. That money is to be used for activities agreed in advance by both parties. A rehabilitation authority was established for the management of those funds. Information as to how those funds have been used for the past decade was requested by the PIREP team but was not provided.

Additional funding totalling about $26 million has come from Australia in 2001-2003 for other bilateral activities largely associated with the refugee relocation scheme. Currently Australia has effectively taken over the cost of fuel for the electricity supply on Nauru and has many activities with NPC focused on the rehabilitation of power generators, refitting the fresh water distiller and other public infrastructure.

1.5.6 Rehabilitation

After the fiscal problems, the most pressing issue is rehabilitation of the mined out areas that comprise 80% of Nauru. Although the $107 million Compact of Settlement of 1993 was specifically to undertake rehabilitation of mined out areas, ten years later there is no visible evidence of rehabilitation topside. Numerous ideas have been proposed and studied but action has been minimal and the problem is very difficult. The limestone pinnacles left after the removal of the surrounding rock phosphate make it impossible to use the land unless either soil is imported to replace the phosphate or the pinnacles are removed. Both seem to be almost insurmountable problems and represent a mammoth investment.

Whatever is decided for rehabilitation, it will not be a quick solution. A century of concentrated commercial effort was needed to get topside into its present state and an equally concentrated effort will be needed for its rehabilitation. However the incentive of profits drove the mining; for rehabilitation huge amounts of money will have to be invested and where that will come from is not known.

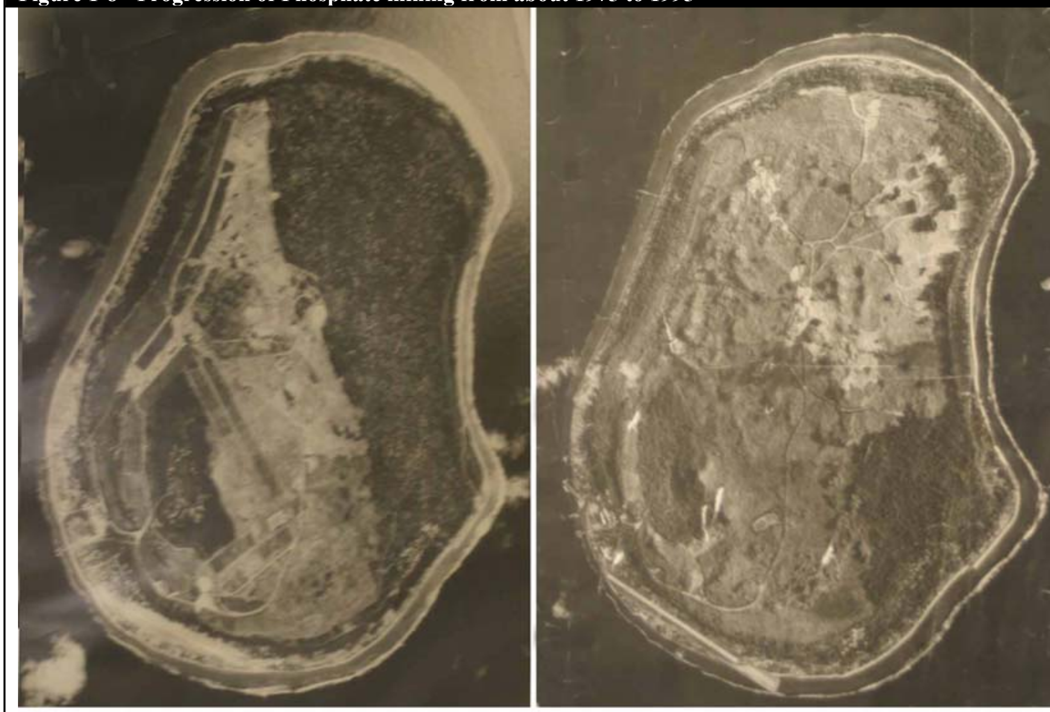
1.6 Institutional Context for Energy

The NPC provides all energy for Nauru except for some liquid petroleum gas (LPG) that is privately imported. As a result the energy infrastructure is well integrated.

There is no government energy office. Renewable energy is not designated as a responsibility for any government officers and departments interested in renewable energy operate independently. Except for the solar water heaters installed by PWD on new government housing in the 1980s and the Tokyo Electric Power Company (TEPCO) Ocean Thermal Energy Conversion (OTEC) pilot project in 1981, there has been no attempt to utilise renewable energy. A 2005 European Union (EU) project with a renewable energy focus is being mainly handled by the environment division as the project is viewed within government as an aspect of climate change activities.

Nauru has no personnel with experience in renewable energy development and few with any training at all in either renewable energy or energy efficiency technologies.

Figure 1-8 - Progression of Phosphate mining from about 1975 to 1995



c.a. 1975 *c.a. 1995*

Source – Government of Nauru Aerial Photos (dates estimated)

2 ENERGY

2.1 Energy Supply

2.1.1 Petroleum

Operational Structure

NPC remains the sole purchaser and wholesale distributor of petroleum products except for LPG and Jet fuel. LPG is imported privately and NPC has ceased providing Air Nauru with jet fuel due to payment collection problems. Air Nauru now does its own tendering and purchasing although delivery is coordinated with NPC and storage remains in NPC tanks. Due to prior problems with credit, Mobil and Shell are no longer willing to be contracted as providers to Nauru; all petroleum purchasing is tendered on a shipload basis and payment made as cash on delivery. Supplies come from several sources, although shipment from FSM is common. Ships deliver petroleum products on about a three month cycle. The phosphate ship loading system includes piping for fuel uptake and pumps deliver the fuel to the topside tank farm located about 30 metres above sea level. Due to the need for available cash and the relatively long period between ship arrivals, annual delivery amounts vary greatly.

Table 2-1 - Fuel Deliveries 1999-2003 (litres)

	1999	2000	2001	2002	2003	Average
Petrol	3,118,707	999,542	3,522,926	2,940,131	6,858,850	3,488,031
ADO	10,446,041	3,050,666	8,057,090	18,822,123	7,167,802	9,508,745
Jet Fuel	2,876,808	370,023	1,830,368	2,475,188	547,757	1,620,029
Heavy Oil	852,432	0	0	0	0	
Kerosene	635,142	0	0	0	0	
Waste Oil		877,004	59,132	0	0	

Source: NPC

Table 2-1 shows the fuel deliveries to Nauru for 1999-2003. The large variation from year to year makes it difficult to determine a trend. In general it appears that petrol use has a small increasing trend since 1999 but diesel and jet fuel use do not seem to be changing much over the long term. There is no clear reason to expect significant future growth in the use of petroleum and there is a likelihood of large reductions in the use of diesel fuel if in the future the cost of electricity provision is passed on to users.

Pricing

Pricing of petroleum products is based on CIF cost with a mark up sufficient to cover the cost of handling and storage. Retailers are not regulated as to price. It is not unusual for there to be a shortage of petrol between ship arrivals and retail and outlets often voluntarily restrict the size of individual purchases of petrol when supplies are short. There have been times when diesel fuel supplies also were in danger of running out and NPC instituted rolling blackouts to stretch remaining fuel stocks until the next shipment.

Storage

The NPC tank farm is located above the main NPC processing facility. Although ageing, it appears well maintained and is operated under Australian standards. Australia sends a team for inspection several times a year and the storage meets the required standards. Table 2-2 shows the storage capacity available.

Table 2-2 - Storage Capacity

bbProduct	Total tonnes
ADO	9508 (2 tanks)
Petrol	1624 (2 tanks)
Jet fuel	4030 (3 tanks)
Heavy oil	4862 (2 tanks)

Source – NPC 2004

Heavy oil and waste oil is used only in the phosphate drying kiln and with the presently low level of production, heavy oil is not shipped in as a separate product due to the high cost of shipping a relatively small quantity of that product. Currently the fuel requirement for firing the kiln is around 19 tonnes per week Used lubricating and engine oil is collected by NPC and delivered to the phosphate processing facility in 200 litre drums and when that is not sufficient, diesel fuel is used to make up the difference. Presently, waste oil represents about 20% of the fuel used. Shipping used engine oil from FSM in drums has been tried but the high shipping cost makes it cheaper to use diesel fuel.

Distribution

Distribution is directly from NPC storage by tanker truck. Retail sales of petrol and diesel for boats and vehicles is through private filling stations located in strategic places around the ring road.

2.1.2 Electricity

Institutional Structure

Electricity generation remains part of the NPC structure along with all other public utility services.

Generation, transmission and distribution system

Although there are thirteen generators at the NPC power plant, only five containerised Cummins diesel powered 800kW units one Caterpillar 1.5 MW unit and one 1.5 MW Paxman unit are operational. A second new Paxman 1.5 MW will be installed late in 2004 and a second 1.5 MW Caterpillar unit is undergoing overhaul and the other units are awaiting parts for repairs. Table 2-3 shows the installed capacity, operational status and approximate age. AusAID is providing funding for the renovation of existing generation units but no repair schedule was available.

AusAID has been paying all generation fuel costs for several years and is paying for the five containerised portable generator units that currently provide the bulk of the power. The 0.8 MW containerised Cummins diesel powered generators have an estimated rental cost of $15,000/month each. AusAID also has installed two 550 kVA Cummins generators at the Meneñ hotel, one 550 kVa Cummins generator at each of the two refugee camps and a 250 kVa Cummins generator at the storage warehouse that serves the refugee camps. All the AusAID generators external to NPC operate continuously providing 2.5 MVA of capacity that does not have to be provided by NPC. NPC does provide power to the Meneñ hotel, the refugee camps and the IOM storage warehouse if the AusAID generations have to be out of service.

The Cummins container units and the fixed Caterpillar engines average about 3.6 kWh/litre. The older slow speed diesels can go as high as 3.8 kWh/litre.

All transmission is through 11 kV in a ring main configuration. Some of the NPC industrial facilities are distributed at 3.3 kV but all domestic and commercial customers use 415V distribution lines.

Table 2-3 – Installed generators and their thiord quarter -2004 status.

Designation	Manufacturer	Nameplate capacity	Status
Engine 1	Ruston	2.5 MW	Out of service, waiting for parts
Engine 2	Paxman	2.MW	Out of service, waiting for parts
Engine 3	Caterpillar	1.6 MW	Out of service, waiting for parts
Engine 4	Ruston	1.8MW	Out of service, waiting for parts
Engine 5	Ruston	1.8MW	Out of service, waiting for parts
Engine 6	Ruston	1.6 MW	Out of service, waiting for parts
Engine 7	Paxman	2 MW	In service
Engine 8	Caterpillar	1.6 MW	In service
AusAID rental	Cummins 1	0.8 MW	In service
AusAID rental	Cummins 2	0.8 MW	In service
AusAID rental	Cummins 3	0.8 MW	In service
AusAID rental	Cummins 4	0.8 MW	Out of service, waiting for parts
AusAID rental	Cummins 5	0.8 MW	In service

Source – Brief Information on Electrical Power and Water Desalination in Nauru, NPC 2004

Pricing and collection

Prior to about 1990, electricity was effectively provided at no cost in that meters were read but no collections made. The present tariff of $0.09 per kWh domestic and $0.13 for other users remains far lower than the real cost of production and distribution.

Due to the inability of the GoN and the NPC (who together employ 90% of the salaried persons in Nauru) to pay full salaries, the NPC has not attempted to collect domestic or government electricity bills since July, 2003, although meter readings are still being taken and bills sent out monthly. Commercial users are expected to pay their bills.

Regulation

There is no formal regulation of the electricity sector although NPC as a government owned corporation must necessarily respond to the requirements of Government regarding pricing and service delivery.

2.1.3 Renewables

There currently is no renewable energy or energy efficiency activity in Nauru.

2.2 Energy Demand

2.2.1 Petroleum

Transport

There are no data separating land and marine transport fuel use but the great bulk of petrol use is for land transport and the great bulk of diesel fuel use is for electricity generation. No data could be provided regarding the number of vehicles until the 2002 census tabulation is complete.

Air Transport

Air Nauru currently operates one Boeing 737 for international flights. There is no domestic aviation.

Electricity Generation

All electricity generation is by diesel.

Industrial Thermal

During the years when phosphate processing was at a high level, heavy oil was used for firing the drying kiln. In recent years, waste oil supplemented by diesel fuel has been used to fire the kiln since that is lower in cost than the small-scale delivery of heavy oil by ship. The requirement varies according to the quantity of phosphate being processed but in the first quarter of 2004 it averaged 19 tonnes a month.

Household Lighting and cooking

The majority of households cook with electricity although increasingly frequent power outages are driving a change to LPG. No domestic use of kerosene remains.

LPG

LPG is imported in filled cylinders, not in bulk, so the cost is high relative to Kiribati and FSM where shipments are in container sized cylinders. LPG is imported by NPC and a private company. Usage is small, mainly confined to several Chinese restaurants on Nauru and a few houses that have converted from electricity to LPG for cooking.

2.2.2 Electricity

Reliable, up to date electricity production and use data was not available. Because the rapid and large shifts in the economy are likely to have major effects on electricity usage, trends from older data are not very useful for forecasting purposes. Therefore forecasts have been made based on the old data with adjustments for expected changes in usage resulting from the economic crisis.

The peak demand occurs when the mining processing and the cantilevers are in operation at lunch and dinner time (the domestic sector peak time). That has been typically 6.8 to 7.2 MW due to the heavy use of electric cookers plus the industrial load from NPC. The minimum demand has been around 5.6 MW, only a modest reduction from the maximum peak due to the high percentage of air conditioning and refrigeration in the load. As the industrial load has fallen with falling phosphate production, maximum peaks have dropped to around 6 MW and off-peak loads have dropped as low as 4.2 MW when the phosphate mining and processing plants are not operating. There is no obvious seasonal or weekly variation in load although weekend loading is perceived as slightly higher than week day loads since workers are home and office loads are left running. Although the percentage of the load that is air conditioning is not known, it is definitely high since air conditioners are generally left on 24-hours a day in homes and offices. The 1992 census showed ownership of air conditioners in 65% of all households, of which about half had more than one installed (with one household claiming to have eight air conditioners). Although 2002 census household data has not yet been tabulated, the number is expected to be even higher. The majority of households still cook with electricity. With the highly subsidised tariff, electricity remains cheaper for cooking than LP gas but gas is increasing in use to some extent due to the fear of power outages interrupting meal preparation and also due to the perception of gas providing faster, more controlled cooking.

Domestic

In 2000-2001, domestic use of electricity amounted to 18.4 GW. With 1677 households enumerated in 2002, electricity use per household is one of the highest in the Pacific with an average use of 915 kWh/month. That high value is largely due to electric cooking and the heavy use of inefficient window type air-conditioners. Though the tariff is heavily subsidised at $0.09/kWh, the main reason for this high usage is because people have not been required to pay the bills even though a bill is presented every month. In the 1980s that was because there was the feeling that there was so much money available that there was no need to collect and today it is because there is so little money available that government and NPC cannot pay full salaries so NPC could not collect if they wanted to. It is certain that this high level of usage will fall rapidly once fiscal responsibility is assumed by government, customer payment discipline is imposed by NPC and electricity prices rise to be more in line with the real cost of production.

Commercial

A high percentage of commercial usage is for ice making for fish storage, for the two hotels, for the three larger stores and for the numerous Chinese restaurants on the island. The 2001-2002 commercial demand totalled 5,848,607 kWh.

Industrial

The NPC phosphate production facilities represent the only industrial use of electricity in Nauru. In 2001-2002 the demand was 20,400,000 kWh. The energy use changes with phosphate production so it is likely that the industrial energy use has fallen significantly since 2001.

2.3 GHG Inventory due to energy use

2.3.1 Carbon Dioxide

Since up-to-date electricity data was not available and because there have been large changes in the economy since the last year that there was reliable data, there are likely to have been large changes in energy use. Therefore a sectoral forecast is not possible, only an estimate based on the petroleum import information can be used as a basis for a CO_2 emissions estimate. It is unlikely that the high level of per-capita energy use can be maintained for the long term given the probable steep drop in GDP Therefore, it is likely that GHG production will fall in the future due to reduced energy use for industry and households. It is reasonable to assume as a worst case scenario no growth in energy use in the next decade and therefore no change in GHG emissions. A more likely scenario is a reduction in energy use from the present level.

2.3.2 Opportunities for Reduction

The primary opportunity for reduction is the implementation of a rational price for energy services and disciplined collection of power bills. Most consumers will respond with an immediate reduction in energy use. Electricity generation can be cut by as much as 50% through supply side efficiency improvements, the elimination of unnecessary loads, improved efficiency of appliances and the switching off of appliances when not actually in use. This should be done before or in conjunction with the much less cost effective renewable energy installations.

Solar energy is the only renewable energy resource known to be capable of immediate development in Nauru. Thus the impact of renewable energy on the generation of electrical energy is unlikely to be greater than five percent. This is the case because grid connected PV without storage is the only economically reasonable approach for Nauru and there is limited ability of a small diesel grid to absorb the rapidly varying power coming from solar PV arrays that occurs without batteries or other storage to average out the variations. Though the *power* penetration by PV to a small diesel grid may be as high as 20% of the noon time peak demand for the power system, the *energy* penetration will be much lower because solar energy is only available during the day, varies continuously over the day and clouds further decrease the energy delivered.

Table 2.4 - Petroleum imports and GHG for 2003 and projections for 2013

	2003						2013			
Fuel	**KL**	**KT**	**TOE**	**GHG (t)**	**GHG (Gg)**	**% of GHG**	**AAGR**	**KL**	**GHG (Gg)**	**% of GHG**
Petrol	3,119	2,277	2,482	7,798	7.8	*17.2%*	0%	3,119	7.8	*16.6%*
Aviation Gas	0.0	0.0	0.0	0.0	0.0	*0.0%*	0%	0	0.0	*0.0%*
Jet fuel	2877	2,283	2,489	7,480	7.5	*16.5%*	2%	3507	9.1	*19.4%*
Kerosene	635.0	500.0	545.0	1,778.0	1.8	*3.9%*	0%	635	1.8	*3.8%*
Distillate	10,446	8,778	9,480	28,204	28.2	*62.3%*	0%	10,446	28.2	*60.1%*
LP Gas	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total	*17,077*	*13,838*	*14,996*	*45,260*	*45.3*	*100.0%*	0.4%	17,707	46.9	100.0%

Although it is likely that LPG will increase in use for household cooking, there is no data on the amount presently being used and no sound basis for forecasting though if electricity prices rise, conversion by households from electrical cooking to LPG is very likely. In any case, LPG is not likely to be a significant GHG producer relative to jet fuel and ADO.

The maximum reduction in GHG that could result from renewable energy alone is on the order of 5% of fuel used for power generation but a reduction of as much as 50% appears possible with an aggressive energy efficiency programme that includes replacement of inefficient appliances, raising the electricity price to at least equal its cost and disconnection of service for non-payment of energy bills. In addition, there are small savings possible for transport fuel use.

Table 2.5 summarises the maximum potential savings of 16.6 Gg or 35% of 2013 emissions. Of this about 83% of the savings is from energy efficiency measures and 17% from solar energy.

Table 2.5 - Indicative Maximum Fuel Savings & GHG Reductions, 2013				
Resource or technology	**Potential fuel savings**	**Potential CO_2 savings (Gg / year)**	**% of total savings**	**Comments**
Solar	1,045 KL	2.8	17 %	5% of ADO used for electricity
Energy efficiency				
Electricity [5]	5,223 KL	13.4	81 %	50% of ADO for electricity
Transport [6]	156 KL	0.4	2 %	5% of petrol use
Total		*16.6*	*100 %*	
Source: PIREP team estimates				

[5] Current levels of electricity use in Nauru are unsustainable and 50% of the volume of fuel used for electricity generation in 2013 is not unreasonable with an all-out effort, that is 50% of 10,446 KL = 5,223 KL. However, if 5% of all ADO for electricity is displaced by solar PV, then the GHG savings from electricity efficieny must be reduced to 95% x 5,223 or 4,962 KL. This is 47.5% of 2013 ADO use.

[6] Energy efficiency measures for transport could save 5% of the 2013 ground transport fuel use of petrol or 0.05 x 3119 KL = 156 KL, all of which would reduce GHGs. It is assumed there would be no efficiency savings in marine or air transport.

3 POTENTIAL FOR RENEWABLE ENERGY

3.1 Resources

3.1.1 Solar Resource

As can be expected at an equatorial location, solar radiation is high. ARM measurements indicate an average of about 5.8 kWhr/m^2/day with only modest seasonal variation.

Due to a relatively high frequency of clouds, tracking the sun or concentrating the resource using reflectors or optics does not result in enough increase over the output from fixed photovoltaic panels to be sufficient to cover the added cost of purchase, installation and maintenance. Without tracking, solar thermal systems cannot consistently achieve a high enough operating temperature to be economically effective. Therefore only solar photovoltaic based electricity production with fixed panels appears to be technically appropriate.

3.1.2 Wind Resource

There has been no attempt to measure the energy content of wind on Nauru. Existing meteorological measurements indicate strong directional and speed seasonality with the period from May - November showing easterly winds in the 2.5-5 m/s category. December - April data shows westerlies in the 5-9 m/s range. No data are available of either energy content or variability.

The absence of cyclones is a major advantage for the use of wind in Nauru but the seasonality of the wind speed makes it difficult to economically justify wind power although the very high cost of electrical energy on Nauru is in its favour. Additionally, the directional change from easterly to westerly makes it more difficult to choose a site for wind turbines that is optimal the year around. In any case, until measurements specifically for wind energy determination are taken and analysed, the actual economic value of wind energy for electric power generation remains in the realm of speculation.

3.1.3 Biomass Resource

Figure 1-8 shows the progressive loss of biomass due to mining. By 2004, virtually all but a small coastal area had been stripped of trees. Although it is conceivable that rehabilitation efforts could recover a major part of the biomass resource lost to mining, for the near term the resource is inadequate to form the basis of any significant energy producing effort. Less than 15% of the land area has not been mined or cleared for human habitation. This represents only about 3 km^2 of land available for biomass production, insufficient to provide much energy benefit and in any case, that land is much more valuable for economic trees such as breadfruit and coconut than for growing fuel.

Biofuels also are conceptually possible for future development with coconut plantations being possible as part of the topside development. However, the concept lies many years into the future and at present the coconut resource is only sufficient for household use.

Biogas generation in small quantities is also possible utilising the waste from the pigs and chickens on the island. However the numbers are small and the animals not concentrated sufficiently to make biogas an economically interesting energy resource.

3.1.4 Hydro Resource

Nauru has no hydro resource.

3.1.5 OTEC Resource

OTEC resources appear excellent. Not only is Nauru in a high surface temperature area of the ocean, the island has a rapid drop off from the edge of the reef to 4000 metres allowing a land based OTEC plant to be built, clearly a better economic option than a floating plant.

3.1.6 Geothermal Resource

No developable geothermal resource is known to exist nor is one likely.

3.1.7 Wave Energy Resource

In general, the wave energy resource is modest in comparison to higher latitude island countries. Although there has not been a wave energy resource assessment in Nauru, it is probably similar to that of Kiribati with wave power ranging from 10 kW/m to 15 kW/m, a relatively low energy level that is not very attractive for wave power generation.

3.2 Appropriate Technologies for Development

The renewable energy technologies that provide the most promise are solar and OTEC with wind a possibility that needs further resource study.

3.2.1 Solar Thermal

Although the climate is not appropriate for the use of solar thermal energy for electricity generation, it is appropriate for water heating using solar energy. Nauru has a significant percentage of housing that, from the type of system design and condition, appears to have had solar water heaters installed in the late 1980s. An interview with the Director of Public Works confirmed this and he noted that the installations were included on new housing built by government in that period. Most of the installed water heaters are of the thermosiphon type with a separate storage tank inside the building. By 1990, around 30% of the housing stock included solar water heating. Unfortunately, today the units appear poorly maintained and in several cases were installed improperly, so their present utility is questionable and interviews indicate that few still work. Modern combined tank/collector units of the Solahart type are seen on Nauru homes but only rarely. Since solar water heaters quickly clog with calcium carbonate scale when Nauru ground water is circulated through them, they require frequent maintenance unless rain water or desalinated water is used for heated water use. Although the significant economic advantage of solar water heating over electric based water heating should be made known to households, the priority for hot water in Nauru homes needs to be evaluated and incentives developed only if it is known that there is significant electricity based water heating that can be replaced by solar heaters.

In theory, solar distillation is a possible means of producing fresh water and has been used in other parts of the world where fresh water availability was low. However, thousands of square metres of collection surface would be needed to produce the volume of fresh water needed by Nauru making the technology costly. The high cost of the facility combined with the problems of land tenure on Nauru makes solar distillation less attractive than other means of fresh water production.

3.2.2 Solar photovoltaics

The most common use of solar photovoltaics in the Pacific has been for the electrification of isolated, rural homes having energy requirements limited to lighting and entertainment appliances under 20kWh/month. Nauru is fully electrified by the grid and the average household use is over 1000 kWh/month making it unreasonable to replace the grid connection by a stand-alone, household solar power system.

Figure 3-1- Domestic solar water heater installation

Herb Wade 2004

However, the high cost of electricity supply does make the use of solar photovoltaic panels to supplement the diesel generation a possible application if a connection is directly made and no storage battery included in the system. In 2002, a French consultant, reporting on a pre-feasibility study for the upcoming €1.5 million EU project for Nauru, recommended that Nauru consider the installation of at least 100 peak kilowatts (kWp) of grid connected solar photovoltaics topside as part of rehabilitation efforts. Certainly the operating and maintenance cost for such a project would be modest and this could be economically reasonable if a donor organisation such as the EU were to provide the majority of the capital investment. Grid connected PV systems have been operational in the USA, Japan and Europe for nearly 20 years and a significant component of German and Japanese renewable energy investments in recent years have been for grid connected PV systems. In the Pacific, trials of a 10kW grid connected system in Fiji have been underway for almost seven years and a feasibility study of a 1 MW PV installation is being carried out by the Fiji Electricity Authority.

The approach recommended by the EU consultant, that of a single large 100 kWp array of solar panels, should be reviewed. World experience with grid connected solar photovoltaic systems has shown that distributed arrays in modules of from 3-10kWp each are not only more cost effective than a single large array, they also are practical for roof mounting on public buildings thereby totally avoiding the problem of land tenure faced by large area ground based arrays. Also by distributing the modules over a wide area, power swings on partly cloudy days are greatly reduced.

3.2.3 OTEC

OTEC shares with geothermal energy the significant advantage over solar, wind and wave power that it can provide continuous steady power indefinitely without fuel inputs. Solar, wind and wave power vary unpredictably according to weather conditions and cannot provide steady power without expensive batteries or other forms of energy storage.

Since about 1999, the University of Saga (Japan) has been promoting to PICs the OTEC design created by their President, Mr Hauro Uehara. Designs based on the Uehara thermal cycle are claimed to allow economically attractive construction of OTEC plants in the 3 MW power range, a power level considered too small to be cost effective with earlier designs. Trials of a floating 1 MW Uehara Cycle plant constructed on a barge off the coast of India were planned for 2003 but have been delayed due to serious engineering problems with the intake pipe, so the system remains essentially untested.

Hawaii based OTEC expert, Dr. Luis Vega, notes that; *"Technical and economic studies as well as experimental work have been conducted by numerous private and public entities in France, Japan and the USA. It was concluded that, for example, in Hawaii electricity production with OTEC technology is cost effective for 50 MW or larger plants. This conclusion is independent of the type of OTEC power cycle (i.e., Open, Closed, Kalina or Uehara) utilized. Moreover, it was concluded that commercialisation ought to be preceded by the design, installation and operation of a pre-commercial plant sized at about 2-5 MW."*

"The situation in some Pacific Island nations is such that smaller OTEC plants (e.g. 1- 10 MW) configured to produce desalinated water in addition to electricity could be cost effective. However, because the technology is presently not commercialised, proposed installations in independent island states must be implemented without any financial responsibility assumed by their governments."[7]

[7] Vega, Luis "Ocean Thermal Energy Conversion Primer" Marine Technology Society Journal, Vol. 36, No. 4, pp 25-35, Winter 2002/2003

4 RENEWABLE ENERGY EXPERIENCE

4.1 Past Projects

Although PWD included solar water heating on new government homes constructed in the 1980s and a few solar panels were imported for technical trials, no other activities for renewable energy use have been carried out in Nauru except for the first Pacific trial of an OTEC plant.

In 1981 and 1982, the Tokyo Electric Power Company (TEPCO) in association with Toshiba installed and began technical trials of a mini-OTEC facility at the west coast of Nauru on the shore across from the Civic Centre in Aiwo. The facility had a gross power continuous rating of 100 kW and was expected to provide a net power of around 14.9 kW. The design was of the closed cycle low pressure turbine type and used Freon 22 as the working fluid. Very expensive titanium heat exchangers were used to provide high efficiency heat exchange at the low temperatures used in the plant.

The design was to use a 27.8 kW peak rated pump to bring 0.395 m^3/s of warm 29.8° surface water into the facility on the hot side. For the cold side, a 43.3 kW peak rated pump brought water at 7º from 580 metres deep through a 945 metre long 700 mm polyethylene inlet pipe at a flow rate of 0.382 m^3/s. A Freon pump rated at 15.3 kW peak circulated the working fluid at 74 tonnes/hour and a 2.5 kW pump provided high pressure oil for the bearings of the 3000 rpm axial flow turbine. Although intended for 100kW continuous operation, the system flows could be increased to provide a maximum of 120 kW gross which delivered a maximum net power of 31.5 kW.

At the time, the Nauru installation was the first land based OTEC plant in the world to produce net power, it was also the highest power OTEC plant ever operational and the first to feed power to an operating commercial grid. It was known that it would not be a cost effective power supply for Nauru when it was installed and the system was not intended as a permanent installation but only a technical trial, and it actually operated as a power generator feeding the Nauru grid for only 240 hours (a record for OTEC at the time, the floating 50 kW Hawaii mini-OTEC built about the same time ran only 110 hours). The actual cost is not available but estimates go higher than US$1 million, all paid by TEPCO and Toshiba.

Since that early installation, there have been significant improvements in high efficiency low temperature heat exchanger designs, eliminating the need for the use of very expensive titanium metal. Additionally, an open cycle OTEC system has been successfully operated in Hawaii. That design would be of particular interest to Nauru since a side benefit is the production of large amounts of fresh water. Also, the large volume of nutrient rich 7º C water could be used for district air conditioning and aquaculture thereby providing significant additional side benefits.

Shortly after tests were complete, a storm destroyed the inlet pipe and the facility was dismantled.

4.1.1 Lessons Learned for Nauru

- A land based, closed cycle OTEC plant can work in Nauru
- Solar water heaters require proper installation and maintenance if they are to work for the long term

4.2 Current Projects

None

4.3 Confirmed Future Projects

The European Union has allocated € 1.5 million for development of renewable energy and/or energy efficiency projects in Nauru. The pre-feasibility study proposed both energy efficiency measures and 100 kW of grid connected solar photovoltaics. The project start has been delayed until 2005 at which time it is expected that further project development and feasibility studies will take place before a final project design is accepted. The funds are specifically not to be directed toward experimental technologies, only those that have been commercially proven and preferably have had some prior success in the Pacific islands. Completion of the project is unlikely before 2008.

4.4 Proposed Projects

- A wind power resource study is proposed for topside sites
- Promotion of energy efficiency measures for domestic and commercial customers of NPC with emphasis on water heating, refrigeration, air conditioning and electric cooking. The project should includes audits, recommendations, component selection, component import, component purchase finance and installation
- Multiple 4-6 kW grid connected solar generators distributed around the island to gain experience in grid connected solar.

5 Barriers to Development and Commercialization

The following list of barriers was developed through interviews and situation analysis. No S.W.O.T. workshop was held in Nauru.

5.1 Known Barriers

5.1.1 Fiscal and Financial Barriers

The current unstable financial condition of the Nauru Government is the primary barrier to the development of renewables as a sustainable energy source. Next on the list of barriers must be those relating to the relative cost of renewable energy relative to conventional energy, both in terms of its actual financial cost and the cost of shifting from familiar and convenient fossil fuels to unfamiliar technologies

Taxes and import duties for renewable energy in Nauru are not an issue since Nauru currently has no import duties for anything but alcoholic beverages, tobacco and motor cars. Even if duties are imposed as part of the financial restructuring process, virtually all renewable energy development of any capacity will have to be developed by government. Private sector activities are expected to be limited to solar water heating, a market that has yet to develop in Nauru and is unlikely to develop until the economy stabilises.

Economic collapse. The financial situation in Nauru precludes any capital intensive activity not fully funded by donors. The government has insufficient funds for its own operations and is totally dependent on external funding for capital investments.

No Banking Services Available. There is no fully functional banking institution in Nauru that can provide finance for private enterprise development or personal purchases of renewable energy equipment such as solar water heaters. The Bank of Nauru is not closed but it has effectively no money for loans.

No Local Finance for Energy Development Available. The public sector financial crisis limits energy development options while preventing proper maintenance of existing energy systems. Renewable energy development would require additional staff, training expenditure and investment in maintenance equipment and facilities that currently cannot be funded by the Nauru government even if the primary equipment was to be provided at no cost by an external donor.

5.1.2 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 system 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 electricity tariffs.

High Subsidies for Electricity. Public services operations remain massively subsidised making sustainable development difficult. Under the present tariff charged (and currently not collected) for fossil fuel generated electricity, only a fraction of the real cost can be recovered. Renewable energy has no chance of being competitive under these conditions. Further, artificially low tariffs encourage excess use of electricity making it even more difficult for renewables to offset a significant percentage of the conventional energy that is used.

No National Energy Policy. Without an energy policy that clearly spells out the roles of the various government departments, the NPC and the general public, development of renewable energy and energy efficiency technologies are likely to remain fragmented and unsustainable.

5.1.3 Institutional Barriers

In Nauru the NPC is the only organisation that can be expected to implement renewable energy since it has control of both transport and electricity fuel supplies and electricity generation. The institutional requirements for operating and sustaining renewable energy systems are not the same as for conventional operations and some modification of the existing institution will have to take place if renewables are to become a significant component of the Nauru energy economy.

No Energy Agency Structure in Government. There is no government support for energy development through policy measures, manpower allocation or budget. Several agencies have energy related activities but those activities are not coordinated.

Small Size and Population. The small population and its lack of adequate technical capacity is a major barrier to successful development of renewable energy and energy efficiency measures in Nauru. Its small size limits the possibilities for land use for energy purposes.

Lack of technical training facilities. No local technical education facilities are currently available on Nauru that address electrical trades training and most training that is available overseas has only marginal relevance to the situation in Nauru.

Land issues. Land issues are complicated and landowners are often not resident in Nauru but in Australia making negotiations difficult and costly. If a major shift to renewables is to take place, biofuels/biomass production will be required, at least until OTEC technology is commercially available. Since biofuels and biomass energy systems require large tracts of land with the fuel delivered in a coordinated manner, land issues are viewed as a barrier to renewable energy penetration much beyond 10% of total energy use in Nauru.

5.1.4 Technical Barriers

As with most PICs, electrical and mechanical equipment is at risk in Nauru due to the tropical, marine environment. Solar PV, wind, biofuels and possibly biogas are the technologies that can be used and all involve mature technologies. However special characteristics of the equipment are needed for long, trouble free life in the Nauru environment.

Difficult environment for electrical and mechanical equipment. The tropical marine environment of Nauru is one of the most difficult for mechanical and electronic equipment. Obtaining equipment suitable for installation in Nauru is difficult and expensive. Electronic control systems for both wind and solar systems and the DC to AC converters for grid connected solar are particularly vulnerable and must be designed specifically with the salt laden air, high ambient temperature and moist conditions in mind.

Few developable renewable energy resources. Useable resources appear to be limited to solar, biogas and possibly wind. There is no opportunity for hydro development. Biomass and biofuel development face major additional barriers of labour cost and land tenure problems.

Lack of experience with comparable systems in the Pacific. As the smallest country in the Pacific and with very limited internal technical capacity, Nauru must look to other countries for experience that can be transferred. Although there is a wealth of experience with solar home systems in the Pacific, there is no opportunity for their use in Nauru. Integrating solar energy or wind energy into an existing grid has no long term, successful experience in the Pacific that is consistent with Nauru's requirements. Although both technologies have long been used in industrialised countries of the world, most of the experience is on a scale that is not directly transferable to Nauru. Demonstration projects, pilot projects and technology transfer programmes are needed to gain experience with hybrid technologies.

5.1.5 Market Barriers

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

Small size. The country is too small to support the sufficiently large energy oriented private sector necessary to consistently provide high quality in design, installation and maintenance support of energy systems.

High energy use per household. High usage of electricity due to the universal use of freezers, air conditioners and refrigerators that has resulted from the highly subsidised tariff, makes it difficult and expensive to convert to renewable energy leaving no opportunity for the private sector.

Lack of experience. There are few technically experienced persons in the private sector capable of developing renewable energy projects and providing for their sustainable operation.

5.1.6 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 Nauru has none presently in place.

Limited knowledge of renewable energy at high levels of government. The small size of Nauru means that there is only a small support staff for even top level decision makers and decisions must be made based on decision maker's personal knowledge and readily available information. For decision makers in Nauru to include the appropriate use of renewable energy in energy development plans, they must have a trusted source of information and advice. While reducing this barrier overlaps with public information programmes, special effort to meet the specific needs of decision makers is required.

Limited public awareness of energy efficiency and renewable energy options. The most cost effective approach to reducing petroleum use in Nauru is clearly through energy efficiency improvements. Energy efficiency also has by far the largest potential for GHG savings over the next 10 years. However, there is little public knowledge of demand side management techniques or of energy efficiency improvement in general. There is also a large scope for supply side efficiency improvement at NPC. If energy efficiency and renewable energy are to be accepted as substitutes for petroleum, awareness of their capabilities – and shortcomings – needs to be much improved. In general there needs to be more information available to decision makers, the general public and businesses regarding the relative advantages, disadvantages and costs of renewable energy and energy efficiency technologies.

6 Implementation and Capacity Development Needs

6.1 Petroleum

NPC has long experience in dealing with petroleum tenders and shipping costs and there is no clear need for capacity development in this area.

6.2 Electricity

Although there is a problem with the availability of skilled mechanics and electricians for the power sector, the problems with the power system are more basic and capacity development for staff is not likely to be of much immediate benefit. If the government finally faces its fiscal responsibilities and restructures its finances so that it possible to rehabilitate the power system in other than a crisis environment, capacity development will then become important.

6.3 Renewables

Capacity development will be required in association with the EU project. Although initial training of personnel responsible for project installation and maintenance will undoubtedly be provided under the EU project, continuing training after the project period ends will not. Therefore some process for maintaining a high level of competence for maintenance of the installed system will have to be developed for implementation by about 2008. It would be reasonable for the EU to co-finance a long term training programme with the GEF or other external agency with the EU developing the immediate training and the co-financing organisation developing the follow-on, long term training development.

6.4 Reducing Barriers Through Capacity Development

6.4.1 Fiscal and Financial Barriers

Project development support. There is need for local staff capacity development and direct assistance with the development of project documentation acceptable by donor 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 Nauru. These need to focus on not only NPC but all and other individuals in Nauru responsible for the creation of project proposals and documentation. A number of other PICs are in need of similar assistance and support through a regional project appears appropriate.

NPC tariff development support. Under the present system, the NPC management proposes a tariff and forwards recommendations to cabinet for consideration. Though it is clear that the tariff structure that is imposed can have a major effect on social, economic, environmental and development issues as well as on the economics of renewable energy implementation there is no formal consideration of these issues. The NPC , cabinet or cabinet advisors need assistance in estimating the effects that tariff changes will have on the country. This could be provided through a regional advisory service, informational materials provided to the appropriate parties and direct training of the NPC and cabinet advisory staff.

6.4.2 Legislative, Regulatory and Policy Barriers

Energy Policy development. Over the past decade there have been several attempts to assist PICs develop energy policies. A problem that has been common to those attempts is that the policy concepts have been developed externally and though those policies have sometimes been formally accepted by countries, their application has been minimal because the governments that must implement the policies had little real input to the policy making process. For written policy to be effective in must be implemented and for implementation to take place, implementers must have a stake in implementation success. The PIEPSAP project is addressing this issue starting in late 2004 and is expected to thoroughly involve the government in the policy development process so that the resulting policy will be one that is acceptable by the present government and can be expected to continue to be acceptable by future governments and NPC personnel.

6.4.3 Institutional Barriers

Training for personnel with energy responsibilities. Training in renewable energy technology and energy efficiency measures needs to be made available on a continuing basis for government officers who have energy related job functions. It is important that these persons understand the opportunities, advantages and disadvantages of the various types of renewable energy technologies and energy efficiency measures that are available so they can properly judge what should be used in Nauru. Since there is a continuing turnover of these staff, such training would have to be available for the long term. The regional training programme being planned by ESCAP is expected to include this type of training.

6.4.4 Technical Barriers

Wind energy resource survey. Though it appears unlikely, there may be a modest wind energy resource in Nauru. Sites "topside" should be checked with proper wind resource measuring equipment followed by professional analysis to determine if there is any economically reasonable possibility of wind generation providing grid power. Since a number of PICs also would benefit from wind resource surveys, a regional programme seems reasonable.

6.4.5 Market Barriers

The basic problem of the market being too small and dispersed to support private development of renewable energy resources 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 large scale renewable energy in Nauru.

6.4.6 Informational and Public Awareness Barriers

Information delivery to decision makers. Through in-country programmes, sessions at international assemblies of decision makers, PPA annual meetings, SOPAC meetings, Forum meetings and other meetings that include high level decision makers, information needs to be provided those decision makers regarding the appropriate technologies for Nauru energy development and problem areas that need to be avoided. Government officers with energy responsibilities and cabinet advisory staff should receive special 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. There is little public knowledge about biofuel, biogas, wind power, solar PV 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 Large Scale Renewable Energy Use

Solar PV

Since biomass does not represent an energy supply resource for Nauru, only solar and wind technologies are practical for the near term large scale use of renewable energy. Without energy storage, solar can only provide fuel savings during the day and cannot deliver more than about 20% of the electricity demand at any time without concern for the stability of the grid as the passage of clouds turns the solar power on and off. With a distributed system made up of many 3-6 kW rooftop modules, land use issues can be avoided and power stability issues are reduced though the limit remains on the order of 20% of demand by PV. There is no capacity benefit for solar since there is no power at night and clouds can interrupt generation during the day so full capacity has to be retained in the diesel system. Although as much as 20% of noon-time demand (when the maximum solar input is received) can be met by solar PV without storing energy in batteries, the energy input van be only on the order of 5% since there is no power from the system at night and the power during the day varies both due to the normal diurnal cycle and clouds.

Although solar PV can be arranged as a large array at a single site, it is technically and economically more reasonable to distribute the capacity in modules of 3-6kWp of solar PV using NPC and government building rooftops to avoid land tenure issues. The distributed system provides increased reliability, less fluctuation due to cloud passages and greater ease of maintenance than large arrays. Using distributed arrays, there is no negative environmental effect caused by their presence. No social effect is likely since the power is simply delivered on the same system as the conventionally generated electricity.

7.1 Wind Power

Wind power also cannot provide more than about 20-25% of electricity demand but can provide power at night. Unfortunately wind resources are variable and there will be periods of calm, so there is no capacity benefit from the wind and there still needs to be full availability of power from diesel or other always available sources.

7.1.1 Other renewable technologies and energy storage

OTEC offers hope for renewable energy based generation that could provide a large scale reduction or even eliminate diesel generation in Nauru but the technology remains decades from commercial application.

In the distant future, topside rehabilitation may have progressed to the point where biofuel plantations could be possible but today no firm plans for such development are in place.

Energy storage in batteries and other forms is possible but at the scale needed to significantly impact the electric power system on Nauru it is prohibitively expensive. It is technically possible to use photovoltaics or wind to generate hydrogen as a storage medium and use fuel cells for power generation but the technology is not yet available to economically generate and store hydrogen or for electricity production from fuel cells that is comparable to the cost of diesel generation.

8 Opportunities for Capacity Development and co-financing

The serious economic problems that Nauru is facing today makes it unlikely that there will be any renewable energy investments other than those being proposed by the EU. Any co-financing arrangements would most likely have to be arranged on the basis of the EU project though there is a small possibility of Australian investment in power infrastructure in the future that conceivably could benefit from co-financing for capacity building, particularly as relates to energy efficiency.

9 ENERGY EFFICIENCY

9.1 Petroleum Use

The primary use of petroleum is for Air Nauru and for NPC power generation. Ground transport use is significant but only about one-third the use of diesel or jet fuel. There is little opportunity at this time for improvement in marine use efficiency since usage appears to be quite low. Access to the reef and the open ocean for fishing is easy and most subsistence fishing is done from traditional wooden canoes or through short trips using outboard equipped aluminium boats. Currently there are trials for locally based commercial fishing but fuel usage is low.

On a per-capita basis, vehicle ownership is high. In 1992, more than one vehicle per household was reported. 2002 numbers are reportedly similar although actual data could not be made available. Motorcycles are also a common means of transport with 1992 figures indicating that about half of the households owned at least one. There is reason to believe that the average fuel efficiency of the 2002 vehicles is better than those of 1992 but no specific data could be obtained. In any case, it is clear that personal transport could benefit from improved efficiency of fuel use since vehicle maintenance tends to be poor and vehicle occupancy low. There is no formal public transport although private vans and modified Land Rovers circulate the island carrying passengers for hire. There are some buses on island and when petrol is in short supply, government and NPC employees may receive free bus transport.

9.2 Electricity Supply

The electricity supply system has been neglected for a decade or more and generation has become a hodge-podge of old and middle-aged fixed machines, mostly out of service awaiting repairs, and many rented, containerised units. Reliability of supply is poor with several hundred outages a year. Because of the poor reliability of power, the Meneñ Hotel, which is now mainly used for housing expatriate workers employed by government and the OIM (the operator of the refugee camps), has its own generation (provided by Australia) in the form of a pair of 550 kVA diesel generators and each of the two refugee camps also has its own power supply consisting of a 550 kVA diesel generator at each site. The supply warehouse used by OIM to support the refugee camps is also continuously powered by a 240 kVA diesel generator.

The technical losses and fuel efficiencies for the engines are not known but it is known that there is room for very significant improvement both in generation and in distribution efficiencies.

9.3 Electricity Use

Electricity use per household is more than double that of Palau, the second highest household electricity user in the Pacific. It is more than 30 times greater than household electricity use in urban Kiribati. Clearly this is a place where tremendous reductions in both demand and energy are possible. However, as long as electricity is provided at far below its real cost – effectively at zero cost to domestic and Government consumers in 2004 – it is unlikely that attempts to curb energy use through anything but unit price increases and disciplined collection of payments will have any effect.

10 Annexes

Annex A – Persons Interviewed by the Local and International PIREP Team

Mr. Joseph Cain	Permanent Secretary, Department of Island
Mr. Peter Depta	Acting Secretary for Finance

Development and Industry (IDI) Nauru Government

Mr. Joe Hiram	Manager, Nauru Phosphate Corporation
Mr Timothy Aingamea	Electrical Superintendent, Nauru Phosphate Corporation
Mr. Ande Dabuae	Head, Nauru Vocational Training Centre
Mr. Manfred Depaune	Chairman, Nauru Insurance Corporation
Mr. Brian Starr	Project Officer, Department of Island Development and Industry (IDI) Nauru Government
Mr Depia Gadabu	Statistics Bureau, Nauru Government
Mr Adonis Stephen	Environment Insect Pest Control Department of Island Development and Industry (IDI), Nauru Government.
Mr Nicko Dabureiya	Atmospheric Radiation Measurement Programme Department of Island Development and Industry (IDI), Nauru Government.

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