SPREP

Pacific Islands Renewable Energy Project

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

GEF

UNDP

The Secretariat of the Pacific Regional Environment Programme

Pacific Regional Energy Assessment 2004

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

TUVALU

National Report

Volume 15

PIREP

our islands, our lives...

SPREP IRC Cataloguing-in-Publication Data

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

xii, 59 p. : figs., tables ; 29 cm. – (Pacific Islands
Renewable Energy Project. Technical report ; no.15)

"This report is based on data gathered by a
PIREP team consisting of Isaia Taape, Kapuafe Lifuka,
Timaio Auega and Herbert Wade with input and assistance
by Mr. James Conway".

ISBN: 982-04-0300-6

1. Energy development – Tuvalu. 2. Energy sources,
Renewable – Tuvalu. 3. Energy research – Tuvalu.
4. Conservation of energy resources – Tuvalu. 5. Conservation
of natural resources – Tuvalu. 6.Energy consumption
- Climate factors – Tuvalu. I. Taape, Isaia. II. Lifuka, Kapuafe.
III. Auega, Timaio. IV. Conway, James. V. Pacific Islands
Renewable Energy Project (PIREP). VI. Secretariat of the
Pacific Regional Environment Programme - (SPREP).
VII. Title. VIII. Series.

333.794159682

Currency Equivalent: 1.0 AU$ (AUD) ≈ 0.74 US$ (March 2004)

Fiscal Year: July 1 to June 30

Time Zone: GMT / UTC plus 12 hours

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

Mr Isaia Taape, Country Team Coordinator

Mr Kapuafe Lifuka, Local Consultant

Mr Timaio Auega, Local Consultant

Mr Herbert Wade, International PIREP Consultant/Team Leader

with input and assistance by

Mr. James Conway

The international consultants visited Tuvalu in March 2004. Information for the report was gathered both during and after the visits by the national consultant. The energy staff provided generous support and assistance during the visit. All discussions were held on the island of Funafuti.

The Tuvalu National PIREP Country Team, Secretariat of the Pacific Regional Environment Programme, the United Nations Development Programme and others reviewed an earlier draft of this report. However, the contents are the responsibility of the undersigned and do not necessarily represent the views of the Government of Tuvalu, the national PIREP Country Team, SPREP, UNDP, the Global Environment Facility or the many individuals who kindly provided information on which the study is based.

Herbert Wade

September 2004

ACRONYMS

AAGR	Average Annual Growth Rate
AC	Alternating Current
ACP	African, Caribbean, Pacific countries
ADB	Asian Development Bank
ADO	Automotive Diesel Oil
AusAID	Australian Aid for International Development
BoT	Bank of Tuvalu
BP	British Petroleum
CCA	Common Country Assessment (of the UN)
CIF	Cost+Insurance+Freight
COOP	Co-operative Organisation
CPI	Consumer Price Index
CROP	Council of Regional Organisations of the Pacific
DBT	Development Bank of Tuvalu
DC	Direct Current
DSM	Demand Side Management for efficient electricity use
EC	European Community
EDF	European Development Fund
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENSO	El Niño/El Niña oceanic climate cycle
ESCAP	Economic and Social Commission for Asia and the Pacific (UN)
ESCO	Energy Service Company
EU	European Union
EWG	Energy Working Group of CROP
FTF	Falekaupule Trust Fund
FY	Fiscal Year
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GMT/UTC	Greenwich Mean Time/Universal Time Coordinate
GNP	Gross National Product
HF	High Frequency
Hp	Horsepower
HPI	Human Poverty Index
IMF	International Monetary Fund
IUCN	International Union for the Conservation of Nature
JICA	Japan International Cooperation Agency
kV	Kilo-Volts (thousands of volts)
kVA	Kilo-Volt-Amperes (Thousands of Volt Amperes of power)
kW	Kilo-Watt (Thousands of Watts of power)
kWh	Kilo-Watt-Hour (Thousands of Watt Hours of energy)
kWp	Kilo-Watts peak power (at standard conditions) from PV panels
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
MOU	Memorandum of Understanding
MWE	Ministry of Works and Energy
NASA	National Aeronautics and Space Administration (USA)
NORAD	Norwegian Agency for International Development
OTEC	Ocean Thermal Energy Conversion
PACER	Pacific Agreement on Close Economic Relations
PDMC	Pacific Developing Member Countries (ADB)
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
PIEPSAP	Pacific Islands Energy Policies and Strategic Action Planning
PIFS	Pacific Islands Forum Secretariat

PIREP	Pacific Islands Renewable Energy Project (GEF/UNDP)
PPA	Pacific Power Association
PREA	Pacific Regional Energy Assessment (1992)
PV	Photovoltaic
RET	Renewable Energy Technology
RFP	Request for Proposals
SCF	Save the Children Federation
SHS	Solar Home Systems
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SWH	Solar water Heater
SWOT	Strengths, Weaknesses, Opportunities and Threats
TCS	Tuvalu Cooperative Society
TEC	Tuvalu Electricity Corporation
TMTI	Tuvalu Maritime Training Institute
TNPF	Tuvalu National Provident Fund
TSECS	Tuvalu Solar Electric Cooperative Society
TTF	Tuvalu Trust Fund
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USP	University of the South Pacific
V	Volts
VAT	Value Added Tax
WB	World Bank
Wh	Watt hours of energy
WSSD	World Summit on Sustainable Development

Energy Conversions, CO_2 Emissions and Measurements

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

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

Diesel Conversion Efficiency:

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

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

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

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

EXECUTIVE SUMMARY

1. Country Context

Physical Description Tuvalu lies about 1100 km due north of Fiji centred at about 8° south latitude and 177° east longitude. The EEZ is 900,000 km^2 in area. The total land area of 26 km^2 is spread over eight islands. The largest, Vaitupu, has an area of about 5.6 km^2 while the smallest, Niulakita, has only 0.42 km^2 of land. Funafuti atoll is the centre of government as well as the centre for air and sea transport.

Population. Growth has been slow with the 1990 population 9043 and the 2002 population 9,300. The slow growth is attributed to emigration, particularly to Australia and New Zealand. There are about 1570 households with nearly six persons each. Funafuti with 4492 persons has more than 48% of the population. Vaitupu with 1591 is a distant second and the other islands range from 400-700 except for tiny Niulakita with only 35 persons resident.

Environment As is the norm for atolls, the soil is low in fertility and only a narrow range of food plants can be supported. The sea is the primary source of local food. The climate is tropical to equatorial. Tuvalu has had tropical cyclones to cause serious damage but their passage is not common though storm surges, winds and heavy rain can be damaging to the low lying islands even if a cyclone does not actually go through Tuvalu. Rainfall averages 3500 mm per year with April - November lower than the rest of the year. Droughts do occur and maintaining a fresh water supply on densely populated Funafuti is increasingly a problem. The primary source is rainwater but in recent years a 65,000 l/d desalinator is also in use. Some pumping from wells is possible but water is brackish and wells can easily be over pumped and cause an incursion of salt water.

Climate change is worrisome since Tuvalu will lose land area rapidly as the sea level rises. In terms of per-capita GHG emissions, Tuvalu is now the upper half of the PICs with higher per-capita emissions than Tonga, Samoa, Fiji, Tokelau, Kiribati, Vanuatu, PNG and the Solomon Islands.

Political Development. Though Tuvalu has links to Micronesia, Polynesian settlers from Tonga and Samoa probably settled Tuvalu in the early 1300s. It was not until the 1800s that European contact was consistently made through missionaries and the feared “blackbirders” or slavers. Prior to 1900, the Tuvalu population was probably less than 3000 largely due to losses of men to the slave ships from South America.

In 1892, the British declared Tuvalu a protectorate and the island group were governed as the Ellice Islands. In 1916, the Ellice Islands and the Gilbert Islands were joined for administrative purposes. In 1974 the Ellice Islands chose to split from the Gilbert Islands (later Kiribati) and became Tuvalu with full independence in 1978.

Government is organized along the lines of the British Westminster system as a constitutional monarchy with the British Crown at its head as represented by a Governor General who is appointed on the recommendation of the Prime Minister and Cabinet. The *Fale I Fono* (House of Assembly) has 15 members elected every four years by popular vote. The Prime Minister is selected from Parliament and the up to four member Cabinet is selected by the Prime Minister. There are eight island courts. A High Court sits twice a year and its decisions can be appealed to the Court of Appeals in Fiji.

Economic Overview. Tuvalu ranks third among the Pacific developing member countries of the ADB in the Human Poverty Index. The primary problem for Tuvalu’s economic development is its small size and its isolation. The Tuvalu Trust Fund provides over 10% of the Government budget. Marketing of the “dot TV” internet domain has provided several million dollars in income and there is substantial income from the sale of foreign fishing licenses and remittances from overseas residents and seamen. Copra is no longer traded and exports of products are almost nil. Donor inputs in 2001 amounted to over one-third of GDP with Japan the main contributor and Taiwan second. The ADB was a distant third.

Government is the main employer and provides around 70% of salaried employment. The private sector consists mainly of small shops and service providers on Funafuti and agriculture for export to Funafuti on the outer islands.

The *M.V. Nivaga II* and the *M.V. Manu Folau* provide inter-island shipping. Only Funafuti has a full service wharf where larger vessels can tie up. Shipments to outer islands must be transferred to small boats for landing, often at some risk to cargo and passengers.

Of the 28 km of roads in Tuvalu, 19 are on Funafuti. Most vehicles are owned by the government or government owned corporations though there is a rapidly increasing private ownership of vehicles. Housing is mostly concrete floor and walls with a metal roof.

The main financial institutions are the Development Bank of Tuvalu that focuses on development loans and the National Bank of Tuvalu which is a full service commercial bank.

Institutional and Legal Arrangements for Energy. There is no centralization of energy activity, regulation or administration. The energy office within the Ministry of Works and Energy develops energy policy and administers renewable energy projects. The Tuvalu Electricity Corporation (TEC) manages all grid based electrification on all islands. Petroleum is handled by the importer, BP, with no government regulation.

A generic National Energy Policy was approved by Cabinet in 1997 but has not been enforced.

2. Energy Supply, Demand and the GHG Inventory

Energy Supply. All fuel is imported by BP, the only importer since before Independence in 1978. All storage and facilities are owned by BP. All fuel imports except diesel fuel for the TEC is subject to import duty and VAT.

The Electricity supply includes 2.4 MW of capacity on Funafuti, 260 kW of capacity on Vaitupu and from 160-180 kW on the other islands (excluding Niulakita where solar power is used). The TEC has a country wide staff of about 70 and was corporatized in 1990.

Technical losses are estimated to be 9-10% which is somewhat high but non-technical losses are low at four to five percent. Reliability has historically been good though recent problems with the 1 MW generator has resulted in more frequent outages. Japan is currently developing a project for improving the Funafuti power supply and a more reliable supply should be one of the important results.

The outer islands were switched from solar power to diesel grids in 2000. Fuel efficiency for outer island generation is not good though operational efficiency varies widely from island to island. Power is provided 18-hours a day.

At $0.34 on Funafuti and $0.30 on the outer islands the domestic electricity tariff is well below cost, especially on the outer islands where generation costs are over $1.50 per kWh. Tariffs are effectively set by cabinet after being proposed by the TEC Board of Directors. In real terms electricity prices are lower now than ever before while the costs of generation have gone up due to price rises in fuel and labour.

Until the mid-1990's most outer island homes were served by solar home systems that provided lighting and basic entertainment services. The institution that operated the over 400 systems on outer islands, the Tuvalu Solar Electric Cooperative Society (TSECS) has been deregistered as a cooperative and no longer provides electricity services.

Only solar photovoltaics and solar water heaters have proven successful in Tuvalu. Biomass is limited since most of the land is covered by coconut trees that have more economic value as coconut producers than as fuel. Biomass for energy is hampered by the poor soils that make recovery of the resource slow and by the limited land area that generally can be used more profitably for something other than growing fuel. The large number of coconut trees make biofuel production possible and that should be carefully investigated as it is a potentially large renewable energy resource.

Energy Demand. Petroleum replaced biomass as the largest energy source sometime in the 1990s. The marine transport and power sectors are the largest users of fuel with about an even split of the 2.7 ML of ADO that was imported in 2003. The 790 kl of petrol imported in 2003 was divided between land transport and outboard motor use for boats. About 278,000 litres of petrol was shipped to the outer islands in 2003, virtually all used for outboard motors. The 400 kl of kerosene imported in 2003 was shared about half and half between domestic users and aviation. There is no domestic aviation though Tuvalu purchased a share in Fiji Air and it provides the international service twice a week with additional flights when traffic is heavy. In the 1990s, kerosene was seen as a replacement for wood and in the 2000s, LPG is replacing kerosene, particularly on Funafuti where over half the households do some cooking with LPG. Around 36.5 tonnes of LPG were imported in bulk tanks in 2003.

The maximum demand in Funafuti at the time of the PIREP visit (March 2004) was about 800 kW though that is expected to increase later in the year when the massive new government office building is occupied. Sales in 2003 totalled 3850 MWh on Funafuti and a total of around 450 MWh for the outer islands. Appliance ownership is high, even on the outer islands with a high percentage of households having washers, irons, refrigerators and freezers.

Using almost 30MW/month in 2003, by far the largest user of electricity has been the Tuvalu Cooperative Society (TCS), the importer and distributor of most food products in Tuvalu. This is expected to be eclipsed by the energy used in the new government building after it is occupied in mid-2004 with its estimated 365 kW demand. The heavy use of air-conditioning will be required due to the large glass expanse to the east and west and the poorly shaded exterior design that results in substantial solar heating in the morning and afternoon.

Future Growth in Energy Demand and GHG Emissions

Growth both in the land transport sector and electricity sector is expected to occur at a 3% to 4% rate over the next 10 years. LPG is expected to grow at nearly double that rate while kerosene use for households is expected to decline equally rapidly. The current CO_2 production is estimated at about 10.3 Gg/year with a 2013 projection of 13.0 Gg assuming no addition of renewable energy or energy efficiency measures. With the maximum expected use of solar energy and biofuels by 2013 saving about 0.8 Gg per year and energy efficiency measures saving about 1.4 Gg per year, a 17% reduction in GHG production in 2013 appears possible.

3. Potential for Renewable Energy Technologies

Solar. The solar resource has been proven sufficient to power solar home systems reliably. The central Tuvalu resource is estimated at about 5.5 kWh/m^2/day with higher values to the north and lower values to the south.

Wind There has been no wind resource measurement on Tuvalu. Meteorological measurements indicate a seasonal, highly irregular pattern of wind speeds generally below the speed necessary for economic production of power. However, it is likely that there are better locations for wind power than the Funafuti airport and a proper assessment should be made of winds along the reef and in the lagoon where there is no interference from the tall coconut trees that cover the land areas.

Biomass Around 1600 ha (54% of total land) is coconut woodlands. A high percentage of available biomass is in the form of coconut trees. Heavy use of the resource for fuel is not possible due to the slow growth of the trees but there can be a significant amount of biomass made available through replanting of the senile trees that will take place if the coconut industry is revived by conversion to biofuel production. Whether the best economic use of the senile trees will be for fuel or for wood products should be determined before large scale replanting takes place.

Biofuel. Although copra production has fallen to low levels, the coconut resource remains and it represents sufficient capacity to provide a high percentage of the diesel fuel used for power generation without much rehabilitation. The problem is that the high cost of outer island labour and shipping costs have priced Tuvalu out of the coconut oil market. However, there are non-financial benefits to local fuel production, particularly protection against large increases in petroleum prices or a loss of reliable supply due to war or other problem in major oil producing areas. The potential for biofuel is the largest of any renewable energy resource available to Tuvalu for GHG reduction and petroleum import reduction.

Biogas There is significant potential for biogas production from pig manure if arrangements can be made to pen all island pigs in one space and collect the manure for gas production.

Wave. Wave energy measurements indicate that there is a moderate wave energy resource in Tuvalu but at this point in time there are no commercially available wave energy conversion machines available for use.

OTEC Although there is a large OTEC resource, there are no commercially available OTEC generators and at the small size needed by Tuvalu, when they become available it is likely that the cost per kW will be too high.

4. Experiences with Renewable Energy Technologies

Solar Photovoltaics Tuvalu was one of the world's first countries to attempt rural electrification using solar photovoltaics. Over the period 1984-1994, over 400 solar home systems were installed on the outer islands reaching nearly 40% of all rural households. Unfortunately, institutional problems caused the ultimate failure of the programme and most of the systems were abandoned after diesel powered grids were installed on the outer islands in 2000. There is discussion regarding adding solar PV to the outer island grids but unfortunately, the designs of the outer island power systems did not include the necessary features to allow optimal connection of PV to the grid and the cost effectiveness and reliability of the existing systems, if converted to hybrid operation, is expected to be significantly lowered. Only Niulakita and a few remote islets of Funafuti now use solar energy as their source of electrical supply.

Solar Thermal Solar water heaters have been installed on commercial buildings and homes successfully. Their cost and the limited market for piped hot water have prevented their wide spread use.

Wind Power Effectively none other than small multi-bladed windmill water pumps.

Biofuels and Biomass There has been no experience.

Biogas No experience

5. Energy Efficiency Activities

Activities by the TEC over the past decade have generally been focused on increasing, not decreasing electricity use. Small programmes to audit government facilities have been carried out in the past but with no measurable reduction in energy use over the long term. The potential for energy efficiency improvement is high, particularly in reducing the solar load on the new government office building.

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

Barriers to Renewable Energy Development.

- Diesel fuel is duty and tax free for power generation.
- Requirement for complex project proposals by financing institutions.
- Lower cost of petroleum than for renewable energy sources in Tuvalu.
- Increasing outer island labour costs.
- Highly subsidised TEC tariffs.
- Lack of clear policy for energy development.
- Limited capacity at the energy office for renewable energy and energy efficiency development.
- High cost of marine and land transport.
- Land tenure issues.
- Difficult environment for electrical and mechanical equipment.
- Solar not considered in outer island grid designs.
- Lack of experience with comparable renewable energy systems in the Pacific.
- Lack of adequate resource information.
- Lack of adequate technical capacity on outer islands.
- Small area and dispersed population.
- Limited knowledge of renewable energy and energy efficiency at high levels of government.
- Limited public awareness of energy efficiency and renewable energy options.

7. Capacity Development Needs for Removing the Barriers

- Project development support programme.
- Fiscal policy development programme.
- Energy policy development assistance.
- Electricity tariff development support.
- Training for Energy Unit personnel.
- Support for the development of a biofuel delivery institution.
- Capacity development for the design, installation and maintenance of renewable energy systems.
- Assistance for the development of standards and certification procedures for renewable energy technologies.
- Support for resource surveys.

- Other implications of large scale use of renewable energy.
- Decision maker information delivery programme.
- Public information programmes.

8. Implications of Large Scale Renewable Energy Use

The only opportunity for large scale solar use is for grid connected photovoltaics. Since the solar electricity is delivered in the same way as diesel power, no social effect is expected. Since the systems are likely to be installed without batteries, no environmental effect is expected either. If storage batteries are used, their recycling will be essential if environmental damage is to be avoided.

Large scale use of biofuels benefits both urban and rural populations. However for biofuels to be competitive with imported fuels, the process of biofuel production will have to be optimised from the gathering of coconuts to the final processing of coconut oil into fuel. There is potential for social problems relating to land use, proper sharing of benefits and maintaining the resource.

Biogas production also has the potential for social problems relating to the sharing of benefits and the use of land for the penning of village pigs. There is potential for improved environmental conditions through the reduction of released methane (a greenhouse gas over 20 times as damaging as carbon dioxide) and the containment of pig waste and its conversion to high quality fertilizer.

9. Implementation of the Capacity Development Opportunities

There are no committed renewable energy projects at this time that can be a co-financing partner. However, when such projects are developed, capacity development is essential to their success and co-finance should be sought.

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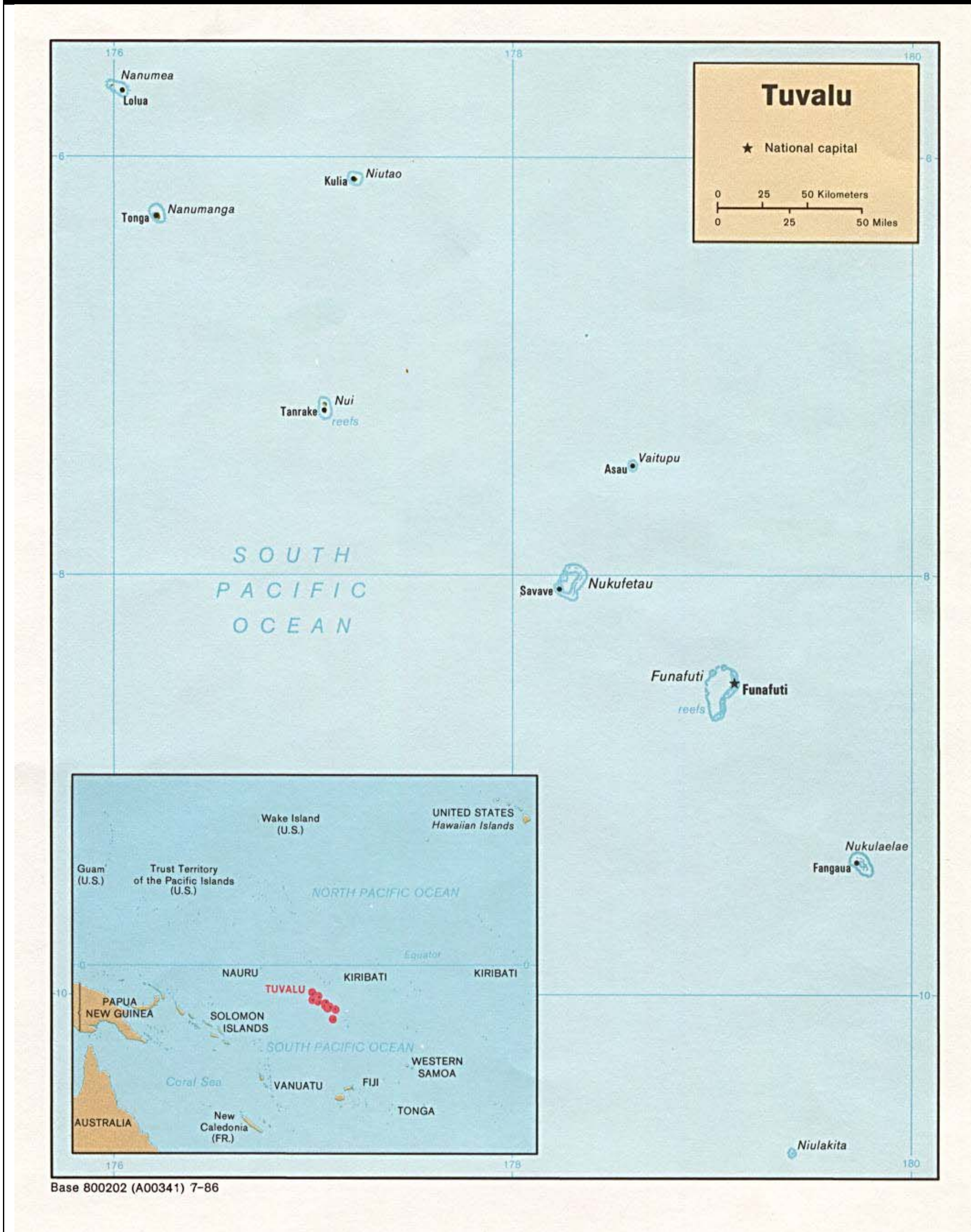
Map of Tuvalu and its location in the Pacific



Source: ADB

1. COUNTRY CONTEXT

1.1 Physical

Lying about 1100 km north of Fiji, Tuvalu consists of six atolls having a large lagoon enclosed by a reef and three raised coral islands having no large lagoon. The total land area is 26 km^2 and the EEZ is 900,000 km^2 in area. The islands are grouped in a southeast/northwest chain from 11° to 5ºS latitude clustered between 176° and 179° E longitude. The largest island, Vaitupu, has a land area of about 5.6km^2 while the smallest, Niulakita has about 0.42 km^2 of land. The maximum elevation in the country is less than three meters above mean sea level making the country very susceptible to sea level rise and storm surges from cyclones.

Funafuti atoll has become the centre of government largely because of its large lagoon that has a deep water access to the sea for shipping and the airport that was constructed during World War II when Tuvalu was a staging area for the American assault on Japanese held islands to the north.

1.2 Social

The heavy concentration of jobs and facilities on Funafuti has resulted in a migration of population from the outer islands to increasingly overcrowded Funafuti. In the first half of the 20th century, the population of the nine islands was distributed along the lines of land area with Vaitupu having the most people. After the war the airport and harbour increased the economic importance of Funafuti and after independence in 1978, the migration rate increased with opportunities for government jobs resulting from the separation of Tuvalu from the Gilberts and the more "modern" lifestyle attracting people.

Table 1.1 – Population Statistics, 1991-2002

Island	Land km^2	1991	2002	% of total	Density 1991 pop/km^2	Density 2002 pop/km^2	%Change	2002 Households	Persons per household
Nanumea	3.87	824	664	7.1%	213	172	-5.4%	128	5.2
Nanumaga	2.78	644	589	6.3%	232	212	-2.2%	119	4.9
Niutao	2.53	749	663	7.1%	296	262	-3.0%	143	4.6
Nui	2.83	606	548	5.9%	214	194	-2.5%	108	5.1
Vaitupu	5.6	1202	1591	17.1%	215	284	7.0%	237	6.7
Nukufetau	2.99	751	586	6.3%	251	196	-6.2%	118	5.0
Funafuti	2.79	3839	4492	48.3%	1376	1610	3.9%	639	7.0
Nukulaelae	1.82	353	393	4.2%	194	216	2.7%	68	5.8
Niulakita	0.42	75	35	0.4%	179	83	-18.2%	8	4.4
TOTAL	25.63	9043	9300	100	353	363	0.7%	1568	5.9

Source: Tuvalu Statistics Office

Although there has been a stated intent to decentralize government over the past 20 years with the shifting of several government departments to other islands, particularly Vaitupu, in fact if anything the concentration of government resources on Funafuti has increased in the past five years with major infrastructure projects on Funafuti for roads, schools, health services and the construction of a large government office building. while expenditures on the other islands has remained relatively constant except for the construction of diesel powered electrification systems on all outer islands in 2000 and a wharf and secondary school upgrade project for Vaitupu in the 1990s.

The nearly static population for the country as a whole is due mainly to migration to foreign countries, particularly Australia and New Zealand, rather than to a low rate of natural population growth. Although the outward migration has kept population pressures from increasing, the people migrating tend to have a higher level of education than the population on average and this has been a factor that has limited the ability of Government to locate qualified local staff to fill technical and administrative positions.

Each island (except tiny Niulakita) has several villages. Funafuti and Vaitupu each have nine villages although in many cases the villages are contiguous and boundaries are political rather than physical. On some islands, like most of Funafuti and Vaitupu, travel between villages is by road. In a few cases, villages are on different islets of the atoll and may only be accessed by boat from other villages.

1.3 Environmental

The soils have limited fertility and support a narrow range of food plants unless the soils are modified artificially. However, the sea is never more than a few hundred metres away and there is a great diversity of life on the reef that can be combined with the products of the numerous coconut and pandanus trees on land to support the human population consistently and in relative comfort.

Table 1.3: Status of Ratification of Environmental Treaties and Conventions by Tuvalu

Status in Tuvalu	Protection of natural resources (SPREP Convention	Hazardous wastes (Waigani Convention)	Nuclear free Pacific (Rarotonga Treaty)
Signed Ratified Entered into force	4 Aug 87	21 Sept 2001	6 Aug 1985 16 Jan 1986 11 Dec 1986

Note: The above treaties and conventions are briefly described in volume 1, the PIREP Regional Overview report

The climate is tropical to equatorial. Tuvalu is out of the main South Pacific storm belt and tropical cyclones are infrequent but do sometimes hit the southern atolls inflicting considerable damage due to winds and storm surges. Heavy rains, storm surges and high seas are not unusual as side effects of storms passing to the south in the November to March cyclone season. Well remembered is Hurricane Bebe of 1972 that struck Funafuti with waves washing over the land from sea to lagoon causing loss of life, and the destruction of most structures.

There is little seasonal temperature change with daytime maximum temperatures in the low 30s and night time temperatures in the mid- twenties. The 3500mm average rainfall is somewhat seasonal with April through November averages lower than the rest of the year but with no month averaging less than 230mm[1]. Droughts do occur and maintaining

[1] Funafuti values. There is some variation from south to north with the northern islands somewhat drier and having a greater tendency to droughts.

a fresh water supply on densely populated Funafuti is increasingly a problem. Rainwater holding tanks have been mandated. The Vaiaku Lagi hotel construction included a large underground tank and the new government office building also has a large underground water storage tank. There is a 65,000litre/day reverse osmosis type desalinator also in use. Outer islands depend mainly on rainwater storage for their fresh water supply although in an emergency, some pumping from wells is possible without damage to the fresh water lens that is within the porous coral of the atoll. Unfortunately, the water problem continues and remains to be solved.

Tuvalu has been vocal in international assemblies on climate change and has expressed great concern about sea level rise over the past decade, calling for other countries to work together to reduce greenhouse emissions lest Tuvalu become uninhabitable due to sea level rise. But also during the period 1994-2003 the Government of Tuvalu itself increased national greenhouse gas emissions nearly 100% through the shifting of outer island electrification programmes from solar to diesel and rapidly expanding the use of air-conditioning in government offices. Though Tuvalu as a country has a tiny contribution to GHG for the world, on a per-capita basis – the only realistic basis for comparison – Tuvalu is in the upper half of the PICs in GHG production at about 1,160 Gigagrammes of CO_2 per person per year. Tonga, Samoa, Fiji, Kiribati, PNG, Solomon Islands, Vanuatu, and Tokelau have lower per-capita CO_2 emission values[2].

The urbanization trends, with the population shifting from outer islands to the more economically advanced islands of Funafuti and Vaitupu, has placed considerable environmental pressure on the urban islands, particularly Funafuti with its population density of 1610 persons per km^2. The main settlement of Fogafale on Funafuti has a population of more than 4000 persons, around 40% of the nation's population. Water supply and waste disposal have been particularly difficult on Funafuti with funding for the expensive permanent solutions not yet found.

There is no specific environmental legislation. EIAs may be required by donor agencies on specific projects, as is the case with the sports field construction that is currently underway with partial funding by AusAID, but that is the exception rather than the rule.

1.4 Historical and Political

Despite the facts that Tuvalu is geographically linked with Micronesia and the people of Nui speak a language derived from I-Kiribati, cultural indicators suggest that Polynesians from Samoa and Tonga and Uvea (Wallis) settled most of the island group early in the 14th century. As Pacific Islands go, Tuvalu was undisturbed by European explorers until quite late in history. Don Alvaro de Mendaña y Neyra, on a Portuguese voyage of discovery, passed through Tuvalu in 1597 but he was looking for a continent not a group of tiny atolls and made no contact. European contact began in earnest with the British sponsored visit of Captain John Byron (grandfather of the famous poet of the same name), and all of the islands were finally mapped by 1826. Known to Europeans initially as the Lagoon Islands, they were renamed the Ellice Islands in honour of the British member of parliament who owned a ship that called in at Funafuti in 1819.

[2] PIREP Regional Report, SPREP 2004

In the mid-1800s the slaver ships of the Blackbirders descended on Tuvalu and decimated many of the island's populations, taking many persons to South America to be slaves on plantations. Prior to 1900, the Tuvalu population was probably less than 3000 largely due to the losses of able bodied men to the labour "recruiters" from South America.

In the late 1800s, the Pacific islands were being divided among German, USA, Spanish and American interests. To halt the labour "recruitment" of the Blackbirders and to forestall encroachment into the region by Germany and the USA, in 1892 the Gilbert and Ellice Islands were named a British protectorate after obtaining agreement from the traditional leaders of the islands.

The Ellice Islands were administered by Britain from Fiji as a protectorate from 1892 to 1916 and as part of the Gilbert and Ellice Islands British colony from 1916 to 1974. The colony became self-governing in 1971, and in 1974 the Ellice Islanders voted for separate British dependency status, splitting from the Gilbert Islands (later Kiribati) and officially became Tuvalu which means "eight together". They became fully independent in 1978 and is now the second smallest fully independent country in the World (Nauru is smaller) although not a member of the United Nations until 2000.

The government is organized along the lines of the British Westminster system as a constitutional monarchy. The British monarch is head of state, exercising executive authority through an appointed governor-general who is appointed on the recommendation of the prime minister and cabinet. Parliament, the *Fale I Fono* (House of Assembly), has 15 members elected every four years by universal adult suffrage of all citizens 18 or older under a constituency based system. The prime minister and deputy prime minister are elected from parliament by the members and up to four members of cabinet areselected by the prime minister. Government is based on Funafuti. Outer islands are each governed by a six person council, the Kaupule, also elected every four years.

There are eight island courts with limited jurisdiction. A High Court sits twice a year and its decisions can be appealed to the Court of Appeals in Fiji.

1.5 Economic Development

There has been no development plan written since the Kakeega O Tuvalu of 1995to 1998. The plan focused on public sector reforms, private sector, human resource development, outer island development and infrastructure and despite its age remains the primary reference for Tuvalu development efforts. After the expiry of the Kakeega in 1998, the government used Vision 2015, from the Head of State budget speeches, as guidelines for national development.

Table 1.2 - Tuvalu and Regional Economic Treaties

Status	SPARTECA	PACER	PICTA
Signed Ratified Entered into force	14 July, 1980 4 May, 1981 3 June, 1981	18 August, 2001	18 August 2001

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

With a Human Poverty Index (HPI) of 7.3 in 2002, Tuvalu ranks as third among the Pacific developing member countries (PDMCs) of the ADB. Tuvalu's Human

Development Index (HDI) of 0.583 is midrange by PDMC standards.[3] The primary problems facing Tuvalu for economic development is its small size and its isolation. The ADB considers Tuvalu as having made good progress toward reaching the Millennium Development Goals and UNDP classes most of the goals as "probable" for achievement by 2015, the exceptions being "maybe" for HIV/AIDs control, hunger and reversing environmental damage.[4]

The Tuvalu Trust Fund (TTF), established in 1987 through a $26.4 million investment by Australia, New Zealand, the UK and Tuvalu, provides a significant input to the Tuvalu economy, around 11% of the government budget since 1990[5]. In 2002, the market value of the TTF was about $70 million. Other non-donor sources of income include the marketing of the "dot TV" internet domain, foreign fishing licenses and remittances from seamen or Tuvaluans working overseas. Copra, once the dominant export, is no longer traded due to the cost of outer island labour and transport increasing the cost of the product beyond market acceptance. Donor inputs in 2001 amounted to more than one-third of GDP.

The "DotTV" income results from the 1999 sale of rights to the internet country identifier, .tv, to a domain name rental agency, DotTV, mainly for the use of television stations having Internet sites. The agreement initially provided for five quarterly payments of US$1 million and a lump sum payment of US$12.5 million after Idealabs, the main investor, exercised a call option. In 2000, Tuvalu acquired US$3 million in DotTV stock. In late 2001, VeriSign bought DotTV and the Tuvalu share of the sale was a lump sum payment of about US$10 million. VeriSign has agreed to pay about US$2.5 million annually plus 5% of any revenue over US$20 million in any one year for the following 15 years.

Table 1.3 – Economic Indicators 1995-2002 (2001-2002 estimated)

Economic Measure	1995	1996	1997	1998	1999	2000	2001	2002
GDP at current prices ($'000)	11,869	16,998	18,670	23,045	22,706	23,388	24,323*	25,053*
GDP per Capita	1,669	1,765	1,903	2,194	2,216	2,260	2,283*	2,406*
population '000	9,500*							9,300
Exports f.o.b. ($'000)	189	361	373	678	2,108	1,363		
Imports f.o.b. ($'000)	6,562	5,999	8,144	11,408	16,461	23,613		
Trade Balance ($'000)	6,373	5,638	7,771	10,730				
Exchange Rate (average, $ per US$)	1.349	1.278	1.347	1.592	1.600	1.700	1.900	

Source – United Nations Common Country Assessment, Tuvalu United Nations, Suva, 2002

* Estimated value

The economy is almost totally supported externally with exports of products almost nil. Government is by far the main force in the economy providing almost 70% of salaried

[3] *Country Strategy and Development Programme Update 2003-2005*, Asian Development Bank

[4] ibid.

[5] ibid.

employment in Tuvalu. The private sector consists mainly of small shops and service providers on Funafuti plus agriculture for export to Funafuti on the outer islands. The high cost of access and limited development of tourist facilities has made tourism almost non-existent with most visitors arriving on business. Several guest houses and a government operated, 16 room hotel provide accommodation on Funafuti while a small private hotel is operated on Vaitupu. Government rest houses and private homes provide limited visitor services on the other islands. There is a small cottage industry for making fans and local handicrafts for sale to visitors with a shop at the airport but even such tourist basics as picture postcards are generally not available.

Figure 1-1 – Key Development Indicators for Tuvalu (2000)

Indicator		Overall	Male	Female
Population	(2001; estimated)	10,339	–	–
Urban	(1999; estimated)	51 %	–	–
Growth rate	(% per year; 1991-2001)	1.35 %		
Life expectancy at birth	(2000; est)	66	64	69
Maternal mortality	(1992-99; est)	–	–	100-200
Infant mortality	(/1000 live births, 2000)	29		
Child mortality rate	(0- 5 yrs; 1991)	59		
GDP per capita	(Austr $; 2001)	A$ 2,286	–	–
GDP/capita growth	(%/yr; 1999-2003)	1.2%		
Aid per capita	(A$; 1990-'00)	A$ 900		
Dependency ratio	(mid 2000 est)	69.5		
Access to safe drinking water	(%, 1991)	85%	–	–
Access to sanitation	(%, 1991)	49%	–	–
Phones	(% of population; 1990 & '99)	1.3 5.5		
Adult literacy	(census; 1991)	95	95	95
Births attended by trained health worker	('00)	100%	100%	100%
Underweight children	(% < 5 yrs; 1990s)	3	–	–
Filariasis microfilaria	(%; 1973 & 1999)	0.9 22.3	–	–
Infant immunisation	(DPT3 coverage, 2000)	90		
Total fertility rate	(1997)			3.2
Human Develop. Rank among PICs	(1998)	8th of 14	–	–
Human Poverty Rank among PICs	(1998)	4th of 15	–	–
Gender Development Rank among PICs	('98)	1st of 15		
Gross enrolment early child education	(1998)	91%	–	–
Net enrolment primary school	(1995-1999)	100%	100%	100%
Members of Parliament	(%, 2001)	100%	100%	0%
Labour force	(1991?; % of total)	100%	62%	38%
Prof/tech/admin/mgt	(1991 census)	100%	61%	39%
Clerical workers	(1991 census)	100%	35%	65%

Source – United Nations Common Country Assessment, Tuvalu UN Suva, 2002

In recent years, Japan has been the major donor agency contributor with Taiwan second. Together they contributed nearly 80% of donor inputs to Tuvalu in 2002. The ADB was third with only seven percent .

Outer island development has been placed as a priority by government with some devolution of authority to the traditional Kaupule (Island Councils) and through the creation of the Falekaupule Trust Fund (FTF), a fund developed jointly by ADB and the Government of Tuvalu for use of the Kaupule. About half the funds are from the national government, about 40% from ADB and the rest from the rural islands themselves. Although the FTF is ostensibly for rural development, Funafuti has a major share somewhat blurring the Fund's rural development focus.

1.5.1 Transport

In the 1970s and early 1980s, a seaplane service provided passenger and light freight transport between Funafuti and the outer islands. That was discontinued for financial reasons and only sea transport is available between islands. Airport construction is on the list of possibilities for the outer islands, notably for Nukufetau and Nanumea where there were WWII airports that can be rehabilitated, but benefits would be modest and there are other higher priority investments that need to be made on the outer islands.

Inter-island shipping is handled by the 1200 tonne *M.V. Nivaga II* which has recently been joined by the smaller *M.V. Manu Folau*, a gift from Japan. Only Funafuti and Nukufetau have safe access to the lagoon for larger vessels and only Funafuti has a wharf where these vessels can offload cargo. Vaitupu has a wharf suitable only for smaller vessels. For the other islands, goods are taken through narrow channels in the reef on small outboard engine powered boats. During conditions where seas are running high, access may be dangerous or impossible, even on Vaitupu where access has been improved.

A 35 tonne vessel, the *Manaui* is owned by government as a fisheries training vessel and is sometimes used for non-scheduled inter-island travel, especially where medical evacuation or project development activities are involved and the scheduled shipping does not fit the need.

In the 1980s a fibreglass catamaran was purchased from a Marshall Islands builder by the US based Save the Children Federation (SCF) to meet their needs for inter-island passenger services relating to SCF projects. Unfortunately the craft turned out to be a poorly performing vessel on the open sea and was used little outside the Funafuti lagoon. A privately owned vessel began inter-island service in 2000 but service ceased when it sank. In 2003, there was no private inter-island transport operating on a regular basis.

There are 28 km of roads in the whole country, with 19 of them on Funafuti and most of the rest on Vaitupu[6]. Vehicle ownership has increased dramatically over the past 10 years on a rate of increase basis although on a per-capita basis it remains quite low with only 124 vehicles registered in the country at the time of the 2002 census and anecdotal evidence is that the numbers increased rapidly in 2003 -2004. Most vehicles are owned by government either directly or through government owned corporations. Over 95% of vehicles are on Funafuti and nearly all of them are used by government or government owned corporation employees. However, the completion of the road improvement project on Funafuti has accelerated the private import of automobiles and though hard data is not available, anecdotal evidence is that there has been a marked increase in private vehicle ownership since the 2002 census[7]. Personal transport by motorcycle is common and bicycles are also used although mostly by school age persons. On Funafuti there is a private bus service that covers most of the heavily populated areas. Most roads on Funafuti were recently paved while outer island roads are of crushed and compacted coral, though still useable in all weather.

Housing has shifted from mostly traditional in the mid-20th century to today's mostly western style, multiple roomed concrete walled homes that have a steel roof. Although the outer islands have been slower in shifting to western style housing, by the 2002 census, most housing on the outer islands is also of concrete and steel western style construction.

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[6] UN Common Country Assessment: Tuvalu, UN Suva, 2002

[7] *Country Strategy and Development Programme Update 2003-2005*, Asian Development Bank

1.5.2 Tuvalu Maritime Training Institute

An important source of rural income is remittances from seamen on merchant vessels, mostly European. The government operated Maritime Training School was corporatised into the Tuvalu Maritime Training Institute (TMTI) in 2000. The facility meets International Maritime Organisation standards with added upgrading started in 2002 through an ADB loan. The facility provides basic seaman training and upgrade training for advancement in rank within the merchant marine services. An estimated $5 million a year in remittances are provided by about 450 seamen to families in Tuvalu.[8]

TMTI is being considered for further development into a national vocational-trades training centre though it is agreed that must be done without losing its principal focus of seaman training.

1.5.3 Finance

Development Bank of Tuvalu (DBT)

The Development Bank of Tuvalu was established under the Development Bank of Tuvalu Act of 1990 as a bank to carry out general banking business in accordance with accepted international banking principles and practices. It started operation on 24 June 1993 by taking over assets and liabilities of the Business Advisory Bureau which was then dissolved. Activities of the DBT to1999 resulted in large losses and in that year a reorganisation was proposed that included merging with the National Bank of Tuvalu. That merger has not taken place and by the end of 2000, the accumulated loss totalled $1 million and arrears at 17% on a $1.6 million loan portfolio.[9]

The principal activities and objectives of the bank are the provision of financial and advisory assistance to its clients for the long term economic and social development of Tuvalu.

The DBT has a mandate to:

- provide short, medium and long term finances;
- identify and promote new potential ventures;
- provide technical, managerial and business advisory services;
- offer equity participation in major projects considered to be of national interest;
- provide guarantee for loans/finance offered by other financial sources; and
- assist in the rehabilitation and continuation of weak but financially viable projects.

The bank finances developmental projects within the agricultural, fisheries, industrial, community development and commercial sectors. It also ensures that financial assistance is within the general framework of the government's economic policies, plans and priorities with emphasis given to enterprises that:

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[8] *Tuvalu 2002 Public Sector Review*, ADB 2002

[9] *Tuvalu 2002 Public Sector Review*, ADB 2002

- use local materials in processing and manufacturing;
- make use of those technologies that will provide more opportunities for effective employment and training of Tuvaluans;
- contribute effectively to the broadening of the capital base of local entrepreneurs; and
- promote exports and develop products that allow for imports substitution.

The DBT provides loans at essentially commercial interest rates. Where they differ from the National Bank of Tuvalu, the only commercial bank in Tuvalu, is mainly in their acceptance of a higher risk for investments that show promise for the development of local human and physical resources.

About 40% of loan activities are for the outer islands despite the fact that nearly 60% of the population is rural. This reflects the limited opportunities for investment on the outer islands in comparison to Funafuti where producer to market transport costs are lower and there are more skilled persons available for production. It also reflects the fact that DBT is located on Funafuti and lengthy loan negotiations are therefore much easier for residents.

The DBT has a loan from the European Investment Bank (EIB) of 0.7 million Euro for ongoing lending. In addition the EIB has also approved a 0.3 million Euro loan to the Government of Tuvalu to be injected to the Development Bank as additional paid up shares. As a condition to the approval of these two capital inputs the government also had to provide the equivalent of 0.3 million Euro to the DBT.

National Bank of Tuvalu (NBT)

The National Bank of Tuvalu has nearly $20 million in customer deposits and is currently the only commercial bank operating in the country. Though now 100% government owned, it has links with ANZ and Westpac banks in Fiji though it is operated as an independent entity within Tuvalu. It provides standard commercial bank services to its customers. Loans are generally required to be secured by assets and personal loans are about 60% for personal loans (weddings, funerals, motorcycle purchase etc.) and 30% for housing construction and renovation. Commercial loans for short term working capital (often in the form of an overdraft allowance on a checking account) are common and longer term financing of low risk capital projects is possible although unusual. The bank provides funds transfer services, savings accounts and foreign exchange services as well as the usual checking accounts. Credit cards are not generally honoured in Tuvalu although NBT can provide small cash advances to individuals using some types of credit cards within one or two days of application.

On the outer islands, an NBT agent on each island handles banking transactions and the Tuvalu Cooperative Society (TCS) also provides some basic banking services such as inter-island funds transfers and small loans.

Tuvalu National Provident Fund

The Tuvalu National Provident Fund (TNPF) receives member contributions and invests them on their behalf using professional funds managers. Returns on investment have been reasonable with a return on assets between 1984 and 2000 of 9.2percent.[10]

1.6 Institutional Context for Energy

There is no centralization of energy activity, regulation or administration. The two person energy office under the Ministry of Works and Energy (MWE) is primarily entrusted with the continuing development of energy policy and the administration of renewable energy projects. The government owned Tuvalu Electricity Corporation (TEC) manages all grid-based electrification on all islands. Petroleum is handled under non-competitive agreements with outside suppliers, currently British Petroleum.

There is no formal energy price regulation. Petroleum and renewable energy prices are market driven and electricity tariffs are proposed by the TEC Board of Directors but actually are set directly by cabinet.

The Tuvalu Solar Electric Cooperative Society (TSECS) – see Annex 1 – has been deregistered as a Cooperative. The former TSECS manager and senior technician are now paid by government and the Energy Unit is now responsible for overseeing the installation, operation and maintenance of PV systems that fall under government jurisdiction..

A generic National Energy Policy for the PICs was promoted by the Forum Secretariat in the mid 1990s. A policy based on the Forum Secretariat generic policy was approved by cabinet in September, 1997, but has not been enforced by subsequent governments.

[10] *Tuvalu 2002 Public Sector Review*, ADB 2002

2 Energy

2.1 Energy Supply

2.1.1 Petroleum

Institutional structure

All fuel is imported by BP (formerly BPAmoco and before that British Petroleum) who has provided fuel since before Independence. BP owns all storage facilities and other petroleum infrastructure in Tuvalu. No tenders or price specific contracts are invoked. From their stocks, fuel is sold at wholesale and retail. All fuel imports except diesel for the TEC is subject to import duty and VAT but the Tuvalu Electric Corporation is exempt from both for fuel purchases.

Source and delivery mechanisms

BP delivers fuel from costal tankers shared with Shell that originate in Fiji on about an eight week cycle. Around 300 Tonnes of diesel fuel, 100 Tonnes of petrol and 75 Tonnes of Jet fuel are provided on each shipment. Fuel is transported from bulk storage in 200 litre drums or using tractor drawn tanker trailers to deliver fuel to TEC, government facilities, the airport and wholesale customers.

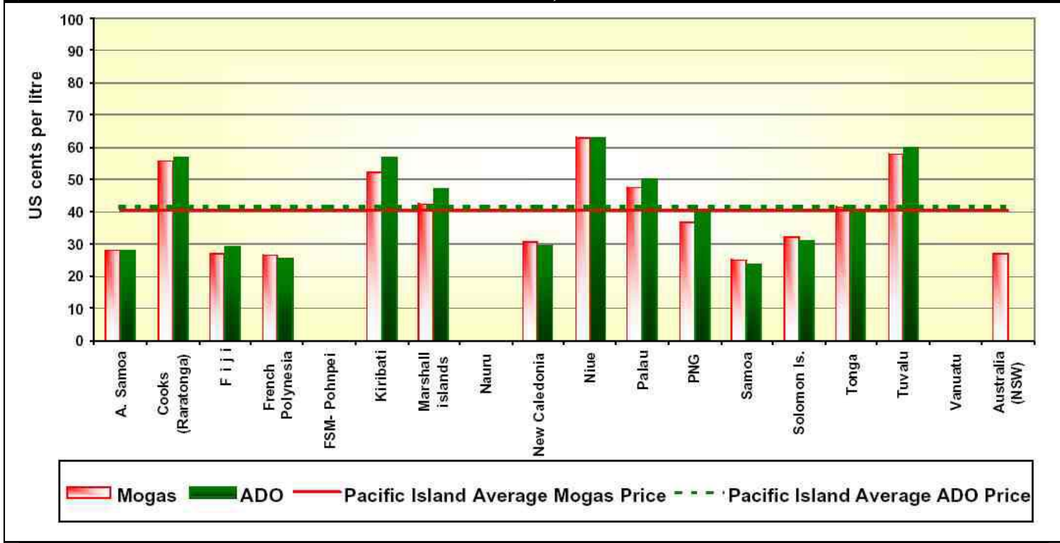
For the outer islands, petrol and kerosene is transported in 200 litre drums. Diesel is carried in the delivery ship's fuel tanks (mainly the *M.V. Manu Folau)* and pumped into drums on arrival for carrying ashore in small boats for all islands. None of the outer islands have bulk storage for fuel although Vaitupu deliveries are reaching the point where local bulk storage makes economic sense. Delivery is approximately every fortnight although storms and other factors can disrupt the schedule.

LPG is imported privately in container sized bulk tanks holding approximately 18 tonnes of product. Smaller cylinders are filled at the bulk tank storage site (immediately adjacent to the BP petroleum storage area) either directly for customers who bring in empty cylinders or, more commonly, filled cylinders are exchanged for empty ones at retail outlets.

Pricing

Fuel prices are not regulated; they are set by BP based on CIF cost. Tuvalu, the Cook Islands and Kiribati all have about the same wholesale ADO and Petrol prices (Figure 2-1). Although a price reduction might be possible through a tendering process, the long term relationship with BP is considered an advantage to Tuvalu. It is believed that BP also values that long relationship and should there be an interruption in international petroleum supplies, BP would give Tuvalu a higher priority for supply than would a company engaged under a cut-throat negotiation process or under a tendered, limited term contract.

Figure 2-1 - PIC Wholesale Petrol and ADO Prices (excluding import duties and taxes; Nov/Dec 2003)



Source: Pacific Fuel Price Monitor, Edition 7 version 2 (PIFS; 12 May 2004)

Storage

Fuel storage is near the wharf well away from densely populated areas. It is owned by BP with Australian storage and safety regulations enforced by periodic visits of inspectors from Australia. Approximately six weeks of supply at normal use rates is maintained. Expansion of the facility is underway with the shifting of the BP office from within the storage area to a new location across the road making room for additional facilities within the fenced tankage area.

2.1.2 Electricity

Institutional Structure

Table 2.1 - Installed Capacity for TEC

Name of Station	Size of Plant
Funafuti	1x 1020kVA 1x 500kVA 2x 350kVA 1x 180kVA
Nukulaelae	3x 60 kVA
Nukufetau	2x 60 kVA 1x100 kVA
Vaitupu	2x 100kVA 1x 60 kVA
Nui	1x 100 kVA 2x 60 kVA
Niutao	1x 100kVA 2x 60 kVA
Nanumaga	1x 100 kVA 2x 60 kVA
Nanumea	1x 100 kVA 2 x60 kVA

Source – TEC Operations Report, Jan – July 2002

The Tuvalu Electric Corporation is a government owned corporation that operates under an Electricity Act that gives it exclusive right for grid based electricity provision throughout Tuvalu. Initially only operating in Funafuti, in the late 90s the TEC began operating the Vaitupu secondary school power system and in 2000 installed and began operations on all of Tuvalu islands except Niulakita. All generation is diesel based. The TEC has a country wide staff of around 70 persons. By Tuvalu business standards the TEC has been well managed since corporatisation in 1990 and has provided generally reliable electricity service to Funafuti although rapid load growth has created capacity and reliability problems recently. It has been continually hampered by the government's requirement that electricity be sold below cost – far below cost on the outer islands – and the TEC's resultant dependence on subsidies for adequate cash flow.

Generation, transmission and distribution system, Funafuti

Generation on Funafuti is primarily by diesel at one power station (the Fogafale power station) located at the airport. Table 2.1 shows the installed generation capacity. Distribution is all underground at 11kV to local transformers and 400V for low voltage distribution to users. The 11kV system is in a ring main configuration around the heavily populated area allowing fault isolation without loss of power to most of the system but the extension to the wharf and beyond has no alternatives for feed so users at the end of the feeder always lose power when any fault anywhere on that line occurs. Much of the distribution is over 20 years old and is in generally poor condition. JICA is planning to fund construction of a new power house and TEC office, and intends the improvement of distribution to areas where a high security of supply is needed, specifically the new hospital and the wharf. It is assumed that repairs to the existing distribution will also be made where needed. All of Fogafale islet and neighbouring Tegako islet, connected by causeway with Fogafale, is now served by the TEC. Some separate islets of the atoll have small inhabited areas that continue to have no power or are served by solar home systems (Funafala) or stand-alone diesel power (Amatuku).

The Tuvalu Marine Training Institute (TMTI) on Amatuku, a small islet separated by a few hundred metres of reef from the part of Funafuti Atoll served by the TEC grid, currently has an independent diesel generator operated by TMTI though it has been proposed for future connection to the TEC grid via a short submarine cable.

The 1MW genset has had problems with the alternator and was out of service at the time of the country visit. With the peak load in 2003 at about 770 kW, there remained adequate capacity so long as all other engines remained operational although management expressed concern for system reliability when the new government office building comes on line with its estimated 350 kW of demand.

Fuel efficiency varies according to whether or not the optimum generator mix can be placed on line but is typically 3.5-3.8 kWh/litre, a reasonable figure for a diesel power plant feeding a load of the type found on Funafuti.

Technical losses are estimated at around 9% -10% which can be improved. Non-technical losses appear to be a relatively low 4%-5% of which some is due to un-metered street lighting. Fee collection tends to be high because TEC promptly disconnects non-paying customers although government customers tend to receive much more leeway than commercial or domestic customers.

Power upgrades and training have been provided by the EU, AusAID and JICA. In association with AusAID, training workshops have been held for outer island staff in electrical safety, maintenance and electrical theory. Top level staff has also received training in distribution management and generation maintenance in Japan (funded by JICA). The level of competency is good despite the continuing problem of losing technical staff to emigration or jobs outside TEC.

Generation, transmission and distribution system, Outer islands

In 2000, outer islands were switched from solar home systems to diesel grids except for Niulakita. Table 2.1 shows the installed capacity on each island. Unlike other Pacific outer island electrification, all island generation systems were done at the same time allowing unification of design, purchasing and installation. The entire rural electrification installation process was completed in a year using local budgetary sources. Except for Vaitupu, where there was already some electrification present, the spare parts stocks and training for all islands could be combined since all systems are essentially the same. All systems have multiple generators to provide for ease of maintenance and acceptable fuel efficiency at varying load conditions. All distribution is underground at low voltage. Plans are in place and most of the materials have been purchased to provide an 11kV connection between the three generation sites and load centres on Vaitupu – the main village, the national secondary school and the Agriculture Department centre.

Fuel efficiency for outer island generation is often poor, ranging from 1.81 to 3.06 kWh/litre. Data from outer islands operations is not considered reliable, however, and these figures need to be confirmed. If efficiencies are below 2.5 kWh/litre, modifications to engines or the system of operation need to be made.

Outer island energy supply originally was typically for 17- hours a day. It is now 18- hours a day. One month of trial with 24- hour operation on all islands in 2001 resulted in an increased average energy demand (and of course also fuel use) of 41% over that experienced with the then 17- hour power.

Pricing

Tariffs are set directly by cabinet. Effectively, there has been no domestic tariff change since 1982 since at that time there was a charge of $0.30/kWh for the first 100 kWh and $0.38/kWh for higher usage[11]. The tariff now has a flat structure with different levels for different customer classes. Currently the cost per kWh is $0.47 for commercial and government everywhere in Tuvalu. On Funafuti domestic customers pay $0.34 per unit. On the outer islands, they pay $0.30. Shortly after electrification of the outer islands, the TEC estimated the true cost of generation (excluding capital amortisation) to be over $1.50 per kWh. Generation on Funafuti is known to be well above $0.34 per kWh. Therefore there is need for a large annual subsidy to maintain a positive cash flow at the TEC. The highly subsidised tariffs do not reflect the true cost of service provision and encourage waste.

Regulation

There is no formal regulation of the TEC although setting tariffs does require a cabinet decision. The TEC regulates others through their imposition of Australian standards for wiring and safety in electricity system installation and servicing.

[11] *Pacific Regional Energy Assessment*, Vol. 11 Tuvalu, World Bank 1992

2.1.3 Renewables

Institutional Structure

There are no laws or regulations directly relating to renewable energy implementation. Each organization or agency using renewable energy typically seeks its own funding and makes its own arrangements for purchase, installation and maintenance of renewable energy systems. Where systems are being provided by an external donor, the energy office may act as the interface between the donor and the recipient organization.

The Tuvalu Solar Electric Cooperative Society (TSECS) provided the institutional structure for solar PV based rural electrification from 1984 to about 1996. Cabinet voted for its deregistration in 1999 and that action was carried out in 2004 with the transfer of its remaining responsibilities to government.

Telecom, with about 30kWp of photovoltaics installed throughout the islands, has the largest functioning renewable energy installations and their design, specification and implementation is all internal to Telecom.

Technologies

As in all of the Pacific Islands, cooking has traditionally used biomass – usually coconut husks and locally gathered deadwood – for fuel. As in all of Polynesia, the use of biomass for fuel has been steadily falling for the past decade and is being replaced by kerosene and LPG. Even on the outer islands, biomass is no longer a primary fuel for cooking with over 90% of 2002 census respondents citing electricity, kerosene and LPG as used for cooking. Biomass is known to remain in use on the outer islands for some cooking but as there are no recent outer island household surveys, its quantification is not possible.

Solar water heaters are used on some government housing and the government hotel but few private houses have installed a water heating device of any kind. There is limited demand for piped hot water for residences since in the hot climate bathing in cool water is preferred and with modern detergents, hot water is rarely used for clothes or dish washing.

Only solar photovoltaics has thus far been used successfully in Tuvalu for electricity generation using renewable energy. Although there have been installed a few Australian/American style multi-bladed water pumping windmills, they were not replaced when they failed or were damaged by cyclones and none are currently functioning. No trials of wind power for electricity generation have been made and none are planned.

Biomass (based on the replacement of senile coconut trees) has been proposed as a fuel for small steam generation for several atoll countries, but the decline of copra prices has made senile tree replacement uneconomic for most of the PICs. Also the limited supply of senile trees for fuel and the cost of conversion of senile trees to useable fuel combine to make the process of limited long term value. Should there be a rejuvenation of the coconut oil industry, a large scale replanting will probably be necessary and economic use of the senile trees should be reconsidered.

2.2 Energy Demand

2.2.1 Petroleum

Petroleum is currently the largest energy source used in Tuvalu, replacing biomass at some time in the 1990s. The marine transport and electric power sectors are the largest individual users of diesel fuel. Petrol is used for land transport on Funafuti and outboard powered private boats on all islands. The team estimates that on a national scale, petrol use for boats exceeds that used for land transport although there is no hard data available separating the two uses.

Kerosene is shared between domestic users and aviation. No data is available that separates the two uses. Domestic use of kerosene rose rapidly during the 1990s as it replaced wood for cooking. Today, LPG use is increasing as a replacement for kerosene, particularly on Funafuti where over half of households do some cooking with LPG. From the 2002 census data, it is clear that most households use several fuels for cooking since they cite electricity, kerosene and LPG use at the same time and this makes it impossible to accurately estimate domestic kerosene use without household energy survey data that clearly separates the fuel used in homes using several modes of cooking.

Data from a Vaitupu energy survey in 1989 indicates an average household use of kerosene for cooking of about 20 litres per month. On that basis, the 833 outer island households found in the 2002 census to use kerosene for cooking would use around 200,000 litres of kerosene a year. Assuming that around one-fourth of the cooking is done with kerosene in the 578 Funafuti homes that list kerosene as a cooking fuel, then that would add about 35,000 more litres of kerosene use for a total of about 235,000 litres per year for Tuvalu cooking. The 2002 kerosene import was stated by BP to have totalled 386,000 litres for aviation and domestic uses.

Table 2.2 – Petroleum Imports 1984-2003

YEAR	Petrol (kl)	ADO (kl)	Jet Fuel Kerosene (kl)
1984	365.2	490.5	421.1
1985	378.3	580.5	444.8
1986	410.3	635.4	450.2
1987	415.8	760.4	572.1
1988	455.2	650.8	585.4
1989	460.2	920.6	750.8
1990	487.6	850.6	860.5
1991	497.5	870.2	890.6
1992	530.8	1080	910.1
1993	598.7	1190	950.5
1994	636.5	1192	302.6
1995	582.8	1435	367.5
1996	256.3	1589	386.1
1997	450.6	1760	552.9
1998	n/a	1894	1,022
1999	514.3	1802	1,435
2000	n/a	1888	193.4
2001	702	2541	360
2002	794	2776	386
2003	784	2628	394

Source – James Conway and Statistics Department

Table 2.2 is a composite table with data from several sources. The 2001-2003 data is from BP Tuvalu records and believed to be of good quality. Other data was gleaned from various reports and statistics department data that apparently is based on customs records. The various sources were not consistent and it appears that some data may be based on dollar value though labelled as litres, some based on calendar year and some on fiscal year.

Air Transport

Since early 2003 when Air Kiribati ceased flights to Tuvalu, Air Fiji, partially owned by Tuvalu, has provided the only scheduled air service. Flights twice a week are scheduled and additional flights are added under special circumstances. The aircraft used by Fiji Air allow around 20 persons plus freight for each flight. Australian military flights also sometimes stop at Funafuti.

There is no internal air transport, so all aviation use can be considered as exported although in fact the regular Air Fiji service is strictly for the benefit of Tuvalu and fuel for that service probably should be counted toward Tuvalu's greenhouse gas production. However there are no records that could be made available that allow that use to be accurately separated from other uses of kerosene.

Industrial Thermal

The only use of thermal energy in the past for industry has been the drying of copra for export. The copra export trade has ceased due to the low prices in the world market and the increasing cost of labour on the outer islands.

Land and Marine Transport

Most land transport uses petrol. Use of outboard motors is common and on the outer islands is the primary use of petrol although on the larger islands motorcycle use is also significant. Land transport requirements for petroleum are modest with less than 100 automobiles, trucks and vans on Tuvalu's roads in 2002. Unfortunately sales data is not available that separates the use of petrol between land and water transport. BP estimates shipment of petrol to the outer islands to have been 278,000 litres in 2003 representing about 25 litres of petrol use per household per month.

Table 2.3 – Ownership of Bicycles, Hand Carts and motor vehicles

	Households	Bicycle	Motor Bike	Car	Truck	Van	Hand cart
Nanumea	128	103	65	1	1	1	45
Nanumaga	119	93	58	0	0	0	42
Niutao	143	111	55	0	1	0	13
Nui	108	83	47	4	2	1	21
Vaitupu	237	164	164	1	2	0	52
Nukufetau	118	72	7	0	1	0	35
Funafuti	639	197	423	61	29	28	107
Nukulaelae	68	48	4	0	0	0	19
Niulakita	8	5	0	0	0	0	0
TOTAL	1568	876	823	67	36	30	334
% Funafuti	40.75%	30.83%	66.20%	9.55%	4.54%	4.38%	16.74%
% rural	59.25%	73.09%	43.06%	0.65%	0.75%	0.22%	24.43%

Source – 2002 Census

There is little diesel fuel used for land transport thus diesel fuel for transport is largely used for inter-island shipping since no foreign fishing or merchant vessels regularly call at Tuvalu for fuel. The three government owned ships, the *Nivaga II*, the *Manu Folau* and are mainly used for inter-island voyages but also are used for external charters and infrequent voyages to Fiji or New Zealand for maintenance and shipping. The *Manaui* is not used for scheduled inter-island voyages but is sometimes used for inter-island charters and other non-scheduled voyages between islands as well as its intended use as a fisheries support vessel. Since virtually all diesel fuel is used either for marine transport or electricity generation, subtracting generation use from total imports indicates that in 2003 approximately half of diesel use, 1300 kilolitres, was for marine transport.

Electricity Generation

Petroleum use for electricity generation has risen at a rapid rate in the past fifteen years driven both by the addition of diesel powered electricity systems on all the outer islands (except Niulakita) and the increased use of air conditioning in government offices.

Table 2.4 – Diesel fuel use for power generation 2000-2002 (Fogafale power plant)

Funafuti Generation Statistics	**2000**	**2001**	**2002**
MWh generated	3555	4411	4658
Litres of ADO	1,001,200	1,271,660	1,325,560
Fuel efficiency kWh/litre	3.55	3.47	3.52

Source – TEC 2004

Household Lighting and cooking

Figure 2-2 – Solar lighting systems in Tuvalu

Herb Wade 1994

Virtually all household lighting is by electricity, although there remains minor kerosene use on outer islands since power is not provided 24- hours a day. Cooking is largely by kerosene but the specific amount of kerosene shipped to the outer islands was information that was requested but could not be provided. There are no data to show the relative use of kerosene, biomass and LPG in cooking on the outer islands so any estimates that are made will be only indicative. On Vaitupu in the late 1980s, household kerosene use for cooking was found to be about 20 litres/month per household, so on that basis outer island use for cooking is estimated at 200,000 litres/year.

Table 2.5 – Use of Cooking Appliances by Island										
Island	Households	Electric stove	Gas	Kerosene	Rice Cooker	Electric toaster	sandwich maker	Electric fry pan	Electric Kettle	Cake Mixer	Microwave Oven
Nanumea	128	1	4	114	4	2	7	2	13	10	1
Nanumaga	119	3	14	108	9	6	10	3	19	19	1
Niutao	143	0	14	119	6	3	3	1	18	24	0
Nui	108	3	11	97	6	9	12	6	17	17	1
Vaitupu	237	6	29	216	19	20	15	10	35	33	2
Nukufetau	118	3	16	110	9	8	11	2	17	9	1
Funafuti	639	27	335	578	147	204	198	77	261	206	34
Nukulaelae	68	1	31	62	5	2	2	0	10	8	0
Niulakita	8	0	0	7	0	0	0	0	1	0	0
TOTAL	1568	44	454	1411	205	254	258	101	391	326	40
% Funafuti	40.75%	4.23%	52.43%	90.45%	23.00%	31.92%	30.99%	12.05%	40.85%	32.24%	5.32%
% rural	59.25%	1.83%	12.81%	89.67%	6.24%	5.38%	6.46%	2.58%	13.99%	12.92%	0.65%

Source: 2002 Census

LPG

LPG is imported in container sized tanks by a private dealer independent of the petroleum supplier. Gas use grew very slowly in the 1980s and 1990s largely because pre-filled portable cylinders were imported at high cost from Fiji and empty cylinders returned, incurring another shipping cost. With the bulk shipments that have been received in recent years, 36.5 tonnes in 2003, the cost per filled cylinder is significantly lower and the cleaner, odour free and convenient cooking with gas has rapidly increased in popularity on Funafuti with over half of the households doing some cooking using LPG.

On the outer islands, there is no bulk delivery, so the problem of shipping filled cylinders and re-shipping the empties to Funafuti remains and the cost is somewhat higher. But even on the outer islands, around 13% of households use gas, up from almost none ten years ago, and its use is expected to grow further.

Figure 2-3 – Petroleum and LPG storage, Funafuti

Herb Wade 2004

2.2.2 Electricity

Household electricity use has remained relatively constant since the mid-1990s on Funafuti but has grown rapidly on the outer islands as households purchase refrigerators and freezers to connect to the grid supply. **Figure 2-4** shows the demand growth by sector. The rapid rise in government electricity demand before 1997 is attributed to the increasing use of air conditioning. The rapid rise in domestic use after 2000 is the result of electrification of the outer islands. The steady growth of commercial use corresponds to sectoral growth.

Table 2.6 - Number of TEC Customers by Island (2002)

Customer Type	Nukulaelae	Nukufetau	Vaitupu	Nui	Niutao	Nanumanga	Nanumea	Funafuti
Domestic	74	160	206	129	143	125	145	670
Commercial	2	2	3	2	4	6	4	138
Govt.	3	6	18	7	6	3	3	84
Total	**79**	**168**	**227**	**138**	**153**	**134**	**152**	**892**

Source - TEC

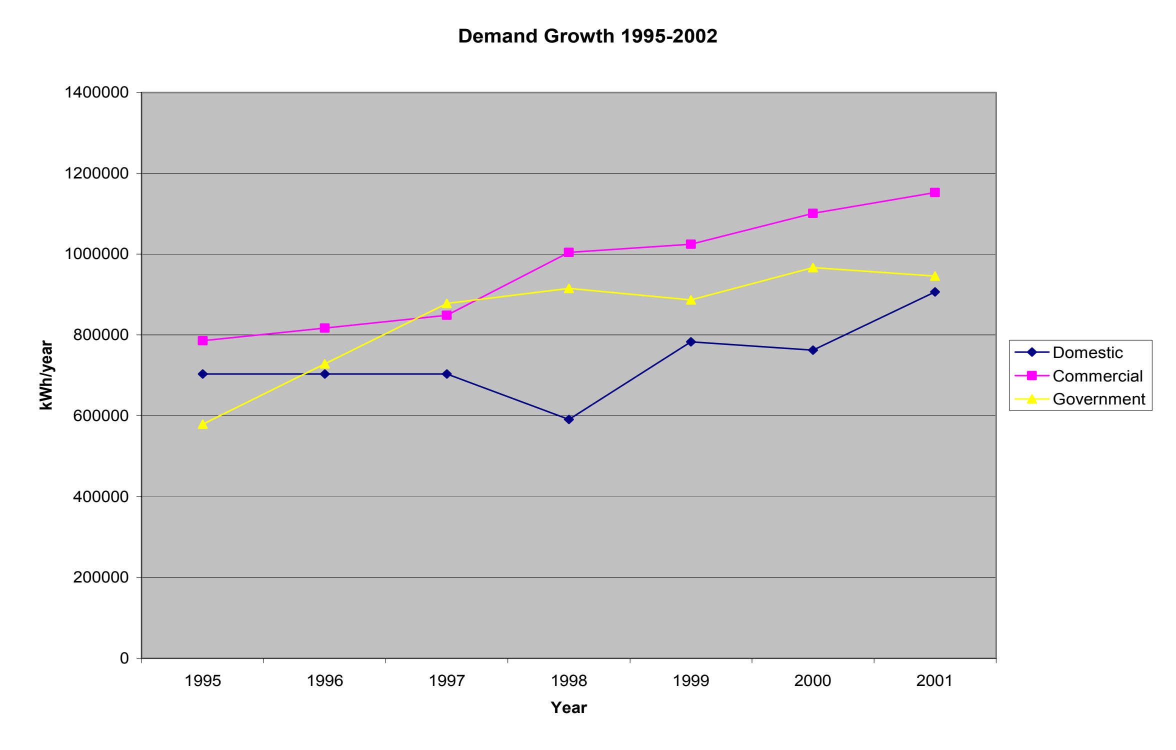
Table 2.7 – TEC Funafuti Statistics, 1999-2003

	1999	2000	2001	2002	2003
Generated MWh	3,117.0	3,224.0	3,555.0	4,411.0	4,658.0
Domestic customers	n/a	n/a	n/a	n/a	670
Commercial customers	n/a	n/a	n/a	n/a	138
Government customers	n/a	n/a	n/a	n/a	84
Total MWh sold	2,694.0	2,829.0	2,848.0	3,845.0	3,849.0
Domestic sales MWh	762.8	762.3	906.4	1,365.2	1,209.8
Commercial sales MWH	1,024.7	1,100.7	1,152.5	1,487.5	1,567.4
Government sales MWH	887.0	966.4	945.8	1,403.2	1,072.2
Fuel Used (kilolitres)			1,001.2	1,271.7	1,325.6
Max Demand	580	633.0	642.0	731.0	774.0
Station Use	124	119.8	111.0	122.2	142.0
Fuel Cost $/litre			0.7732	0.7672	0.7814
Oil use			1,800	3,478	4,936
Fuel Efficiency kWh/litre			3.55	3.47	3.51

Source – TEC

The outer islands are still well behind Funafuti in the ownership of small, but high demand, appliances such as electric kettles and toasters (Table 2.5) but as these items are common as Christmas presents from Funafuti and overseas relatives, their use is expected to rapidly catch up with that of Funafuti. Currently all outer island generation is less than a 24- hour supply with 18- hours typical. Long range patterns in the Pacific have been to gradually increase the hours of supply and once 24- hour supply is available another short but intense burst of appliance buying tends to occur with a corresponding increase in energy use. Month long trials of 24- hour supply were made in 2001 on all islands. The energy demand and therefore fuel use increased 41% over the use for the then 17- hour supply.

Figure 2-4 - Electricity Demand Growth by Sector 1995-2001 (Funafuti)



Source – TEC 2004

For the first half of 2002, The Funafuti power system had generation of 2,514,541kWh of which 2,152,945 kWh was sold, 50,880kWh was estimated as un-metered street light use and 69,622kWh as powerhouse use. Thus undocumented loss (mostly technical losses in distribution) was 241,105 kWh making technical losses about 12% of generation which is high for system technical losses. Total losses (un-metered loads, powerhouse use and undocumented losses) accounted for 14% of generated energy, an amount that can be substantially improved.

Domestic

In 2003, the average domestic use was around 180 kWh/month on Funafuti and about 45 kWh/month for outer island customers. The primary energy use in households in Tuvalu is for refrigeration. During the mid-1990s the TEC imported low cost, low efficiency refrigerators and sold them to TEC customers to facilitate the increase of electricity revenues on Funafuti. Largely as a result of that promotion, about half of the households on Funafuti have a refrigerator and about half have a freezer (some houses have both, they were counted independently). On the outer islands after two years of electrification, around 11% of households had a refrigerator and 38% had a freezer. Since the power is not on 24-hours, people often use freezers as refrigerators since they tend to have more insulation and are usually top loading, so the interior cold is held better during the time when power is off. Unless there is a substantial percentage of the freezer space filled with frozen foods, domestic freezers do not provide safe, long term frozen food storage when the power supply only operates around 17 -18 hours a day but they do provide adequate refrigeration for short term storage of food that is not frozen.

Table 2.9 – Major Appliances and Telephones by households								
Island	Households	Freezer	Refrigerator	Washer	Sewing Machine	Fan	Iron	Fixed Telephone
Nanumea	128	28	12	70	83	51	38	13
Nanumaga	119	49	7	69	80	57	36	16
Niutao	143	35	12	41	86	48	34	11
Nui	108	35	9	55	47	56	41	7
Vaitupu	237	104	37	130	141	114	130	11
Nukufetau	118	56	20	53	66	56	41	15
Funafuti	639	322	316	457	354	519	472	249
Nukulaelae	68	47	5	47	39	37	25	8
Niulakita	8	0	0	0	1	0	1	0
TOTAL	1568	676	418	922	897	938	818	330
% Funafuti	40.75%	50.39%	49.45%	71.52%	55.40%	81.22%	73.87%	38.97%
% rural	59.25%	38.11%	10.98%	50.05%	58.45%	45.10%	37.24%	8.72%
Source – 2002 Census								

Table 2.8 - Outer Island Power Statistics for May 2002 (17- hour power)[12]							
Characteristic	Nukulaelae	Nukufetau	Vaitupu	Nui	Niutao	Nanumanga	Nanumea
Generated kWh	4383	5723	21800	4754	4409	5144	6751
Sold kWh	4007	5518	16725	4518	4234	4922	4499
Peak Load (kW)*	15.3	20.7	65.1	16.2	18.3	21.6	20.3
Domestic sales kWh	3758	5222	13263	3844	3757	4017	3754
Domestic customers	74	160	206	129	143	125	145
Domestic kWh/customer	51	33	64	30	26	32	26
Commercial sales kWh	117	1 32	1281	566	372	577	525
Commercial customers	2	2	3	2	4	6	4
Commercial kWh/customer	59	66	427	283	93	96	131
Kaupule sales kWh	132	164	2181	108	105	328	220
Kaupule customers	3	6	18	7	6	3	3
Kaupule kWh/customer	44	27	121	15	18	109	73
Fuel Used litres	2375	2668	7150	2480	1856	2835	2206
Fuel Efficiency kWh/litre	1.85	2.15	3.05	1.92	2.38	1.81	3.06
Calculated system losses	9%	4%	23%	5%	4%	4%	33%
Source – Tuvalu Electricity Corporation Operations Report Jan-July 2002							
*Nanumea, Nanumanga and Nukulaelae peak load data is for June 2002, May data was not available							

A problem that the outer island power systems face is that all refrigerators and freezers tend to start as soon as power returns creating a very high demand for starting all the

[12] Nanumea generation data is considered suspect due to the unusually high fuel efficiency and unusually high system losses. A more reasonable figure for generation would be around 5075 kWh resulting in a fuel efficiency of 2.30 and losses of 11percent.

motors and higher than normal power to keep them all running simultaneously for an hour or two before their thermostats begin cycling the motors. With 24- hour operation, the motors tend to cycle more randomly and peak demand tends to be lower for the same appliance mix.

As Table 2.9 shows, there is a high percentage of ownership of washing machines and irons, even on outer islands (50% have washers and 37% irons) which also can create problems of excess demand. Some small island power systems in the Pacific divide households into two groups, one that is asked to do washing and ironing in the morning and one that is asked to schedule it for the afternoon in order to help even the load over the day.

A clear indicator of the relatively high availability of money to households on the outer islands is the presence of video systems in over 30% of rural homes. There is no broadcast TV and there are no satellite TV systems on the outer islands so VHS tape, DVDs or VCDs are required for playing. A substantial business on Funafuti and the outer islands has evolved around their supply, mostly in the form of short term rentals.

Table 2.10 – Use of Entertainment Appliances by Island

Island	Households	Radio	Stereo	TV	VCR	DVD	Video or Digital camera	PC	Other
Nanumea	128	63	50	35	49	20	7	0	2
Nanumaga	119	55	40	42	42	23	5	2	0
Niutao	143	41	50	51	46	22	3	1	1
Nui	108	56	38	38	35	13	3	0	1
Vaitupu	237	123	87	76	96	34	9	1	1
Nukufetau	118	58	38	46	33	22	8	1	1
Funafuti	639	308	369	416	389	217	135	87	5
Nukulaelae	68	34	24	29	31	13	2	0	0
Niulakita	8	4	1	0	0	0	0	0	0
TOTAL	1568	742	697	733	721	364	172	92	11
% Funafuti	40.75%	48.20%	57.75%	65.10%	60.88%	33.96%	21.13%	13.62%	0.78%
% rural	59.25%	46.72%	35.31%	34.12%	35.74%	15.82%	3.98%	0.54%	0.65%

Source: 2002 Census

Computers are rare in households on the rural islands and in 2002 were found in only 13% of Funafuti homes where there is much better access to software and lower priced used computers are often available. Also, frequent contact with computers in government offices has resulted in higher computer literacy on Funafuti particularly among civil service personnel. Internet access remains expensive in Tuvalu and therefore does not provide the strong incentive for having a computer at home that has developed where access is low cost.

Commercial

By far, the largest user of electrical energy is the Tuvalu Cooperative Society (TCS), the importer and distributor of most food products in Tuvalu. Its electricity use of nearly 30MWh/month is mostly for cold storage of produce and meats in cold storage containers and at the Fusi (cooperative store) retail outlets.

Telecom is the second largest energy user using around two-thirds of the energy of the TCS and the Vaiaku Lagi Hotel is a distant third with its use of around 8,000 kWh/month.

Figure 2-5 - 20 Largest Electricity Users kWh/month (2003)

Class	Name of Customer	kWh
Commercial	Tuvalu Cooperative Society	26,986
Commercial	Telecom	18,777
Commercial	Vaiaku Lagi Hotel	8,080
Commercial	Tuvalu Media Corporation	6,221
Government	Hospital	6,033
Government	MET Station	4,558
Commercial	National Bank of Tuvalu	4,512
Commercial	EKT (Tuvalu Church) Main Office	3,748
Government	PWD	3,460
Commercial	NaFICOT	3,457
Government	Marine and Port Services	3,297
Government	Education	3,279
Government	Local Government Offices (Funafuti)	3,217
Government	Waste Management Office	2,776
Government	Main Wharf	2,726
Government	Tuvalu IT	2,082
Commercial	Alpha Pacific Navigation B	1,886
Government	Customs Office	1,822
Government	Disaster Management Office	1,707
Government	Treasury Dept.	1,682

Source - TEC

Government

The new Princess Margaret Hospital is the largest government electricity user on Funafuti. Schools on Funafuti do not board students, so there are no kitchen, dormitory or food storage facilities. Office equipment and a few air conditioners comprise the main load so in general Funafuti schools are not heavy energy users.

The Vaitupu secondary school is the only secondary school in Tuvalu that boards students. Its load is the largest single load on Vaitupu and one of the largest loads in the nation. When it was refurbished and upgraded with Japanese funding in the late 1990s, an independent power plant for the school was installed with operation under the TEC. With the completion of the TEC grid on Vaitupu and its connection to the school, that plant remains available to supplement the grid supply and as a standby generator.

Government, in the decade between 1987 and 1997, was the fastest growing load on Funafuti, mostly through increasing use of air conditioning and computers. The offices that were air conditioned were not designed for interior climate control but for natural ventilation and included louvered windows and large open spaces. Air conditioning has been through the use of room sized units making the overall efficiency of electricity use for air conditioning quite low.

Figure 2-6 - New Government Building, north wing

Herb Wade 2004

The fall in government energy use in 2002 was caused by the shift of offices from the old government facility into temporary offices awaiting completion of the new office building. The massive new government office building located near the airport on Funafuti was funded through a grant from the Republic of China (Taiwan). It will combine most of the government offices into one building that has zone regulated central air conditioning. Although its exterior envelope design is not well suited to the tropical Pacific climate with its large expanses of windows that are oriented to capture the sun's heat in the morning and afternoon, the air conditioning machinery will at least operate more efficiently. Theoretically, when the new building is occupied, the total electricity demand by government will rise from an estimated 174 kW demand for the old offices to 360 kW for the new building. But the offices being vacated are not likely to remain vacant long and the load in two or three years can be expected to be even greater than that seen immediately after occupancy of the new building.

2.3 GHG Reduction Potential

Renewable energy and energy efficiency measures can have an impact on carbon dioxide emissions and there is some potential for methane emission reduction if urban waste is pre-processed for controlled methane production and burning instead of atmospheric release.

2.3.1 Carbon Dioxide

Growth in electricity use is expected through increased use of appliances, particularly on the outer islands, and increased commercial energy use as the economy grows. Kerosene is expected to be largely replaced by LPG during the next decade. Marine use of fuel will probably increase slowly since greatly increased ship traffic between islands is not likely and rapidly increasing fishing boat use is also unlikely.

2.3.2 Opportunities for Reduction

If, by 2013, all outer islands electricity generation were converted to 100% renewable energy and renewable energy plus energy efficiency measures replaced 25% of energy used for electricity generation on Funafuti, there would be approximately 1.5 Gg of CO_2 saved. If transport efficiency measures were to reduce transport fuel use by 10%, an additional saving of 0.7 Gg of CO_2 could be saved for an overall saving of about 2.2 Gg or a reduction of about 17% over the 2013 projected emissions. To accomplish this is considered the maximum possible for the next decade. To achieve this reduction would require elimination of most barriers to renewable energy development and aggressive investment programmes for solar PV and biofuel production plus strong measures to control the growth of the use of petroleum for transport.

Table 2.11- Petroleum imports for 2003 and projections for 2013 (splits for kerosene and ADO estimated)

	2003						2013			
Fuel	KL	KT	TOE	GHG (t)	GHG (Gg)	% of GHG	AAGR	KL	GHG (Gg)	% of GHG
Motor Spirit	784	572	624	1,960	2.0	*19.1%*	4%	1,161	2.9	*22.5%*
Jet fuel	194	154	168	560	0.5	*4.9%*	2%	236	0.6	*4.8%*
Kerosene	200.0	157.5	171.7	560.0	0.6	*5.5%*	-2%	163	0.5	*3.5%*
ADO for electricity	1,400	1,176	1,271	3,780	3.8	*35.9%*	3%	1,881	5.1	*39.2%*
ADO marine use	1,230	1,034	1,116	3,321	3.3	*32.4%*	1%	1,359	3.7	*28.3%*
Lubricating oil	5	5	5	13	0.0	*0.1%*	3%	7	0.0	*0.1%*
LP Gas	71.5	36.5	42.7	114.4	0.1	*1.1%*	6%	128	0.2	*1.6%*
Total	*4,085*	*3,294*	*3,571*	*10.252*	*10.3*	*100.0%*	1.9%	4.935	*13.0*	*100.0%*

Note: no data is available on lube oils so conversions are estimated

Table 2-12 summarises the likely maximum potential GHG reductions from renewable energy and energy efficiency by 2013: 2.2 Gg or 17% of 2013 emissions. Of this, about 36% would be from renewable energy and 64% from efficiency measures.

Table 2.12 - Indicative Maximum Fuel Savings & GHG Reductions, 2013

Resource or technology	Potential fuel savings	Potential CO_2 savings (Gg / year)	% of total savings	Comments
Solar and biofuel	282 KL	0.8	36 %	15% of ADO used for electricity
Energy efficiency Electricity [13] Transport [14]	 240 KL 152 KL	 0.7 0.7	32 % 32 %	 15% of ADO for electricity 10% of ground transport fuel
Total		2.2	*100 %*	

Source: mission estimates

[13] There is considerable scope for demand-side management measures in Funafuti, especially in building energy use. Energy efficiency measures for electricity could save 15% of the volume of fuel used for electricity generation in 2013, that is 15% of 1,881 KL = 282 KL. However, if 15% of all ADO for electricity is displaced by biofuels and solar PV, then the GHG savings to Tuvalu would be 85% x 282 = 240 KL, or 0.65 Gg. There would be an additional 42 KL of fuel saved which would be from renewable energy and not reduce GHGs.

[14] Energy efficiency measures for transport could save 10% of the 2013 ground and marine transport fuel use or 0.1 x 1161 KL (petrol) plus 0.1 x 1,359 KL (distillate) = 152 KL, which would reduce GHGs by 0.66 Gg. It is assumed there would be no efficiency savings in air transport.

3 Renewable Energy

3.1 Resources

3.1.1 Solar Resource

The Forum Secretariat installed a solarimeter in Tuvalu in the mid-1990s and the New Zealand Meteorological Service was contracted to collect the data and make it available to the Forum Secretariat and Tuvalu. Unfortunately shortly afterward the New Zealand Meteorological Service was privatised and the data was never provided. However, the long term use of solar photovoltaics for lighting and small appliance use as well as for Telecom station power has adequately demonstrated that Tuvalu has sufficient solar resources to allow cost effective development for many applications.

Since atolls have little affect on local oceanic weather patterns, the NASA satellite solar radiation measurements for the ocean around the islands of Tuvalu have reasonable accuracy. The NASA measurements for central Tuvalu indicate an annual average of 5.54 $kW/m^2/day$ at the optimum tilt angle for the solar panels. This is consistent with the known performance of solar PV installations on Funafuti.

Table 3-1 – Satellite based solar radiation data for Tuvalu – tilted surface

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
5.24	5.03	5.11	5.59	5.65	5.66	5.58	5.80	6.02	5.75	5.77	5.31	5.54

Source – http://eosweb.larc.nasa.gov/sse/

Tuvalu has a long north/south span. It is reasonable to expect the solar resource to vary from north to south and a resource assessment is need to determine the real resource available on each island so that engineering designs can be optimised for any future grid connected solar installations to supplement the existing diesel powered grid.

3.1.2 Wind Resource

There has been no attempt to measure the wind energy resource in Tuvalu. Meteorological measurements indicate a seasonal, highly irregular pattern of wind speeds below the 5-6 m/s average generally considered the minimum for cost effective energy production. Given the very limited land area of the atolls and the land tenure problems associated with the use of land, siting of large arrays of power generating wind machines on land may be difficult. Also, the tall coconut trees would have to be cut back some distance from the machines to ensure that the turbines would have full access to the wind. Thus if wind power were to be used in Tuvalu, locating the machines on the circling reef or in the lagoon may be the most practical option. Unfortunately, that introduces the need for high cost undersea electrical cabling and an increased maintenance cost for the machines themselves. This will increase the wind speed requirement for a cost effective resource.

Despite the probability of the economics for wind power being unsatisfactory now, the future may bring the price of imported energy to a level that will allow wind power to provide energy at a comparable or lower cost, so it is recommended that a good quality wind energy resource assessment be carried out for Funafuti with measurement tower sites located where wind machines would be most likely to be installed.

3.1.3 Biomass Resource

Biomass

In an atoll situation, the turnover of biomass is relatively slow, relating to the poor soils and growing conditions, so there is little opportunity for establishing biomass plantations for energy production. The scale of agricultural processing is also unlikely to be great enough to make biomass energy generation cost effective. The only significant biomass resource is coconut trees. Biomass energy based on the replacement of senile coconut trees has been considered as a fuel for small steam generation for several atoll countries but the decline of copra prices has made senile tree replacement uneconomic for most of the PICs. Also the limited supply of senile trees for fuel and the cost of conversion of senile trees to useable fuel combine to make the process of limited long- term value. Should there be a rejuvenation of the coconut oil industry, a large scale replanting will probably be necessary and economic use of the senile trees should be reconsidered.

Table 3.2 – Biomass Distribution in Tuvalu

Type	ha	Percent
Coconut woodland	1,619	53.9
Broadleaf woodland	122	4.1
Coconut & Broadleaf	51	1.7
Scrub	419	13.9
Pandanus	10	0.3
Mangroves	515	17.1
Others (e.g. low ground cover)	33	1.1

Source: SOPAC

Unfortunately, good quality numerical data regarding the productivity of various components of the biomass resource are not available for Tuvalu though, as with other atoll countries, it appears that there are sufficient biomass resources for household use, including crop drying, but not for sustained, large scale power generation.

Biofuel

About half of the land area in Tuvalu is classed as coconut forests and the coconut is the only significant tree resource. In 2002, and other years recently, copra exports actually fall on the expenditure side of the balance sheet as a result of government production subsidies, which, for example, were roughly 400% of the export price in 2002. In 2002, the government spent $140,000 on copra subsidies that generated an eventual production rate of 107 tonnes, which is equal to $1309/tonne. This is more than double the nominal $605/tonne earned in 1984 when export prices peaked. Although the government spent $140,000, this generated only $26,750 in underlying export earnings and did not produce the desired growth in export earnings.

Since biofuel in the atoll context means coconut oil, the problem is the same as with copra production: the cost of oil production with the labour cost in Tuvalu is too high to compete with diesel fuel. The oil cost without major subsidies significantly exceeds the cost of diesel fuel anywhere in Tuvalu. Only in those countries where rural labour prices are very low – such as Vanuatu, PNG, the Solomon Islands and possibly Kiribati – does it appear that coconut oil can be price competitive with diesel fuel at today's prices and without subsidy.

However, developing coconut oil as a fuel does represent a possible hedge against major price increases for diesel fuel or the disruption of supply due to a major war in the Middle East. So detailed planning for the replacement of diesel fuel with coconut oil does appear to be a reasonable activity as do small scale trials of oil production and its use for generation on outer islands in order for personnel to gain necessary experience and for the development of institutional systems that can be efficiently extended for larger scale production if needed. In particular, should the long range plan of increasing solar input to outer island power systems be implemented, using coconut oil to run the stand-by diesel engines to supplement the solar panels during long cloudy periods may make good economic sense as well as completely removing the need for fuel imports to the outer islands for power generation.

Biogas

On most of the islands of Tuvalu, pigs remain free-ranging although the Kaupule (Island Councils) have been moving toward requiring penning of household pigs. There is some potential for biogas generation if community pigs could be kept penned in a small area that was associated with a biogas digester to both produce gas and reduce the waste disposal problem. However, to be useful for energy it would be necessary to include equipment for gas compression and storage with either piping to nearby houses or additional compression into pressure cylinders of the same type as are used for LPG.

In China, for example, digesters are installed for households with two or three pigs. The household can combine the pig waste with the human waste in the small digester and if properly maintained it will produce sufficient biogas for all household cooking needs. In Fiji, Chinese style digesters are installed on small dairy farms and the waste colleted at milking times provides sufficient methane gas for all household cooking needs with some surplus for hot water production. Since methane is 21 times as potent a greenhouse gas as carbon dioxide, its use as a renewable energy resource is particularly valuable from an environmental point of view.

3.1.4 Hydro Resource

There are no hydro resources in Tuvalu.

3.1.5 OTEC Resource

Although there is known to be an accessible OTEC resource in Tuvalu, the technology has never been used in a commercial installation and despite 20 years of experimentation has not moved into even the pilot stage of commercialisation. In any case, most independent analysts consider the smallest economically attractive OTEC installation to be far larger than the power demand on Funafuti is likely to ever be and for that reason alone it appears unwise to spend much time and money in a detailed resource survey.

3.1.6 Geothermal Resource

There is no known geothermal resource in Tuvalu.

3.1.7 Wave Energy Resource

Although there is known to be a moderate wave energy resource in Tuvalu as based on wave energy measurements funded by the Norwegian Agency for International Development (NORAD) and carried out by OCEANOR during 1987 to 1995 for SOPAC[15], there is no commercially available, cost effective conversion equipment available for installation. A number of companies and laboratories are experimenting with different technologies to convert wave energy to electrical energy but none are past the trial stage. Of particular concern for wave energy is the significant risk of damage by cyclone passage when the associated wave energy is very high.

3.2 Appropriate Technologies for Development

The only renewable energy technologies with operational experience in Tuvalu are the combustion of biomass on a small scale, small wind powered water pumps and solar photovoltaics for off-grid power. Solar water heating, biogas, biomass and biofuels are likely to be economically appropriate for development under conditions that may exist in the future. Wind power may also be appropriate but the resource needs to be further investigated before proceeding with trials.

3.2.1 Solar photovoltaics

Grid connected solar PV can be used to reduce fuel imports. The high cost of generation on the outer islands makes inclusion of PV as a supplement to the existing diesel general reasonable. Although there is more opportunity for supplementing the grid with PV on Funafuti, the economics are not so favourable since the cost of supply is much lower. Development of PV for grid connection is recommended to be in the form of multiple 4-10 kW power modules complete with panels, battery storage and inverters rather than a single large PV system. This approach allows the use of lower cost commercial grade batteries and a more cost effective maintenance system.

There remain some households on most islands that do not have access to the grid. Solar home systems of a size that can provide the households with their electrification needs can be made available with maintenance provided through the TEC technical staff on each island.

3.2.2 Solar Thermal

At this time, there is little demand for water heating outside of visitor accommodations and the hospital. Should a market develop for piped hot water for households, solar water heating should be promoted by government though information programmes and incentives for their installation. Local plumbing and building businesses should be encouraged to stock, sell and install solar water heating units. The market is too small, however, to support the development of manufacturing of SHW units in Tuvalu.

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[15] Barstow, S.F. and Haug, O., *The Wave Climate of Tuvalu*, SOPAC Tech. Report no. 203 1994

3.2.3 Wind energy

Wind power has not yet been used successfully in the Pacific as a long term energy source, partly due to a marginal wind resource, partly due to unexpectedly high maintenance costs and partly due to cyclones damaging installed units. In Tuvalu, until at least two years of continuous resource assessment has been completed that show an economically useful, developable resource, wind power systems are not appropriate for deployment for power generation.

A particular problem with wind power on atolls is the prevalence of coconut trees. A wind turbine must be well above trees or located in an area far from tall trees. To get above the coconut trees would require a very tall, expensive mast. To find an area far from tall trees either would require an offshore or reef installation or the clearing of a large land area, which on an atoll would represent a significant portion of the total habitable land. While lagoon or reef mounting of a wind machine is technically possible, the cost of submarine cabling and the difficulty of maintenance are problems that can offset the relatively low capital cost of wind turbines.

3.2.4 Biofuel

Coconut oil as a diesel fuel replacement shows technical promise, has been used successfully for many years in other countries and is a resource that can be developed in Tuvalu. The primary obstacle is economics and as the price of diesel fuel rises, coconut oil will probably at some point become a cost effective replacement.

Coconut oil is a renewable energy source complementary to the use of solar PV for electricity generation on the outer islands of Tuvalu. When the percentage of total energy demand provided by solar PV reaches about 70%, the marginal cost for each additional percentage increase goes up rapidly because the size of the array needed to cover long cloudy periods for a specific energy requirement rapidly becomes larger as the required percentage of reliable power provision approaches 100%. Adding coconut oil fuelled diesel generation to handle the last 15-20% of energy needs would be much more cost effective than attempting 100% renewable energy by solar PV alone.

Biofuel is the only renewable technology that can be adapted easily for transport use and since it represents a good complement to solar or wind energy by providing back up diesel power during low periods of wind or solar, it is reasonable that the development of coconut oil as a fuel be the subject of planning and trials in the near future.

3.2.5 Biogas

It would be possible to provide useful cooking gas from a piggery based biogas digester if community pigs were kept in a concentrated area that was designed to allow easy collection of wastes and their transfer to a digester. If development of a community pig housing area or commercial piggery is undertaken, including a biogas digester would allow not only the production of cooking gas but also would help dispose of waste.

Urban waste disposal also offers an opportunity for biogas generation. As a part of the Funafuti waste disposal development work, there should be consideration of biogas generation as a part of the project though experience in other Pacific Islands with small scale trials of the technology have not been encouraging.

3.2.6 OTEC

Ocean energy technologies have a long period of technical and commercial development ahead of them before Tuvalu can expect to be able to find them suitable for power generation.

Hawaii based OTEC expert, Dr. Luis Vega, notes that *"Technical and economic studies as well as experimental work have been conducted by numerous private and public entities in France, Japan and the USA. It was concluded that, for example, in Hawaii electricity production with OTEC technology is cost effective for 50 MW or larger plants. This conclusion is independent of the type of OTEC power cycle (i.e., Open, Closed, Kalina or Uehara) utilized. Moreover, it was concluded that commercialisation ought to be preceded by the design, installation and operation of a pre-commercial plant sized at about 2 to 5 MW…The situation in some Pacific Island Nations is such that smaller OTEC plants (e.g., 1 to 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."*[16]

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

4 RENEWABLE ENERGY EXPERIENCE

4.1 Solar Photovoltaics

Except for cooking with fuel wood, very small scale coconut oil production (at a small Vaitupu oil expeller facility intended for soap production, not for energy) and attempts to provide outer island households with high efficiency wood stoves (by SCF) for cooking with biomass, solar photovoltaics is the only renewable technology used in Tuvalu. Although there were PV panels used by Telecom and SCF had tried PV in a few households as early as 1980, the formation of the Tuvalu Solar Electric Cooperative Society by the SCF in 1984 was the first organized effort to develop renewable energy for more than specialty use in Tuvalu.

The TSECS was designed by the SCF as an Energy Service Company (ESCO) that would own the PV systems, maintain them and would receive their funding from the collection of fees from users sufficient to pay the cost of maintenance and of replacement of components when they failed. The institutional design was based on the Fiji 1983 village cooperative scheme but to avoid the capacity limitations of village level cooperatives that caused the projects in Fiji to fail, a national cooperative was formed in the hope that the broader base would allow the development of professional management and a well trained technical staff and allow greater fee collection discipline than can be maintained at the village level.

Figure 4-1 – Outer island SHS

Herb Wade (1995)

The TSECS as a cooperative was operated by a committee of COOP members, the TSECS Management Committee, elected by the membership. Members were households that paid an $50 membership fee to receive an SHS and agreed to pay $6.25/month as a service fee. The Management Committee hired a General Manager and had oversight and approval of the General Manager's activities including hiring of staff and budgets.

The SCF managed the COOP from 1984 to 1988 when SCF pulled out of Tuvalu leaving the TSECS to the Management Committee and the local manager that had been put in place by the SCF. That manager soon left the TSECS and the Management Committee hired a new General Manager who was in office until 1994 when he was fired and jailed for stealing the TSECS cash reserves. After that trauma, the TSECS appeared to lose its ability to function rationally as an organisation and did not operated as an actual ESCO after about 1996.

From 1984-1994, many of the TSECS customers that had system failures had to wait long periods, in some cases up to two years, to have their systems repaired because the TSECS refused to use the money that had been collected from users for the purchase of replacement parts and instead waited for new batteries or controllers to be provided by donors. After 1996, the island technicians were left to their own devises and were inconsistent in their quality of service. On some islands, many of the systems were out of service more often than not. Matters in the field and in the Funafuti office were very disorganized. Records were sparse and there was confusion regarding the tariff to be collected. Many of the customers' systems did not fall into the categories defined by the tariffs since most households had lights removed, failed, or never installed. To pacify customers the senior technician granted some islands a 50% discount without central office approval or knowledge. By 1998 the TSECS had devolved into individual island solar collectives with local technicians paid *ad hoc* for services by customers.

In 2000 the TEC installed diesel generation on all outer islands except Niulakita making the SHS and TSECS redundant. The TSECS still has not been disbanded although its organized activities ceased years ago and a cabinet directive for its dissolution was issued in 1999. Until the TSECS accounts are closed out, its assets – including around 40kWp of solar panels and some other useable components on outer islands plus its office building on Funafuti – remain in legal limbo. The TSECS General Manager and Senior Technician are now paid by government and sit in the office of the Energy Planner to assist in the operation and maintenance of energy office managed renewable energy projects.

At its peak, over 400 households, around 40% of those on outer islands, were provided lighting by the TSECS. The initial systems were powered by a 35Wp panel but over the years, system size increased to as much as 150 Wp for a house and trials had begun for the provision of much larger systems for refrigeration and video use at the time of the COOP collapse in 1994.

The TSECS was wholly capitalized by aid donor gifts and all replacement components were provided by donor gifts. The collected money, mostly siphoned off by the corrupt general manager, was never used for anything except for paying labour and administrative costs.

The first five years of TSECS operation were characterized by technical problems and their solution with user service irregular and only fair in quality. After 1988 and system upgrades by donors, system reliability increased and until the COOP collapsed financially in 1994, the ESCO performed generally quite well and customer satisfaction was rated as high. After 1994, service quality remained reasonably good for about two years because of the new EU equipment that had been installed but without adequate maintenance the service rapidly degraded thereafter. More details on the TSECS history are in Annex 3.

TSECS characteristic	Comment
Location of the project	All islands of Tuvalu
Operational dates	1984—1994 fully active, 1995-2000 increasingly inactive, 2000-present moribund
2003 operational status	Inactive. Management staff now under the energy office, field operations ceased. Electrification now by diesel grid systems on all islands except Niulakita.
Primary objectives	To meet the basic electrification needs of off-grid households and health centres through the provision of SHS to provide lighting and basic entertainment appliance needs. To grow with the needs of the people to provide for a larger range of appliances when demand increased..
Population served	All off-grid households. About 400 households actually served, off grid clinics
Funding arrangements	USAID 1984 – 170-35Wp SHS, 2-15W tube lights, no controller EU 1985 – 150-42Wp SHS, 2-16W lights, controller, 90Ah battery, DC/DC converter, NiCd battery charger France 1987 – 170-S.P.I.R.E. controllers, Varta 100Ah batteries EU-1988-90 – 160-55Wp panels, 165 Oldham 100Ah batteries, 175 S.P.I.R.E. controls FSED 1992 – 125-12V, 120Ah BP Solablock batteries France 1991 – 560Wp panels, GIE Soler Refrigerator, S.P.I.R.E. controls, 435Ah 24V battery, 4 CFL lights for clinic installations on 7 islands EU1994 – 60-100Wp SHS, S.P.I.R.E. control, 100Ah Oldham battery, 2-11W,1-7W CFLs EU1994 – 220-50Wp panels to upgrade all customers desiring increased service EU1994- 8 solar fridge trial units including 600Wp panels, 425Ah@24V batteries, S.P.I.R.E. Controller, Soler Energie Refrigerator, 4-CFL lights
Implementation arrangements	TSECS installation and maintenance. Designs by donor agencies. 1985 EU project supported by FSED. Other French and EU projects supported by FSED, S.P.I.R.E. and GIE Soler, Tahiti
Source of maintenance and operation funds	Fees supposedly. Actually, all replacement components were provided by donors.
What input comes from recipients	$50 connection fee (TSECS membership share payment), $6.25/month fee
Local involvement in project implementation, operation and maintenance	Local island technicians trained and used for maintenance but paid by TSECS (until the late 90s when payment began to be direct from users.
Capacity building components	Multiple training experiences in Fiji, Thailand and Tahiti for TSECS manager and senior technical staff. Training for local technicians in 1989 by outside trainers. On the job training during installations
Relative success at achieving project objectives	After five years of solving technical problems, service provision was good and customer satisfaction good with a 200 household waiting list for more systems. After 10 years, the General Manager embezzled most of the cooperative's funds and the TSECS collapsed due to bad decisions by the Management Committee apparently resulting from the trauma of the bankruptcy of the cooperative by its manager.
Project characteristic	Detailed comments about the project characteristic

TSECS characteristic	Comment
Primary problem areas	Initial problems, 1984-1990, were technical with undersized panels, badly designed controllers, poor quality of battery. By 1990 panel size had increased to a minimum adequate size, high reliability S.P.I.R.E. controllers had been installed and deep discharge, long life batteries were in place. After 1990 the problems have largely been institutional with inadequate fiscal controls allowing major misuse of funds, micro-management by the Management Committee paralysing operations and a lack of will on the part of the Management Committee to enforce collections and to spend money for repair of systems when needed. In 2000 diesel grid systems were installed on all outer islands except Niulakita making the PV systems unnecessary for most households.
LESSONS LEARNED	The primary determinate for long term success was institutional not technical. Components have to be carefully selected to provide good service in remote Pacific Island conditions The quality of post-installation support is critical to sustainability Users paid fees consistently if reliable service was provided. They did not pay if service was not good System abuse was minimal when desired services were provided. When desired services were not available, people abused systems trying to get them The COOP structure has basic flaws that make it unsuitable for ESCO type of institutional structure in Tuvalu and most Pacific Islands due to inadequate fiscal oversight and poor objectivity by membership committees setting policies.

In 1999, Government identified a need for solar powered water pumping systems for five outer islands that could pump water from the fresh water lens lying under the atoll surface. The water would be used when rainwater does not meet the needs of the populace. On some islands, these pumps would replace windmill pumps that were no longer working. Five BP-FP2-11-8 solar pumping system were purchased for installation. Each consisted of:

- 1 – stainless steel floating pump with 1500 W DC brushless motor
- 14 – 80Wp 36cell PV panels
- Motor controller – maximizer
- Cables, float switch and mounting hardware

The pumps have been installed on Vaitupu and Nukufetau with Nanumanga, Nanumea and Niutao yet to be installed. Nui declined an installation because of fear of over pumping the lens and causing salt water entry to wells and Taro pits.

4.1.1 Current Projects

In 2000, the island of Niulakita was not considered large enough to warrant installation of a diesel generation scheme under the TEC and solar electrification was planned. Although there were several TSECS installed solar systems on the island, they needed rehabilitation and additional systems were needed to complete electrification of the 8 households and other facilities on the island. In 2002 it was decided to use government funds to purchase 20 systems for installation on Niulakita and for spare parts. Existing clinic and telecom installations were upgraded. The systems were designed by the Energy Planner and included 100Wp of solar panel, a semiconductor type Morningstar controller, a Fiji made 65 Ah C_{10} Pacific Battery unit for storage and three 7 W CFL Solsum (Germany) brand lights. The systems were installed in 2003. Maintenance is by local technicians with support as necessary from the energy office. Government has accepted the responsibility for long term maintenance and battery replacement. Fees for system use were established but collection rates were poor because of limited cash availability on Niulakita. Recently the Energy Office has worked out a scheme for residents to pay for service through the delivery of comparable value in fresh coconuts instead of cash and a system for payment is being worked out by the Energy Division. The initial response to this method of payment by users on Niulakita has been positive.

4.1.2 Confirmed Future Projects

There are no confirmed renewable energy or energy efficiency projects although French funding is being negotiated for further solar implementation on the outer islands.

4.1.3 Proposed Projects

- To combine the existing solar panels and additional donor provided panels with the diesel systems to make hybrid systems that can operate with a lower fuel input per kWh delivered.
- Wind energy resource assessment on Funafuti.
- Solar energy resource assessment on all islands using good quality solarimeters mounted at the tilt angle used for PV panels, not horizontally as normally used for meteorological measurements.
- Feasibility study and a concentrated planning effort for coconut oil production on outer islands to supplement diesel fuel for electricity generation.
- Feasibility study on the economic use of senile coconut trees removed for replanting with higher yield varieties.
- Small scale trial of outer island biofuel production.
- Feasibility study of community piggeries with associated biogas production.

5 Energy Efficiency

Where renewable energy must be integrated into a conventionally fueled energy systems, such as is now the case in Tuvalu, it is important that there be minimal waste of the high cost energy from renewable sources. Therefore in a fully electrified country like Tuvalu, it is important to pair energy efficiency measures with the development of renewable energy as a replacement for fossil fuel use.

5.1 Petroleum Use

Marine transport, both using petrol for personal boat use and diesel for inter-island shipping, has potential for improvement in the efficiency of fuel use. Measures intended to penalize the use of oversized outboard engines, to provide incentives for shifting to engines with high fuel efficiency and encouraging more local subsistence fishermen to use traditional sailing canoes could reduce petrol use significantly.

Programmes for engine maintenance, instruction for marine technical staff in engine tuning and for ship officers in operational methods for increased fuel efficiency could be cost effective through fuel use reduction. Ship owners should be made fully aware of the considerable savings in fuel cost that are possible through efficiency improvement measures.

In recent years there has been a trend toward importing larger and less fuel efficient vehicles for government transport. Government needs to consider fuel efficiency as an important part of the specification for replacement vehicles. In particular, diesel powered vehicles provide advantages both in fuel efficiency and maintenance. In the environment of Tuvalu, diesel vehicles have no disadvantages beyond a slightly higher initial cost that is soon recovered in fuel and maintenance savings. They also may be operated on coconut oil based fuels with little or no modification.

5.2 Electricity Supply

Supply side efficiency improvements are generally easier to attain and tend to be more permanent than demand side measures. The TEC on Funafuti is operating with over10% in technical losses. This is rather high for a system of its size and improvements of at least 2% -3% are probably immediately cost effective. This is to be addressed in the upcoming JICA funded power development project.

5.3 Electricity Use

In 2003, a survey of around 500 Funafuti homes detailing appliance use was carried out by the Energy Office. The survey included a listing of appliances found in the home, their demand in Watts and a tabulation of possibilities for energy efficiency improvement in lighting. Unfortunately the data was entered into Microsoft Excel in a format that makes it difficult and time consuming to analyse and for energy planning purposes it is not easy to analyse although it does immediately show that Funafuti homes typically have a wide range of electric appliances. The survey did show that by changing existing lights to energy efficient units, potentially an average of 97 watts per house in demand could be saved – assuming all lights are turned on. However in normal use all lights are not on at the same time lowering the actual benefit somewhat.

There is considerable opportunity for the improvement of electricity use efficiencies. In particular lighting, refrigeration and air conditioning uses can be reduced by 10% or more through replacement of the existing appliances with ones of higher inherent efficiency.

The new Government Building in particular can have the air conditioning load reduced significantly by the addition of highly reflective film to the huge area of glass exposed to the sun. As can be seen in Figure 5-1, the west wall of the central area of the building uses a design typical of passive solar heating systems in cold climates, a design that is very poor for an air conditioned space in the tropics. In the climate of Tuvalu this will impose a large heating load on the air conditioning system in the afternoons and lower the level of comfort in the space immediately behind the glass wall.

Figure 5-1 – New office building, west facing facade

Herb Wade 2004

Adding highly reflective film to the glazing can greatly reduce the afternoon heat entry from this large solar collection area and that on the east facade can be similarly treated to reduce the morning heating from the sun.

6 Barriers to Development and Commercialisation

The identification of barriers to the development and commercialisation of renewable energy for Tuvalu was the subject of a S.W.O.T. workshop held in the Vaiaku Lagi Hotel on March 17, 2004. Additional information regarding the barriers to renewable energy development was gathered by the PIREP country team and the PIREP international team. Tuvalu has one of the longest histories of renewable energy based rural electrification in the world and that experience also has been considered in listing the primary barriers that face the large scale development of renewable energy to replace fossil fuel use in Tuvalu.

Though the barriers are categorised into similar groups, the placement in categories is somewhat arbitrary. It is recognised that many barriers have implications in several categories.

6.1 Fiscal and Financial Barriers

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

Taxes and import duties for renewable energy in Tuvalu are much less of an issue than in larger countries since virtually all renewable energy development of any capacity will have to be developed by government. With the TEC electrification of the outer islands, the private sector opportunities are insufficient to allow development of a business focusing on renewable energy implementation. The TEC will necessarily have to take the lead role and private sector activities are expected to be limited to solar water heating, a market that has yet to develop in Tuvalu and is unlikely to develop until household incomes increase significantly.

Diesel fuel is duty and tax free for power generation. Import duty and VAT are charged for the import and sale of renewable energy equipment placing renewable energy at a cost disadvantage.

Complex Project Proposal Requirements by Financial Institutions. Investment in energy systems in Tuvalu has always been by government or international funding agencies and there is no reason to believe that will change in the foreseeable future. Therefore access to finance is not a major barrier. If the government places a priority on energy development, finance can be obtained on good terms. However, obtaining either donor or loan based finance typically requires the preparation of complicated project proposals. In larger countries, there are persons who specialise in interfacing with international finance institutions but that is not practical in Tuvalu. Therefore even though finance is theoretically available, it may not be obtained because adequate project proposals cannot be prepared or are not even attempted due to their complexity and unfamiliarity. To reduce this barrier, capacity building for those responsible for renewable energy proposal preparation at the Ministry of Works and Energy and the TEC would be beneficial. External advisory services can be of benefit as well.

Price of petroleum. For the types of renewable energy that are practical for Tuvalu, the primary financial barrier is the fact that petroleum remains the lowest cost option for energy production. Both photovoltaics and biofuel development must receive large subsidies if the end user is to have to pay no more than would be the case if petroleum fuels were used. In the case of solar PV, that can be a one time capital investment but for biofuels, capital investment is modest and a continuing subsidy would be necessary. There are no significant opportunities for reducing this barrier in Tuvalu other than direct subsidies to renewable energy or increased taxes on fuels.

Increasing outer island labour costs. As the outer islands move away from subsistence activities and into the money economy – something that is accelerated by the development of rural electrification through diesel power – the cost of labour rises making it more difficult to obtain the labour intensive renewable energy capacity needed to develop biofuels, biomass and biogas at a competitive cost. This can be offset by reducing the labour requirement for the energy production through mechanisation of production processes, such as copra cutting, but that will require an initial investment and development of a maintenance capability for the equipment.. It also is offset by increasing the price of fossil fuels to allow the higher cost renewable energy fuels to compete. Providing a direct subsidy for the production of renewable energy based fuels is another possible option though it should be transparent and paid at the fuel delivery point directly relating to the volume of fuel produced.

6.2 Legislative, Regulatory and Policy Barriers

The legislation establishing the TEC 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 TEC with a mandate to incorporate it into its power systems would be beneficial. Such a mandate would have to include provision for the government to cover any added cost of investment and energy production that exceeds that found with fossil fuels. A significant weakness, largely due to the small size of the country, is the lack of structures in government specifically for the regulation of TEC tariffs.

Highly Subsidised TEC Tariffs. With TEC tariffs far below the real cost, especially on outer islands, TEC must regularly ask for financial support from the government to cover losses. This support tends to be slow in coming and less than is really needed. It will be especially difficult for the TEC to add even higher cost generation in the form of solar and biofuels. To reduce this barrier, government needs to allow TEC to recover the full cost of generation through customer tariffs supplemented by a transparent per kWh subsidy that pays the difference between what the government feels is a proper price for customers to pay and the real cost of providing the power. The process of setting tariffs should include analysis of the probable fiscal, financial, social and environmental effects of the tariff, something that has not yet been included in the tariff setting process. This barrier is linked to the information access barrier below since part of the requirement for setting a proper tariff is a good understanding of the benefits, costs and capabilities of those renewable energy technologies that can be integrated into the TEC system.

Lack of clear policy for energy development. Without a clear policy for energy development that government genuinely agrees to consistently follow, major energy sector decisions, such as the rapid conversion of outer island electrification from solar to diesel, tend to be made with inadequate analysis of the consequences or consideration of alternatives. The PIEPSAP project is expected to address this barrier.

6.3 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 structure 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 at a minimum cost.

Limited capacity in the Energy Office for renewable energy and energy efficiency development. While most of the implementation of renewable energy will necessarily be carried out by the TEC, the Ministry of Works and Energy will still have an important policy development and policy implementation function. The Ministry also will implement, maintain and manage those few renewable energy installations that are outside the TEC grid area. Over the past decade there has typically been only one person taking part in energy related activities for the Ministry of Works and Energy. This has created a difficult situation since sending that person abroad for training leaves no one to carry out the day to day requirements of operating the energy office. On the other hand, without overseas training the quality of work that is done will be lower than if training had been carried out. If energy is to be taken seriously in Tuvalu, it will necessary to have both positions that are allocated for the energy office filled so that one person can be on training while the other remains available to carry out the day to day tasks of the office.

High cost of land and marine transport. The physical conditions on the islands and the fact that the population is dispersed over eight islands makes both land and marine transport expensive in Tuvalu. Further, shipping capacities are limited making it difficult to keep up with shipping demands efficiently. Transporting large quantities of low density biomass fuels can be expensive and difficult to arrange. To reduce this barrier, an institutional structure that encourages local production of higher density fuels, such as coconut oil, will be needed so that the need to ship biomass materials to a distant site for processing into useable fuel will be minimised.

Land issues are a barrier to the development of biomass based renewable energy technologies. The sustainable production of biomass for large scale energy production requires large, easily accessed land areas and coordinated planting and harvesting to ensure a sustained fuel supply. The very limited land area of Tuvalu and the land tenure issues that exist are significant barriers to biomass based renewable energy development. To offset these barriers to allow a reliable supply of biofuels to be developed at minimum cost, it will be necessary to create an institutional structure that bonds the many small land holders into operational units that so their activities can be coordinated.

6.4 Technical Barriers

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

Difficult environment for electrical and mechanical equipment. The tropical marine environment of Tuvalu is one of the most difficult for mechanical and electronic equipment. Obtaining equipment suitable for installation in Tuvalu 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.

Solar not considered in outer island grid designs. Though the later addition of renewable energy to outer island diesel power systems was considered probable during the project development phase, actual system designs do not facilitate the addition of solar PV or other renewable energy. This will make the integration of renewable energy more difficult and system reliability lower since the PV systems will need to use complex electronic controls to mix the PV power with the diesel power or else the existing power systems will need to be modified to allow integration of solar and wind power without those controls. Both approaches incur added cost and represent a barrier to the sustainable application of solar and wind energy for Tuvalu outer island grid systems.

Lack of experience with comparable systems in the Pacific. As one of the smallest countries in the Pacific with very limited internal technical capacity, Tuvalu must look to other countries for experience that can be transferred to Tuvalu. Although there is a wealth of experience with solar home systems in Tuvalu and the Pacific in general, integrating solar energy or wind energy into an existing grid has no long term, successful experience in the Pacific that is consistent with Tuvalu's requirements. Although both technologies have long been used in industrialised countries of the world, most of the experience is on a scale that is not directly transferable to Tuvalu. While there has been practical experience in Vanuatu with biofuels,that has been transport related where Tuvalu's need is for power generation. Though there are similarities there are also differences and the experience is useful but cannot be directly transferred. Demonstration projects, pilot projects and technology transfer programmes are needed to gain experience with hybrid technologies and biofuel preparation for power generation.

Lack of adequate resource information. Only the solar resource is reasonably well understood in Tuvalu. The wind resource is known only in the meteorological sense and then only on a few islands. The coconut resource is known only in the most basic sense: the approximate number of trees. Little information is available about their productivity. For cost effective development of renewable resources, improved understanding of the nature of those resources is required.

Lack of adequate technical capacity on outer islands. A continuing problem with outer island development of energy supplies is obtaining and keeping an adequate technical staff that can properly operate, maintain and repair the energy systems. Technical training is not readily available, especially for renewable energy technologies and turnover of personnel is common since once a person is technically trained, moving to Funafuti for a better job is made much easier.

6.5 Market Barriers

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

Small area and dispersed population. Tuvalu's small size and its dispersal over eight islands severely limits the opportunity for private sector development of renewable energy. Even in PICs several times larger than Tuvalu, the market for the materials and skills associated with renewable energy development is small and private sector development potential modest. For the foreseeable future, management of renewable energy development will remain a government responsibility though the private sector can be involved through contracts for specific services and materials. It is noted, however, that biofuel development does impact on the private sector at the grower level though the market development and delivery of the product will need to be public in nature.

6.6 Informational and Public Awareness Barriers

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

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

Limited public awareness of energy efficiency and renewable energy options. The most cost effective approach to reducing petroleum use in Tuvalu is clearly through energy efficiency improvements. However, there is little public knowledge of demand side management techniques or of energy efficiency improvement in general. Although solar PV for home electricity use is well known in Tuvalu, its use to supplement diesel grids is not well known. Biogas, biofuels and wind power are not generally known as possible renewable energy resources for Tuvalu. If energy efficiency and renewable energy are to be accepted as substitutes for petroleum, awareness of their capabilities – and shortcomings – needs to be improved.

7 Implementation and Capacity Development Needs

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

7.1 Categories for capacity development

7.1.1 Petroleum

All functions in the petroleum sector are being carried out by BP and their training programme appears adequate to ensure proper safety, storage maintenance and other operational activities.

7.1.2 Electricity

The TEC has a well developed training plan in effect. However, if solar PV is to be integrated with the outer island electricity systems, there will need to be additional training provided to both TEC senior staff and outer island technicians in the areas of design, installation, operation and maintenance of the solar PV supplementary power systems.

7.1.3 Renewables

The Energy Unit has a relatively high staff turnover and the current personnel have not received significant training in renewable energy applications. Two levels of training appear to be needed, general concept training so staff will understand the requirements for development of different renewable energy technologies and specific training related to projects in place or planned.

It is clear from the PIREP data gathering effort that there is a need for additional development of capacity within the Energy Unit for energy data collection, posting and analysis. That remains an important function for the Unit and support in that area needs to be continued.

Project development and management skills are weak and management capacity development is essential if energy activities are to be efficiently carried out.

7.1.4 Energy Efficiency

Because Tuvalu is essentially fully electrified from a grid, the primary use of renewable energy will have to be for replacement of energy being generated from fossil fuels, not the delivery of new energy to areas not being served by fossil fuel sources. Thus the more conventional energy being used, the more costly it will be to replace it with renewables. Reducing energy waste through energy efficiency measures is important to both control GHG emissions and to ensure that the expensive energy from renewable sources is not being wasted. Presently, Tuvalu has little public or private capacity for developing and implementing energy efficiency measures. Considerable development of capacity for public information, project design, energy auditing, building envelope design, solar entry prevention, appliance efficiency measures, transport efficiency measures (particularly marine), air conditioning efficiency and lighting efficiency measures is needed. The potential for energy efficiency improvement is significant but cannot be realised without well prepared and executed energy efficiency improvement programmes.

7.1.5 Regulation

Tariffs are set by Cabinet after recommendation by the TEC Board. The Cabinet, their advisors, management of the TEC, the TEC Board and the staff of the Energy Unit need additional advice and information regarding the effect of different tariff structures, prices and the effects of serious underpricing of electricity such as is now the case in the outer islands.

7.2 Capacity Development for Specific Barrier Reduction

7.2.1 Reduction of Fiscal and Financial Barriers

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

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

7.2.2 Reduction of Legislative, Regulatory and Policy Barriers

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

Electricity tariff development support. Under the present system, the TEC management proposes a tariff to its Board of Directors. The Board then makes a determination as to the appropriateness of the tariff from the TEC point of view and forwards recommendations to Cabinet for final determination. Though it is clear that the tariff structure that is imposed can have a major effect on social, economic, environmental and development issues as well as on the economics of renewable energy implementation, there is little capacity for analysing the effect that a proposed tariff may have on these factors. The TEC, the TEC Board and Cabinet advisors or the Cabinet itself need assistance in estimating the effects that tariff changes will have on the country. This could be provided through a regional advisory service, informational materials provided to the appropriate parties and direct training of the Cabinet advisory staff and TEC personnel.

7.2.3 Reduction of Institutional Barriers

Training for Energy Unit personnel. Typically, energy office personnel move to another position after a few years. That means that training for energy officers is required to be continuously available to support capacity development so the energy officers can properly fulfil the technical and administrative tasks set before them. There is no training available in Tuvalu for the technical component of their work and the training needs to be made available without more than a few months delay after a new person takes an energy position. This implies that the training will need to be external and regional in nature since a training programme cannot be sustained on the basis of the needs of Tuvalu alone. The regional training concept being developed by ESCAP in late 2004 is expected to address this issue.

Development of a biofuel delivery institution. If biofuel is to be a cost effective replacement for diesel fuel, an institutional structure will have to be developed that will (a) enable a large number of small coconut growers to pool their resources; (b) ensure that each grower receives proper compensation for their efforts; (c) minimizes the labour component of the biofuel production process; (d) manages small biofuel facilities on each island to avoid the problems and expense of shipping; (c) ensure that a fuel supply is of consistent quality and available as needed. This structure needs to benefit from the experience of actual biofuel suppliers and funding will be needed to bring together persons from other countries with commercial biofuel experience (e.g. Vanuatu, Philippines) to work with Tuvalu to design an institutional structure that specifically fits its needs. Since this problem is common to several countries, a regional conference plus a follow up outreach programme with a specific focus on Tuvalu may be appropriate.

7.2.4 Reduction of Technical Barriers

Capacity development for the design, installation and maintenance of renewable energy systems. Although there is experience with the design of solar home systems, hybrid systems are unfamiliar and considerably more complex. TEC technical staff will need to understand the design parameters and characteristics of the various types of hybrid systems possible for Tuvalu and at least be able to judge whether or not externally developed designs are appropriate or not. Also, training in the operation and maintenance of the systems will have to be developed within the TEC, possibly with the assistance of the TMTI, so that field technicians can be trained and their skills maintained. Since several countries will require training in hybrid design and also will need to develop local training capacity, a regional programme for that purpose appears appropriate.

Development of standards and certifications for RETs. Although there are international standards already developed and being developed for RETs, they are generic and must be fitted to the local situation. Because equipment must be manufactured to survive under the harsh conditions of Tuvalu, those requirements need to be embodied at least as purchasing guidelines or, better, as actual standards for the purchasing of RET equipment. Unlike the training programme, a standards and certification development programme needs to be done only at several year intervals. As this is a multi-country issue, with similar problems facing Kiribati, Tokelau, RMI and FSM, a regional programme is appropriate.

Resource Surveys. For the most cost effective renewable energy development, it is important that there be accurate knowledge of the availability of the resource at the site where it is to be developed. Wind power is very site specific and expert assistance is needed to judge where the best sites are likely to be and to prepare a programme for wind energy assessment. For biofuel development, knowledge of the actual location and productivity of coconut trees is vital. Most of the work in these surveys can be carried out by local personnel though assistance will probably be needed in designing the surveys and in locating proper sites to carry them out. Analysis of the results will also require external assistance, preferably in the form of on-the-job training for local energy personal so the process can be repeated in the future with minimal external assistance. Several countries face this problem for biofuel, solar and wind energy making resource surveys a good candidate for a regional programme.

7.2.5 Reduction of Market Barriers

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

7.2.6 Reduction of Physical Barriers

Although the physical conditions of Tuvalu cannot be addressed through capacity development measures, some of the effects can be offset through high quality communications using data links between islands. A major constraint in the operation of the TSECS during the 1980s- and early 1990s was the difficulty of communicating with customers and field personnel from the main office on Funafuti. Many of the problems that were faced by the TSECS could have been avoided if inexpensive, fast and comprehensive communications had been possible. Consideration should be given to the possibility of improved data communications between islands and utilising that communications capability to improve the cost effectiveness and reliability of outer island energy systems.

7.2.7 Reduction of Informational and Public Awareness Barriers

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

Public information programmes. Although solar energy for home electrification is well known in Tuvalu, there is little public knowledge about biofuel, biogas, and wind power or hybrid systems. As this is a need for most of the PICs, the necessary public information materials can be developed regionally and delivered to countries along with short term training and advice in their proper delivery.

8 Implications of Large Scale Renewable Energy Use

Solar

The only significant use of solar for the future is connection to existing grids to reduce fuel used by the diesel generators. There would be no clear social advantage to using solar PV for grid supplementation since the end user will not see any difference in quality or quantity of service, the solar energy will simply reduce the fuel requirement for the diesel engines. From an environmental point of view there will be a reduction in GHG emissions and less air pollution due to the reduction in diesel fuel use. From a national point of view there will be a reduction in the effect oil price changes have on the economy and a lowering of risk of economic disruption due to an interruption in petroleum supply or a rationing of its quantity. However, since the cost of power generation from PV is greater than that of diesel, there is a financial cost incurred that offsets these advantages.

Land issues for large scale solar implementation for grid power supplementation can be a social problem. Solar home systems do not present this potential social problem because each user reaps all the benefits from the system installed on their land. In the case of community power systems, that is not the situation. Land can be a limiting factor for large scale solar energy use in Tuvalu and the equitable distribution of the benefits of solar installations on private land may present a social problem similar to those faced in Fiji, Solomon Islands, Samoa and other countries where there is hydro development.

A further problem is that of energy storage. For the solar PV to provide more than around 20% of the power system noon-time demand, either some sort of energy storage will be needed or a complicated computer controlled power management system installed. Since complex power control systems are not appropriate for use in Tuvalu, energy storage appears to be necessary. The only storage that is presently cost effective is lead acid batteries and if solar PV is to be used on a large scale for combination with diesel power on the outer islands, a large battery storage system will have to be installed.

Currently and for the foreseeable future, the most cost effective battery arrays use medium sized (200-300 Ah at C_{10}) batteries. Likewise the most cost effective inverter systems appear to be in the 4-10 kW range. So presently, the best approach to adding solar PV to outer island diesel power is through a multiple of 4-10 kW capacity power modules that include a PV array, a medium sized battery array at 120 VDC or higher and a three phase inverter set that allows direct connection with the grid and parallel operation with other inverters. By standardising on the PV power systems through the use of multiple identical modules connected in parallel, the same spare parts, batteries and maintenance training can be used for all islands. A further advantage is that the failure of one power module would not cause a complete power failure.

However, the use of storage batteries creates an environmental hazard and the requirement for recycling of failed batteries. Local disposal is not appropriate since lead residues can leach into the soil, contaminate ground water and cause reef life to be contaminated if batteries are dumped in the sea. For grid power systems, fairly large industrial quality batteries are usually used. This is a definite advantage since a 10 year life can be anticipated with that type of battery and also they have higher value for recycling when they do fail. Because it is not cost effective to ship only a few batteries at a time, it will be necessary to make available indoor storage for spent batteries until a sufficient number are accumulated to make an economically reasonable shipment to a recycling centre in New Zealand or Australia. Standardising on the battery eliminates the potential problem of having many different types of batteries to recycle

Biofuel

Biofuel production provides good benefits to both rural and urban populations. Rural areas receive a significant boost in cash income and urban dwellers benefit from using a fuel that has a relatively constant, controlled price, a fuel that is not a spill hazard and a fuel that burns with lower atmospheric pollution than ADO. From a national point of view, the large scale use of biofuel provides some protection against economic disruption due to externally imposed changes in imported fuel prices and reduces the risk of serious problems due to delays or disruption in fuel deliveries.

However, the relatively high labour and transport costs make it difficult for locally prepared biofuels to compete with imported diesel fuel. Also limited land area and land tenure problems can create social problems related to the equitable sharing of benefits. Large scale biofuel use includes the need to design an equitable method of developing the coconut plantations and compensating land owners then creating a labour efficient process for the gathering, transport and processing of coconuts or other oil crop. For the biofuel to be the lowest possible cost at the use location, careful system design for the whole process, from tree to end use, will be necessary. This is a particular issue for atoll islands where the transport from place to place in the atoll is expensive and access poor.

Biogas

Biogas production at the scale needed to replace LPG and kerosene use for cooking will require concentrating the housing of pigs and chickens to allow economic production of gas. This will require social adjustments to i)make the communal housing of the animals practical, ii) in the allocation of labour for operating the digester and iii) in the equitable distribution of the gas that results.

The gas can be used to operate a near by engine or it can either be collected and piped under pressure to houses or compressed into cylinders and provided to houses in the same form as LPG is delivered now. That technical requirement will cause the development of mechanical skills and some technical employment on outer islands. As with solar PV, considerable ground space will be needed and that may be difficult to arrange on some islands. A process considered equitable by all parties will need to be imposed for payment to land owners and animal owners that somehow relates to the amount of gas produced.

Environmental benefits of biogas production include management of animal wastes, the very significant reduction in GHG emissions (since methane is a powerful greenhouse gas) and generation of high quality, safe fertiliser for gardens. Additionally, there will be improvements in kitchen environments since the gas has no foul odour and burns without smoke.

9 Implementation of Capacity Development and Co-Financing Opportunities

At the time of writing, there are no firm renewable energy donor projects that provide an opportunity for co-financing by PIREP. However, there are several tasks that are considered useful for future co-financing should the opportunity arise. They are:

- if plans for developing photovoltaics for supplementing outer island diesel electrification are to be carried out successfully, significant capacity development for TEC in the areas of system design, installation, operation and maintenance will be required. This will be necessary both at the time of project implementation and repeatedly for the indefinite future and could be implemented as co-financing in association with the finance of the hardware component;
- capacity building for the energy office regarding project development, project management and energy data management is needed if renewable energy and energy efficiency measures are to be rationally and effectively implemented. The relatively rapid staff turnover will require repetition of capacity building efforts every few years. This is most likely to be able to be co-financed relative to a regional project by SOPAC, ESCAP or other agency that supports regional capacity development efforts;
- cabinet advisors, the TEC management and energy office personnel need specific training in the development of electricity tariffs and analysing their relationship to social and economic development in Tuvalu. This can be also tied to regional capacity development efforts, possibly PIEPSAP;and
- technical assistance and training related to the development and management of biofuel production in Tuvalu will be needed if renewable energy is to impact transport at all. This should be directed at agricultural specialists working with coconut growers as well as energy department personnel. Regional programmes for biofuel development are being considered and if carried out, would be suitable for co-financing of biofuel technology capacity building in Tuvalu.

Annex 1 – Persons Consulted for PIREP

Anisi Penitusi	Manager Engineering, Tuvalu Telecom Corporation (TTC)
Falani Boreham	Acting Mechanical Engineer, (TEC)
Fiamalu Leupena	Businessman, SF Hardware
Filipo Taulima	Director PWD
Iete Tapeva	Director Rural Development
Ionatana Peia	General Manager National Bank of Tuvalu
Isaia Taape	Assistant Secretary Works and Energy
Kapuafe Lifuka	Energy Department
Kelesoma Saloa	International Water program
Kilateli Epu	Senior observer Meteorological Service
Kokea Logo	Assistant Engineer (TTC)
Hon Maatia Toafa	Deputy Prime Minister, Minister for Communications and Transport, Minister for Works and Energy
Mafalu Lotolua	General Manager (TEC)
Malie Lototele	Director Economic Planning
Mataio Tekinene	Director of Environment
Molipi Tausi	Energy Planner
Nielu Meisake	Assistant Energy Planner, Energy Department
Polu Tanei	Acting Inspector, TEC
Poni Favae	National Adaptation Plan of Action Coordinator, Regional project for small island states
Popu Asuelu	Businessman, TV Variety
Semai Apinelu	Assistant Director of Statistics
Semu Malona	Statistics officer
Siose. Teo	n/a
Susan Tupulaga	Waste Management Coordinator, Tuvalu Gov
Dr. Tekaai Nelesone	Director of Health
Taukave Poolo	General Manager, Development Bank of Tuvalu
Taukiei Kitala	Project Officer, TANGO
Teo Pasefika	Manager, Tuvalu Gas Company
Timaio Auega	Energy Department
Uale Sinapati	Acting Director, Marine and Port Services
Vete Sakaio	General Manager, BP Tuvalu

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Annex 3- The Tuvalu Solar Electric Cooperative Society

The TSECS was organized with a structure based on the 1983 Fiji village cooperatives but gained from the Fiji experience by moving from village level cooperatives to a national level organization. In Fiji the village cooperatives were found to have too limited capacity in business and technical maintenance to be sustainable. By shifting to a national scale cooperative it was hoped that the larger number of customers and the expected distancing of the cooperative management from local politics would allow its operations to be more professionally managed and based on sound business principles.

In April, 1984, the TSECS formally began operations and using funding from USAID, 170 SHS were ordered from a Fiji supplier. The systems included a 35Wp panel and a low cost battery using automotive design but with thickened plates to allow for deeper discharging without permanent damage. Two 15 Watt 12VDC lights were included. Though the initial specifications included a discharge controller, the local Telecom manager, the only person with prior solar experience in Tuvalu, said it was not needed and would only be something else to fail in the system. Within a year, all 170 units had been installed on the houses of persons willing to pay the $50 installation fee and an $6.25/month service fee that was intended to pay for maintenance services and replacement of the battery when it failed.

The initial installations were found to be unreliable and did not meet user needs even for basic lighting because the panels were too small and the lights were used longer than anticipated by the designers. Also batteries started to fail within 6 months because of repeated deep discharging that occurred since a discharge controller was not included.

Those initial 170 systems were upgraded under a grant from France in 1985 that added a good quality controller (the S.P.I.R.E. Pacific controller) and a true deep discharge battery (Varta 100 Ah). Unfortunately, the panel capacity remained too limited to provide the full services desired by the customers.

In 1985, a second batch of 150 systems were installed using EU funding. Panel size was increased to 42 Watts and a controller included but again, Fiji made batteries that did not have a deep discharge design were used. These systems performed very poorly and could not consistently provide more than two hours of light a day. The Fiji designed controller had a power requirement far greater than appropriate, the panel remained too small for the customer needs and the battery was found to have a short life.

The EU was then requested to assist in the upgrading of the PV systems to fully meet user needs. A project was developed that, between 1987 and 1990, provided 160 panels of about 45Wp capacity, 175 S.P.I.R.E. Pacific controllers and 165 high quality, deep discharge batteries made by Oldham, France. These components were installed on the houses of customers that were members of the TSECS who were having problems with the existing systems. In 1992, an additional 125 BP Solarbloc batteries were purchased by the Forum Secretariat and provided to Tuvalu to replace the batteries provided by France in 1987 that were failing and those of the original USAID project that were still in place.

In 1994 the Tuvalu component of the Lomé II PV Follow-Up project and a national project funded under Lomé III funding were combined. That allowed the addition of more panels to existing households, installing new systems, replacing ageing batteries and generally upgrading existing systems so by the end of that project nearly all 400 households served by the TSECS had from 90-150 Wp of panels, a high reliability S.P.I.R.E. controller and a high quality deep discharge battery. Additionally, looking to the future when outer island households would be able to afford more appliances, each island was provided with a complete solar refrigerator system for introduction of larger capacity systems. The intent within the project was for the refrigerator system to be made available to regular TSECS customers who would be willing to pay the increased service fee but the TSECS opted to install all the refrigeration systems in the local technician's houses. Solar refrigerators were also installed in all outer island dispensaries under the EU project with maintenance contracted to the TSECS.

Thus by 1994, most of the technical problems had been solved, most TSECS customers had systems that would meet their lighting needs and were using reliable charge and discharge controllers feeding a high quality, long life battery. The upgrade program included a significant training component that improved maintenance and system reliability. The TSECS, after 9 years, was finally providing good service with resulting customer satisfaction and what appeared to be an institutional and technical system that was sound for the future.

In the background, however were many institutional problems that had not surfaced during the scramble to get the systems working properly, though the signs were there. Some of the signs were:

- The TSECS had never used *any* of the money collected from customers for battery replacement or spare parts. All funds that were collected either paid for labour and administrative support or were put in an interest bearing account.
- Barkley's bank, then active in Tuvalu, provided a zero interest 10 year development loan to the TSECS of $25,000 for capital investment and upgrading of systems. The money was placed in an interest bearing account and never used to develop the TSECS even though at the time of the loan many customers had failed batteries that should have been replaced.
- By 1990, the TSECS had cash reserves of over $50,000 yet were making customers with failed batteries wait until the next donor program provided replacement batteries instead of purchasing them immediately.
- Tools provided under projects were lost, damaged or somehow disappeared but were not replaced by the TSECS, instead more were requested under the next donor project leaving technicians for years with inoperative meters, broken hydrometers and short of hand tools.

The TSECS was not actually operating as an ESCO, it was managing donor projects and never was able, after its separation from the SCF in 1988, to properly manage the service provision component of its responsibilities to TSECS members.

In 1994, as part of the EU project implementation, it was found that there were large discrepancies between what outer island customers were claiming about payments and what was in the TSECS records. A deeper investigation ensued and it was discovered that the General Manager had periodically and systematically diverted funds for his own benefit for at least several years. The exact amount of loss to the TSECS was never determined but estimates placed it between $30,000 and $50,000. The accounts of the TSECS were almost at zero, even the $25,000 loan from Barkley's had disappeared. The General Manager was tried, found guilty and sentenced to seven years in jail and a new manager hired.

The new General Manager immediately began to reform the internal structure of the operation. By 1995 the new General Manager had turned the operation around, dramatically improving the rate of collection and had convinced Barkley's Bank to forgive their loan (by then Barkley's was no longer operating in Tuvalu) bringing the TSECS to much better, though still shaky, financial condition.

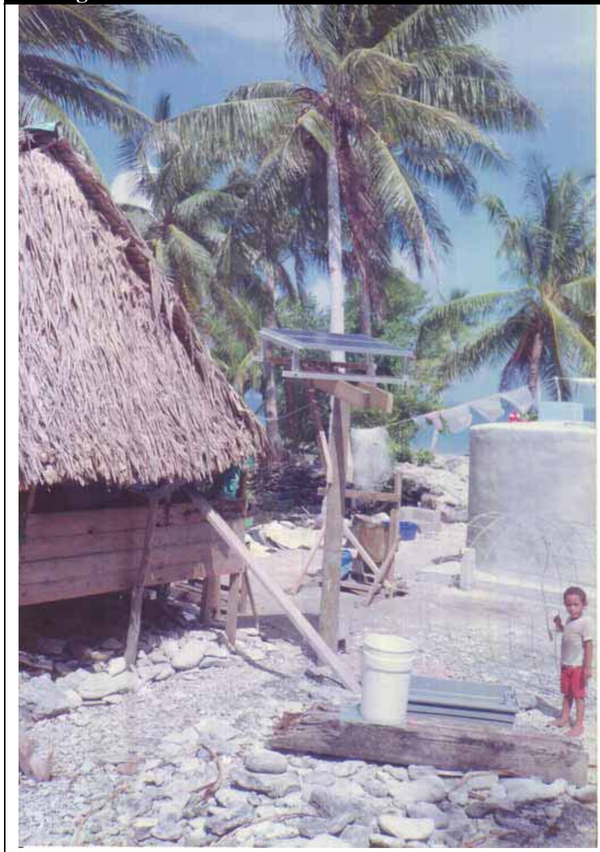
In 1996, the Management Committee of the co-operative voted to suspend the General Manager as they suspected him of misuse of travel funds despite no actual proof and despite the extraordinary improvement in the administration of the TSECS which he had accomplished. They also voted to lower the service fee for all members to $5 (well below a level to allow sustainability) and voted to double the technical staff on each island despite the fact that maintenance had been of high quality with the single island technician because the new General Manager had instituted improved training and supervision processes. These actions were reviewed by the government agency responsible for regulating cooperatives and were not allowed to be placed into effect due to their clear fiscal irresponsibility.

The Government regulatory decision that the dismissal of the manager was not well founded resulted in reinstatement of the General Manager but the Management Committee continued to micro-manage the cooperative and in a later meeting again fired the General Manager who did not contest the decision realizing that it would be impossible to carry out his responsibilities without the confidence and cooperation of the Management Committee. By late 1996, the local technicians were effectively made independent operatives with their payment coming directly from customers rather than from the TSECS headquarters. Support from Funafuti was greatly reduced. By 1998 although the TSECS remained registered as a cooperative, support services had devolved to those which could be accomplished by outer island technicians with no spare parts and no technical support. Few systems could be repaired when they failed. A number of external consultancies (SOPAC 1998, JICA 1998, EU 1999, ESCAP 2000) recommended that the TSECS be reorganized as a government corporation on the pattern of the Tuvalu Electric Company (TEC) in order to salvage the large investment already made in outer island solar systems and to work toward increasing outer island electrical services through expansion of the solar capacity. In 1999, Cabinet ruled that the TSECS should be dissolved. However no action was taken until July 2004 when the TSECS was deregistered as a cooperative in Tuvalu. At the time of writing, the disposition of TSECS assets is not known.

In late 2000 the outer islands were electrified by diesel systems using Tuvalu government funds. Although some PV systems still remain partially operational serving households not yet connected to the new grids, they do not represent a significant energy supply.

The Government of Tuvalu has placed the TSECS general manager and senior technician under the energy office with salaries paid by Government and responsibility for the activities formerly carried out by the TSECS are being handled by the Government.

Figure 9-1 – SHS installed at an outer island home



Herb Wade (1995)

Lessons Learned

Despite its serious problems, the TSECS had the distinction of having provided solar electricity service to Tuvalu rural citizens for over 10 years making it one of the longest running village electrification schemes in the Pacific whether solar, hydro or diesel based. As the first "solar utility" or solar based RESCO to survive for the long term, its well documented history provides valuable lessons in institutional design for rural electrification projects in other Pacific countries.

1. **The primary determinate for long term success was institutional, not technical.** After initial technical adjustments to bring systems to the level needed to properly service the users needs, almost all problems with the program were related to social, cultural or administrative difficulties. The service oriented administrative and maintenance system used by the TSECS appears to be the key to their relatively long term success. It is important to note that this was not due to technically superior PV systems but to an administratively appropriate and culturally relevant organization. Indeed, the technical quality of the aid provided PV lighting systems in Tuvalu was so poor prior to 1990 as to be an embarrassment to the donor organizations. Also, other countries in the region, including Fiji, the Marshall Islands, FSM, Saipan and Tonga, received USAID or EU funded PV systems for rural electrification of communities essentially identical to those in Tuvalu but had their projects fail while those same technical systems provided basic lighting for Tuvalu outer island households for many years.

2. **Components must be carefully selected to provide good service in remote Pacific island conditions.** The high cost of access and shipping plus the limited competence of on-island technicians make it imperative that long life components that fit the

environmental conditions of the Pacific Islands are chosen for outer island electrification.

3. **Quality of post-installation support is vital to long term success.** During the first year of operation, the TSECS attempted to provide maintenance services through visits to the outer islands by Funafuti technicians. Typically technicians visited every three months on a cycle corresponding to the outer island shipping schedule. Customer response was poor with many complaints and customers having several months of loss of service due to the long time between service visits. When local technicians were trained and hired and maintenance scheduled on a monthly basis, customer satisfaction rose dramatically and problems with collections were equally dramatically reduced.

4. **Customers paid fees consistently if the promised services were provided.** There was a clear correlation between the quality of service provided and the collection of fees from users. In the early years of the TSECS collections were poor and service also poor due largely to the installation of systems that were too small to provide the desired level of service and the initial decision to attempt to service the installations from Funafuti. From about 1988 to about 1996 when service was good, collections were also high. In the years after the collapse of the TSECS service worsened and collections became increasingly difficult.

5. **System abuse was minimal when the desired services were provided.** A common complaint with service oriented structures is abuse of the systems by users. Most system abuse in Tuvalu was traced to customers not receiving the level of service expected for the fees being paid. When system size was increased and the quality of maintenance services maintained, system abuse was rare even though all components were open to access by customers.

6. **The Cooperative structure has basic flaws that make them unsuitable for PV system implementation through the ESCO concept.** While cooperatives have the advantage of directly involving users in the program, it also depends on a management structure run by users. This creates several serious problems: (1) users are reluctant to charge themselves the real, full cost of service so fees are often set too low causing the COOP to have to provide reduced maintenance services; (2) management is by a user's Management Committee. Since long term planning and resource management is essential for a successful ESCO operation, the lack of business skills and experience found in the user's committee tended to result in an emphasis on short term benefits at the expense of long term success; (3) Few fiscal and operational restrictions apply to cooperatives and it is very common to find serious fiscal irregularities and little recourse available for users through the legal system.