SPREP PROE

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

COOK ISLANDS

National Report

Volume 2

PIREP

our islands, our lives...

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

Mr Mata Noora, National PIREP Coordinator

Ms Carinna Langsford Local Consultant

Mr Peter Johnston, International PIREP Consultant

and

Mr Herbert Wade, International PIREP Consultant/Team Leader

with the assistance of Mr Tom Wichman

The international consultants visited the Cook Islands from 13-19 December 2003 and 22-29 January 2004. All discussions were held on the island of Rarotonga. Information for the report was gathered by the National Consultant during the two missions and afterwards, supplemented by additional efforts by Mr Wichman. The National Coordinator and his staff were very helpful throughout the exercise. This report reviews the status of energy sector activities in the Cook Islands in early 2004.

An earlier draft of this report was provided to the Cook Islands Government, the Secretariat of the Pacific Regional Environment Programme, and the United Nations Development Programme for comments. Although some comments were received, the contents are the responsibility of the undersigned and do not necessarily represent the views of the Government of the Cook Islands, SPREP, UNDP, and the Global Environment Facility, or the individuals who kindly provided the information on which this assessment is based.

Herbert Wade

Peter Johnston

October 2004

ACRONYMS

AAGR	Average Annual Growth Rate
AC	Alternating Current
ACP	African, Caribbean, Pacific countries
ADB	Asian Development Bank
BHP	Broken Hill Proprietary
CROP	Council of Regional Organisations of the Pacific
DC	Direct Current
DIB	Development Investment Board
DSM	Demand Side Management for efficient electricity use
EC	European Community
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENSO	El Niño-El Niña oceanic climate cycle
EPS	Electric Power Supply
ESCAP	Economic and Social Commission for Asia and the Pacific (UN)
EU	European Union
EWG	Energy Working Group of CROP
FSED	Forum Secretariat Energy Divison
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GMT/UTC	Greenwich Mean Time/Universal Time Coordinate
GNP	Gross National Product
GoCI	Government of the Cook Islands
Hp	Horsepower
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	Liquified Petroleum Gas
MD	Maximum Demand
MDG	Millennium Development Goals
MFEM	Ministry of Finance and Economic Management
MoW	Ministry of Works

NEP	National Energy Policy
O&M	Operation and maintenance
OMIA	Office of the Minister of Outer Islands Affairs
OTEC	Ocean Thermal Energy Conversion
PACER	Pacific Agreement on Closer Economic Relations
PDEEAP	Pacific Danish Environmental Education and Action Program
PEDP	Pacific Energy Development Programme (UN 1982-1993)
PIC	Pacific Island Country
PICCAP	Pacific Islands Climate Change Assistance Programme (GEF/UNDP)
PICTA	Pacific Island Countries Trade Agreement
PIEPP	Pacific Islands Energy Policy and Plan
PIEPSAP	Pacific Islands Energy Policies and Strategic Action Planning
PIFS	Pacific Islands Forum Secretariat
PIREP	Pacific Island Renewable Energy Project (GEF/UNDP)
PPA	Pacific Power Association
PREA	Pacific Regional Energy Assessment (1992)
PREFACE	Pacific Rural/Renewable Energy France-Australia Common Endeavour
PV	Photovoltaic
SHS	Solar Home System
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SWOT	Strengths, Weaknesses, Opportunities and Threats
TAU	Te Aponga Uira O Tumu te Varovaro (electric utility)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USP	University of the South Pacific
V	Volts
VAT	Value Added Tax
WB	World Bank
Wh	Watt hours of energy

Energy Conversions, CO2 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:

Actual efficiencies are used where known. Otherwise:	litres / kWh:	Efficiency:
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. The Cook Islands consists of 15 islands totalling 240 km^2 of land, located half way between Hawaii and New Zealand. Nearly 90% of land and population are in the southern group of eight mostly elevated, fertile islands. The northern islands are low-lying, sparsely populated, coral atolls. 17% of all land is arable and 13% is under permanent cultivation.

Population. The population in December 2001 was 18,027 including visitors, a 5.6% decline since 1996. The main island of Rarotonga, with two-thirds of the population grew by 8.6% from 1996-2001, with all other islands declining on average by 26%. Excluding visitors, the national population dropped by 17% since 1996, largely due to emigration. The Ministry of Finance and Economic Management (MFEM) has projected population growth of 1.6% (medium growth scenario) through 2022.

Environment. The climate is maritime tropical with a small temperature difference between day and night and modest seasonal changes. Rainfall is about 2000 mm with two-thirds falling between November and April, strongly affected by the El Niño-Southern Oscillation, which can cause rainfall declines of up to 60% in the southern group and increases of 200% or more in the north during El Niño conditions. On average, three cyclones occur every two years, usually between November and April. Biodiversity is not high anywhere in the country but the northern atolls are very low in land-based biodiversity. The Government of the Cook Islands (GoCI) has signed various treaties and conventions related to environmental protection, including the United Nations Framework Convention on Climate Change (UNFCC) and the Kyoto Protocol, with energy use implications.

Political Development. The islands became a British protectorate in 1888, with administrative control transferred to New Zealand in 1900. In 1965 Cook Islanders chose self-government in free association with New Zealand, with the unilateral right to full independence. The GoCI is responsible for internal affairs, with New Zealand responsible for external affairs and defence. The government is a Westminster-style parliamentary democracy with a unicameral parliament of 25 members elected by popular vote to five-year terms. The voting system gives considerable power to very small sparsely populated outer islands. A House of *Ariki* (chiefs) advises on traditional matters but has no legislative power. Each outer island has an elected Island Council presided over by a mayor. There was considerable devolution of political and economic responsibility to local governments, then a reversal of this policy, but frequent changes in political alliances may affect actual directions and outcomes.

Economic Overview. Economic development is hindered by isolation from foreign markets, the very small domestic market, limited natural resources, natural disasters, a diminishing skilled labour force, and inadequate infrastructure in the remote islands. Tourism provides the economic base, agriculture has limited potential, and manufacturing is mainly fruit processing, clothing, and handicrafts. Trade deficits are offset by remittances from emigrants and by aid from New Zealand. Real gross domestic product (GDP) grew steadily for a decade from 1982, followed by decline. Recent real GDP growth has been 2.7% (1999), 13.9% (2000), 4.9% ((2001) and 3.9% (2002). Emigration of skilled workers is a continuing problem, which may constrain future growth.

About 75% of outer island households engage in fishing, mostly for household use, compared to 29% in Rarotonga. The northern group has shifted from land-based agriculture as their principal economic activity to sea related activities, notably pearl and seaweed farming. The southern group continues to grow bananas, taro and cassava. Overall, agriculture provided about 15% of GDP in 2000. The Rarotonga economy is largely trade and service oriented.

Institutional and Legal Arrangements for Energy. A small Energy Division within the Ministry of Works deals with energy planning and policy but staff devote more time to electrical inspections than energy. The Director reports to two ministers, with ministerial responsibilities related to energy scattered over a number of ministries with overlapping mandates. In 2003, Cabinet endorsed a National Energy Policy (NEP), which aims to *"to facilitate reliable, safe, environmentally acceptable,* *and cost-effective sustainable energy services."* The NEP includes a strategic plan with activities, lead agencies, indicators of success, assumptions, risks and time frames. The policies and activities are reasonably well thought-out, clear and consistent but there is neither a budget allocation for implementing activities nor indications of priority.

Several Acts of Parliament deal directly with energy or related issues: 1) the *Energy Act* specifies the responsibilities of the Energy Division (to plan, promote and help develop energy, establish standards, review legislation, promote conservation, encourage research, monitor electricity tariffs, and monitor and approve quality of petroleum products and compliance with fuel standards) but provides no powers to enable the Division to carry out these functions effectively; 2) the *TAU Act* established a government-owned utility to generates and distribute electricity for Rarotonga, with no power legislation for other islands; 3) the *Environment Act* is applicable to Rarotonga, Aitutaki and Atiu, with no energy-specific provisions, although biomass use for energy is effectively restricted; 4) the *Dangerous Goods Act* addresses safe storage and handling petroleum fuels but there are no specific standards or inspection procedures; and 5) the *Building Controls and Standards Act* requires building permits for storage of 22,730 litres or more, but there are no conditions governing such permits.

Inter-ministerial Energy Committees. A national committee established for the GEF/SPREP/PICCAP has been re-established and enlarged under the Division of Energy to direct national PIREP activities and implicitly other energy developments. However, decisions regarding energy use are often made at high level without consultation with officials responsible for energy matters.

2. Energy Supply, Demand and the GHG Inventory

Energy Supply. The Cook Islands are overwhelmingly dependent on imported refined petroleum fuels, which probably account for 90% of gross energy supply, biomass providing the remaining 10%, mainly for cooking. Petroleum imports in 2003 were about 11 million litres of refined products but recent oil import data are inconsistent so this is an estimate. Petroleum fuels are supplied by Mobil and British Petroleum (BP), with Triad purchasing fuel from BP. Wholesale prices of gasoline and automotive diesel oil (ADO), excluding taxes and duties are considerably higher than average for Pacific Islands Countries (PICs) overall and about double those of nearby French Polynesia.

Energy Demand. There is very limited information for estimating energy use by the government, commercial, industrial, household or transport sectors. There have been no recent surveys and the oil importers were unwilling to provide any sales data. Accordingly, it was not possible to produce a meaningful energy balance, which would have been useful for projections of likely future energy use and the potential for GHG reductions. Nonetheless, transport appears to be the biggest user of fuel, followed by electricity generation. There is no significant commercial use of biomass for energy, and fuelwood for cooking has largely been replaced by kerosene and liquid petroleum gas (LPG). According to the 2001 census, wood is used as the principal cooking fuel by 10.9% of all households (Rarotonga 0.6%, Southern Group 28.7% and Northern Group 34.1%).

Nearly 99% of all households had electricity in 2001, of whom 94% were connected to an island grid, 8% had solar photovoltaic (PV) systems and 3% used small diesel generators (with some households obviously having access to more than one source). In the northern islands, 60% of households were connected to an island grid and 43% had PV systems.

Rarotonga accounts for the bulk of electricity generation. In 2003, *Te Aponga Uira Otumute Varovaro* (TAU) had 6.8 MW (continuous rated capacity) of diesel generation. In 2002, maximum demand was 4.4 MW (growing 5% per year since 1985) and generation was 25 GWh (growing 9.4% per year since 1997). TAU calculates the cost of electricity generation and distribution in Rarotonga in early 2004 as NZ 35 ¢/kWh. The domestic tariff is 23 ¢/kWh for a small lifeline level of consumption, increasing to 49¢ above 240 kWh per month and for all commercial customers.

Outer island electrification has been problematic since the 1970s. Excluding the largest, Aitutaki, outer island systems suffer from irregular fuel supply, poor fuel handling, inadequate maintenance and poor facilities. Each local government is responsible for its power system, although general subsidies continue to be provided from the national government, some of which is used for electricity operations. The charge to consumers varies by island, typically 36-44 ¢/kWh for households and 40 – 60 ¢/kWh for commercial users, excluding value added tax. There are no reliable estimates of the cost of outer island supply. In 1998, the ADB calculated costs ranging from 43¢/kWh in Aitutaki to 100¢ in Palmerston, and averaging 58 cents.

Future Growth in Energy Demand and GHG emissions. Small economies tend to have highly variable economic growth. MFEM has estimated GDP growth (medium scenario) of 3% per year through 2022, and population growth at 0.8-1.6% per year although even 0.8% may be optimistic considering recent trends. TAU expects peak demand to grow at 8% assuming tourism continues its recent growth. The PIREP mission estimates, with considerable room for error, that fuel use will grow by 4.2% annually overall with GHG emissions increasing from 28.5 Gg in 2003 to 42.9 Gg in 2013. The projections are 'business-as-usual', i.e. they assume no significant new investments in either renewable energy or energy efficiency. Under an aggressive effort to introduce renewable energy and improve energy efficiency, the Cook Islands could probably reduce the 2013 level of GHGs by a maximum of 13 Gg of which 84% would be from RE investments and 16% from EE. This optimistic estimate is an upper limit, ignoring a number of practical technical, economic and social constraints.

3. POTENTIAL FOR RENEWABLE ENERGY TECHNOLOGIES

Biomass. There have been no surveys of biomass energy resources in the Cook Islands since the 1980s. Approximately 65% of the land probably has light to dense tree cover with biomass energy potential. It is unlikely, however, that any of this will be or should be used for energy purposes, other than meeting existing demand for fuelwood. Virtually all economically reasonable biomass based energy generation in the Pacific utilises waste products of concentrated agricultural or wood processing industries. Neither is likely to be developed. There are about 43,000 coconut trees considered by households as useful nut producers, with over 97% of production used for household purposes. In some PICs, there is considerable potential for coconut oil from copra as a fuel. In the Cook Islands, copra no longer has economic importance and market prices are far too high for serious consideration of such an option. .

Biogas. Pigs and chickens represent a significant resource for biogas production through anaerobic digestion of their wastes.

Solar. Solar energy is an excellent resource in the Cook Islands, particularly for atolls. The Forum Secretariat collected two years (1995-1996) of horizontal, global solar radiation data through the Southern Pacific Wind and Solar Monitoring Project, which showed that insolation, corrected for a tilted collector, averages over 5.5 kWh/m^2 per day. Satellite data indicate that solar radiation in the northern group is somewhat higher than in Rarotonga, but there are no surface measurements to confirm this.

Wind. The Forum Secretariat's wind and solar monitoring project is the main long term data source for Rarotonga wind energy, and is used to estimate wind regimes of other islands. At Ngatangila Point, wind data recovery was 100% during two years of monitoring. The annual average wind speed was 5.5 m/s. The highest hourly and daily averages were 17.7 m/s and 14.0 m/s respectively. Correlations with a six-year average for Rarotonga airport indicate that long-term wind speeds could be about 5% higher than those measured, and wind energy fluxes might thus be 15% higher (as wind energy is proportional to wind speed cubed), with calculated annual average wind energy at 10 m of 180 W/m^2. A study in May 1999, using data from Ngatangila, estimated a wind speed of 6.1 m/s at 30 m, based on an algorithm called the L Weibull coefficient. A subsequent Danish feasibility study in 1997 estimated annual average wind speeds in the range of 6.1-7.5 m/s (at 30 m), suitable for economic power generation.

Hydro. The Ministry of Works has monitored water flows at a number of sites on Rarotonga. There were rough estimates in 1990 of hydro potential at several sites of possibly several hundred kilowatts, but development costs would be too high for economic development.

Wave. In 1987, a Norwegian / SOPAC regional wave energy resource assessment program included the Cook Islands. Ocean swells and wave conditions were measured with Waverider buoys at Rarotonga and three years of satellite data were assessed for ocean waves. The southern islands were found to have the highest wave energy resource of all countries included in the study (23-28 kW/m). In the northern Cooks, the resource was also high for such low latitude. Close to the coast of Rarotonga, the buoy measured a long-term average of 24.5 kW/m. There is a large potential resource but all installed wave energy systems globally are experimental or prototypes and cannot be considered for commercial use.

Ocean Thermal Energy Conversion. The temperature difference between deep ocean and surface waters can be exploited for energy production. Experimental units have been tried in the Pacific but none were operated reliably or for long. The OTEC potential is not known for the Cook Islands but is clearly much larger than the total electrical energy requirements of the country.

Geothermal. The geothermal energy resource in the Cook Islands is unknown.

4. Experiences with Renewable Energy Technologies

Largely through the late Stuart Kingan and his staff, numerous trials of small wind, solar photovoltaics, electric transport and biogas generation were carried out from the late 1970s until the early 1990s. The projects yielded valuable technical and social information for later projects.

Solar Photovoltaics. All outer islands have had, or still have, some household PV systems for lighting and radio operation. Most were small government pilot projects but none included mechanisms for proper maintenance or financial sustainability. Some solar pumps, a fish freezer and refrigerators have been installed on outer islands, also with minimal post-installation support. No information could be found on performance, cost, ownership or fate. Telecom has installed many PV generators, ranging from 600-7,800 peak watts (Wp) with excellent performance and high reliability due to good installation and maintenance using well-trained staff. The largest PV project was electrification of Pukapuka in 1992 with loan finance from France: over 46 kWp of solar panels for over 160 household and public systems, including communal refrigerators and streetlights.

Solar Thermal. Solar water heaters (SWH) were used as early as the 1950s in the Cook Islands. Today about half of the existing housing, and nearly all the new housing and commercial buildings, have SWHs, mainly imported from Australia.

Wind Power. Multi-bladed windmills were used for water pumping prior to the 1970s but suffered damage from salt air, humidity and cyclonic winds. They are no longer used. Wind turbines for battery charging were used from the late 1930s until about 1955. In 1975, a small French wind generator was installed to power a marine beacon at Penrhyn. Stuart Kingan installed several very small (under 1kW) locally made wind turbines on Rarotonga and elsewhere in the 1970s but no serious effort was made to develop wind power until the late 1990s.

In principle, wind could provide substantial direct input into the Rarotonga electricity grid. TAU (in early 2004) considers the maximum acceptable cost for purchasing energy from wind systems to be NZ 15¢/kWh. The cost can be higher on the outer islands, where generation costs are higher. A Danish feasibility study in the late 1990s found three sites on Rarotonga with an average resource estimated at 7 m/s or higher. They proposed a 300 kW Danish system, then costing around $1m dollars, with possible Danish and local finance, but no further action was taken. Also in the late 1990s, an American company proposed a 1 MW wind farm using wind turbines. It was rejected due to high cost and a system that was considered too large for Rarotonga.

SPC evaluated sites in Rarotonga, Atiu and Mangaia in 1999, concluding that a 600 kW installation could be accommodated by the Rarotonga grid. However, the study proposed a smaller pilot project for Mangaia, which was later funded under SPC's PREFACE project. Two 20 kW turbines were installed in 2003 and are operational. Due to data logging problems, no output data are yet available.

In late 2001, a UN team proposed a 1.8 MW wind farm (8 x 225 KW turbines) for Rarotonga and a German/local group proposed a 3.75 MW wind farm (5 x 750 kW turbines). An independent assessment concluded that the UN proposal was sound, but that the wind resource at the site must be monitored for 18-24 months prior to implementation of so large a project. At the time of writing, no monitoring had begun.

Biofuels and Biomass. Before 1980, biomass was the primary household energy source, used for cooking and copra drying. It is now a minor energy source, although still significant on the outer islands. In the mid 1980s, the GoCI considered developing a 1.7 MW biomass fuelled steam generation system for Rarotonga. It was rejected for economic, land use and logistics reasons. In 1983 EPS operated a small sawdust fuelled gasifier but there were problems and tests were abandoned. Coconut oil has been used in very small trials as a diesel fuel replacement but the high cost of oil has prevented its economic, commercial use.

Hydro. No hydro systems have been installed or seriously considered.

Biogas. Eleven biogas units were built at piggeries in Rarotonga in the late 1980s and early 1990s, of which two are operating. Their purpose was primarily environmentally appropriate waste disposal and the gas is vented, not used for energy.

Ocean Energy. In 1976, water flow through reef channels was considered for power generation. The ESCAP Coordinating Committee for Offshore Prospecting, South Pacific (CCOP/SOPAC, the forerunner of SOPAC) was asked to arrange a feasibility study but the resource was not considered satisfactory for development.

OTEC. In 2003, Xenesys of Japan proposed, with cabinet approval, carrying out a feasibility study for OTEC, a 3 MW Uehara cycle, 3 MW plant for Aitutaki and two 3 MW plants for Rarotonga. No progress has been reported, although presumably Xenesys is developing the proposal for possible Japanese finance. The GoCI should be careful not to become an engineering trial site for unproven OTEC technology.

Wave. No wave energy generation has occurred in the Cook Islands and none are planned.

Geothermal. No geothermal surveys were found for Rarotonga, the only island likely to have a developable resource.

5. Energy Efficiency Activities

There appears to be considerable scope for improving the efficiency of energy use, particularly within the tourist industry, government and transport. The benefit from renewable energy will be maximised if overall demand for energy is minimised; large-scale renewable energy investments will be more cost effective if energy efficiency measures have reduced the demand for energy.

Several energy audits were carried out with donor support in the 1980s-1990s, particularly at hotels but there are few records of content or impact. In 2002, the Rarotongan Hotel arranged an audit to reduce their electricity bill. Although not satisfied with the study, they implemented some recommendations and believe there have been savings. A tourism company, Island Hopper, built a new office in 2003. The design includes some PV, insulation, high thermal mass, and low-energy lighting and computers. Press releases suggest a three to four year payback of the added cost of energy savings. Although the design appears to be optimised for New Zealand rather than Rarotonga, and would probably benefit from more shading of windows of smaller area, it is clearly a marked improvement in energy efficiency compared to typical offices in Rarotonga.

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

Barriers to Renewable Energy Development. Principal issues related to renewable energy are poor reliability of outer islands energy supply and potential for increased use of renewable energy for transport and electrical generation.

- For general renewable energy use, a barrier is the failure of installation planners to make adequate arrangements for good technical design, proper operation and maintenance.

A common barrier to integration of renewable energy into an existing utility is the lack of understanding, experience and confidence in generation technologies that are not already being used.

- Technology inertia is therefore a barrier. TAU personnel are familiar with diesel generation and there is a strong preference for development to proceed along familiar lines.

A barrier specific to the Cook Islands is the devolution of responsibility for energy supply on outer islands to the island councils, which have inadequate capacity for financial management or maintenance. The GoCI has no budget for renewable energy and energy efficiency but the real barrier is the lack of a renewable energy development plan from which a rational budget can be developed.

- There is no development plan for renewable energy for Rarotonga or the outer islands making access to finance for significant renewable energy implementation difficult. The effective independence of outer island power systems makes development of a national plan very difficult.
- A barrier to the development of private companies providing renewable energy equipment is the small and sporadic markets so a full-time effort by any company is not justified.
- The capacity of the Energy Division and TAU are inadequate to handle large-scale renewable energy implementation. Finance, technical development, purchasing and installation capacity are almost non-existent for non-conventional large scale energy implementation.

Energy projects are sometimes approved and implemented without input from trained Energy Division staff, resulting in projects without adequate consideration of economics, technical issues and sustainability. The draft National Energy Policy does not clearly define the role of the Energy Division or procedures for development of energy projects to consider their appropriateness.

- A barrier to the development of sustainable energy projects is thus the lack of processes within the NEP that clearly define the processes to follow in energy project development.

Barriers to Energy Efficiency Development. Energy efficiency measures involve households, businesses, government and barriers that differ from those for renewable energy:

- a lack of public information regarding the technology and economics of energy efficiency is a barrier to implementation of energy efficiency measures for all end-use sectors;
- the lack of opportunity for micro-finance of energy efficiency technology may be a barrier to the implementation of energy efficiency in all sectors;
- a lack of Cook Island-specific energy efficiency standards for design and construction, and for appliances, is a barrier to implementation of energy efficiency;
- users often need assistance in selection of equipment, location of suppliers, finance of equipment and installation but that is not included in government efficiency programmes and is not generally available from local businesses; and
- the lack of evidence that energy efficiency does in fact work in the Cook Islands context. Energy efficiency measures need to be monitored for a long period to show they provide the benefits claimed.

7. Capacity Development Needs for Removing the Barriers

Some important areas in need of capacity development are:

- a better understanding of the practicality and economics of the various renewable energy technologies at high levels within government;
- improving the capacity of the TAU for forward planning, financial structuring and decision-making based on marginal costs;
- improving the capacity of the TAU to develop and integrate renewable energy of various types as generation options through training in the specific technologies to be used;
- improving the capacity of the TAU to design and implement energy efficiency measures that are less costly to develop than additional generation capacity;
- improving private sector capacity to carry out a full programme of energy efficiency measures and monitoring of results;
- develop capacity in the tourism sector (including hotel owners) to recognise opportunities for energy efficiency measures, cost effective use of renewable energy, and management skills to take advantage of opportunities;
- improve Division of Energy capacity in data gathering and analysis;

- develop Energy Division capacity to prepare and implement standards and certification schemes for energy efficiency and renewable energy;
- increase training capacity for both energy efficiency and renewable energy so it is continuously available over the long term as personnel change jobs or migrate; and
- improve capacity on outer islands for development of energy systems and management of supply and maintenance.

8. Other Implications of Large Scale use of Renewable Energy

Social and Economic Implications. Widespread renewable energy could improve energy security and make more money available locally for reaching the Millennium Development Goals. It is more likely that renewable resources can improve energy availability and productivity on the outer islands than Rarotonga. Wind, biomass and biofuel development could increase economic benefits to rural households (where the resource tends to occur) through land rentals, employment, the commercial sale of biomass for conversion to energy, and general rural economic development.

Environmental Implications. Widespread use of renewable energy can, if not carefully developed and implemented, result in environmental degradation and should always include a thorough environmental impact assessment and an evaluation of alternatives. Energy efficiency measures rarely cause negative impacts and should be addressed before undertaking a large-scale renewable energy initiative. The main potential for reducing GHG emissions through renewable energy appears to be from wind, biofuels and solar PV. For these, environmental issues are as follows:

- the main issues regarding wind energy have been complaints about noise and concerns that birds may be killed as they fly into rotors. Noise is unlikely to be a serious concern in the Cook Islands, where wind turbines would be much smaller and quieter than those being installed in large countries. Serious bird damage is unlikely unless a turbine is sited near nesting areas;
- the impact of biofuels should be no more severe than current agricultural practices. Biofuels tend to be low in emissions. In case of spillage, they biodegrade readily; and
- large-scale solar development requires recycling of spent batteries, otherwise toxic chemicals may be released into the ground and water.

9. The Implementation of the Capacity Development Needs and Co-Financing Opportunities

The small population of the Cook Islands and emigration make it difficult to retain capacity to develop, design, specify, install and maintain large-scale renewable energy. External technical and possibly managerial assistance will continue to be required. Training and capacity development should focus strongly on project management and maintenance and include establishment of permanent technical training facilities for renewable energy technicians. This could be co-financed by project implementing agencies. For example an externally funded wind farm on Rarotonga, as proposed, will require long-term training to operate, maintain and repair the systems and in management and planning for further wind energy development, and this will need finance.

The most effective immediate measure for reducing growth in GHG emissions appears to be energy efficiency measures to reduce maximum demand for electricity. External assistance needs include the design of measures best suited for the country, management training and assistance to the GoCI, TAU and the private sector for implementation, development of financial arrangements for implementation, and support for monitoring and analysis. This long-term requirement implies the need for a structure within TAU or the Energy Division specifically for energy efficiency improvement and maintenance. Considerable external finance will be necessary to bring both the private and the public sector capacity to a level that can implement and maintain effective energy efficiency measures.

Virtually all renewable energy development in the Cook Islands requires external finance, along with a wide range of technical and non-technical support services so there are opportunities for co-finance in every energy development project, both for hardware and training and management support.

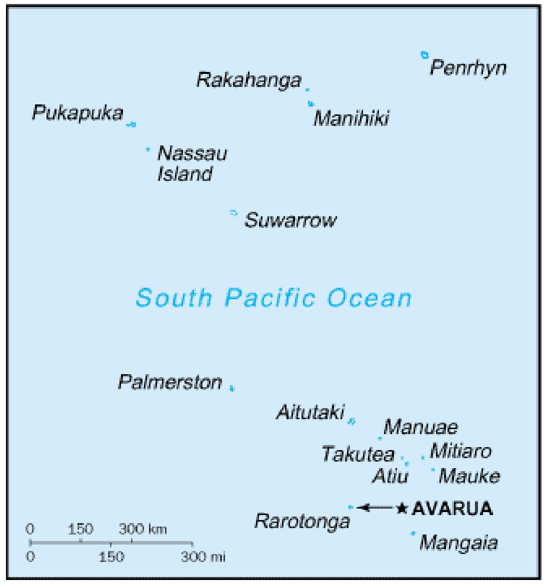
TABLE OF CONTENTS

1 COUNTRY CONTEXT

1.1 Physical Description

The Cook Islands, (Figure 1-1), consists of fifteen small islands with a total land area of only 240 square kilometres (km^2) located between latitudes 9º-22º South and longitudes 157º-166º West, about half way between Hawaii and New Zealand. Over 88% of the land is concentrated in the southern group of eight mostly elevated, fertile islands where 90% of the populace lives. The northern Cook Islands are low-lying, sparsely populated, coral atolls. There are 120 km of coastline. Arable land comprises 17% of the total and 13% is under permanent crops. The Exclusive Economic Zone (EEZ) is 1.8 million km^2.

Figure 1-1 - The Cook Islands



Source: CIA Factbook 2003

Table 1-1 summarises key physical characteristics by island. The capital, Avarua, is located on Rarotonga, the country's largest and highest island. All islands are inhabited except Manuae and Takutea. Suwarrow has only a caretaker resident living there.

Table 1-1 - Physical Features of the Cook Islands

Island	Island Type	Area (km^2)	Maximum Elevation	Principal Habitats
Southern: Rarotonga	High volcanic	67	652 m	Strand vegetation, extensively modified coastal forest and wetlands, fernlands, cloud forest, inland forest
Mangaia	Raised coral	52	169 m	Makatea forest, wetlands modified by agriculture, fernlands, cloud forest, inland forest, freshwater lake
Aitutaki	Volcanic and coral	18	124 m	Strand vegetation, lowland forest greatly modified by agriculture, saltmarsh wetlands
Atiu	Raised coral	27	72	Makatea forest, wetlands greatly modified by agriculture, freshwater lake, fernlands
Mauke	Raised coral	18	29	Makatea forest, wetlands greatly modified by agriculture, fernlands
Mitiaro	Raised coral	22	15 m	Makatea forest, wetlands greatly modified by agriculture, freshwater lakes
Manuae	Atoll	7	10 m	Strand vegetation; significant seabird nesting sites
Takutea	Sand cay	1	5 m	Strand vegetation; seabird andturtle nesting sites
Northern: Penryhn	Atoll	10	5 m	Strand vegetation; seabird and turtle nesting sites
Manihiki	Atoll	5	5 m	Strand vegetation; seabird and turtle nesting sites
Pukapuka	Atoll	4	5 m	Strand vegetation; seabird and turtle nesting sites
Rakahanga	Atoll	4	5 m	Strand vegetation; seabird and turtle nesting sites
Nassau	Sand cay	1	9 m	Strand vegetation; seabird and turtle nesting sites
Suwarrow	Atoll	0.4	5 m	Strand vegetation; seabird and turtle nesting sites

Source: Initial National Communication Under the UNFCCC (Government of Cook Islands, 1999)

1.2 Population

The total population of the Cook Islands, as enumerated on 1 December 2001, was 18,027 including 3,010 visitors, a 5.6% decline since the 1996 census. Rarotonga, with 12,188 people (two-thirds of the total), grew by 8.6% since 1996, the other southern group islands (4,013 people) declined by 26.0%, and the northern group (1,826 people) dropped by 25.6%. Although Rarotonga's total population has grown, the resident population – i.e. those usually living on the island – decreased by 17% since 1996, largely due to migration to New Zealand. Cook Islands citizens have free access to New Zealand and through New Zealand to Australia. Overall growth is due to an increase in tourists and short-term foreign workers.

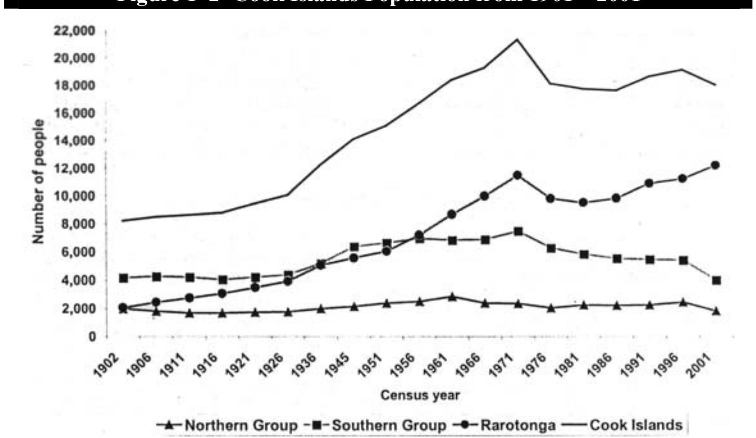
Population by island is shown in Table 1-2. There is no formal distinction between urban and rural communities but Rarotonga is primarily urban or peri-urban, with the entire population living within 25 minutes travel time from Avarua. The population elsewhere is rural. As illustrated in Figure 1-2, the trend of migration to Rarotonga through depopulation of the other islands has continued for the past thirty years.

Table 1-2-

Island & Region	Total
Rarotonga	12,188
Southern group	**4,013**
Aitutaki	1,946
Mangaia	744
Atiu	623
Mauke	470
Mitiaro	230
Northern group	**1,826**
Palmerston	48
Pukapuka	664
Nassau	72
Manihiki	515
Rakahanga	169
Penrhyn	357
Suwarrow	1
Total	***18,027***

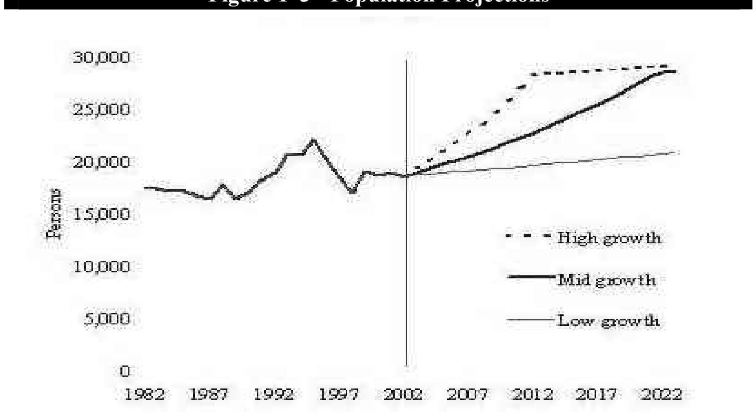
Source: 2000 Census

Figure 1–2- Cook Islands Population from 1901 – 2001



Source: Results of Cook Islands Census of 2001 (GoCI, 2002)

Figure 1–3 - Population Projections



Source: National Development Forum (MFEM, 18-19 November 2003)

In November 2003, the Ministry of Finance and Economic Management (MFEM) projected population through 2022, shown in Figure 1-3, with low, medium and high growth rates dependent on government policies regarding migrant labour, absorptive capacity for tourists (the mainstay of the economy) and assumptions regarding economic growth. For the low growth scenario, the population's average annual growth rate (AAGR) over the next twenty-years is 0.8%; for the medium and high scenarios, it is about 1.6 per cent. There are no projections by island or island group but outer island populations are expected to continue to decline. Assumptions regarding population growth and the distribution among islands have, of course, implications for the likely patterns of future energy use and the practical options to provide energy.

1.3 Environment

With the northern most island at 9º S. Latitude and the southern most at 22º, the southern group experiences a somewhat different climate than the north. Throughout, however, the conditions are maritime tropical with a small range of temperature between day and night and only modest seasonal changes that increase in degree towards the south.

Typically rainfall is around 2000 mm with two thirds falling from November to April. Easterly trade winds dominate with some seasonal variation. Rainfall patterns are strongly affected by the El Niño-Southern Oscillation (ENSO) with southern group rainfall falling by as much as 60% and the northern group increasing by up to 200% during El Niño conditions.

On average, three cyclones occur every two years usually between November and April. They are severe enough to seriously disrupt the economy and cause flooding, storm surges and wind damage This is why cyclones warrant consideration in designing development activities.

The southern group, including Rarotonga (Figure 1-4) is largely of volcanic origin, has 88% of the land area, and with its fertile soils represents most of the agricultural production and a land-based life style. The northern group, mostly atolls, is more dependent on the sea – particularly the atoll lagoon – as the land has poor soil and problems with water supply.

Biodiversity is not high anywhere in the Cook Islands, but the northern atolls are very low in land-based biodiversity.

Figure 1-4 - Rarotonga from the Air

Source - Tourism photo, undated

The Cook Islands has signed various treaties and conventions related to environmental protection, including the United Nations Framework Convention on Climate Change (UNFCC), the Kyoto Protocol, the Convention to Combat Desertification and the Convention on Biological Diversity. The initial national communication to the UNFCC, indicating greenhouse gas emissions, vulnerability and adaptation to climate change, was submitted in

October 1999. Table 1-3 summarises the status and date of signing of some key environmental conventions.

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

Status in Cook Islands	Protection of natural resources (SPREP Convention)	Conservation of nature (Apia 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	25 Nov 87 9 Jul 89 22 Aug 90	 24 Jun 87 26 Jun 90	17 Sep 95 30 Oct 00 ?	06 Aug 85 28 Oct 85 11 Dec 86	16 Sep 98 27 Aug 01 n/a *	Acceded to Vienna Convention, 21 Mar 86

Note: The above treaties and 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.

1.4 Political Development

Named after Captain James Cook, who sighted them in 1770, the islands became a British protectorate in 1888, with administrative control transferred to New Zealand in 1900. In 1965 Cook Islanders chose self-government in free association with New Zealand, with the right to full independence at any time by unilateral action. The Government of the Cook Islands (GoCI) is fully responsible for internal affairs, with New Zealand retaining responsibility only for external affairs and defence. The government is a Westminster-style parliamentary democracy with Queen Elizabeth II as head of state. Parliament is unicameral with 25 members elected by popular vote to five-year terms under a voting system that gives considerable power to very small outer island constituencies. At the time of writing, a national election was planned for September 2004. There is also a House of Ariki (chiefs), which controls large areas of customary communal land (and all land is customary), advises on traditional matters, and maintains considerable influence, but has no legislative powers. Each outer island has an elected Island Council presided over by a mayor.

At the time of writing, the Prime Minister (PM) since February 2002 had been Dr Robert Woonton. He chooses a cabinet collectively responsible to parliament. In November 2003, as parliamentarians 'crossed the floor' for the fourth time in as many years, 'Aunty' Mau Munukoa replaced Dr.Terepai Maoate as Deputy Prime Minister. He had only become DPM in January 2003. Such changing alliances are common; as the Asian Development Bank (ADB, *Asian Development Outlook 2003*) notes, *"One notable policy direction was the decision to reverse the devolution of political and economic responsibilities to local governments. However, repeated changes of key political figures ... may affect the direction and actual outcomes of government policy."*

Table 1-4- The Cook Islands and Regional Economic Treaties

Status	SPARTECA	PACER	PICTA
Signed Ratified Entered into force	14 July 1980 12 Nov 1980 01 Jan 1981	18 Aug 2001 28 Aug 2001 3 Oct 2002	18 Aug 2001 28 Aug 2001 13 Apr 2003

Source: Discussions with Pacific Islands Forum Secretariat (late 2003)

As shown in Table 1-4, the government is signatory to the three Pacific regional trade and economic trade agreements, the most important of which are the Pacific Island Countries Trade Agreement (PICTA) and the Pacific Agreement on Closer Economic Relations (PACER; between PICTA signatories and Australia and New Zealand). The GoCI has also signed the

Cotonou Agreement, providing membership in the African Caribbean Pacific (ACP) group of countries, and thus access to further development assistance from the European Union.

1.5 Economic Overview

The Cook Islands' economic development is hindered by the isolation of the country from foreign markets, the extremely limited size of domestic markets, limited natural resources, periodic devastation from natural disasters, a diminishing skilled labour force due to emigration, and inadequate infrastructure, particularly in the more remote islands. Tourism provides the economic base, agriculture has limited potential, and manufacturing is mainly fruit processing, clothing, and handicrafts. In 2002, pearls – although less than half the value of 2000 and 2001 exports – constituted 60 per cent of all exports followed by fish and fruit. Trade deficits are offset by remittances from emigrants and by aid supplied overwhelmingly from New Zealand. In the 1980s and 1990s, the country lived beyond its means, maintaining a bloated public service and accumulating a large foreign debt. Recent trends in Gross Domestic Product (GDP) are summarised in Table 1-5 below and key economic indicators are shown in Table 1-6.

Table 1-5 - GDP at Constant 2000 Prices by Industry: 1997 – 2002 ($ millions)

Year	1997	1998	1999	2000	2001	2002	% contribution in 2002
Total	153.3	152.1	156.2	177.8	186.6	193.3	100 %
Agriculture and fishing	16.3	21.8	23.8	23.8	23.1	25.3	13.1 %
Mining and manufacturing	4.0	5.0	5.1	6.1	7.0	6.9	3.6 %
Electricity and water	2.8	2.8	3.1	3.5	3.7	3.9	2.0 %
Construction	3.3	4.0	4.3	5.1	6.1	6.8	3.5 %
Wholesale and retail trade	29.2	30.7	33.6	39.7	42.3	45.6	23.6 %
Restaurants and accommodation	16.5	15.9	17.0	23.3	25.0	24.7	12.8 %
Transport andcommunications	18.4	17.1	20.2	25.2	28.0	29.0	15.0 %
Finance and business services	14.2	15.8	15.0	16.9	17.0	16.8	8.7 %
Community and personal services	3.8	3.8	4.4	5.2	5.7	6.4	3.3 %
Public administration	377.8	29.0	23.8	23.2	22.6	22.4	11.4 %
Ownership of dwellings	11.6	11.5	11.4	11.3	11.3	11.2	5.8 %
Less imputed bank charges	4.6	5.3	5.6	5.5	5.3	5.3	2.7 %

Source: Cook Islands Annual Statistical Bulletin (GoCI, July 2003)

Table 1-6 - Key Economic Indicators for the Cook Islands: 1997 - 2004

Indicator	1997	1998	1999	2000	2001	2002	2003 e	2004 p
GDP growth (% per year)	-1.5	-3.5	0.7	7.9	5.1	0.3	2.4	2.5
GDP/capita growth (% per year)	–	1.2	7.8	14.5	9.6	4.0	1.5	3.2
Value added in agriculture (% per year)	12.2	-17.2	-28.2	32.3	-24.0	–	–	–
Value added in industry (% per year)	6.4	3.3	7.0	6.8	-0.8	–	–	–
Value added in services (% per year)	-7.4	-0.8	13.9	6.6	0.6			
Inflation rate (% per year)	-1.2	1.2	1.3	1.7	9.4	3.9	3.4	3.4
Growth in merchandise exports (% per year)	-39.5	-10.0	41.2	38.6	100.9	-39.1	–	–
Growth in merchandise imports (% per year)	-4.8	-10.2	-3.6	18.0	13.0	-8.8	–	–
Balance of trade (US$ m / yr)	-41	-37	-35	-40	-41	-40	–	–
BOP on current account (US$ m / yr)	-4	-2-	-2	-2	5	6	–	–
BOP on current account (% of GDP)	-3.7	-2.9	-2.2	-2.6	6.3	6.3	5.9	–
External debt outstanding (US$ m)	31	65	64	58	53	54	–	–
Debt service ratio (% of exports)	11.0	3.7	4.8	3.5	3.5	–	–	–

Exchange rate $ / US$1.00 (annual ave.)	1.5	1.9	1.9	2.2	2.4	2.1	–	–

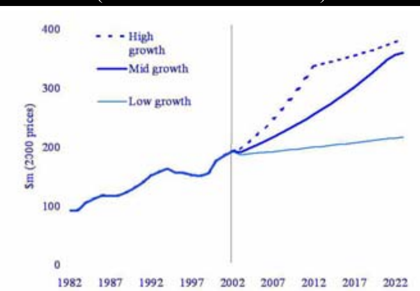
Note: GDP and exchange rates for calendar year; other data for fiscal year (e.g. FY2003 = July 2002–June 2003); – = unavailable
Data from ADB differ somewhat from that of GoCI but both sets are broadly indicative of economic trends.
Source: *Asian Development Outlook* (ADB, 2003) e = estimated; p = projected; BOP = balance of payments

Reforms from the mid-1990s, including the sale of state assets, the strengthening of economic management, a dramatic reduction in public sector employment, the encouragement of tourism, and a debt restructuring agreement have collectively rekindled investment and growth.

As shown in Figure 1-5 the economy grew steadily from 1982 through the early 1990s, followed by four consecutive years of decline. Since 1999, the economy has recovered with the GoCI (*Annual Statistical Bulletin*, 2003) reporting real growth rates as follows: 1999 (2.7%), 2000 (13.9%), 2001 (4.9%) and 2002 (3.9% projected).[1] Accurately estimating future economic growth for a small country so highly dependent on tourism is difficult but MFEM has developed scenarios through 2022, ranging from a modest low growth (assuming a very slight increase in tourism) to rapid growth (rapidly increasing tourism with a large increase in foreign workers). The average annual growth rate (AAGR) for low, medium and high growth estimates are about 0.5%, 3.0% and 3.4% respectively. The high-growth scenario assumes rapid growth initially (5.8% for a decade) until social, environmental and infrastructural constraints depress growth. The emigration of skilled workers to New Zealand is a continuing problem, which may constrain future growth.

The GoCI recognises that foreign investment can make enormous contributions to the economic and social development of the country.[2] There are three commercial banks (ANZ, Westpac and the Bank of the Cook Islands) and the Cook Islands Development Bank, with foreign investment controlled by the Development Investment Board (DIB). Every foreign enterprise, where foreign equity exceeds 33% must apply for registration with the DIB. The *Development Investment Act 1995-96* spells out general regulations and requirements related to establishing new enterprise in the Cook Islands. All foreign investment must: 1) make a significant economic contribution; 2) be environmentally sound; 3) be socially acceptable and harmonised; and 4) not bring the Cook Islands into disrepute. New foreign investment must also act in accordance with sector-specific legislation dealing with agriculture, mergers and acquisitions, real estate, and marine resources where applicable. The government is particularly keen to encourage joint ventures of local and overseas investors, especially where the overseas involvement leads to the expansion or establishment of new export markets, brings essential technical and management expertise, or provides capital which otherwise would not be available locally. There are no foreign exchange controls. Company tax is charged at a flat rate of 20%, and there is a value added tax (VAT) of 12.5%. A withholding tax of 15% is imposed on payments of interest and dividends for overseas investors but this may be rescinded for companies contributing to

Figure 1–5 - Cook Islands Economic Growth 1982-2002 and Projections through 2022
(GDP in constant 2000 $)



Source: National Development Forum (Nov. 2003)

[1] These are in New Zealand dollars; the data differ from ADB estimates.

[2] The sources for this paragraph are *Foreign Investment Climate in South Pacific Forum Island Countries* (PIFS, 2001) updated from *Asian Development Outlook* (ADB, 2003), the *Cook Islands Investment Guide* (DIB, undated) and interviews in Rarotonga (December 2003).

national development. The GoCI is not party to any double-taxation agreement or tax treaty with other countries. For particular sectors (e.g. commercial agricultural livestock and fishing operations, commercial manufacturing, and tourism), discretionary incentives exist to encourage investment. These include exemption from customs duty and import levy; permission to lease land; work permits; tariff protection; accelerated depreciation allowances; and training incentives. The PICTA and PACER agreements are expected to provide incentives for tariff reforms.

For local investors, the commercial banks require 50% equity and the development bank 30% equity before considering a loan. In early 2004, the interest rate was 8.95% plus a risk margin which varies from about 1.4 per cent. There are no special incentives for investments that improve energy efficiency or produce energy from local renewable resources.

1.5.1 Agriculture and Fisheries[3]

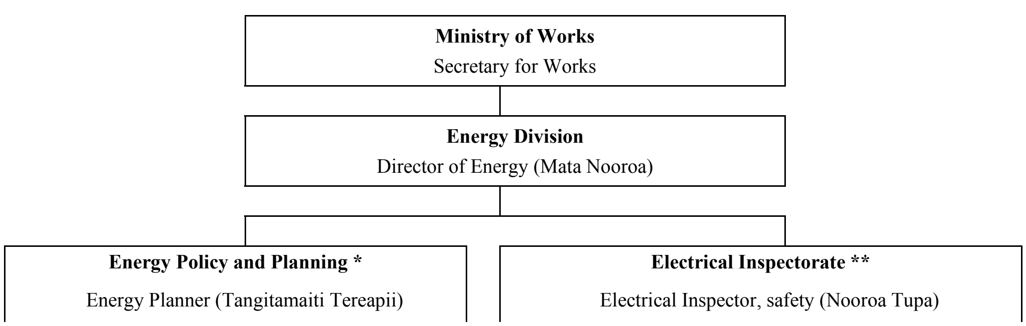
According to a 2000 agricultural census, about 75% of outer island households engage in some form of fishing, mostly for household use. In Rarotonga, 29% of households undertake some fishing activity. Of all households surveyed, only 1% indicated that fishing was a primary commercial activity and 12% claimed to have sold some fish at one time or another but did not consider their fishing to be a commercial activity.

The northern group with poor soil and limited land area has shifted from land based agriculture as their principal economic activity to sea related activities, notably pearl farming (Manihiki and Penrhyn) and seaweed farming (Pukapuka). The southern group with a cooler climate and better soils continues to base have the productive economy on bananas (Aitutaki), taro or cassava (Atiu and Mangaia, Mauke, Mitiaro). The Rarotongan economy is now largely trade and service orientated, although the production of bananas, papaya, citrus, nono, taro and vegetables remains important. For the country as a whole, agriculture provided an estimated 15.2% (1990 prices) of GDP in 2000. A high percentage of the population claims to be involved in agriculture but less than one percent consider themselves to be engaged full time. Based on weekly pay divided by hours worked, agricultural workers earned from about $6 to more than $10 per hour in 2000.

1.6 Institutional and Legal Arrangements for Energy

There is an Energy Division within the Ministry of Works (Figure 1-6). The Director, who is a member of the board of the Rarotonga electricity utility (Te Aponga Uira O Tumu-Te-Varovaro or TAU) supervises four other staff, heads the division and reports to the Secretary of Works, who is in turn responsible to the Minister of Works.

Figure 1-6 - Organizational Chart of the Ministry of Works, Energy Division (2004)



[3] The source for the agricultural and fishing section is the *Cook Islands 2000 Census of Agriculture and Fisheries* (MAF 2000).

Energy Officer (David Akaruru)

Electrical Inspector, standards (Paiau Pirake)

** Includes renewable energy, efficiency and monitoring of electricity tariffs andpetroleum*

** Also *includes some energy auditing*

The capacity for energy planning, administration and policy is even weaker than the small number of staff suggest. Two deal primarily with inspections of electrical wiring and related electrical standards and safety issues, matters not normally handled by energy planning officials in other PICs. The Director is also the Chief Electrical Inspector and spends up to half of his time managing inspection and safety matters.

The Director is also responsible to the Minister for Energy for some aspects of the division's work, with an informal allocation of responsibilities shared between the Energy and Works Ministers. As shown in Figure 1-7, Ministerial responsibilities for matters related to energy are actually scattered over a number of separate ministries and the mandates overlap. There appears to be some confusion among public servants and others regarding authority, responsibility, accountability and reporting.

Table 1-7 - *De Facto* Ministerial Responsibilities for Energy Matters (December 2003)

Ministerial Responsibility:	**Prime Minister**		**Minister for Energy †**		**Minister for Island Administration**	**Minister for Works**	**Minister for Internal Affairs**	
Responsible for:	Oil spills; Waste oil management; Environmental impact assessments; Emissions	Electricity policy and tariffs on Rarotonga	Renewable energy; Sustainable Energy Committee	TAU social issues (e.g. street lighting)	Implicit subsidy for outer islands electricity (See note 5)	Energy policy overall; Electrical safety	Petroleum storage and safety	Petroleum pricing and quality
Responsible through:	Environmental Services	TAU	OMIA as Committee secretariat	Cabinet	OMIA	Energy Division	Labour and Consumer Services (including Dangerous Goods Inspector)	

Notes: 1) Energy Division staff report informally to the Minister of Energy for renewable energy matters and to the Minister for Works for energy policy matters (including electricity planning, electricity tariff and monitoring fuel standards and quality)
2) PM is responsible for government-owned corporatised entities, including TAU, through Cook Islands Investment Corporation.
3) A 'Sustainable Energy Committee' was established by cabinet in September 2001 but apparently has never met.
4) No formal cash subsidies for outer island electricity supply. The office of the Minister for Outer Island Administration (OMIA) administers general grants to the islands some of which are used for electricity.

Energy Division responsibilities include the development of national energy policy, energy planning and the gathering of energy related statistics. The division monitors electricity tariffs and petroleum usage but has no regulatory power. The majority of activities of the Energy Division involve electrical inspection and acting as an interface between internal and external agencies supplying funding for renewable energy or energy efficiency projects and the project recipients. Energy Division staff also regularly provide technical advice and support to the outer island governments in energy matters, although not formally mandated to provide that service.

In Pacific Island Countries (PICs), the Energy Division does not typically handle all energy sector matters. For example, in small countries with fuel price controls the Finance Ministry often administers pricing whereas other ministries or the petroleum company (with better technical skills) will oversee transport, storage and safety. It is also common for an energy office to deal with overall electricity utility policy but with cabinet, the Finance Ministry or the utility itself having the final say on tariff levels. However, the responsibility for energy in the Cook Islands are unevenly dispersed and hinder the development and implementation of consistent energy policies and their administration.

1.7 Energy Policy

In 2003, Cabinet endorsed a National Energy Policy (NEP), which is similar to the format and structure of the 2002 Pacific Islands Energy Policy and Plan (PIEPP). The NEP includes an overall national energy policy statement, "to facilitate reliable, safe, environmentally acceptable, and cost-effective sustainable energy services for the people of the Cook Islands" and a number of guiding principles with goals for sustainability, self-sufficiency, efficient service delivery, and financial independence. Over time, for example, cross-subsidies among electricity users are to be eliminated and those who receive electricity through renewable energy systems are to pay monthly fees sufficient to meet operating and maintenance (O&M) costs – including the eventual replacement of the system components. There are broad policies for overall energy planning and management, the power sector, renewable energy, petroleum fuels, transportation, and environmental aspects of energy – with efficient energy use specified throughout. The NEP includes a Strategic Plan with specific activities, lead agencies, indicators of success, assumptions and risks, and a time frame for each policy area. The policies and activities are well thought-out, clear and consistent. However, there are no specific budget allocations for implementing any activities or indications of what the priorities are. The NEP has not been an input to an economic national planning exercise coordinated by MFEM, but the planning only began in September 2003.

1.8 Energy-related Legislation

There are several acts of the Cook Islands Parliament that deal directly with energy issues and others dealing with related issues:

- The *Energy Act (Act No. 18 of 1998).* Under the provisions of the Act, that came into force on 1 September 2000, *"the principle functions of the Division shall be to: a) plan for, promote, and encourage … the development of different sources for the generation of energy including, but not limited to, diesel, gas, coal, photovoltaic, ocean, thermal, wind, and biomass generation; b) ensure standards of safety, efficiency, and economy of operation in respect of the generation, transmission, and distribution of energy; c) review any Act or legislation that may affect the energy sector; d) promote and encourage the safe and efficient use of energy; e) promote and encourage measures for conservation of all forms of energy; f) encourage research regarding exploitation of different energy sources consistent with local requirements and resources, bearing in mind the benefits of conserving the environment; g) monitor electricity tariffs; and h) monitor and approve the quality of imported petroleum products, and compliance with fuel standards."*

  The Energy Division has clear responsibilities within the law regarding energy planning and use. The bulk of the Energy Act, however, deals with electrical inspection and safety. Virtually all of the powers of the Division relate solely to these inspection functions, not the energy matters listed above. NEP 2003 specifies that sustainable and renewable energy sources are preferred for development where these are commercially proven and viable in the Cook Islands context. The GoCI has also signed the UNFCCC (on climate hange) and has pledged[4] to reduce emissions of Greenhouse Gases (GHGs), which can most easily be accomplished through improved energy efficiency and increased use of renewable energy sources to replace petroleum. However, those responsible for energy planning have no power under the Energy Act to carry out these functions.

[4] There is, however, no legally binding obligation under the UNFCCC or the Kyoto Protocol.

- The *Te Aponga Uira (TAU) O Tumu-Te-Varovaro Act (Act No. 17 of 1991* and various amendments through 1999). The TAU Act established a government-owned utility that generates and distributes electricity for the island of Rarotonga. The Act requires TAU to assure efficient supply of energy. However, there is nothing in the Act regarding renewable or sustainable energy and no requirement to promote the efficient use of energy. Under the Act, the Board of Directors includes the Secretary of the Ministry of Energy as an *ex-officio* Director. There is no longer a Secretary for Energy but, at the time of writing this report in early 2004, there has been no amendment clarifying board membership. Currently the Director of Energy sits on the TAU Board, representing the (non-existent) Secretary for Energy. Virtually all of the Energy Division's powers to influence power sector planning, efficient use of energy and renewable energy are derived from membership on the TAU board.
- The *Environment Act of 2003*. A revised Environmental Act came into force in December 2003 and is applicable only to Rarotonga (formerly covered by the *Rarotonga Environment Act 1994-5* and subsequent amendments, 1998-1999), Aitutaki and Atiu. There is nothing specifically dealing with energy although provisions restrict the practical use of biomass for energy production. The Act is to *"provide for the protection, conservation, and management of the environment in a sustainable manner"* and might in principle be used to promote renewable energy and improved efficiency.
- The *Dangerous Goods Act (Act No. 21 of 1984* and associated regulations of 1991*).* This Act requires an Inspector of Dangerous Goods to assure the safe storage and handling of a range of dangerous substances such as flammable materials. It specifically includes petroleum fuels and their storage tanks. However, there are no specific standards for petroleum or its storage, handling and inspection. The officials responsible (Ministry of Internal Affairs) rely on the petroleum companies and storage tank owners to comply with requirements.
- The *Building Controls and Standards Act (Act No. 11 of 1968* and its associated 1991 Regulations) requires building permits for all storage tanks with a volume of 5000 imperial gallons (22,730 litres) or more but there are no specific conditions governing such permits.

1.9 Inter-ministerial Energy Committees

An inter-ministerial 'Advisory Committee on Energy' was formed in 1999 or 2000 and met about five times. By late 2001 it was inactive and had been replaced by a 'Sustainable Energy Committee', which was to advise on outer island energy and consider proposals for grid-connected wind power systems. It apparently has never met. A national committee originally established for the GEF/SPREP/PICCAP has been re-established and enlarged under the Division of Energy to direct national PIREP activities and, implicitly, for considering other energy sector developments. It has met twice between late 2002 and late 2003. Informal *ad hoc* committees continue to consider energy issues, for example during 2003 to consider the potential of 'ocean thermal energy conversion' (OTEC, discussed further in chapter 3) for Rarotonga. Decisions regarding energy planning and use are often made at high level with little or no consultation with the officials who are responsible for energy matters.

2 Energy Supply, Demand and the GHG Inventory

2.1 Energy Supply

The Cook Islands are overwhelmingly dependent on imported refined petroleum fuels for national energy needs for electricity generation, for transport by land, sea and air and for lighting and cooking. Given the high use of Liquefied Petroleum Gas (LPG) and kerosene for cooking, it is unlikely that biomass provides more than about 10% of gross national energy production. Solar and wind energy together account for well under 1%, and there has been no development of the small hydropower resource. Petroleum therefore accounts for about 90% of the total energy supply.

2.1.1 Petroleum

Table 2-1 – Petroleum product imports 1995-2003 (thousands of litres)

Year	Petrol	Jet Fuel	Av Gas	Lube Oil	Diesel	Kero	LPG	Total
1995	4461	7851	8	227	8395	119	244	21306
1996	4415	5093	1	160	7864	26	334	17893
1997	3964	7645	4	93	7242	54	145	19148
1998	4038	7053	2	39	7846	16	207	19200
1999	4215	4383	6	139	8295	42	200	17279
2000	Data lost due to computer malfunction							
2001	4116	7463	8	187	7170	21	191	19157
2002	4520	2343	0	148	4899	11	710	12631
2003	4683	182	4	111	5945	1	172	11098

Source: Statistics Department

Petroleum import data could only be obtained from the Statistics Office; the petroleum companies did not provide information on imports or sales. The reported Statistics Office imports are based solely on customs data and are known to be unreliable for some products. There are also clear errors in some entries, making the whole data set suspect. Petroleum use in the Cook Islands can differ significantly from imports during any given year depending on the number of fuel shipments during the year (often less than once per month) and changes in stock levels at the end of the year. This can cause large variations between yearly values (particularly with LPG) but these variations average out over several years. Unfortunately, without the cooperation of the petroleum companies for the provision of import and sales data, an accurate estimate of petroleum use by sector is not possible.

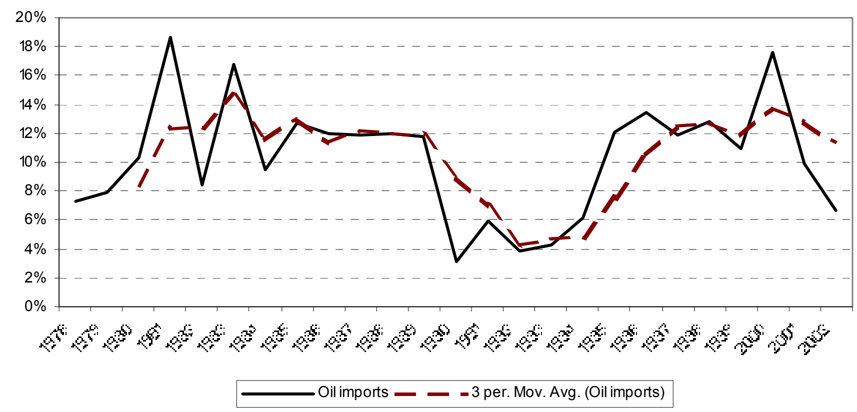
The Cook Islands are relatively high per capita users of LPG, which for Rarotonga is provided by Boral Gas of Australia through a local agent. Aitutaki imports LPG directly from New Zealand while the other outer islands receive LPG from Rarotonga distributors. Although Cook Islands petroleum fuel prices are high in general, wholesale LPG prices in Rarotonga, excluding import levies and taxes, are about 20% below the average for PICs.

In the early-mid 1980s, there was considerable concern regarding the rising cost of petroleum and the growing percentages of imports accounted for by petroleum products. Figure 2-1 (the dashed moving average trend line) suggests that petroleum fuel imports as a percentage of total imports by value are similar now to those of the early 1980s.

Petroleum fuels are supplied to the Cook Islands by Mobil and British Petroleum (BP). Triad, a subsidiary of Broken Hill Proprietary (BHP) of Australia, purchases fuel from BP for distribution within the country. Both Mobil and BP ship products from refineries in Australia and Singapore via Fiji using local coastal tankers (LCTs; about 700–5000 dry weight tonnes) to bulk storage in Rarotonga. Except for automotive diesel oil (ADO) used for power generation on the larger islands, fuels are shipped to outer islands in 200 litre drums. As the Cook Islands study of the *Pacific Regional Energy Assessment* (PREA, volume 2; World

Bank, et.al, 1992) observed over a decade ago, small quantities, long transportation routes, and trans-shipment combine to result in landed costs of petroleum products above those of several neighbouring PICs. Recent wholesale prices of gasoline and ADO (excluding taxes and duties) are shown in Figure 2-2. Prices in Rarotonga are considerably higher than average for PICs overall and about double those of nearby French Polynesia.

Figure 2-1 - Petroleum as Percentage of Total Imports: 1978 - 2002



Source: Cook Islands Statistical Bulletin (GoCI, July 2003)

Figure 2-2 - PIC Wholesale Petroleum Fuel Prices
(excluding import duties and taxes; late 2003)

Source: Pacific Fuel Price Monitor, Edition 6 (PIFS; February 2004)

2.1.2 Biomass

Although at one time the largest national energy source, biomass no longer has that role. With only 10.9% of homes still cooking with firewood and no commercial users, the energy contribution of biomass appears to be less than 890 tonnes of oil equivalent (toe) annually.

2.2 Energy Demand

The Cook Islands is an affluent country compared to most PICs, and this is reflected in the pattern of energy demand.

2.2.1 Petroleum

Without cooperation of the suppliers, there is no practical way to determine the demand for petroleum products for the GoCI, or commercial, industrial, domestic or transport sectors. Jet fuel and aviation gasoline is obviously used for air transport and petrol for ground transport. For other fuels, demand by sector must be estimated, sometimes crudely.

Transport is the largest user of petroleum products in the Cook Islands, particularly jet fuel. Jet fuel is often considered to be an export or bunker product but was included by the 1992 Pacific Regional Energy Assessment (PREA) as local consumption since it is mainly related to the transportation of tourists, the mainstay of the national economy. This report retains the PREA convention. There are no records of fuel sold specifically for ground or marine transport but the 2000 census shows private ownership of 3,782 motorcycles, 1,365 cars, 546 trucks, 438 utility vehicles and 309 vans. The number of commercial and government vehicles is not included in the available statistics nor is the number of boat motors available. It is assumed that all petrol and all ADO not used for public electricity generation is for ground and marine transport, although in fact some ADO is used for private generation by households and hotels.

Distillate used for electricity generation is estimated from power sector data presented later in this section. For Rarotonga, the TAU average of 3.8 kWh per litre is used. OMIA records indicate 3.0 kWh/litre for Aitutaki and typically 2.4 kWh/l for other islands, for which generation is minor so the accuracy of the estimate will not affect results.

Direct use of fuel for business or commercial use is quite small mostly limited to transport.

Due to its convenience and the relatively high cost of kerosene in the Cook Islands, LPG sales have increased steadily both on Rarotonga and in the outer islands. In 2002, outer island sales of LPG represented about 13% of the total volume sold. Since the outer islands represent about 32% of the population, the per-capita usage of LPG by the outer island population is less than half that of Rarotonga, partly due to higher cost and partly to a more traditional lifestyle. However, the suppliers note that there is a continuing trend for increased use by outer island customers, largely as a replacement for kerosene.

Table 2-2– Sales of LPG

Year	Sales (Tonnes)
1996	379
1997	381
1998	346
1999	443
2000	495
2001	502
2002	557
2003	596

Source: Retail suppliers

2.2.2 Biomass

There is no significant commercial use of biomass for energy in the Cook Islands. At the time of the PREA (1992) there was substantial use of biomass for copra drying. Now that the copra trade has ceased, that use is minimal. Fuel wood for cooking has been largely replaced by kerosene and LPG though most families use some fuel wood for traditional *umu kai* (earth oven) cooking for occasional feasts and wood is still used as the principal cooking fuel by 10.9% of all households (Rarotonga 0.6%, southern group 28.7% and northern group 34.1%). There have apparently been no surveys of household energy use in the country and it is not possible to accurately estimate the fuel wood demand without a household energy survey. However, a crude estimate can be made using information from a series of household energy surveys carried out in six PICs in the 1980s.[5] For the six rural surveys, households typically used 4–6 tonnes of wood per year (wet

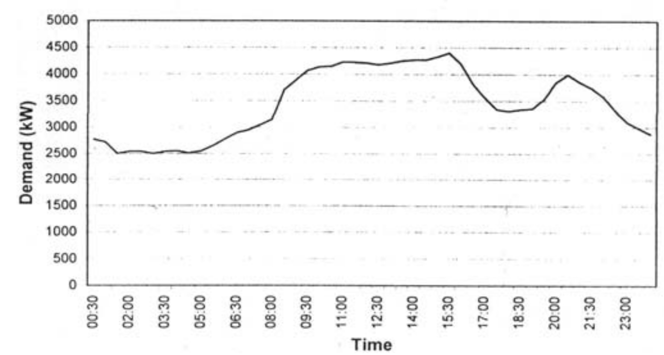
[5] From 1982-1987, fourteen household energy surveys were carried out in rural and urban communities in six PICs by the UNDP/ESCAP Pacific Energy Development Programme (PEDP). For six rural surveys, households typically used 4,000–6,000 kg of wood per year (wet basis) with a gross energy content of 60–90 Gigajoules (GJ). Urban households in two Fiji surveys (i.e. a relatively

basis) with a gross energy content of 60–90 Gigajoules (GJ). Assuming a median use of 5 tonnes/year per household and 15 GJ/tonne, with 10.9% of the 3880 households (2001 census) cooking with wood, a national figure of about 2115 tonnes of firewood is used per year representing around 31.7 Terajoules (TJ) per year or about 745 toe.

2.3 Electricity on Rarotonga

As Table 2-3 shows, nearly 99% of all households in the Cook Islands had access to electricity in December 2001 as reported by the 2001 Census, placing the Cook Islands – along with Niue, Palau, Tuvalu and Tokelau – among those PICs that are essentially fully electrified. Overall, 94% of households were connected to an island grid, 8% had solar photovoltaic (PV) systems and 3% had access to small diesel generators. In the northern Cook Islands, 60% of households were connected to the island grid and 43% reported they received electricity from solar PV systems.

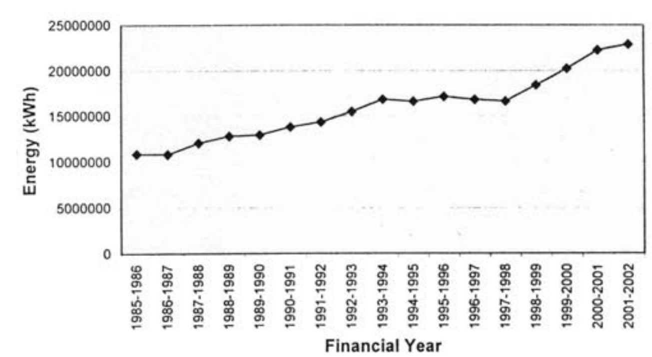
Figure 2-3 - Figure Rarotonga Demand Curve (Jan. 2003)



Source: Avatiu Valley Power Station Generation Study (TAU, 2003)

On Rarotonga, almost the entire population lives along the coast and is well served by TAU's 11 kV transmission and distribution network. In 2003, the installed capacity was 8 MW nameplate (6.8 MW continuous rated capacity). Maximum demand (MD) in 2002 was 4.4 MW, and generation (Figure 2–4) was about 25 million kWh (25 GWh). The annual load factor was about 65% and losses were 8% of energy sent out. TAU had 4,400 consumers and 45 staff. About 3.8 kWh were generated per litre of ADO used.

Figure 2-4 Generation on Rarotonga 1985/86-2001/02 (KWh)



Source: Avatiu Valley Power Station Generation Study (TAU, 2003)

Figure 2–3 illustrates Rarotonga's typical weekday hourly demand in early 2003, Figure 2-4, shows growth in electricity generation on Rarotonga, and Figure 2–5 shows maximum demand growth. On average, the annual growth rate in MD since 1985 has been about five percent .

high income PIC) used 580–850 kg of wood (8.7–12.7 GJ). Results are summarised in the papers of the Pacific Household and Rural Energy Seminar (World Bank/UNDP Energy Sector Management Assistance Programme and PEDP; Port Vila, Vanuatu, November 1990).

Table 2-3 - Electrification of Cook Islands Households: December 2001						
Island or island group	Households	% with electricity	Grid Connection	Diesel generation	Solar PV	No electricity
Rarotonga	2531	99.2 %	98.8 %	0.8 %	5.1 %	0.8 %
Southern Group	965	98.0 %	96.7 %	1.9 %	1.3 %	2.0 %
Northern Group	384	98.7 %	59.9 %	22.4 %	43.0 %	1.3 %
All	3880	98.8%	94.4 %	3.2 %	7.9 %	1.2 %

Note: Percentages add up to over 100% as some households have more than one power source
Source: *Cook Islands National Census of December 2001* (GoCI, 2002)

Since financial year 1997/98 (July 1997-June 1998), generation has grown by 9.4% per year. Until 2001, the peak demand occurred about 8:00 p.m. but this has shifted to the daytime with a second and slightly higher peak largely driven by the increased use of air conditioning. MD grew at an AAGR of 6.0% from FY1985/86 to 1992/93, was then flat until 1997/98 and has since increased by 8.5% annually. Growth in both generation and MD has been due largely to increases in tourist arrivals. TAU expects MD to increase at an AAGR of 6-10% (8% base case) over the next decade, assuming continued steady growth in tourism. For recent years the number of consumers has grown at an AAGR of 2.6% overall but at a much higher 6.1% for the commercial sector. In 2001, domestic consumers were 85% of total and accounted for 44% of sales. Commercial consumers were 15% but consumed 66% of GWh sold.

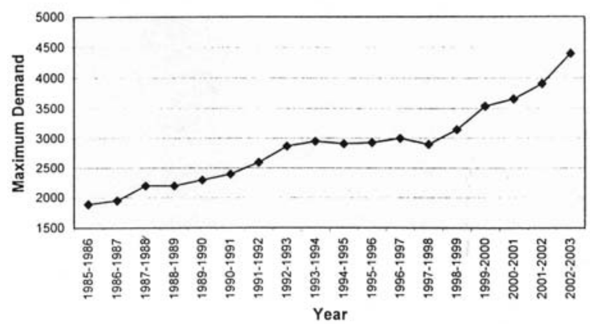


Figure 2-5 - Growth in Rarotonga Maximum Demand

Source: *Avatiu Valley Power Station Generation Study* (TAU, August 2003)

Table 2-4 – TAU Generation, Fuel use and Sales 1994-2003									
	Year 94-95	Year 95-96	Year 96-97	Year 97-98	Year 98-99	Year 99-00	Year 00-01	Year 01-02	Year 02-03
MW MD	2.90	2.93	3.00	2.90	3.15	3.54	3.66	3.91	4.40
Generated MWh	16,623	17,145	16,805	16,643	18,428	20,247	22,267	22,893	24,826
Fuel, kl	4,276	4,441	4,370	4,251	4,727	4,679	5,727	5,900	5,779
Billed MWh	na	na	na	na	16,474	17,873	19,231	20,249	21,987

Source: TAU na = not available

Table 2-5 - Rarotonga Electricity Tariff	
Consumption	**Charge ($)**
Domestic	
1-60 kWh/m	23 ¢/kWh
61-240 kWh/m	41 ¢/kWh
Over 240 kWh/m	49 ¢/kWh
Commercial	
Fixed charge	$5 per month
Flat rate / kWh	49 ¢/kWh

Note: VAT of 12.5% is added
Source – TAU 2003

The cost of electricity generation and distribution in Rarotonga is stated by TAU to be about $0.35 per kWh. The charge borne by consumers is shown in Table 2-5. For households, as consumption increases, the cost per unit consumed also increases, making it an increasing block tariff structure. The charges have been unchanged since January 2001. In effect, the lowest block constitutes a 'lifeline' tariff for low-income consumers. Businesses pay a higher flat rate. Under the reform programme, TAU is becoming increasingly commercialised and is expected to recover all operating costs from its revenue from consumers.

New customers must pay an application fee ($10), a service connection fee ($245 single phase; $400 three phase up to 32 amperes; $1980 for three phase connections of 32-63 amps; and $3100 for 63-80 amp service). There is also a distribution line charge of $1950 per 47 m of overhead line or $2700 per 47m of underground cable, partly refundable if additional customers are connected to the line within 10 years.

2.4 Outer Island Electrification

Outer island electrification has been a problem area for government since its initiation in the 1970s. In general the outer island systems (excluding the largest, Aitutaki) have continually suffered from irregular fuel supply, poor fuel handling, inadequate maintenance skills and inadequate facilities. The quality of the outer island power supply ranges from very good to very poor, according to the management and technical skills and equipment available on each island. Most islands operate the power system for 18-hours or less per day. Long power outages are not unusual, due either to insufficient fuel or to system breakdowns.

Table 2-6 - Electricity Statistics for Outer islands: FY 2002/2003

Island	Installed Capacity (kW)	Maximum Demand (kW)	Sales (thousand kWh)	Supply (hrs/day)	Customers		Fuel use (kWh/l)	Fuel kl	Reported losses (%)
					(dom.)	(comm.)			
Aitutaki	1404	580	3115	24	540	60	3.0	1167	11
Mangaia	332 40 Wind	110	340	24	259	19	2.7	156	20
Atiu	215	90	296	24	231	23	2.9	157	35
Mauke	84	72	180	19	146	21	2.0	97	7
Mitiaro	56	30	96	19	n/a	n/a	2.6	43	15
Pennryn (O)	130	48	88	18	n/a	n/a	2.4	40	9
Pennryn (T)	60	20		18					
Manihiki (Ta)	90	50	86	12	n/a	n/a	3.0	65	26
Manihiki (Tu)	90	48	79	12					
Rakahanga	42	21	29	12	n/a	n/a	2.3	13	6
Pukapuka	35 diesel 46 PV	n/a	n/a	12 diesel 24 PV	144 (est) on PV	n/a	n/a	n/a	n/a
Nassau	1.2 PV (est)	nil	n/a	24	14	n/a	None	n/a	n/a
Palmerston	42	12	n/a	12	n/a	n/a	n/a	n/a	n/a

Notes: Fuel use andlosses for FY 2001/02 &/or 2002/03. n/a = not available
Diesel in Pukapuka is only for government facilities, households are electrified by solar PV

Sources: Installed generators: Tom Wichman (Feb 2004), Generation from *Annual Statistical Bulletin* (2003);
Fuel use and losses (technical and unsold energy) calculated from data provided by Energy Division (Dec 2003)

By an Act of Parliament 1973/74 Number 37 the Electric Power Supply (EPS) was given the exclusive authority and responsibility through out the Cook Islands for electricity generation, no private generation was allowed. Outer island power provision proved to be very difficult for EPS and with its reorganisation into a government owned private enterprise in 1991, becoming the *Te Aponga Uira O Tumu te Varovaro* (TAU), it retained responsibility only for Rarotonga. At that time the Ministry of Energy was formed and outer island electrification shifted to the Outer Islands Power Directorate under the Ministry. In 1998, the government was restructured and the Ministry of Energy dissolved. The Office of the Minister of Outer Island Affairs (OMIA) took over outer island electrification and the Division of Energy within the Ministry of Works became responsible for renewable energy and electricity inspectorate functions. After restructuring, most of the outer island government functions were 'devolved' to the island local governments with the national government providing a budget for local government operations. Therefore currently each island local government is fully responsible for the power system on its island, although general subsidies continue to be provided from the national government, some of which is used for electricity operations. The Division of Energy collects statistics from island power systems and retains responsibility for the inspection of electrical installations on outer islands, but has no responsibility for power system planning, design or implementation. The Energy Division routinely provides advice to outer island power staff but has no authority or responsibility for their function.

Following devolution of responsibility to the councils, there were staffing reductions at the various island power plants and the hours of electrical service decreased for some islands. Maintenance standards and spare parts inventories also declined. OMIA provides some assistance in organising maintenance from Rarotonga but in general the outer islands are fully responsible.

Table 2-6 combines data from several sources to summarise the outer island electrical systems. Data directly collected from the power system operators was used where available.

The data are clearly unreliable. Aitutaki, in its monthly report to the Division of Energy for example, reports selling more kWh than it generates for almost every month since March 2001 with November 2002 reporting sales of kWh nearly triple the quantity reportedly generated. A likely reason for the error is that a new generator was installed in March 2001 in a way that probably bypassed the total kWh meter for the powerhouse. While it is understandable that errors will creep into the data, for Aitutaki to consistently report that it sold more than it generated for over two years suggests that no one is looking at the data or understanding its implications – neither the person entering the data in Aitutaki, nor the Division of Energy staff who tabulates it, nor the Statistics Department staff who arranges for its publication.

Reported fuel efficiencies on Mauke are also consistently over 100% (due to using the wrong numerical sign in the kWh loss column, causing addition of losses rather than subtraction). Fuel efficiencies reported by Aitutaki range from a high of 4.22 kWh/l to a low of 1.71 kWh/l, again clearly due to data error. Mauke reported a realistic fuel efficiency of 1.47 to 2.03 kW/l. The Mangaia and Mitiaro data appear to be of acceptable quality. Different data sources list different installed capacities, different hours of operation and different tariffs. To summarise, while the data in Table 2-6 is probably indicative, it is certainly far from exact.

Table 2-7 – Outer Island Tariff Structures

Island	Domestic	Commercial
Aitutaki	0.44c unit, plus 12.5% VAT	0.60c per unit, plus $5.00 service charge. Subject to 12.5% VAT
Atiu	0.44c unit, plus 12.5% VAT	0.62c unit, plus 12.5% VAT
Mangaia	0.36c unit, plus 12.5% VAT $5.00/month fixed supply charge	0.58c unit, plus 12.5% VAT; 0.10c unit for churches plus VAT $5.00 per month fixed supply charge
Mitiaro	0.36c unit, plus 12.5% VAT	0.58 c unit, plus 12.5% VAT
Mauke	0.36c unit, plus 12.5% VAT	0.58c unit, plus 12.5% VAT
Manuae	Uninhabited island	Nil
Manihiki	0.36c unit, plus 12.5% VAT	0.58c unit, plus 12.5% VAT
Nassau	Nil	Nil
Palmerston	-	-
Penrhyn	0.36c unit, plus 12.5% VAT	0.36c unit!, plus 12.5% VAT
Pukapuka	Nil – no pricing mechanism	Nil under current pricing
Rakahanga	0.40c unit, plus 12.5% VAT	0.62c unit, plus 12.5% VAT
Suwarrow	Govt station	

Source: OMIA – Feb. 2004

Table 2-8 - Cost of Island Electricity Supply (1998)	
Island	**Full Cost $/kWh**
Aitutaki	0.43
Atiu	0.58
Mangaia	0.54
Mitiaro	0.85
Mauke	0.74
Penrhyn	0.85
Manihiki	0.74
Rakahanga	0.88
Palmerston	1.00
All outer isl.	0.58

Source: *Final Report of Cook Islands Power Development Study* (ADB, 1998)

Rarotonga dominates electricity use in the Cook Islands. With the exception of Aitutaki, which has the second largest tourism industry in the country; electricity use elsewhere is modest. Until the outer islands electricity supply devolved to individual Island Councils, domestic consumers in the outer islands paid a flat rate of $0.36 per kWh, whereas commercial rates varied, typically $0.48-0.58 per kWh plus a fee of $5/month. There are no current, reliable estimates of the actual cost of outer island supply. In 1998, the ADB (Table 2-8) calculated costs per kWh, ranging from $0.43 in Aitutaki to $1.00 in Palmerston and averaging $0.58, with TAU (i.e. Rarotonga consumers) cross-subsidising all other islands. Following devolution, each Island Council separately established charges, ostensibly based on the local cost of production. However, council records on the costs of operation and maintenance tend to be poor, there is usually no capital charge element in the tariff, and large subsidies remain.[6] Fuel for the generation of electricity on the outer islands all receive the benefit of being exempt from the Customs Import Levy of $0.22 per litre. However, sales are subject to the usual VAT charge of 12.5 per cent.

All islands except Aitutaki bring in fuel in drums from Rarotonga carried on inter-island ships. Since 2003 Aitutaki has directly purchased diesel fuel through Reef Shipping who import their fuel from Australia and New Zealand.[7] Fuel is transported in 200 litre drums since there is no bulk storage on the island. Deliveries are direct from Auckland with no trans-shipping in Rarotonga. The Aitutaki Power Supply manager noted that purchases are made on the spot market, rather than through a fixed contractual arrangement.

Aitutaki

Aitutaki Power Supply is considering establishing itself as a stand-alone business unit similar to TAU on Rarotonga. For administrative purposes, the financial performance of the power supply on Aitutaki is already accounted for as a separate island entity.

In so far as major tourism development is limited by system capacity, planning for power generation is not being addressed and a development of a new major resort could create immediate power shortages. Interestingly, both the Akitua Resort[8] and the Pacific Resort[9] enjoy power at a favourable fixed contract rate, a practice that lessens the incentive and value to them of energy conservation efforts and encourages load growth at a time when capacity is a problem.

Mitiaro

According to the Mitiaro Island Secretary, the current tender for ADO used in power generation provides fuel at $0.63 per litre from Mobil. Fuel sufficient for three weeks demand is typically ordered. Electricity on Mitiaro is produced 19 hours per day from 5 a.m. until

[6] ADO used for electricity production by TAU and the outer island councils attracts the normal customs levy of $0.12 per litre but is exempt from the normal 12.5% VAT, except for Aitutaki VAT is, however, added to the monthly electricity bill. The outer islanders generally do not incur the various connection and distribution line fees imposed on Rarotonga consumers. The general Island Council budgets (mostly provided by the National Government) are used to subsidise electricity costs outside of Rarotonga and Aitutaki.

[7] It is assumed that most fuel supplies are sourced from the Marsden Point Refinery in New Zealand since Reef Shipping voyages commence from this location.

[8] The Rarotongan Beach Resort purchased the Akitua Pearl Beach Resort and this property now operates on Aitutaki as the Aitutaki Lagoon Resort and Spa.

[9] The Pacific Resort on Rarotonga opened a new resort on Aitutaki in 2002 known as the Aitutaki Pacific Resort.

midnight. Customers include 30 households, a school, two churches, three guesthouses and small government offices. There are no power-using industries on Mitiaro, although a profitable cottage industry is the preparation of maire[10] leaves for the Hawaiian market, and handicraft weaving for export.

Mangaia

Fuel is supplied in drums by Mobil through Toa Petroleum on Rarotonga. Mangaia is the site of the only wind generator in the Cook Islands, installed under the Pacific Rural Renewable Energy France-Australia Common Endeavour (PREFACE) programme in 2003.

Palmerston

Inter-island shipping is irregular, typically every 10-12 weeks, so a 12-16 week fuel supply is generally ordered and power outages do occur. Palmerston Island has a small fishery for local consumption and sales to Rarotonga. With the irregular shipping schedule for delivery of fish to Rarotonga, continuous electricity to run freezers is vital and much of the island budget is used to purchase fuel for the generators. Solar PV has been considered for freezer operation but the capital cost is very high and there are local concerns about reliability. Power is available on a 12-18 hour basis depending on fuel stocks, and the status of the stock of frozen fish. Some households have purchased private generators.

Other islands

No general operational information was provided to the team regarding the grid-based power system details for the other islands. However, those islands that have renewable energy installations are considered in the renewable energy sections later in this report.

2.5 Future Growth in Energy Demand

Small economies like the Cook Islands, who are heavily reliant on a narrow range of exports and services, tend to have highly variable economic growth. There are no obvious structural changes in the Cook Islands economy that would indicate a major change in patterns of energy use. A key export, pearls, has fluctuated markedly in recent years – and output will probably continue to fluctuate – but is unlikely to grow rapidly. The fishing industry is small, is currently in financial difficulties, and is not expected to grow rapidly. Economic growth is highly dependent on tourism, which can be quickly affected by a range of internal, regional and international factors. On Rarotonga or Aitutaki, a single new large hotel can result in a substantial increase in energy use.[11] Growth will also be dependent on the retention of skilled Cook Islanders and size of the declining resident population.

As noted in Section 1.5, MFEM has prepared scenarios suggesting AAGR of GDP in real terms of 0.5%, 3.0% and 3.4% through 2022. Public opinion, judging from the National Development Forum of November 2003, favours relatively low growth, limits on foreign workers in the tourism industry and maintaining a high quality natural environment.

TAU (see Section 2.2) expects its peak demand to grow at an AAGR 8% (base case) over the next decade, assuming continued steady growth in tourism. Implicitly, generation (GWh),

[10] Maire are the fragrant fresh leaves of the Maile fern found in the Hawaiin Islands used in garlands worn for ceremonial occasions.

[11] In December 2003, it was announced in the media that an agreement had been signed to develop the long-derelict "Sheraton" site at Vaimanga on Rarotonga for the Royal Takituma Hilton hotel complex. A sister hotel is planned for Aitutaki. (Source: *Cook Island News*; 18 December 2003).

and thus fuel use, is expected to continue to grow slightly faster than demand (MW). TAU has based its projections on past trends over time, not correlations with economic growth.

The GoCI estimates population growth through 2022 at 0.8-1.6% per year. It has made no estimates of the populations or economic activity for the outer islands, but assumes a modest continued depopulation. If outer island depopulation continues at recent rates (25% in the past five inter-Censal years), depopulation could of course dramatically affect energy use options and consumption patterns.

Table 2-9 includes petroleum import data from Cook Islands customs figures for 2003 with projections for greenhouse gas emissions in 2013. The projections assume continued rapid growth of tourism for the next five years then reaching saturation with little further growth in the industry for the next five years and little new renewable energy electricity generation. The projections are 'business-as-usual', that is they assume no significant new investments in either renewable energy or energy efficiency.

Table 2-9 - Petroleum imports for 2003 and 'business-as-usual' projections for 2013

Fuel	2003					2013			
	KL	TOE	GHG (t)	GHG (Gg)	% of GHG	AAGR	KL	GHG (Gg)	% of GHG
Motor Spirit	4,683	3,726	11,708	11.7	*41.0%*	3%	6,294	15.7	*36.7%*
Aviation Gasoline	4.0	3.1	9.2	0.0	*0.0%*	0%	4	0.0	*0.0%*
Jet fuel	182	157	473	0.5	*1.7%*	2%	215	0.6	*1.3%*
Kerosene	1.0	0.9	2.8	0.0	*0.0%*	0%	1	0.0	*0.0%*
Distillate Fuel	5,945	5,395	16,052	16.1	*56.3%*	5%	9,684	26.1	*60.9%*
Lubricating oil	111	121	278	0.3	*1.0%*	5%	181	0.5	*1.1%*
LP Gas	1.2	0.7	1.9	0.0	*0.0%*	3%	1.6	0.0	*0.0%*
Total	*10,927*	*9,404*	*28,524*	*28.5*	*100.0%*	*4.1%*	*16,381*	42.9	100.0%

Notes: 1) No data available on lubes so conversions are estimated;
2) Distillate appears to be underreported as total is slightly less than electricity use from Tables 2-4 & 2-6.

It is noted that the jet fuel imports for 2003 are far lower than for 2001 and earlier, and do not reflect the actual fuel used for bringing in tourists. Assigning values of GHG for jet fuel to the country is necessarily arbitrary since there is no way to separate the fuel used specifically for arrivals in the Cook Islands from those transiting to other destinations. The jet fuel volume indicated for 2003, however, appears to be largely for local flights and does represent GHG emitted specifically due to Cook Islands activities. Assuming no investments, or very minor investments, in renewable energy and improved efficiency, GHG emissions are expected to increase at an AAGR of about 4.2% over the next decade.

2.6 Maximum GHG Reduction Through Renewable Energy & Energy Efficiency

For TAU the only renewable energy technology (RET) currently available for new generation is wind power. Assuming the maximum penetration claimed to be technically possible by proponents of wind power, perhaps 30% of system demand at any given time can be provided by wind for a small utility such as TAU. If it is assumed that wind is suitable for economic power generation, and if wind power were added at the maximum technically practical rate, the annual reduction in GHG attributable to wind by 2013 could be 6.3 Gg (assuming that electricity generation would otherwise consume 80% of diesel fuel in 2013). Actual GHG reduction for full-scale wind implementation would probably be less than half that amount due to the inability of the wind farm to maintain 30% of load continuously due to inconsistency of the wind regime in the Cook Islands and other factors. To date no developing country power system has had a wind energy penetration as high as 30%, and this amount is predicated on the expectation of further technical developments in the future that would make this possible.

Investment in grid-connected solar could also reduce diesel fuel use. However directly connected solar can also can be assumed to contribute in a practical sense no more than a maximum of about 30% of system load using the technologies expected to be available over the next 10-years. Since solar power is only available about eight hours each day, the maximum theoretical energy penetration becomes more like 10% saving about 2.1 Gg of GHG in 2013 through fuel savings for generation. As with wind power, solar currently cannot contribute anywhere near the 30% that is assumed here so this estimate is considered very optimistic.

Likewise a rehabilitation of the coconut plantations and conversion of all products to biofuels could perhaps contribute an additional 10% of reduction in total diesel fuel imports by 2013 in which case an additional 2.1 Gg of GHG would be avoided for each year there after.

Each of these investments would represent an all out effort to introduce renewable energy, yet taken together represent a total maximum saving of about 10.6 Gg or around 25% of the total. It should be noted that the wind and solar implementations involve large foreign exchange transactions for equipment so the offset of foreign exchange through reduction of fuel imports would not be 100% by any means. On a global scale, there is substantial energy expended in the manufacture of wind and solar hardware, thus global GHG reductions for the implementation of solar and wind systems are substantially less than local reductions. Development of biofuels, however, has little foreign exchange component, little embedded energy component and has the additional advantage of benefiting the lowest income groups. So from a purely GHG reduction point of view, biofuels have a higher potential for global GHG reduction and a more positive effect on the economy.

The most cost effective approach to GHG reduction in the Cook Islands for the medium term is through improved efficiency of fuel use, which can relatively easily achieve 10% fuel use reductions and with concerted efforts probably as much as 25% in the Cook Islands, with little reduction in quality of life, significant benefits in foreign exchange transactions and increased local technical employment. Over the next decade, however, energy efficiency measures (mainly demand side management in transport and electricity) are likely to reduce GHG emissions by only 2.1 Gg. Table 2–10 summarises the potential GHG reductions. Indicative savings are about 13 Gg or about 46% of the 2003 emissions from energy. Of this, 84% would be from renewable energy and 16% from energy efficiency measures.

Table 2–10 - Indicative Maximum Energy Savings & GHG Savings from RE & EE, 2013

Technology	Savings in fuel (KL)	GHG savings (Gg)	% of savings	Comments / Assumptions
Wind	2,324	6.3	48 %	Maximum technical penetration of 30% of generation
Biofuels	968	2.6	20 %	Rehabilitation of coconut plantations; 10% of ADO
Solar PV	775	2.1	16 %	Maximum technical penetration of 10% of generation
Efficiency (transport)	629	1.6	12 %	10% of 2013 motor spirit use
Efficiency (electricity[12]	50% of 387	0.5	4 %	10% of distillate for power generation
Hydro or geothermal		0	0	Hydro Insignificant; no known geothermal resource
Total		*13.1*	*100%*	

Note: conversions from energy use to Gigagrammes (Gg) of emissions from conversion table of page iv.

[12] 5% x 80% x 9684 KL = 387 KL in fuel savings. However, 50% of ADO for electricity is renewable so only half of the savings contribute to GHG reductions.

3 POTENTIAL FOR RENEWABLE ENERGY TECHNOLOGIES

3.1 Biomass

There have been no surveys of biomass energy resources in the Cook Islands since the 1980s. During the 1990s there was significant spread of urban and peri-urban development reducing biomass resources further. Based on an estimate of 18% of the land as cleared for agriculture and 17% for developed properties, approximately 65% of the Cook Islands is expected to have light to dense tree cover with biomass energy potential. It is unlikely, however, that any of this will be or should be used for energy purposes, other than meeting the existing modest demand for fuelwood, partly because of transport problems and partly because of the new *Environment Act* of 2003 that will make it very difficult to obtain permission to legally cut trees other than those specifically planted for economic purposes. While theoretically it would be possible to plant trees for fuel on existing cleared agricultural land, the value of the trees for energy will be lower than that of the crops the trees displace.

As a practical matter, virtually all economically reasonable biomass based energy generation in the Pacific utilises waste products of concentrated agricultural processing industries (rice husks, bagasse) or factories serving the wood products industry (mill waste). Neither industry exists in the Cook Islands and neither is likely to be developed in the future if current trends continue, as seems likely.

The investigations for a 1.7 MW wood fired generator for Rarotonga in the 1980s indicated serious logistical problems in moving large volumes of relatively low energy density wood from forest to power plant and the area of land required for tree plantations to support the operation of the plant would be far higher than can be allocated for that purpose. There were also expected to be significant environmental issues related to chemical use. Add to these basic problems the thorny land tenure issues that still plague the Cook Islands, and the use of biomass for significant energy production appears unlikely for the foreseeable future.

The 2000 Agricultural Census indicates that around 43,000 coconut trees are considered by households as useful nut producers (trees producing nuts within a reasonable collection distance), with over 97% of their production for household purposes. The national average for human consumption as shown by the census was 13 coconuts per week per household with the outer island households consuming an average of 23 per week and Rarotonga only six. The largest consumption of coconuts was for animal feed. The average weekly consumption of coconuts for households feeding animals (mainly pigs) was 90 per household (50 for Rarotonga and 125 for the southern group). Overall, some 84% of household coconut use was for animal feed in 2000. In terms of copra production, animal feed is the equivalent of about 29 tonnes per year (based on 4,500 nuts per tonne of copra). Copra production is so low that it is not even enumerated in the census and copra is no longer a product that has economic importance in the Cook Islands.

There do remain a large but unknown number of ‘wild’ coconut trees, trees producing coconuts in areas where there is no nut collection. Theoretically these ‘wasted’ nuts could be collected for the production of biofuel but with the high labour and transport cost in the Cook Islands, the biofuel that would result would almost certainly be much more expensive than diesel fuel at present prices.

3.2 Biogas

The 2000 Census shows the pig population of the Cook Islands to be 17,578 and the chicken population to be 31,406. Other animals, including goats, cattle, ducks, horses, dogs and cats were counted but represent a small percentage of the domestic animal population. The pigs and chickens represent a significant resource for biogas production through anaerobic digestion of their wastes. There have been at least 11 trials of biogas digesters in the Cook Islands, with three still in operation in early 2004 at piggeries.

3.3 Solar Energy

Global solar radiation data, on a horizontal surface, continue to be collected by the meteorological office at their headquarters near Rarotonga airport. Although the accuracy of the measuring instrument is not the best possible, measurements from the photocell based instrument are adequate for estimating solar performance and determining the size of solar systems needed to perform a given task. Additionally, two years (1995-1996) of horizontal, global solar radiation data was collected and analysed by the Pacific Islands Forum Secretariat (PIFS) Southern Pacific Wind and Solar Monitoring Project. The available data are summarised in Table 3-1 below. It is likely that the solar resource improves towards the north but regrettably there was no attempt by the GoCI to gather solar radiation data in association with the Pukapuka solar project. Satellite data indicates that the level of solar radiation in the northern group is somewhat higher than in Rarotonga but no surface measurements are available for confirmation. Unlike larger mountainous islands such as Rarotonga, cloud patterns over the atoll islands are similar to those over the open sea so the satellite data – the average of a large area of the earth's surface that is mostly ocean – is likely to be a good indication of ground level values for the northern group.

Table 3-1 - Solar Radiation Measurements, Meteorological Office site. (1995 data not complete)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1986						3.283	3.658	4.118	4.493	5.501	6.163	6.422	4.805
1987	5.098	5.616	5.242	4.925	3.082	3.600	3.600	3.917	5.098	6.192	5.990	5.875	4.853
1988	5.299	5.789	5.962	3.773	3.974	3.312	3.485	4.723	5.386	6.278	5.299	5.558	4.903
1989	5.645	6.394	0.000	4.378	3.888	3.715	3.686	4.723	5.443	5.443	5.270	5.933	4.956
1990	6.941	5.386	5.933	4.349	3.514	3.974	3.917	5.126	5.242	5.645	6.278	6.019	5.194
1991	5.962	5.386	5.818	4.608	3.629	3.456	3.859	4.378	6.048	0.000	6.336	5.990	5.043
1992	6.019	6.422	5.472	4.435	3.859	3.658	3.686	4.262	5.990	5.962	6.739	6.768	5.273
1993	6.509	5.962	5.184	4.550	3.946	3.686	3.370	4.003	5.069	5.933	6.710	6.019	5.078
1994	5.386	5.990	5.386	4.320	3.571	3.686	3.110	4.579	4.694	6.106	6.480	5.558	4.906
1996	5.069	5.213	5.299	4.176	3.283	3.226	3.773	4.406	5.184	5.472	6.134	6.048	4.774
1997	6.653	6.509	4.637	4.147	3.773	3.629	3.226	4.349	4.579	6.163	6.480	5.904	5.004
1998	6.250	4.723	5.069	4.982	4.003	3.571	3.254	4.464	4.954	6.221	6.480	5.674	4.970
1999	5.875	4.867	5.155	4.954	3.168	3.427	3.686	3.917	4.666	4.694	6.278	5.702	4.699
2000	5.990	6.250	5.472	4.579	3.485	3.312	3.370	4.147	4.954	5.357	6.451	5.933	4.942
2001	6.250	5.472	5.069	4.090	3.542	2.794	6.106	4.522	4.608	5.933	6.365	6.163	5.076
2002	6.077	5.760	5.242	4.435	4.320	3.514	3.859	4.061	5.386	5.155	5.155	6.422	4.949
2003	6.394	5.789	4.579	4.320	3.600	3.600	3.859	4.032	5.126	5.501	6.336	4.694	4.819
Average	*5.963*	*5.720*	*4.970*	*4.439*	*3.665*	*3.510*	*3.740*	*4.351*	*5.152*	*5.378*	*6.174*	*5.891*	*4.965*

Source – Cook Islands Meteorological Service

Note that all radiation measurements were taken related to a horizontal surface. Because the sun's position in Rarotonga is on average lower in the northern sky than directly overhead, tilting the radiometer toward the north increases the energy available and also reduces the amount of seasonal change in radiation received. Although computer programs are available to convert from horizontal to tilted radiation values, their accuracy varies according to the cloud conditions. For solar engineering use, it is much to be preferred that measuring instruments be tilted toward the equator at the latitude angle from horizontal so that measurements accurately predict the energy received by a solar collector. This is particularly the case for Rarotonga and the southern group as they are high enough in latitude for the effects of collector tilt to be important.

Table 3-2 - Solar radiation measurements from the FSED Wind and Solar Resource Project

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1995	4.990	5.930	4.795	3.06	2.635	2.858	3.170	3.547	4.27	5.050	4.595	5.510	4.200
1996	4.540	4.730	4.701	3.800	2.927	2.730	3.250	3.925	4.599	4.680	6.045	5.720	4.303
Average	*4.760*	*5.330*	*4.748*	*3.430*	*2.781*	*2.794*	*3.210*	*3.736*	*4.430*	*4.860*	*5.320*	*5.610*	*4.2514*

Source – *South Pacific Wind and Solar Monitoring Project*, Forum Secretariat 1996

The PIFS data are about 10% lower than data provided by the Meteorological Office for 1996. This may be instrument error since the type of instruments used has an absolute accuracy of worse than ±10% or it may reflect an actual difference between the two sites. When the measurements are corrected to the latitude angle for a tilted collector, the average rises to over 5.5 kWh/m^2 per day and the monthly variation is reduced. This is consistent with experience with the performance of solar equipment installed in the Cook Islands.

3.4 Wind

The PIFS Southern Pacific Wind and Solar Monitoring Project remains the primary long term data source for Rarotonga wind energy, and is used as a starting point for estimating the wind regimes of the other islands. The project team visited Rarotonga in November 1993 and selected Ngatangila Point (21^o 14' 18" S; 159^o 43' 35" W), a coastal site on a coral outcrop for wind monitoring as it had 270^o of unobstructed exposure from the southwest to east through northwest encompassing the predominantly easterly winds, good access by road, and was located within 200 m of the 11 KV grid. In November 1994, heavy-duty anemometers were installed on a tower at a 10 m height, and a silicon cell pyranometer was mounted near the top of the tower on an arm to the north long enough to prevent the anemometer from casting a shadow over the sensor at the summer solstice. Data-loggers recorded hourly values of average, maximum, minimum and standard deviation of wind speed, average and standard deviation of wind direction, and hourly totals of solar radiation.

Figure 3-1 - Energy Planner Tangi Teriapi at Ngatangila wind monitoring site

Source – Peter Johnston (Dec. 2003)

Over two years of monitoring, wind data recovery was 100%. For the two-year period, 60% of winds were from the northeast, east and southeast. The annual average wind speed was 5.5 m/s with annual average speeds faster in 1995 than in 1996. Monthly average speeds were highest in August, September and October and lowest in February and March. The fastest gust recorded during 1995 and 1996 was 25 m/s, influenced by a low pressure cell on 9 April 1995. The highest hourly and daily averages were 17.7 m/s and 14.0 m/s respectively also 9 April 1995.

Correlation of measured wind speed data during 1995-1996 with a six year average for Rarotonga airport indicate that the wind speeds in 1995-1996 were on average slower by 5% at the airport, being faster only in January, August and September in 1995 and June and October in 1996. This suggests that long-term annual average speeds at 10 m could be 5% faster than the averages recorded at the airport, and wind energy fluxes might be 15% higher (as the energy of the wind is proportional to wind speed cubed). The calculated annual average of wind energy flux at 10 m was 180 W/m^2. Considering the variability in the 10 m wind energy flux, the coefficient of variation (equal to the standard deviation divided by the mean, expressed as a percentage) was 46%, which is high variability. The site used for the data gathering is not suitable for a wind energy system but was believed by the installers to be indicative of nearby and probably better hilly sites, which were not useable without removing the tree cover.

A study by Vergnet in May 1999 used data from the Ngatangila Point monitoring site and estimated a wind speed of 6.1 m/s at 30 m height (based on a L Weibull coefficient of 2.2). A feasibility study commissioned by the Danish NGO Forum for Energy and Development (FED), funded by the Danish Government and undertaken in 1997 by COWI/Risoe, identified Rarotonga sites having an estimated annual average wind speed in the range of 6.1-7.5 m/s (at 30m) suitable for economic power generation, Once a specific site is selected, the feasibility study recommended further on-site wind measurements. In 2002, one of those sites was proposed by other consultants in for on-site monitoring to confirm the COWI/Risoe estimates.

3.5 Hydro Resource

Figure 3-2 - Water Flow Monitoring, Rarotonga (Source: MoW)

Source – MoW

The Ministry of Works (MoW) has monitored water flows at more than five sites on Rarotonga from about 1998 to 2002, but the monitoring was for assessing water supply not hydro potential. According to the staff at MoW, there were some rough, informal estimates of hydro potential at several sites in Rarotonga about 15 years ago but apparently there was no written report and reportedly the estimates indicated no resource worth developing for power. It was suggested at the time that there is a possible total potential of "several hundred kilowatts" but flows are known to be highly variable from water supply flow measurements and the geology is not good for water storage in reservoirs so no further studies have been carried out. TAU does not consider hydro to be an economic option for future capacity expansion.

3.6 Wave Energy

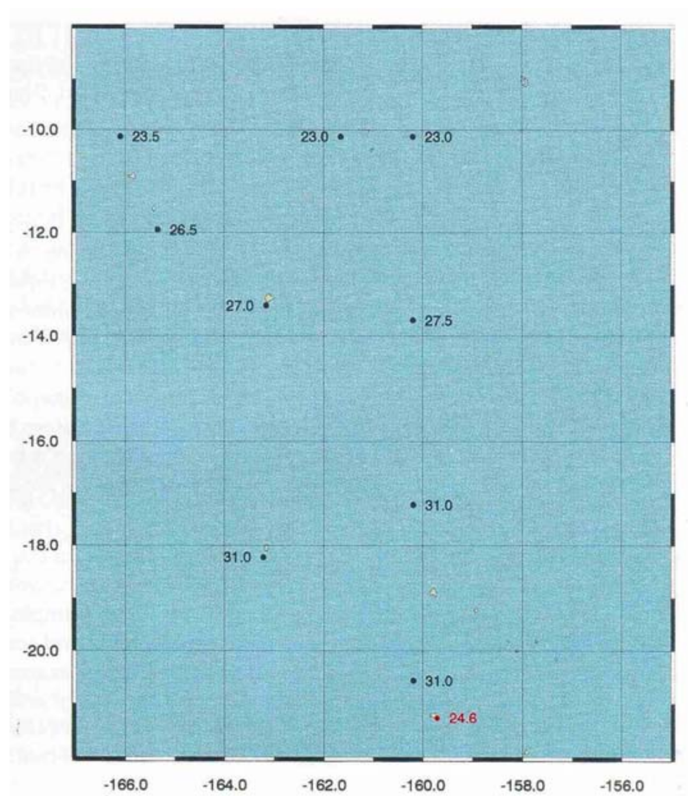
A 1987 regional wave energy resource assessment program was funded by the Government of Norway in association with SOPAC[13]. The Cook Islands was included in this program, and measurements of ocean swells and wave conditions were taken using Waverider measuring

[13] Barstow, Stephen & Falnes, Johannes ,*Ocean Wave Energy in the South Pacific – its resource and utilisation*, (SOPAC Misc Report 234), 1996 and Barstow, S.F. and Haug, O., *The Wave Climate of the Cook Islands*, SOPAC Tech. Report no. 200, 1994

buoys at Rarotonga. Sites were selected on the south and eastern coasts due to the predominant easterly trade winds and southerly swells. Wave direction is a critical factor in determining the wave energy at a given coastal location. However directional wave measurements were not taken at Rarotonga. They were assumed to follow the probable weather pattern of having directional waves travelling north-easterly to south-easterly for wind based seas, and for swells rising southwest to southeast.

Another major source of wave data used in the study was three years of data from the GEOSAT satellite altimeter during the Exact Repeat Mission from November 1986 to September 1989. Based on satellite data, (blue data points in Figure 3-3) the southern Cook Islands were found to have the highest wave energy resource of the islands included in the Southwest Pacific measurements. In the northern group, the resource was also found to be high for such a low latitude, from 23 kW/m to 28 kW/m. Close to the coast of Rarotonga (the red data point in Figure 3-3), the Waverider buoy measured a long-term average energy of 24.5 kW/m, somewhat lower than the 31 kW/m from the open sea satellite data. The most important sources of the wave energy, are the trade winds, and swell from storms in the Southern Pacific Ocean.

Figure 3-3 – GEOSAT (blue) and Waverider (red) data



Source: SOPAC Misc Report 234, 1996

Of lesser importance for energy but of great importance for system design, are the northerly swells, which can be quite strong during the November to March period associated with tropical cyclones. Such storms can produce wave heights more than twice as high as swell extremes and trade wind seas. They also carry many times the energy and can easily destroy wave energy conversion machinery not specifically built to withstand the high energy levels. During El Niño years, tropical cyclones occur more frequently in the South Pacific and wave energy can be expected to be greater on an annual basis.

It is clear that wave energy is a large potential resource but its conversion into useful forms remains experimental, with no installed systems beyond the prototype stage. Additionally, it is not clear what environmental effects the use of high capacity wave energy conversion devices may incur.

3.7 Ocean Thermal Energy Conversion (OTEC)

The temperature difference between deep oceanic water and tropical surface water can be used for energy production. Several experimental units have been tried in the Pacific (Hawaii, Nauru, Japan) but none have proved capable of sustained, reliable operation at a cost that is comparable to diesel generation. Although the potential has yet to be accurately measured for the Cook Islands, clearly it is much larger than the total energy requirements of the country. That it can be utilised economically and with little environmental impact is unlikely for the near term.

3.8 Geothermal

There have been no resource assessments for geothermal energy in the Cook Islands and the resource, if any, is unknown.

4 Experiences with Renewable Energy Technologies

4.1 History of Renewable Energy Development

Through the use of biomass for cooking and agricultural drying, renewable energy has been traditionally important as an energy source for the Cook Islands. The shift to fossil fuels in the 20th century greatly reduced the importance of these traditional uses and changed the emphasis for renewable energy development to electricity production and the replacement of fossil fuels used for cooking and transport.

Largely through the efforts of the Government Scientific Officer, the late Stuart Kingan, and his staff, numerous trials of small wind, solar photovoltaics, electric transport and biogas generation were carried out in the late 1970s, through the 1980s and into the 1990s. The projects were small and essentially experimental but yielded valuable technical and social information for later projects.

4.2 Solar Photovoltaics

All the outer islands have had, or still have, some small household PV systems suitable only for lighting and radio operation. Most of those have been part of small pilot projects undertaken over the years by the government but none have been installed under structures that allow for proper maintenance or that could be financially sustainable through payments from recipients of the service. Also some solar powered pumps, a solar fish freezer and solar refrigerators have been installed on outer islands from time to time but again post-installation support was minimal, spare parts were not available, local technical capacity was not developed and the installations have mostly been abandoned. Records of the installations are not available and no details of their dates of installation, cost, component specifications, ownership or ultimate fate could be located. Most of these installations were supported with funding from the Secretariat of the Pacific Community (SPC), the Forum Secretariat Energy Division (FSED, since disbanded) or the GoCI, but project records were not available.

Table 4-1 - Outer island PV power for Telecom

ISLAND	SYSTEM Volts	PANELS Number xWp	TOTAL Wp	BATTERIES NumberxVolts	Ah each battery
Mangaia	48v dc	120 x 60 W	7,200	72 x2 V	1,100
Atiu	48v dc	120 x 60 W	7,200	72 x 2 V	1,100
Mauke	48v dc	80 x 60 W	4,800	48 x 2 V	1,100
Mitiaro	48v dc	60 x 60 W	3,600	24 x 2 V	1,100
Pukapuka	48v dc	96 x 60 W	5,760	72 x 2 V	1,100
Palmerston	48v dc	32 x 75 W	2,400	24 x 6 V	250
Rakahanga	48v dc	12 x 75 W	900	8x 6 V	250
	12v dc	8 x 75 W	600	8 x 12 V	120
Manihiki	48v dc	120 x 50 W	6,000	72 x 2 V	1,100
Penrhyn	48v dc	136 x 60 W	7,800	72 x 2 V	1,100
	48v dc	48 x 60 W	2,880	24 x 2 V	110
Total Pv Wp			*49,140*		

Source – Tom Wichman, 2004

Telecom (Table 4–1) has installed photovoltaic generators for most of their outer island installations. Systems range in size from 600 peak watts (Wp) to 7,800 Wp in panel capacity.

Their performance has reportedly been excellent with high reliability due to the high quality of the installations that use industrial batteries and panel capacity that is strictly sized to meet the energy delivery requirements year round. Good maintenance support has been provided using trained, professional staff because of the economic importance of the installations. There is no reason a similar quality of performance cannot be achieved for solar based rural electrification if the electrification authorities are willing to pay the cost of the high quality equipment and can dedicate – and keep properly trained – necessary maintenance personnel to keep the systems operating at their design optimum. Despite repeated attempts, the PIREP team were unable to obtain more information on the Telecom experience.

The 2000 Census shows 23 homes on Penhryn as electrified with solar energy. These appear to be private installations purchased by pearl farmers; no information was available as to the size or use of the systems. The six PV systems for Manihiki appear to be privately purchased systems, again for pearl farmers. Fourteen households in Nassau claim to have solar electricity but the source of their installations was not determined. Interestingly, the census also shows 128 households claiming solar electrification on Rarotonga. However it appears that this is in error due to confusion on the part of the person filling in the census form mistaking solar water heating (SWH) for solar electrification. Nonetheless, there is some use of PV on Rarotonga. The high connection cost for electricity in Rarotonga was one incentive for a small retail business, Joyce Peyroux Garments located in Avarua next to the Banana Court, to install solar photovoltaics to operate the cash register and the few other small appliances needed by the business. The owners anticipate sufficient savings to pay for the PV system as they have no connection fee and no monthly electricity charges.

The largest scale PV project in the Cook Islands is the 1992 electrification of Pukapuka with loan finance from France and technical support by the South Pacific Institute for Renewable Energy (S.P.I.R.E) and Soler Energie of Tahiti. Over 46 kWp of solar panels were installed to make up more than 160 systems including the provision of communal refrigerators and street lights, as well as household and public building power systems. For more details, see Annex A.

4.3 Solar Thermal

The first use of solar energy in the Cook Islands was reportedly in the 1950s when a local resident installed a solar water heater (SWH) into a home. The energy crisis of the early 1980s prompted a flurry of activity in energy conservation and alternative energy. Import duty and tax were removed from imported SWHs to encourage their use. During the high fuel cost years, EPS imported them and sold them at cost to spur the market. A local manufacturer entered the market as well, lasting several years in the business. SWHs were included as part of new government housing. By the late 1980s, it was estimated that one in six houses on Rarotonga had a domestic SWH.[14]

Rarotonga clearly has the largest per-household use of solar water heaters in the region. . Although the 2001 census did not specifically ask about solar water heating, the Energy Office estimates that more than half of the existing housing, and just about all the new housing and commercial buildings being built, include SWHs. A short tour of residential districts confirms the estimate.

The SWHs are primarily imported from Australia with Solarhart and Edwards Solar units dominating the market. Low cost, on demand type gas water heaters are the principal

[14] *Energy in the Cook Islands 1972-2010*, Ministry of Planning and Economic Development 1989

competition. The adoption of SWHs began under a tax incentive program but is now market driven. There are now no subsidies, credit programs or other special incentives for the installation of renewable energy systems of any kind.

PTS Plumbing, an importer of SWHs, estimates continuing sales at about 25 units per year. Larger 300 litre units retail at around $3,700 and $2,700 for a 200 litre unit. Recent demand has fallen off for the company. Raina Trading, importing the Edwards brand, advises that the demand remains unchanged. They continue to import two full containers per year. Most purchasers are homeowners who obtain short-term personal loans for the installation.

On the outer islands, the household demand for hot water from any source is not as great as on Rarotonga. Although some SWHs have been installed, their market penetration is low and not expected to grow rapidly.

4.4 Wind Power

Australian and American style multi-bladed windmills were installed in the Cook Islands for water pumping prior to the 1970s. Although in general they are reported to have functioned satisfactorily, damage from salt air, high humidity and infrequent but violent cyclonic winds resulted in high maintenance requirements. With the spread of the electricity grid and the availability of low cost diesel pumps, water-pumping windmills became more trouble than they were worth and are no longer used.

Wind turbines for battery charging were used prior to World War II and continued for a decade after the war. The New Zealand Department of Transport installed a small French built wind generator in 1975 to power a marine beacon at Penrhyn[15]. In 1981, the New Zealand Meteorological Service installed anemometers on Penhryn, Mitiaro, Aitutaki and Rarotonga at the request of government for more wind data.

Starting with a 1981 proposal by ERA Technology in England titled “Integration of Wind Turbine Generators into Small Diesel-Based Power Systems” followed by a more technical 1984 proposal from ERA for integrating wind with diesel, there has been interest in the use of a wind power supplement for the Rarotonga power system. In 1983, UNDP sponsored a feasibility study of wind on Aitutaki but no installation resulted. Stuart Kingan installed several small (less than 1kW output) locally made wind turbines on Rarotonga and several outer islands for trial and data gathering but no serious effort was made to develop wind power until the late 1990s.

Currently, the only aspect of wind power that can provide substantial energy flows in the Cook Islands is for direct input into an existing electricity grid. TAU (in early 2004) considered wind-based energy at $0.15/kWh to be the maximum acceptable cost. To be acceptable on Rarotonga – ignoring the oil price rises during 2004 – the combination of wind regime characteristics and the life cycle cost of the wind machine must result in production costs no higher than $0.15/kWh on average. The acceptable cost can be somewhat higher on the outer islands, where power generation costs are higher, depending on the size of the power system and the real cost of fuel delivered to the island. The cost of power from a wind generator very much depends on the wind regime, which in turn can be quite site specific. Therefore wind resource measurements to determine the technical potential at the proposed site are the foundation for the development of any grid connected wind project.

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[15] Kingan, *History of Wind Power in the Cook Islands*, Scientific Research Division, Premier’s Department, 1977.

As noted in the previous chapter, the Southern Pacific Wind and Solar Monitoring Project measured a mean wind speed of 5.5 m/s at 10m above the sea at Ngatangiia on Rarotonga, making it very likely that a commercially feasible wind resource can be found at higher elevations and in areas on the island where wind speeds might be higher through the concentrating effect of mountainous terrain.

Following the PIFS resource assessment, a feasibility study was carried out by COWI/Risoe National Laboratory (Denmark) funded by the Danish Ministry of Foreign Affairs under the Pacific Danish Environmental Education and Action Program (PDEEAP). The study located three sites on Rarotonga they believe to have an average wind resource of 7 m/s or more and proposed the installation of a 300 kW Danish manufactured wind turbine at one of the sites. Funding by Denmark for the turbine and its installation were proposed with the government responsible for site preparation and access roads. The expected cost was around $1m dollars, but no further action has been taken on the proposal.

Also in the late 1990s an American company approached the government with a proposal for using refurbished wind turbines that had been replaced with larger units in wind farms. The proposal was rejected because of high cost and the 1 MW of proposed capacity was larger than appropriate for the Rarotonga power system.

In preparation for the Australian-French funded PREFACE project, the SPC sent an engineer from Vergnet, a manufacturer of wind turbines, to evaluate the wind power possibilities of Rarotonga, Atiu and Mangaia in 1999. The pre-feasibility study concluded that up to 600 kW (rated power) of wind installations could be accommodated by the Rarotonga grid. An installation of that size at would have cost an estimated $3m dollars. Assuming an average wind speed of 7.5 m/s, it could have provided 1.6 GWh annually at a cost of $0.13 per kWh, less than the $0.15 considered by TAU as the maximum acceptable cost. The study proposed a pilot project for a smaller system and concluded that of the three islands, Mangaia was easily the best choice for a pilot project.

Figure 4-1 - PREFACE wind energy system, Mangaia

Source – Tangi Teriapi Nov. 2003

PREFACE chose to fund the installation of wind power for Mangaia and a resource assessment and detailed feasibility study was contracted to Vergnet. In 2001, the study proposed a site with two 20 kW turbines as the optimum package. PREFACE approved the project and the turbines were installed in 2003 and are currently operational. Due to technical problems with the data logging system, no output data was available at the time of the PIREP team visits in early 2004.

In late 2001, a UNDP/UNESCO project proposal was developed for a 1.8 MW wind farm with 8 x 225 KW wind turbines. Germany’s Elektro Brand and a local partner separately proposed a 3.75 MW wind farm using 5 x 750 kW wind turbines. An independent assessment (*Evaluation of Grid-Connected Wind Electric Power Project Proposals for Rarotonga, Cook Islands*; Cheatham and Zieroth, UNESCAP 2002) concluded that the UN proposal was sound and superior to the other proposals, but that the wind resource at the proposed site in Rarotonga must be closely monitored over a period of 18-24 months prior to implementation of so large a wind energy project. The on-site wind energy regimes are not yet well enough established to warrant proceeding with a project of that size. If the wind resource is shown by the monitoring to be adequate, the project should be pursued for development through an international competitive bidding process.[16] At the time of writing of this report, no monitoring had yet commenced so a Rarotonga wind power project implementation remains at least two years in the future.

4.5 Biofuels and Biomass

Before 1980, biomass was the primary household energy source for the Cook Islands and was used mainly for cooking and for copra drying. Over the past 20 years, kerosene and LPG have largely taken over as the fuel of choice for cooking and little copra is produced. Thus biomass is now a minor energy source, although still significant on the outer islands.

Although there is a high percentage of tree cover in the Cook Islands, biomass as a large-scale energy source has not been developed. The reasons are largely concern for the environment, land use issues and logistics. In the mid 1980s, requests for expression of interest in the development of biomass-fuelled generation for Rarotonga were sought. Companies from the UK, Australia, New Zealand and French Polynesia responded. A 1.7 MW biomass fuelled steam generation project proposed by SEDEP of Tahiti was selected to be installed at Rarotonga with large *Leucena* fuel plantations to be developed as the fuel source. A small plantation was established by the local promoter of the project as a trial to determine the suitability of *Leucena* as a fuel source. After several years of negotiations and study, in 1989 project was cancelled, largely due to economic considerations, land use problems and the inadequacy of the road system to handle the large fuel transport volume needed to keep the plant running.

In 1983, the EPS was provided and operated a small sawdust fuelled gasifier and tested it for running a small generator, but there were many problems and the tests were abandoned.

Plans were developed by a Peace Corps Volunteer on Mauke to develop biomass, largely coconut waste, for powering the local electricity system. His concept was to use steam power since there was an operating steam system in Fiji and the gasifier experience elsewhere in the Pacific had been poor. The plans were abandoned when the interested expatriate left the island.

In the early 1980s, pine plantations were proposed for Atiu timber production with power generation through a wood gasifier as a by-product. A small gasifier was installed but the results were not sufficiently promising to continue. Around 2,700 acres of maturing stands of *Pinus carribaea* are now present but have not been targeted for harvesting.

Coconut oil has been tried and successfully used in very small trials as a diesel fuel replacement in the Cook Islands but the high cost of the oil has prevented its commercial use. With the relatively high-income levels of the outer islands, there is little incentive to gather and process coconuts for copra given the low price that can be offered. As a result there is no longer commercial production of copra in the Cook Islands. High quality coconut oil is packaged for local and tourist sale as body oil, or processed into coconut oil soap for tourists, but the raw oil is sourced from overseas, as local production is not cost competitive.

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[16] A 'base case' evaluation indicated that the economic internal rate of return of the proposed wind project is less than two percent so the project would not be 'bankable' without donor support.

To increase the production of copra to a scale that would be useful to offset diesel fuel imports, the price will have to increase dramatically with large scale replanting of trees to replace the large existing senile stock. With Rarotonga public market prices for 'drinking' coconuts now $2.00 or $3.00 each, there is understandably little willingness on the part of outer island labour to do the considerable work needed to process large numbers of coconuts for copra since only about $0.10 per coconut can be offered if oil is to be produced at a price comparable to that of diesel fuel in late 2003. Even if diesel prices, and the value of nuts as a fuel source, were doubled, production of coconut oil for fuel appears to be uneconomic.

4.6 Hydro

Although there is no significant hydro potential on the outer islands, on Rarotonga there have been stream flow studies for water supply and some informal power studies have been carried out, though no written reports could be located. The low and inconsistent volume of water flow, combined with unfavourable geologic factors, appear to make hydro development uneconomic and further study is a low priority. No hydro systems have been installed.

4.7 Biogas

Eleven biogas units were installed at piggeries in Rarotonga in the late 1980s and early 1990s. The closure of all but two of the piggeries has left only two operational. Their purpose is more for environmentally appropriate waste disposal than gas production and the gas – which could be used for cooking or lighting – is vented off, unused as an energy source.

4.8 Ocean Energy

In 1976, the water flow through the reef channels was considered for power generation. The ESCAP Coordinating Committee for Offshore Prospecting, South Pacific (CCOP/SOPAC, the forerunner of SOPAC) was asked to arrange a feasibility study but the resource was not considered satisfactory for development.

4.8.1 OTEC

Discussions were held in the early 2000s between the GoCI and staff of Saga University of Japan regarding the possibility of developing an OTEC generation station in the Cook Islands using the proprietary Uehara Cycle for the technical design. In 2003, a Japanese company – Xenesys, the holder of the rights to the Uehara Cycle patents – approached the government offering to obtain funding from Japan to carry out a feasibility study for OTEC in the Cook Islands. In May 2003, Cabinet agreed that the GoCI supports the concept, and Xenesys could develop a proposal for the OTEC feasibility study and seek its funding. The proposal is to focus on the feasibility of plants using the Uehara cycle with a 3 MW plant for Aitutaki and two 3 MW plants for Rarotonga. No further progress has been reported by early 2004, although presumably Xenesys is developing the proposal. It is noted that Palau is also considering a 3 MW Xenesys OTEC plant. Careful evaluation of any prior OTEC installations using the Uehara Cycle, and the specific plans for Cook Island plants, should be undertaken by an independent organisation competent in OTEC engineering before the GoCI makes any commitments. The GoCI should be careful not to become an engineering trial site for an unproven OTEC technology.

In 2002, Hawaii based OTEC expert, Dr. Luis Vega, noted 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.[17]"

4.8.2 Wave Energy

To date, no wave energy generation trials have been held in the Cook Islands and none are planned.

4.9 Geothermal

To date no geothermal surveys are on record for Rarotonga, the only island likely to have a developable resource and there is no record of plans to proceed with surveys or development.

4.10 Other

Although not renewable energy, the Rakahana Island Council has installed a battery storage system to augment their diesel generator to allow 24-hour power and improve the fuel efficiency of the diesel engine. This is a first step toward creating a hybrid power system wherein the battery bank could be charged by a renewable energy source such as wind or solar energy.

The Rakahana grid is powered by two 20 kVa diesel generators. The system provides power for around 35 households. Until 2002 the power system was operated six hours in the morning and 6 hours in the afternoon and evening. Due to limited power availability, some demand side management was practiced, with half the households washing in the morning and the other half in the afternoon. It was not economically reasonable to operate the system for 24 hours because the fuel efficiency of the engines was very poor at the low loading occurring during the off peak times, typically 12-4 p.m. and 12 a.m.- 6 a.m.

In 2002, Twin Turbines Ltd. of Auckland was contracted by the Island Council to install a battery bank that could be charged by the diesel engines and, using an inverter, operate the power system during off-peak times, permitting 24-hour operation. By using the diesel engine to recharge the batteries, the power level of the engine can be maintained at optimum fuel efficiency and, in theory at least, 24-hour power can be provided at little added fuel cost even though the generator is operating more hours a day. Additionally, engine maintenance should be reduced if the engine is changed from a widely varying load to one that is relatively constant.

The installed battery bank consists of a 384 VDC battery bank with 270 Ah of capacity (104 kWh storage). When the system was installed, the daily energy load was about 85 kWh (at an average demand of 7 kW) making the battery bank capacity sufficient for about 29-hours of power production if the batteries were fully discharged and the demand evenly distributed over the day. Given that the battery bank is intended to operate the system for 12 hours a day during the low demand periods, this represents a reasonable reserve capacity. AC power is

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

provided by a 30 kW sine wave inverter. Battery charging uses a 22 kW battery charger operating from the mains power while the diesel engine is running.

Since commissioning in January 2002, the system has reportedly worked well with minor technical problems readily solved. However, with 24-hour power on the island, the energy demand has increased with the daily average up from 85 kWh/day to 150 kWh/day shortly after commissioning. By late 2003 it appeared to be significantly higher than that. Unfortunately, records are not being kept to allow an accurate comparison of fuel use now with that before the installation of the batteries or to make an accurate estimate of the real cost per kWh of shifting from 12 to 24-hour power.

The large increase in energy usage implies that the recipients do indeed take advantage of the additional hours of power availability indicating that the project is providing added value to the electricity system. It also means that the storage time is now cut to the point where the battery must be deeply cycled to provide the system power for 12-hours or else the engine must be operated significantly longer to keep the battery charge level acceptably high, reducing the battery life and the utility of the storage system.

4.11 Summary

There is substantial experience in the Cook Islands with solar photovoltaics and solar water heating. The new Mangaia wind generator is expected to provide useful experience in the use of that resource. The longest running large-scale renewable energy use outside of Telecom is the Pukapuka island electrification scheme. The most promising new renewable energy use is grid-connected wind as piloted by the Mangaia wind power installation. Table 4-2 and Table 4-3 summarise the characteristics and Annexes A and B provide details of those two important renewable energy installations.

Table 4-2– Pukapuka Solar Project Summary

Characteristics	Detailed comments about the project characteristic
Location of the project	Yato, Toto and Ngake villages on Pukapuka
Commissioning date	December 1992
Budget	French Franc 7 million (approximately US$1.2 million)
2003 operational status	Reportedly about 50% providing lighting services
Primary objectives	To meet the electrification needs of the households on Pukapuka through the provision of large enough solar generators to meet the expressed needs of the people.
Population served	All households on Pukapuka. 664 persons by the 2001 census
Funding arrangements	FF3,850,000 French treasury loan by the Casise Centrale de Coopération Economique (CCCE) to the CIG FF3,150,000 Bank of Indosuez (private) loan to the CIG
Implementation arrangements	S.P.I.R.E. (Tahiti) design, specification, purchase (French components only), installation supervision and monitoring. Soler Energie (Tahiti) installation. Energy Ministry logistical support and assistance in supervision.
Source of maintenance and operation funds	CIG originally, since devolution of development responsibility to island councils, primary responsibility is with the Pukapuka Island Council. Starting one year after installation a fee of $8 for an 8 panel system and $10 for a 12 panel system was instituted but collections have been irregular and the collected money not accounted for.

Table 4-2– Pukapuka Solar Project Summary (continued)

Characteristics	Detailed comments about the project characteristic
What input comes from recipients	In reality almost none. Starting in 1993 users were supposed to pay for services but there was no disconnect for non payment and funds received were not strictly designated for system maintenance.
Local involvement in project implementation, operation and maintenance	Five Pukapuka residents were trained in Tahiti in a two week intensive and practical course in the installation, operation and maintenance of PV systems. Further on-the-job training was provided during the installation period.
Capacity building components	Technical training for technicians and hands on training by Energy Ministry personnel in the establishment and management of a large PV project
Objectives	Technical objectives were met in that the PV generators have operated with almost no repairs for 10 years showing that the use of high quality components especially selected for the island climate combined with sufficient excess capacity to allow batteries to remain at a high state of charge can meet the power generation needs of remote islands. Reliable 24 -hour power was provided Social objectives were partially met in that good quality lighting was provided and power for small entertainment appliances and videos was available. The objective of providing services that were equivalent to a centralized grid system was not met since people were not able to obtain (or afford) the specialized DC powered appliances that would be equivalent to those useable on an AC grid

Table 4-3– Mangaia Wind Project Summary

Characteristics	Detailed comments about the project characteristic
Location of the project	Mangaia
Installation date	Late 2003 commissioning not yet complete
Budget	AU$378,000 including estimated in-kind local contributions
2003 operational status	Operating
Primary objectives	To act as a pilot wind project for the Pacific to demonstrate the practicality of small wind for small island power systems
Population served	Mangaia – 744 persons, 228 households (1999 census)
Funding arrangements	PREFACE
Implementation arrangements	PREFACE and Division of Energy
Source of maintenance and operation funds	Mangaia Power Utility
What input comes from recipients	Payment per kWh used, not separately paid
Local involvement in project implementation, operation and maintenance	Operation and maintenance is fully local
Capacity building components	Utility participation and training. Energy Planning Unit participation and training
Relative success at achieving project objectives	Too early for full evaluation but appears to be on track as planned

5 ENERGY EFFICIENCY ACTIVITIES

Given the relatively high cost of energy compared to per-capita income, energy waste in the Cook Islands appears modest compared to New Zealand or Australia, but relatively high compared with other PICs. Although hard data showing the current efficiency of energy use is scant, by observation there appears to be considerable scope for improvement in the efficiency of energy use, particularly within the tourist industry, government and transport.

For the Cook Islands, the only significant possible use of renewable energy is for replacement of existing energy sources. The benefit from the use of renewable energy will be maximised if the overall demand for energy is minimised. Therefore large-scale renewable energy investments will be far more cost effective if energy efficiency measures that reduce the overall demand for energy are also implemented.

Although there have been a number of formal energy efficiency activities in the Cook Islands over the past 20 years, particularly energy audits, there are few records of their content or their practical impact. In the 1980s, the Pacific Energy Development Programme (UNDP/ESCAP's PEDP) sponsored an energy audit of the Rarotongan Hotel and proposed audits of government facilities, although there is no record of their having been carried out. The Energy Division has worked with resorts, the airport and other energy users to improve energy efficiency on an *ad hoc* basis but there is no formal programme in place.

SOPAC in association with the Energy Division performed an energy survey on Aitutaki in 2000, reported in SOPAC Technical report 314. The report indicates that the activity was primarily data gathering on energy use to identify high users but the effort was considered preliminary and no attempt was made to provide other than general recommendations for energy saving activities. Apparently, no follow up using this basic energy survey effort has been carried out and no follow-up programme to determine the effect of the audit on energy use has been developed.

In 2002, the Rarotongan Hotel hired an Australian consultant to assist in the reduction of their $750,000 annual energy bill. Although Rarotongan management indicated that they were not satisfied with the study, they have implemented some of the recommendations and believe that there has been some saving, though it is not well documented.

An International tourism company, Island Hopper, completed their new office in 2003 near the Rarotonga airport. The office has been publicised as exceptionally energy efficient and dedicated to "green" energy use. Included in the design is a photovoltaic array that provides power for lighting and some other lower power services such as computers, although large loads, such as air conditioners are mains connected. The solar system is described as a "solar UPS" mainly to ensure that basic power services remain available for a few minutes during power outages until the back up generator can start, but in an emergency can operate computers and lights for a longer period. The building design includes insulation and thermal mass as well as low-energy lighting and computer systems. Company press releases indicate a three to four year payback on the approximately $100,000 added cost for the energy saving features. Although the building design appears to be optimised for the New Zealand rather than the Rarotonga climate, and probably could benefit from more shading of windows and a smaller area of windows, it clearly is a marked improvement in energy efficiency over typical small offices in Rarotonga. The company reportedly intends to use the experience from the office construction as a pilot project in order to branch out into energy efficient building locally.

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

6.1 Barriers to Renewable Energy Development

For the Cook Islands, there is essentially full electrification and access by all the population to commercial forms of energy for personal and productive use. The principal problems that remain where renewable energy is an issue are the improvement in reliability of the energy supply on outer islands and potential for increased use of renewable energy for transport and electrical generation to reduce petroleum imports.

Economic development requires successful productive uses of energy. For that to happen the supply needs to be reliable and of adequate capacity. Fish freezers or aquaculture aerators that fail because of power outages are not of much benefit to outer island development. On the outer islands, the poor reliability of the energy supply is a barrier to economic development. Until renewable energy can deliver both the energy capacity needed for the productive uses along with a high reliability of service, it will not be accepted for general economic development purposes. To date, renewable energy projects have been poorly supported after installation, causing reliability problems, in turn resulting in a poor reputation for renewable energy by the general public. That this is not the fault of the renewable energy technology is clearly demonstrated by the preferred use of solar PV for high reliability power supplies for telecommunications facilities. This demonstrated reliability is the result of good technical designs and a commitment to maintenance that has been lacking in renewable energy installations for general use in the Cook Islands.

For most feasible and practical uses of renewable energy in the Cook Islands, fiscal and financial barriers are not much of an issue. There is little opportunity for individuals to utilise renewable energy at the personal level and where those opportunities exist, principally for solar water heating, there are already commercial finance mechanisms in place that appear to be working well. Import duties or the tax structures do not appear to be barriers to renewable energy development in the Cook Islands. Where renewable energy is likely to be used on any real scale, the implementers will be local governments or electric utilities and there are many forms of finance available to them for financially reasonable renewable energy development. Indeed, finance often seems to be available for renewable energy projects that are not even economically reasonable.

One common barrier to the integration of renewable energy into an existing utility system is the lack of understanding, experience and confidence in generation technologies that are not already being used.

- Technology inertia is therefore a barrier. TAU personnel are familiar with diesel generation and there is a strong preference for development to proceed along familiar lines.

A barrier specific to the Cook Islands is the devolution of responsibility for energy supply on the outer islands to the local island councils. While this step is understandable in the context of past experiences, it is now impossible to develop a coherent outer island energy policy or to coordinate energy development on a national basis. Most of the outer islands have inadequate capacity for financial management or maintenance, and power system reliability is poor. This is a barrier not specific to renewable energy but to all energy delivery systems including diesel.

The government has no budget specifically for renewable energy and energy efficiency but the real barrier is not budgetary but rather the lack of any sort of development plan for renewable energy from which a rational budget can be developed. Renewable energy projects are not developed in a planned manner and not interrelated. Therefore each project has a different structure and purpose and requires its own support system. Creating a plan for the implementation of renewable energy for the Cook Islands as a nation appears to be impossible due to the functional independence of the outer islands. However a plan solely for Rarotonga is practical and should be considered a priority if there is a sincere desire on the part of the nation to reduce petroleum imports and control electricity demand growth.

- There is no development plan for renewable energy either for Rarotonga or the outer islands and that makes access to finance for significant renewable energy implementation difficult. Further, the functional independence of the outer island power systems makes the development of a national plan very difficult.

Currently there are no local suppliers specialising in renewable energy equipment although two firms include solar water heaters in their product line. The market for renewable energy devices other than solar water heaters is small and sporadic.

- A barrier to the development of private companies providing renewable energy equipment is the small and sporadic market for those products. The small size of the country and the limited need for renewable energy devices in a fully electrified country combine to make the market too small to support more than a part time effort by any company.

A further barrier resulting from the small size of the country and its limited human resources is that:

- The capacity of the Energy Division and TAU are inadequate to handle large-scale implementation of renewable energy. Finance, technical development, purchasing and installation capacity are almost non-existent for non-conventional energy implementation on a scale large enough to have any measurable impact on fossil fuel use. Likewise, the capacity of the Energy Division and TAU are inadequate for sustainability of large-scale renewable energy implementations, since there is no experience with operating or maintaining non-conventional energy sources.

Considerable training of existing staff and the addition of new staff trained in the operation and maintenance of the renewable technology is necessary if a large-scale renewable energy project is to be sustainable.

One problem that has occurred several times in the Cook Islands has been the approval and development of energy projects at the political level without input from staff of the Energy Division who have received training in renewable energy. As a result energy project development has not always considered economics, technical issues and sustainability. Although there is a draft National Energy Policy, it does not provide clearly defined roles for the Energy Division and in particular it does not establish procedures for the development of energy projects that assure that decisions will consider economic and financial viability, institutional competence and technical appropriateness.

- A barrier to the development of sustainable energy projects is the lack of detail within the current National Energy Policy that clearly define the processes to follow in energy project development.

6.2 Barriers to Energy Efficiency Development

Although renewable energy applications are primarily associated with grid connection, energy efficiency measures tend to be at a more personal level and involve households, small businesses and of course large business and government. Therefore the barriers to their application in the Cook Islands are somewhat different from those for renewable energy.

One significant barrier is the general lack of information available to people regarding actions that can be taken to improve energy efficiency and information regarding the benefits of those actions.

- A lack of public information regarding the technology and economics of energy efficiency actions is a barrier to implementation of energy efficiency measures for all user sectors.

Standards for building construction and for equipment such as refrigerators and air conditioners used in the Cook Islands are usually from New Zealand or Australia. Because of the different climate and use conditions found in the Cook Islands, these are not necessarily directly transferable without modification to fit local conditions.

- A lack of Cook Island-specific energy efficiency standards for design and construction, and for appliances, is a barrier to implementation of energy efficiency technology.

A number of energy audits have been carried out but with little if any follow up to assist users in technology selection, finance or monitoring to determine if the measures implemented have been effective.

- A barrier to the implementation of energy efficiency measures is the fact that users often need assistance in the selection of equipment, location of suppliers, finance of equipment and installation but that has not been included in government efficiency programmes and is not generally available from local businesses.

Confidence in energy efficiency measures is typically based on knowledge that the measures have worked for others in the Cook Islands. Without monitoring of the savings that result from applying the measures, there is no real evidence of their success. Monitoring has not been a part of prior energy efficiency efforts.

- A barrier to the acceptance of energy efficiency measures is the lack of evidence that they do in fact work in the local context. Projects that implement energy efficiency measures need to monitor them for a long period to show that they provide the benefits in terms of both energy savings and cost savings that are claimed.

A barrier to the implementation of energy efficiency measures in large buildings and industry is the lack of people with experience and training to carry out high quality audits and to prepare practical recommendations for implementing the measures. As a result firms from Australia or New Zealand are typically hired at great expense, even though the firms may not have experience with the conditions.

- Public and private sector capacity limitations are an important barrier to the widespread use of energy efficiency measures.

6.3 Summary of Barriers to the development of renewable energy in the Cook Islands.

The following summary of barriers to the development of renewable energy has been divided into categories that are somewhat arbitrary. Many barriers will have implications for several categories.

6.3.1 Fiscal and Financial Barriers

At the top of the list of barriers must be the fact that petroleum is generally a cheaper and more convenient energy source than renewables. Fiscal policy barriers include import duties that unfairly tax renewable energy systems, taxes applied to renewable energy systems that are biased against renewable energy and inadequate government budgets for renewable energy development.

Cost of Petroleum. The primary barrier is the lower financial cost and greater ease of use of petroleum fuels. Introducing a more inconvenient and higher cost energy source to replace petroleum fuels will require both additional money and the willingness of the residents to accept the problems associated with large scale use of the renewable energy resources available.

Dependence on external funding for projects. Donor dependence limits opportunities for funding, adds complexities to project development and also imposes limits on the types and sources of renewable energy technologies that can be used to those considered acceptable by the donor agencies.

High income expectation. Rural incomes and wage expectations are higher than can be provided for the production of economically viable biofuel or biomass.

6.3.2 Legislative, Regulatory and Policy Barriers

The legislation establishing the TAU 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 TAU with a mandate to incorporate it into its power systems would be beneficial.

Lack of a mandate for TAU to include renewable energy in its generation. 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.

Limited capacity in the Energy Division for renewable energy and energy efficiency development. The small size of the Energy Division staff and its responsibilities for electrical inspection as well as renewable energy make it difficult for the division to develop needed national strategies for renewable energy and to develop projects for donor funding.

6.3.3 Institutional Barriers

Throughout the Pacific, one of the main points of failure in renewable energy projects has been institutions that are inadequate to provide sustainable operations. Each form of renewable energy has specific technical and institutional structures that must be in place for receiving payment for energy services, maintenance of equipment and installation of new components. Some renewable energy sources, notably biofuels and biomass, also must include structures to bring together large numbers of independent fuel producers into an efficient operational entity so that the energy source is continuously and readily available as well as produced at minimum cost.

Insufficient technically competent personnel in rural areas. Very limited human resources on the outer islands make it difficult to achieve the level of staffing necessary for reliable technical services.

Fragmented implementation of energy services. The devolution of responsibility for the electricity supply to each of the island councils has the negative effect of fragmenting renewable energy programmes. The technical capacity on each island is very limited and finance more difficult to get when each island must organise its own energy development programme.

Lack of technical training facilities. Local technical education facilities do not include renewable energy in training programmes. There is no local source of technical training for renewable energy technicians.

Ease of migration to New Zealand. There are strong incentives for technically trained personnel to migrate to New Zealand causing a continuing turnover of technical personnel and a continuing need for training.

Limited capacity for renewable energy development at TAU. There is no experience within TAU with grid connected renewable energy systems. If wind or solar power is to be a significant energy source for Rarotonga, TAU will have to develop its capacity to design, install, operate and maintain renewable energy systems.

Inadequate institutional capacity for the design, operation and support of renewable energy systems. A barrier to development and commercialisation of renewable energy is the failure of implementers of renewable energy installations to make adequate arrangements for good technical design, proper operation and maintenance.

Lack of guidelines, standards and certification procedures for renewable energy and energy efficiency technologies. The environmental conditions in the Cook Islands are difficult for electrical and mechanical systems. Equipment selection, system designs and personnel training need to take these into consideration. If renewable energy is to be implemented on a large scale, there need to be well developed guidelines and standards for equipment specification and a system for technician certification to ensure that these special problems of the Cook Islands are considered in implementation programmes.

6.3.4 Technical Barriers

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

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

Lack of experience with comparable systems in the Pacific. Although there is a wealth of experience with solar home systems in the Pacific, integrating solar energy or wind energy into an existing grid has had no long term, success in the region. Although both technologies have long been used in industralised countries of the world, most of the experience is on a scale that is not directly transferable to the Cook Islands. This makes decision makers and investors cautious in developing grid connected wind and solar power for local use.

6.3.5 Physical Barriers

Small and dispersed population. The capacity to develop renewable resources is ultimately limited by the availability of personnel, finance and development of a practical institutional structure. These are constrained by the small size of the Cook Islands and the fact that the population is dispersed over many islands.

Severe weather. Cyclones are infrequent but there is a definite risk of damage to exposed infrastructure such as solar panels or wind machines. Following a cyclone, productivity of coconut trees is reduced for as long as half a year afterwards.

6.3.6 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 programs.

Energy Efficiency Issues. Poor efficiency of energy use is a major barrier to achieving a high percentage of renewable energy in the national energy economy. The relatively high cost of developing renewable energy resources to replace petroleum imports makes the efficient use of energy critical to the success of renewable energy development. Both supply side and demand side efficiencies can be improved.

High energy use per household. High usage of electricity due to the wide spread use of freezers and refrigerators makes it difficult and expensive to convert to renewable energy

Small size of the market. Businessmen tend to focus on low risk investments and it is risky to develop a business specialising in renewable energy when the market is very small.

6.3.7 Informational and Public Awareness Barriers

For renewable energy technology to be accepted, it is important that people at all levels understand its benefits and its problems and become familiar with the idea of replacing fossil fuels with renewable technologies.

Lack of information about renewable energy and energy efficiency at all levels. Although there have been outer island electrification projects using PV and wind, in general there needs to be more information available to decision makers, the general public and businesses regarding the advantages, disadvantages and costs of renewable energy and energy efficiency technologies.

7 CAPACITY DEVELOPMENT NEEDS FOR REMOVING THE BARRIERS

There are significant capacity issues that need to be addressed before renewable energy and energy efficiency can be expected to become major components of the Cook Islands energy picture. Most of the capacity development needs to be focused on institutions that implement energy systems, the Energy Division, the TAU and the outer island power systems. Some important areas in need of capacity development are:

7.1 Reducing Legislative, Regulatory and Policy Barriers

Standards and certifications capacity development. Capacity development is needed in the Division of Energy in the preparation and implementation of standards and certification schemes for both energy efficiency and renewable energy. This is a problem common to almost all the PICs and needs to be addressed regionally.

Energy policy implementation support. Support is needed by the Division of Energy in the development of strategies and programmes that implement energy policy of the government. The PIEPSAP programme under SOPAC is expected to address this issue regionally.

7.2 Reducing Institutional Barriers

Improving the TAU capacity for forward planning. Improving the capacity of the TAU for forward planning, financial structuring and decision-making based on marginal costs. Without solid planning and quality load forecasting, decisions to add capacity tend to be based on crisis management, which invariably results in the addition of diesel capacity since it can be quickly brought on line whereas most renewable energy systems require 4-10 years to develop. Most of the smaller utilities in the Pacific have similar problems and this can be addressed through a regional programme, perhaps through the PPA.

Assistance in developing the energy database. Capacity improvements at the Division of Energy are needed in energy data gathering, data checking, posting and analysis.

Institutional capacity development for renewable energy implementation. The institutions operating renewable energy projects must have available the necessary skills to keep them functioning properly for the long term. Training in both business methods and the development of technical skills is needed. ESCAP is developing a regional training concept that, if implemented, should address this problem.

Capacity development for the outer islands in integrating renewable energy. Programs to improve the capacity on outer islands for the rational development of their energy systems and the management of their supply and maintenance are needed. This problem is not common to other PICs and assistance is needed for the local development of the necessary training and information programs will probably be necessary.

7.3 Reducing Technical Barriers

Capacity development for TAU in renewable energy technology. Improving the capacity of the TAU to develop and integrate renewable energy of various types as generation options through training (at all levels of the technical group at TAU) in the specific technologies to be used. There should be consideration of visits to utilities already integrating the specific technology being proposed in the Cook Islands, for face-to-face discussions about the problems and advantages. These could be useful to increase the confidence of technical personnel at TAU that the technology can be integrated comfortably into the system. This is being addressed at a basic level by the PPA and can be further developed as a regional program.

Improving the capacity of the TAU to address energy efficiency issues. Improving the capacity of the TAU to design and implement energy efficiency measures that are less costly to develop than additional generation capacity and its operation. Demand is expected to increase by six percent per year without energy efficiency measures. If this rate of increase can be reduced, large capital investments in added capacity can also be delayed thereby significantly improving the economics of power production, and reducing increases in debt otherwise necessary to purchase new generating plant. This is a problem common to most PICs and a regional program appears appropriate, probably through the PPA.

Including renewable energy in technical training in the Cook Islands. Training capacity for energy efficiency measures and renewable energy needs to be developed locally so it can be made continuously available as personnel shifts inevitably occur in projects. Training modules focusing on renewable energy and energy efficiency should be made available for integration into technical training programs for electricians and plumbers.

7.4 Market Barriers

Support for the development of businesses to implement energy efficiency technology. Support is needed for the private sector to carry out a full program of energy efficiency measures including audits, design of efficiency improvements, specification of energy efficient components to carry out those improvements, installation of those components and monitoring of the results. The REEP project that is focusing on Fiji and Samoa will develop programs for increasing the capacity of local businesses and engineers to carry out energy efficiency measures and may be a useful model. Since a number of the PICs have need for implementing energy efficiency measures through the private sector, a regional program for their development appears appropriate.

7.5 Informational and Public Awareness Barriers

Information delivery to decision makers. A better understanding of the practicality and economics of the various renewable energy technologies is needed at high levels in government. A continuing problem in many countries of the Pacific is the acceptance at face value of claims regarding renewable technologies by organisations or individuals wishing to sell a product or concept to the country. OTEC, for example, is far from commercially proven and until the technology reaches that stage, the Cook Islands should not expend its very limited capacity, even in feasibility studies since by the time OTEC is commercially feasible, the requirements for feasibility are likely to be very different from those presently assumed. Yet cabinet has approved a Japanese company to not only carry out such a study but to seek funding for implementation when nowhere in the world is there a commercially operating OTEC facility, and the largest OTEC plant that has ever been built was both experimental and a small fraction of the size being proposed for the Cook Islands. This need is common to many PICs and can be a regional program..

Lack of information regarding energy efficiency measures effective for the tourist industry. Hotel owners and others in the tourist industry need to develop the capacity to recognise opportunities for energy efficiency measures and the cost effective use of renewable energy, plus the management skills to take advantage of those opportunities. This can be developed through the provision of information delivery programs focused on the needs of the tourist industry.

8 OTHER IMPLICATIONS OF LARGE SCALE USE OF RENEWABLE ENERGY

8.1 Social and Economic Implications

The primary area that widespread use of renewable energy would affect is improved national energy security through reduction in the effects of oil price changes and supply disruptions on the local economy. Also the reduction in continuing, large overseas expenditures for fuel would make more money available locally for use toward fulfilling the Millennium Development Goals and would benefit society in general.

The small size and low population density on the outer islands, along with the high cost of fuel delivery, makes it more likely that renewable energy can play a more important role in improving energy availability and productivity on the outer islands than on Rarotonga. Solar energy has been important in the development of the black pearl industry and biomass remains reasonably common as a cooking fuel on many of the outer islands.

Many forms of renewable energy including wind, biomass and biofuels offer the possibility of increasing economic benefits to rural households since those renewable resources tend to be available in rural areas. The main benefit of wind energy to landowners is likely to be rents paid for the use of their land. Biofuels in particular offer a high potential for poverty reduction and rural development. Energy provision to rural areas for small rural industry can have local economic benefit but biofuels provide a much greater potential for rural economic development because they are produced in rural areas and the provision of biomass resources does not require high level training, sophisticated tools or significant capital investment beyond that already present in the rural areas. The development of biofuels offers direct and immediate benefits to both urban and rural households and offers social and economic advantages at several levels that cannot be attributed to other renewable energy technologies that tend to be highly dependent on external sources of supply and support.

8.2 Environmental Implications

The Cook Islands must be aware, however, that widespread use of renewable energy can, if not carefully developed and implemented, result in greater environmental degradation than the use of conventional energy. Major development of biomass as a fuel, large wind farms, significant hydro development and the development of OTEC and wave energy installations all include potential for significant environmental damage and must be approached with that in mind.

No large-scale energy project, whether renewably or conventionally fuelled, should be undertaken without a complete environmental impact assessment and a careful evaluation of the alternatives. An increase in energy efficiency measures rarely causes, and usually decreases, environmental impacts and these are generally are more cost effective than increasing the production of energy from any source. In general, before undertaking any large-scale energy development program, whether based on imported petroleum or indigenous renewable resources, energy efficiency should be addressed.

For the Cook Islands, the main potential for reducing GHG emissions through renewable energy appears to be (Table 2–10) from wind, biofuels and solar PV, with wind possibly accounting for more than biofuels and solar combined. For these technologies, environmental issues are as follows:

- *Wind* The main issues which have come up in countries with extensive use of wind energy have been complaints about noise and concern that birds may be killed as they fly into rotors. The noise issue is unlikely to be a serious concern in PICs, where wind turbines would be smaller and quieter than those currently being installed in wind farms overseas. Damage to birds is unlikely to be a serious issue unless a turbine is sited near nesting areas of some endemic or rare species.

- *Biofuels* It is assumed that only areas already under coconut are likely to be considered for coconut oil for fuel, so the impact should be no more severe than current agricultural practices. In terms of use, biodiesel fuels from vegetable oils are very low in emissions, as they contain almost no sulphur or hazardous materials. In case of spillage to the ground or marine environment, they biodegrade readily and do not cause contamination.
- *Solar* Large-scale solar use that incorporates batteries will require establishment of a recycling system for spent batteries, otherwise toxic heavy metals are likely to be released into the ground and water.

9 The Implementation of the Capacity Development Needs and Co-Financing Opportunities

At the time of writing of this report, no renewable energy implementation programmes are confirmed though several are under discussion including wind energy for Rarotonga and solar energy for Pukapuka. Therefore there is no specific co-financing opportunity that is presently available and is directed toward renewable energy.

The small population and the emigration of trained people to New Zealand and Australia will continue to make it difficult to retain sufficient capacity to develop, design, specify, install and maintain large-scale renewable energy schemes. External technical and possibly managerial assistance will continue to be an important component of such projects. Training and capacity development should focus strongly on project management and maintenance since, although project design and implementation can be effectively carried out with external support, continued operation and maintenance must be based on local personnel to be sustainable. Because of the high turnover of trained personnel, training must be an ongoing process, not provided only in conjunction with project implementation. There is therefore an opportunity for external financing for the establishment of permanent technical training facilities for renewable energy technicians. This could be co-financed by project implementing agencies. Of particular interest is the co-finance of on-going training processes that are directly associated with large-scale renewable energy hardware finance. For example if a wind farm is developed on Rarotonga, there will be a long term need for training of technical personnel to operate, maintain and repair the systems and for training of management and planning personnel for further future development of wind energy.

The most effective immediate measure for reducing the rate of growth in GHG emissions appears to be a reduction of maximum demand for electricity through energy efficiency measures. Ten percent or more appears achievable provided external assistance is provided to design a comprehensive plan for multi-sector energy efficiency development, implementation and follow-up. External assistance needs to include technical assistance in the design of the measures best suited for the Cook Islands, management training and assistance to government, TAU and to private companies implementing the measures, the development of financial arrangements for implementing the measures and assistance in supporting the monitoring and analysis necessary to ensure that the measures are working as intended. Since historically, energy efficiency measures have tended to gradually become ineffective, measures to re-establish measures every five to ten years will be necessary to maintain a high level of energy efficiency. This long-term requirement implies the need for establishment of a structure within TAU or the Division of Energy specifically oriented toward energy efficiency improvement and maintenance, and significant effort directed toward capacity development for energy efficiency efforts. Considerable external finance will therefore be necessary to bring both the private and the public sector capacity to a level that can implement and maintain effective energy efficiency measures.

Since virtually all renewable energy development in the Cook Islands requires external finance along with a wide range of technical and non-technical support services, the opportunities for co-finance are present in every energy development project in both the hardware and the training and management support areas.

10 ANNEXES

Annex A - Pukapuka Solar Electrification Project

Pukapuka is a low-lying atoll with three villages (Yato, Toto and Ngake) situated along a 2km road on a single islet of the atoll. The passage into the lagoon is not navigatable by larger vessels making the landing of freight difficult, and damage to goods common. The core public area includes an administrative building, a medical centre, a community building and a school. The government compound is electrified by a diesel engine operated around 12-hours a day.

The Cook Islands Government determined in the mid-1980s that Pukapuka would be electrified and a feasibility study for diesel electrification was carried out. The cost was estimated to be around $1.8 million capital cost. Operation would be from 6- 8 hours per day. The fuel delivery to operate the system reliably could not be guaranteed, however, due to the low frequency and unreliability of shipping to Pukapuka, located some 1400 km from Rarotonga. Therefore in 1987 discussions were initiated between the government and the South Pacific Institute of Renewable Energy (SPIRE) in Tahiti for electrification using solar energy. Given the remoteness of the island, it was agreed that high reliability of the PV systems would be a requirement and also the size of the systems should be sufficient for the stated energy needs of the households. The government indicated that if a PV feasibility study indicated that those requirements could be met within the $1.8 million estimated for the diesel installation, the added advantages of 24-hour solar power and no susceptibility to outages due to slipped shipping schedules – would make that the preferred electrification method.

In 1989 France agreed to finance up to FF 7m for solar electrification of Pukapuka using a combination of FF3,850,000 treasury and FF3,150,000 in private loans. Agreement was concluded in 1990 between *Casise Centrale de Coopération Economique* (CCCE) and GOCI for a treasury loan and in 1991 between the Bank of Indosuez and Government for the private part of the loan. In 1990 the CCCE contracted with SPIRE to carry out a feasibility study and SPIRE sent staff to Pukapuka for that purpose.

The project was considered to be feasible at a cost comparable to the estimated life-cycle cost of diesel electrification and could provide comparable household power with the added benefits of 24-hour power and no susceptibility to fuel outages. The government agreed to proceed in 1991 and SPIRE remained the primary contractor for the project with responsibility for technical design, equipment selection, equipment purchase, installation and post-installation monitoring for at least one year. Installation was sub-contracted to Soler Energie (Tahiti) under SPIRE supervision.

To test the use of PV on the atoll, an initial phase for electrifying three public buildings was carried out. Each of the three solar systems included 28 panels and a 880 Ah (C_{10}) battery intended to operate up to a 200 litre refrigerator, a 300 litre freezer, a video system and six lights. These Phase 1 installations were completed in October 1990.

During this phase a house-to-house survey was made to determine probable energy use. The survey indicated that less than 50% of the households intended to purchase a refrigerator and less than 30% had plans to purchase a video system.

After about a year of operation Phase 2, the household and street light installations, was approved by the government. In Phase 2 the project installed systems on 110 homes with eight modules of 45 Wp each and 17 homes with 12 modules. The 17 homes having 12 modules would share their PV system with a nearby smaller house. At the request of the owners, three houses were fitted with only four panels and a 24V 150 Ah (C_{10}) battery to minimize the maintenance cost to the household while still providing adequate power for lights and small entertainment appliances. The total installed power of 46kWp allowed for all households and public buildings to be electrified and components for 10 more systems were left on island for future expansion.

The eight panel PV design was intended to power a maximum of six high efficiency tube type fluorescent lights (2 at 18W and 4 at 13W) for three hours a day, small entertainment appliance use (radio or cassette player) and either a solar type refrigerator (less than 0.7 kwh/day usage) or three hours of video use each day. The 12 panel system provided for the same loads plus two to three additional lights in the second small house.

Twenty 300 W 240V 50Hz inverters were provided for distribution by the Island Council for small AC appliances, notably video systems. Also 10 24V/12V DC-DC converters were provided to allow those households wanting to operate 12V equipment, such as CB radios, to power them from the installed 24V system.

Eighteen dawn to dusk street lights were included with 12 on streets, two as locator beacons for returning fishermen and the rest at the CICC, Catholic and SDA churches. The churches also were to have small lighting systems installed.

Street lights included 2 panels of 45 Wp capacity, a 100 Ah (C_{10}) 12V battery and a low pressure 18W sodium light. Spare parts for the street lights included 10 Ballasts, 20 bulbs, 2 controllers and 6 batteries.

The primary problem with the implementation of the project was the delivery of the materials and the installation team members from Rarotonga and Tahiti. Though the Cook Islands Government had promised shipping for the project, problems with vessels and with the shipping schedule prevented them from being able to fulfil that obligation and after several months of delay, SPIRE arranged for the French Navy to assist by providing transport from Tahiti to Pukapuka for the installation personnel and the equipment. The equipment delivered amounted to 130 tonnes of materials.

Installation was by two teams consisting of one person from SPIRE. or Soler Energie and two persons from the Cook Islands who had previously been trained at SPIRE in Tahiti. The Pukapuka residents who were designated as maintenance technicians participated in the same SPIRE training and assisted in the installations.

A major stock of spare parts for the home systems was provided including:

- 20 PV modules, Photowatt BPX47-500 rated at 45.2 Wp average
- 12 Batteries (Oldham HVT5S 425 Ah at C/10, dry charged, sealed and provided with acid for activation)
- 50 complete 18W lights and 100 extra tubes
- 50 complete 13w lights and 100 extra tubes
- 10 charge controllers (GIE Soler relay type)
- 20 fuse/breaker boxes
- 100 switches
- 130 power point sockets
- 50 junction boxes

The installation phase lasted three months and was completed in December 1992 in time for Christmas and New Year celebrations.

Monitoring

Post installation visits by SPIRE were not possible due to problems with access until an airport was built in 1994. In March 1995, SPIRE sent Jean-Denis Girard, a SPIRE engineer involved in the project from its inception, and other staff to Pukapuka for a monitoring visit accompanied by government officials and Cook Island technical staff. The visit found the systems to be generally working well and adequately maintained. Three additional eight panel systems had been installed using materials from the spare parts stock on government housing (the government representative's house, the doctor's house and the school teacher's house). The quality of the new installations, done by the local technicians, was equivalent in quality to that of the earlier installations.

Problem areas included:

- a higher rate of failure of lights than expected. Some 20% had failed in the two years of project operation;
- three of the six community freezers and refrigerators were inoperative. One had been destroyed by a disgruntled islander as a result of a politically motivated dispute over refrigerator use and the other two had refrigerant leaks that could not be repaired on island;
- the hospital refrigerator was inoperative due to a refrigerant leak;
- the 12 panel system on the CICC house was seriously over loaded with a freezer, 16 lights and a television and radio powered by an inverter. The visiting team proposed adding eight panels to increase the capacity. Four additional panels were installed but the system still appeared overloaded;
- six of the18 street lights were inoperative due to bulb or ballast failure and no available spare parts. At the time of the visit, all the 10 ballasts and 20 bulbs had been either used or, for reasons unknown, sent to Rarotonga. The recommendation of the visiting team was to consider conversion to the lower cost and apparently higher reliability fluorescent fixtures for the street lights;
- no 12V refrigerators are available from Rarotonga and the cost of import from overseas is prohibitive so many household systems are underutilised and a number of users unhappy because they are unable to have a refrigerator despite having been told at the time of installation that it would be possible;
- although not officially confirmed, the monitoring team was told that some of the spare parts stock was sent to Rarotonga for unknown purposes, leaving the stock on island severely depleted. There was no accountability for spare parts and no records of their use.

In April, 2001, a team from PREFACE and the Cook Islands Government flew to Pukapuka to evaluate the project. Included was Mr Stéphane Pujol from Soler Energie of Tahiti who was part of the original installation team.

Though the details of the findings were lost due to a computer failure, discussions with trip participants yielded the following information:

- most of the PV systems themselves were functioning, though at reduced capacity due to 12 year old batteries;
- none of the street lights were working. None had been converted to fluorescent lights as the SPIRE engineer recommended;

- the primary problem with the systems was failure of users, local government or the national government to work out a satisfactory arrangement for replacing the 24V appliances used in the installations. None of the original refrigerators were found to be operating. The majority of lights were not working and there were no replacement bulbs or fixtures available on island. As these appliances are readily available from sources in New Zealand and French Polynesia, this support failure is surprising and implies a low priority by all parties to the electrification;
- the primary complaints by users remained the same as eight years earlier: a lack of affordable sources for refrigerators and other appliances that would work with the installed systems; and
- access for personnel and cargo remains difficult, expensive and irregular. There have been numerous occasions when fuel has run out due to late delivery or volume shipped being lower than expected;

Later investigation by staff of the Energy Division confirm these findings and note that by 2003, some battery failures have occurred. In 2003, approximately half of the installed household systems had functional lighting.

Institutional Arrangements

Ownership of the systems was initially by the Ministry of Energy, though with the several shifts in the responsibility for outer island electrification over the years, ownership has become uncertain and is now assumed to be by local government since each island is now responsible for their own electrification.

Initially the systems were provided without charge to users but about a year after installation, a fee system of $8 for 8 panel installations and $10 for 12 panel installations was instituted. No information was available regarding fees for the four panel systems or whether or not there were to be payments for community systems. The fees were to be collected by local government and used for repairs and maintenance. Labour for maintenance remained the responsibility of the Cook Islands Government and five local technicians were officially employees of the Energy Ministry. Technicians were supposed to visit each installation for preventive maintenance on a monthly basis.

In fact, collection has been haphazard and maintenance less frequent though generally adequate as far as battery electrolyte and basic system maintenance is concerned. The main problem has been obtaining replacement lights, a number of houses are down to one light and some have no functioning lights. The funds collected have not been accounted for. Virtually all maintenance costs have been borne by the government over the nearly 12 years of project operation.

Conclusion

The Pukapuka experience shows that oversized, high quality PV systems can provide reliable long term, minimal maintenance service for outer island use. However for the PV technical systems to be of value, there must be an institutional system instituted whereby lights, light fixtures and appropriate appliances can be obtained to replace those that fail in normal service. Having a functioning PV system is of little value if the appliances that provide the needed services are not available.

The training that was provided to the local technicians (initially five now reduced to two) by SPIRE included formal training for two weeks in solar technology at the SPIRE training facility in Tahiti and extensive on-the-job training by SPIRE and Soler Energie staff during the installation period. Since the systems themselves have worked reliably for 10 or more years, the quality of maintenance clearly has been adequate and the training effective. Although additional training will be needed to maintain any new equipment that may be installed in the future and for upgrading skills in general, the capacity of the local technicians appears adequate for the long term maintenance of solar PV. If the PV systems are replaced by a central diesel generator, new training and capacity development will be required.

At the time of the Pukapuka installations, the cost of a Wp of solar panels was approximately double that of the international market price today. With today's lower panel cost, the use of inverters to provide 240V AC power from larger panel arrays is more economically reasonable. This now allows the use of much lower cost and more readily available 240VAC appliances, although appliances – particularly freezers or refrigerators – should be selected for low energy consumption and the use of high power demand appliances, such as electric kettles and irons, controlled to prevent overloading.

Given that there is already 46k Wp of solar panels fully functional on Pukapuka, upgrading the systems with more panels, new batteries and the addition of inverters for the provision of 240V, 50 Hz power may represent the most technical reasonable and economically feasible approach to renewing electrification on Pukapuka. Only through that means can the island expect to continue to have reliable 24-hour power that is not at the mercy of irregular shipping schedules for fuel.

Plans for Pukapuka electrification

UNDP/UNESCO has commissioned a study of outer island electrification that includes a 'desk study' of Pukapuka electrification. The terms of reference request the consultant to examine the existing situation and propose, with appropriate justifications, the most appropriate mode for the further development of Pukapuka electricity supply considering, but not limited to, diesel, solar PV and hybrid designs.

At the request of the government, NZAid also proposes a study of options for diesel electrification or hybrid operation on Pukapuka but not including upgrading and rehabilitation of the solar systems. There is an agreement that AUSAid will finance outer island infrastructure development in the Cook Islands but it would be managed by NZAid.

Annex B - Mangaia Grid Connected Wind System[18]

Background

In March, 2002, The Secretariat of the Pacific Community (SPC) and the Government of the Cook Islands signed a Memorandum of Understanding to establish a grid connected wind farm of 30-40 kW capacity on Mangaia Island as a part of the joint Australian-French funded PREFACE project. There are three phases of development.

1. Pre-feasibility phase (Rarotonga, Atiu and Mangaia survey)

2. The second phase, completed in December, 2001, included the installation of a wind monitoring station to confirm the wind resources, the analysis of the technical, administrative and economic feasibility of a wind farm, the creation of a wind map of the island and location of suitable sites for a wind farm and the preparation of technical specifications for the implementation of the project.

3.The third phase, completed in 2003 included tendering for the supplier, purchasing, and installation of the system.

The Utility System on Mangaia

Mangaia is located 150 km east of Rarotonga and lies in the south-east trade wind belt. There are 300 households and approximately 700 inhabitants on Mangaia. There is 332 kW of diesel power (2-80 kW, 1-92 kW, 1-45 kW, 1-35 kW) installed with a 95 kW peak demand. Most of the engines are ageing and are derated. Though population is decreasing slowly due to migration to Rarotonga or New Zealand, the demand has been growing (though less than 4% a year) due to increases in household energy use.

The project objective is to test the technical viability of wind systems in the Cook Islands and to reduce the diesel consumption on Mangaia. The daily load curve shows a first peak in the morning (from 0500 to 0730) and a second one in the evening (from 1800 to 2200 with a maximum between 1900 and 2000). The annual load curve shows a peak during the end of year holiday period, mid-December to mid-January.

For FY 2002, the average energy generated by the plant per month was about 32000 kWh for its 270 domestic and 20 commercial clients. Only four commercial clients consume more than 500 kWh per month with the largest consumer averaging about 600 kWh per month in 2002-2003. A household survey and analysis of domestic consumption shows that refrigerators and freezers represent 35% of the load and lighting 36% — in particular incandescent bulbs that in total represent about 28% of the energy used by households. The average energy bill per month was 28,730 kWh at a cost of $14,240. Payments are collected every month and include the price of electricity ($0.36 per kWh for domestic clients and $0.58 for commercial clients) plus a fixed fee of $5 per month and 12.5% VAT. This makes the average monthly bill for domestic clients about $43 for the 92.5 kWh average consumption with incandescent lights and freezers totalling more than half the monthly energy usage with each at about 28% of the total energy used.

Using the wind map prepared during the pre-feasibility study, a site was located not far from the grid South East of Oneroa village, about 100 m above sea level, on a ridge. The site was estimated have a wind resource of least 7.5 m/s at rotor height. The site was visited and found to have a good wind resource, good proximity to the grid for connection, ease of construction of an access road to the site, no problems with landowners, and low environmental impact. It

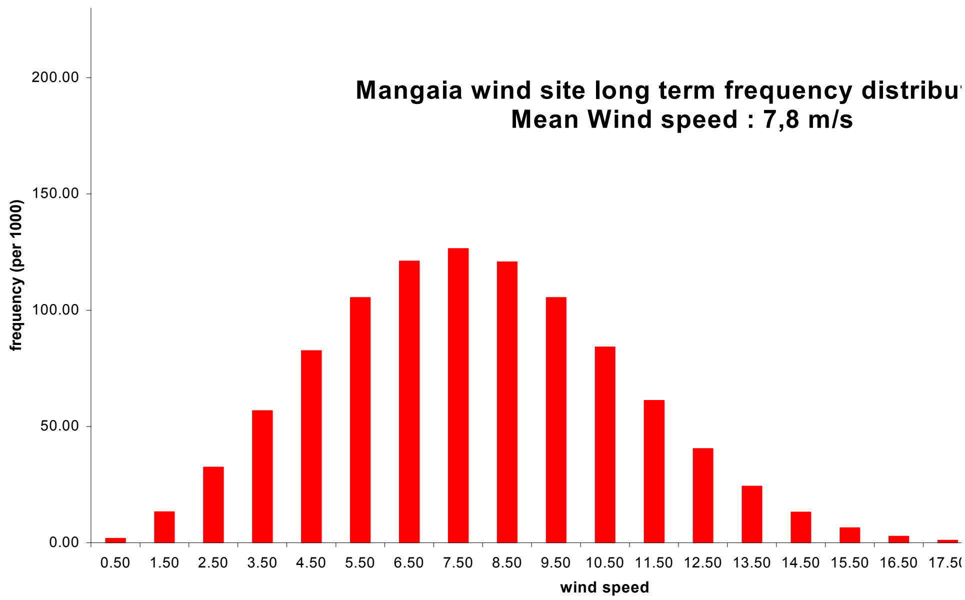
[18] Primary sources were PREFACE documents with updates during the early 2004 PIREP visit

was agreed in November 2000, to proceed with the feasibility study for inclusion of the project under PREFACE funding.

Site Measurement Results

The wind monitoring started on the 18 April 2001 and ended on the 12 October, and confirmed the earlier estimates. After correlation with the measurements in Rurutu in French Polynesia (the closest wind power site), the average wind speed at 30 meters above the ground level was estimated at 7.8 m/s. This level of wind would provide only 7 m/s at 20 m agl making the extra 10 m of tower excellent economics so a 30 meter tower was proposed. Figure B–1 shows the wind speed frequency distribution obtained.

Figure B–1 - Mangaia Wind Site, Long Term Frequency Distribution. Mean = 7.8 m/s



Source: Mangaia Wind Farm, Invitation to Tender, SPC 2002.

For stability of the grid, it is necessary to limit the production of electricity from the wind into the grid to no more than 25% of the actual demand. Therefore the objective for production was 96000 kWh per year. For control purposes, two wind turbines were considered necessary.

Feasibility

As there was no previous wind farm project in the Cook Islands, the main experience in the region comes from the units installed in New Caledonia (Lifou, Ile des Pins, Mont Dore) and in French Polynesia (Rorutu located 750 km east from Mangaia). The technology has been proven and the problems are mainly linked with cyclones, lack of competent maintenance, and disputes with land tenure. To avoid damage to equipment by cyclones, the specifications required a tower that could be manually lowered should a cyclone be expected. Operation and management is by the electricity authority of Mangaia, and a Memorandum of Understanding between the Island Council and the landowners confirms the agreement of all parties.

The tender for the system was based on an energy delivery basis rather than specifying particular types of components. The tender requested the respondents to provide a cost for installing at least a two turbine wind farm that would deliver at least 96,000 kWh per year from the wind at the stated site. Vergnet, who proposed two 20kW turbines, was selected as the contractor.

As a donor financed project, the system was delivered under duty-free status and installed by local labour supervised by representatives from PREFACE and the winner of the tender, Vergnet of New Caledonia. Assembly was completed in 2003 and the turbine began delivering power to the Mangaia grid in 2003. The head of the Mangaia Electricity Authority, Mr. Tony Whyte, was contacted by phone by the PIREP team and confirmed that the wind system was functioning well though instrumentation problems had prevented exact determination of the energy delivery (January 2004).

Economics

Considering the price of fuel delivered to the diesel plant in Mangaia ($0.85 per litre including freight and VAT in 2002) and the probable cost of wind-electricity ($0.22 per kWh for an average wind speed of 7.5 m/s), investing in a wind farm to provide 20 to 25% of the electricity demand appears marginal though reasonable since the diesel consumption should decrease by around 30,000 litres per year – representing about $25,000 per year in fuel cost savings.

The ratio of costs between PREFACE and Cook Islands was around 74/26% with PREFACE investment fixed at AU$280,000 for a total project budget of about AU$378,000. The main contributions from the Cook Islands Government and the Mangaia Electricity Authority were:

- transportation from Rarotonga to the site;
- preparation of a road to access the site and grading the land around the site;
- civil engineering and building a shelter for electrical equipment;
- grid connection underground; and
- phone line connection to allow remote control.

Household and commercial energy surveys were done by PREFACE.

Sustainability

Because the wind generators are to be integrated into the existing power grid, there are no issues of fee collection or institutional structure. The only issue of sustainability will be that of maintenance cost and of actual power production in the Mangaia wind regime. Wind projects in the Pacific have had a history of unusually high maintenance and this is the main concern for sustainability. The successful tenderer for the installation will be required to train utility personnel in maintenance and to make available the necessary spare parts.

Mangaia Wind Farm 2003

(photo by Tangi Tariapi)

Annex C – Persons Interviewed for PIREP

This may not include all those interviewed by the Local Consultant.

Person or Group	Contact Information
Mr Tangi Tereapii, PIREP Coordinator and Energy Planner, Ministry of Works	tangi@energy.gov.ck Ph : (682) 24484 Fax : (682) 24483 ; home: 28405
Ms Carinna Langsford, PIREP National Consultant	langsford@actrix.gen.nz & Frangipani01@hotmail.com NZ Ph (683) 20533 / 55219; Rarotonga (682) 20 533
Other staff of Division of Energy, Ministry of Works (MoW) Mr Mata Nooroa, Director of Energy Mr Paeiu Pirake, Electrical Inspector and Energy Audits Mr David Akaruru, Assistant Energy Planner	Home: 26 262; 55 699
Mr Atatoa Herman, Secretary for Works, MoW	Ph : (682) 20034 ; herman@mow.gov.ck
Mr Keu Mataroa, Policy Adviser and SOPAC representative, MoW	Ph : (682) 20034 ; k.mataroa@mow.gov.ck
Mr George Cowan, consultant engineer, MoW	
The PIREP Country Team (see note below)	
Mr Tom Wichman, energy consultant	Ph: 22178; PO Box 2104 Rarotonga; twichman40@hotmail.com
Mr Arona Ngari, Director of Meteorological Services	
Mr Petero Okotai, Economist, Ministry of Finance and Economic Management	policy@mfem.gov.ck
Ms Bredina Drollet, Economist, Ministry of Finance and Economic Management	policy@mfem.gov.ck
Ms Taggy Tangimetua, Government Statistician, MFEM	
Mr Manfred Fortsch, Governing Director, Marine Engineering Cook Islands Ltd	Formerly oversaw rural electrification, MoW Ph : (682) 25261 & 22313
Ms Pasha Cruthers, Environmental Research Officer, Ministry of Environment	
Ms Mona Matepi, Senior Project Officer, WWF Cook Islands	Ph : (682) 25093 ; mmatepi@wwfcooks.org.ck
Mr Robert Skews, Managing Director, Island Hopper Vacations Ltd	Ph : 22026 & 55035 ; rskews@islandhopper.co.ck
Mr Tereapii (Apii) Timoti, CEO, TAU	
Mr Matthew Paterson, Deputy High Commissioner and NZ Aid Representative, New Zealand High Commission	Ph : (682) 22201 ; paterson@mfat.govt.nz
Mr Okirua Ngaroia, Manager, Mobil Oil Cook Islands	
Mr. Noorea Tou, Relationshipp Manager, ANZ Bank (and Representative of Centre for Development of Enterprise – CDE – ACP Secretariat, Brussels)	Ph : (682) 21750 ; toub@anz.com
Mr Tata Crocombe, Owner/manager, Rarotongan Hotel and businessman	Ph : 28100
Mr Nooroa Raumeam Senior Research Officer, Ministry of Marine Affairs	
Mr Kori Rau, Research Officer, Ministry of Marine Affairs	
Mr Ben Parakpoti, Director of Water Supply, Ministry of Works	
Mr Vincent Peters, Reporter / Presenter, Cook Islands Television	

* The following members of the PIREP Country Team met on Tues. 16 December with the PIREP consultants (Mr Peter Johnston and Ms Corrina Langsford): Mr Tangi Tereapii (Coordinator), Ms Pasha Cruthers (Ministry of Environment), Mr Tom Wichman (consultant), Mr Tenga Epi (engineer, Office of the Minister of Island Administration), Mr Petero Okotai (MFEM), Ms Taggy Tanngimetua (Govt. Statistician), Ms Mona Matepi (WWF), Mr Nooroa Raumea (Ministry of Marine Affairs), and Mr Kori Raumea (Marine Affairs)

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