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

REGIONAL OVERVIEW REPORT

Volume 1

PIREP

our islands, our lives...

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Between one and three international consultants visited each of the fifteen countries separately or as a team between November 2003 and April 2004 (except for Fiji, which was extended until August 2004). In all countries, there were field visits to renewable energy projects, or potential project sites, away from the main urban centre and usually visits to remote islands or rural areas. The consultants' work was facilitated throughout the lengthy mission, analysis, drafting and re-writing process by Mr Solomone Fifita, the Pacific Islands Renewable Energy Project Chief Technical Adviser at the Secretariat of the Pacific Regional Environment Programme. Drafts of national reports benefited from suggestions and comments from United Nations Development Programme (Apia), South Pacific Applied Geoscience Commission; the UNDP Global Environment Facility (GEF) and the national PIREP committees of participating countries.

However, the contents are the responsibility of the undersigned and do not necessarily represent the views of the governments, national PIREP committees, SPREP, UNDP, SOPAC, GEF or the many individuals who kindly provided the information on which this study is based.

Herbert Wade, Peter Johnston and John Vos
December 2004

ACRONYMS

GENERAL:

AAGR	Average Annual Growth Rate
ACP	African, Caribbean and Pacific countries (associated with EU)
ADB	Asian Development Bank
ADO	Automotive Diesel Oil
AFD	Agence Française de Développement (French Development Agency)
AGO	Australian Greenhouse Office
APACE	Appropriate Technology for the Community and Environment (Australia)
AUSAid	Australian Aid
BP	British Petroleum
CAIT	Climate Analysis Indicators Tool (WRI)
CCA	Common Country Assessment (of the UN)
CDM	Clean Development Mechanism (UNFCC)
CHOGRM	Commonwealth Heads of Government Regional Meeting (for Asia/Pacific)
CIF	Cost + insurance + freight
CIRAD	Centre de Co-opération Internationale en Recherche Agronomique pour le Développement
CO_2	Carbon dioxide, a key greenhouse gas
CPI	Consumer Price Index
CROP	Council of Regional Organisations of the Pacific
CSIRO	Commonwealth Industrial and Scientific Research Organisation (Australia)
CURES	Citizens United for Renewable Energy and Sustainability (NGO umbrella),
DANIDA	Danish International Development Agency
DFID	Department for International Development (UK)
DME	Direct Micro Expelling (coconut oil processing)
DSM	Demand Side Management (for efficient energy use)
EC	European Community
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENSO	El Niño / El Niña oceanic climate cycle
ESCAP	Economic and Social Commission for Asia and the Pacific (UN)
EU	European Union
EWC	East-West Center (Hawaii)
EWG	Energy Working Group of CROP
FAO	Food and Agriculture Organization (UN)
FED	Forum for Energy and Development (Denmark)
FSP	Foundation for the Peoples of the South Pacific
FSPI	Foundation for the Peoples of the South Pacific International
FY	Fiscal Year
GDP	Gross Domestic Product
GEF	Global Environment Facility (UNDP, World Bank & UNEP)
GHG	Greenhouse Gas(es)
GMT/UTC	Greenwich Mean Time / Universal Time Coordinate
GNP	Gross National Product
GTZ	Deutsche Gesselschaft für Technische Zusammenarbeit (German Agency for Technical Co-operation)

HDI	Human Development Index (UNDP)
HFO	Heavy fuel oil
IIEC	International Institute for Energy Conservation
IMF	International Monetary Fund
IPP	Independent Power Producer
IRN	International Rivers Network (NGO)
IRR	Internal Rate of Return
IUCN	International Union for the Conservation of Nature
JICA	Japan International Cooperation Agency
JIN	Joint Implementation Network (CDM; Netherlands)
JOCV	Japan Overseas Cooperation Volunteers
JV	Joint venture
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
MSW	municipal solid waste
NASA	National Aeronautics and Space Administration (USA)
NGO	Non Governmental Organisation
NOAA	National Oceanographic and Atmospheric Administration (USA)
NORAD	Norwegian Agency for International Development
NSA	Non State Actors
NZAID	New Zealand Aid
O&M	Operation and maintenance
OPEC	Organisation of Petroleum Exporting Countries
OTEC	Ocean Thermal Energy Conversion
PACER	Pacific Agreement on Closer Economic Relations
PDMC	Pacific Developing Member Country (of ADB)
PEDP	Pacific Energy Development Programme (UNDP/ESCAP, 1983-1992)
PIC	Pacific Island Country
PICCAP	Pacific Islands Climate Change Assistance Programme (GEF/SPREP)
PICHTR	Pacific International Center for High Technology Research (Hawaii)
PICTA	Pacific Island Countries Trade Agreement
PIDP	Pacific Islands Development Program (of EWC)
PIEPP	Pacific Islands Energy Policy and Plan (CROP EWG)
PIEPSAP	Pacific Islands Energy Policy and Strategic Action Planning (DANIDA/UNDP/SOPAC 2004-2007)
PIFS	Pacific Islands Forum Secretariat
PIREP	Pacific Island Renewable Energy Project (GEF/UNDP/SPREP)
PPA	Pacific Power Association (Suva); also Power Purchase Agreement
PREA	Pacific Regional Energy Assessment (WB, PEDP, PIFS, ADB; 1992)
PREFACE	Pacific rural Renewable Energy France-Australia Common Endeavour (SPC)
PREGA	Promotion of Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement (DANIDA/ADB programme in Samoa and elsewhere)
PV	Photovoltaic(s)
REEP	Renewable Energy and Energy Efficiency Program for the Pacific (ADB)
REM	Regional Energy Meeting (of Pacific Islands)
RESCO	Renewable Energy Service Company
RET	Renewable Energy Technology
RFO	Residual fuel oil (heavy fuel oil)

RFP	Request for Proposal
SHS	Solar Home System
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
S.P.I.R.E	South Pacific Institute for Renewable Energy (Tahiti - now closed)
SPREP	Secretariat of the Pacific Regional Environment Programme
SSM	Supply Side Management (for efficient energy supply)
SWH	Solar water heater
SWOT	Strengths, Weaknesses, Opportunities and Threats
UN	United Nations
UNDESA	United Nations Department of Social and Economic Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP/RISØ	Joint UNEP/Danish Centre on Energy, Climate and Sustainable Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
US	United States
USAID	United States Agency for International Development
USDoE	United States Department of Energy
USGIC	United States Geothermal Industries Corporation
USP	The University of the South Pacific
VAT	Value Added Tax
WB	World Bank
WCD	World Commission on Dams (World Bank/IUCN)
WRI	World Resources Institute
WSSD	World Summit on Sustainable Development
WTO	World Trade Organisation

ENERGY AND POWER UNITS:

AC	Alternating Current
DC	Direct Current
kgoe	Kilogrammes of Oil Equivalent
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
kWr	Kilo-Watts power at rated wind conditions (for wind turbines)
MW	Mega-Watt (millions of watts of power)
toe	Tonnes of Oil Equivalent
V	Volts
W	watts
Wh	Watt hours (of energy)

Energy Conversions, CO_2 Emissions and Measurements

The following conventions were used in all PIREP national reports except where otherwise noted.

Fuel	Unit	Typical Density kg / litre	Typical Density l / tonne	Gross Energy MJ / kg	Gross Energy MJ / litre	Oil Equiv.: toe / unit (net)	Kg CO_2 equivalent [e]	
							per GJ	per litre
Biomass Fuels:								
Fuelwood (5% mcwb)	tonne			18.0		0.42	94.0	
Coconut residues (air dry) [a]								
Shell (15% mcwb) harvested	tonne			14.6		0.34		
Husk (30% mcwb harvested	tonne			12.0		0.28		
Average (air dry) [b]	tonne			14.0		0.33		
Coconut palm (air dry)	tonne			11.5		0.27		
Charcoal	tonne			30.0		0.70		
Bagasse	tonne			9.6			96.8	
Coal	tonne			20		0.5	90	
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:

Actual efficiencies are used where known. Otherwise:	litres / kWh:	Efficiency:
Average efficiency for small diesel engine (< 100 kW 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%

Miscellaneous:

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)

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1 REGIONAL CONTEXT

1.1 Physical, Social and Political Context [1]

1.1.1 Size and access

Figure 1-1 illustrates the very small sizes of the Pacific Island Countries (PICs) and their physical isolation. As shown in Table 1-1, the countries range in size from about 12 km^2 of land (Tokelau) to nearly 463,000 km^2 (Papua New Guinea), most having between several hundred and several thousand km^2. The populations range from 1500 people to over five million. Economies range from relatively strong and diversified to almost totally dependent on donor support.

In general, the economies are dependent on development assistance, tourism, receipts from citizens living abroad, agriculture, and services – particularly government services. As small markets far from suppliers, PICs face high import prices for petroleum fuels and high energy costs in general. They also tend to receive low prices for exports, which are expensive to ship in small vessels to far-off markets.

Figure 1-1 – The Pacific Islands

Source: University of Texas website: *www.lib.utexas.edu/maps*

[1] Much of the information in Sections 1.1, 1.4, 1.5 and 1.6 is adapted from annexes to the December 2003 project document for the Danish-funded, UNDP-managed, SOPAC-executed 'Pacific Islands Energy Policy and Strategic Action Planning' project (PIEPSAP), which was prepared by one of the PIREP international consultants. The information has been updated with information from PIREP interviews and the 2004 national PIREP reports.

Table 1-1 – Pacific Island Countries' Land Area and Population			
Country	**Land area (km^2)**	**Population '000 (year)**	**Comments**
Cook Islands	240	18 (2001)	14 islands. 90% of people and 88% of land on eight southern islands (volcanic and raised coral). Northern islands mostly small atolls. Population declined by 17% from 1996-2001.
Federated States of Micronesia	702	107 (2000)	607 islands varying from mountainous to atolls spread over four states extending 2500 km east-west and 1000 km north-south. Population growth of 0.2% per year from 1994-2000.
Fiji Islands	18,300	844 (2004 est.)	320 islands, 1/3 populated. Largest two islands have 87% of land and ~ 95% of population. Population growth ~1% per year.
Kiribati	811	85 (2000)	32 widely scattered atolls in three groups plus one raised coral island stretching 4200 km east-west and 2000 km north-south. Population growth of 1.7% per year (urban + 5.2%, rural - 0.6%).
Marshall Islands	181	54.6 (2004 est.)	29 atolls (22 inhabited) and five raised coral islands (four inhabited). No land higher than 5 m above sea level. Population growth of 1.45% per year 1988-1999. 69% of people in Majuro / Kwajalein.
Nauru	21	10.1 (2002)	Single isolated equatorial island. Two plateaus with 'topside' peak of 71 m, typically 30 m above 'bottom side'. Population growth of only 0.15% per year from 1992-2002.
Niue	259	1.7 (2001-03)	Reputedly world's largest raised coral island. Reef is close to land and no lagoon. Land rises nearly vertically to perimeter height of 25-40 m. Population has been stable at around 1800 in recent years.
Palau	458	19.1 (2000)	200+ islands, most very small, only nine permanently inhabited. 95% of islands and 90% of population within the main reef containing Babeldaob, Koror and Peleliu islands.
Papua New Guinea	462,800	5,200 (2000)	600+ islands, with 80% of population in the eastern half of island of New Guinea. Reported population growth of 3.1%/year 1990-2000 and 2.3% 1980-1990 may be due to coverage errors
Samoa	2,934	176.1 (2001)	Volcanic islands of Savai'i (58% of land and 24% of population) and Upolu (38% and 76% respectively) plus eight small islands. Population growth of 0.56% per year from 1991-2002.
Solomon Islands	28,450	457 (2003 est)	Nearly 1,000 islands of which 350 are inhabited. 6 main islands account for 80% of land area and bulk of population. Population growth of 2.8% per year from 1986-1999, urban growth 3.8%.
Tokelau	12	1.5 (2001)	Three atolls: Atafu, Fakaofo and Nukunonu. Highest land about 5 m above sea level. Population declined by ~ 7% from 1996-2001.
Tonga	748	100 (2002 est)	176 islands in four groups (Tongatapu, Ha'apai, Vava'u & Niua) with 36 inhabited islands. Population growth of 0.35%/year 1986-1996, possibly slightly higher since then.
Tuvalu	26	9.3 (2002)	Six atolls with large lagoons enclosed by a reef plus three raised coral islands without large lagoons. Funafuti with 22% of land has over 48% of population. Population grew 0.25% per year 1991-2002.
Vanuatu	12,200	212 (2004 est)	Over 80 islands, mostly volcanic, 65 populated. 80% of the population, which is 76% rural, is on seven islands. Population grew by 2.6% per year from 1986-1996.

Source: National PIREP reports (2004) Note: ~ is 'approximately'

1.1.2 Internal inequalities

The distances within PICs can be large. Kiribati, for example, has only 85,000 people living on 33 widely scattered low atolls (800 km^2 of land) spread over 4200 kilometres from east to west and 2000 km north to south. Kiribati exemplifies the severe development challenges facing a small, remote and resource-poor island state during a period of rapid global change. The environment is fragile and – particularly in the rapidly-growing island of Tarawa – deteriorating. There is difficulty in providing adequate basic services (e.g. health, education, clean water, electric power, petroleum fuels, and communications) to the people, especially the rural majority. Even in relatively well-developed Fiji, transport services to outer islands are often intermittent with several months between shipments of basic goods, including fuel. Nonetheless, the people of the Pacific have the advantages of strong and resilient cultures, often highly egalitarian societies (with the partial exception of gender equality), strong democratic principles, and extensive sea resources.

1.1.3 Vulnerability

Numerous studies have documented the susceptibility of small island states to external economic fluctuations, natural disasters and environmental shocks. A Commonwealth Secretariat vulnerability index (Commonwealth Secretariat, 2000) ranks the PICs among the most highly vulnerable of the 111 countries studied. An environmental vulnerability index developed by the South Pacific Applied Geoscience Commission (SOPAC) is documenting PIC vulnerability further. The spectre of sea level rise is of particular concern to the atoll populations since most land is typically less than two metres above the present sea level.

1.1.4 Globalisation

Adjusting to the extraordinarily rapid rate of recent global economic, social and cultural change is a challenge for remote island states, which strive for an 'impossible trinity':[2] i) securing the benefits of globalisation; ii) maintaining national sovereignty, and iii) retaining sufficient flexibility to formulate national economic and social policies.

Among the challenges for the Pacific are to adequately protect traditional values such as communal sharing of resources and co-operative economic activity; protect land tenure that is often threatened by resource investments, minimise possible social costs of investment (e.g. increased economic inequality, less control of investment decisions, and declining working conditions), deal with the rapid erosion of preferential market access, afford the costs of joining (or not joining) the World Trade Organisation (WTO), carry out the substantial commitments to the global community summarised in the Millennium Development Goals (MDGs) of 2000, and capitalise on new information and communications technologies which could reduce isolation.

The challenges of adjusting to globalisation are large and the local resources and capacities for making the adjustments are small. Within the energy sector, there may be excellent opportunities for foreign investments and partnerships that can benefit the local people, but the PICs need the legal frameworks, regulations and incentive systems to make them work effectively and to their advantage. There are opportunities for using modern communications technologies in remote areas but without adequate and reliable energy systems in outer islands, these cannot be effective.

1.1.5 Climate change

The 2001 synthesis report of the United Nations Intergovernmental Panel on Climate Change (IPCC, 2001) concluded, with a 'robust level of confidence', that global

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[2] This term was coined by the late Fijian economist and Vice Chancellor of the University of the South Pacific, Savenaca Siwatibau.

warming is underway and likely to increase during this century at rates unprecedented in the past 10,000 years. Subsequent reports have confirmed this conclusion. For small islands, the IPCC warns of deteriorating coral reefs, mangrove intertidal areas and seagrass beds, major species loss, worsening water balances in atoll nations, and declines in vital reef fisheries – all with a medium-to-high confidence level. For the Pacific islands, the World Bank warns (WB, 2000) of likely reductions in agricultural output, declines in ground water quantity and quality, substantial health impacts (increased diarrhoea, dengue fever and fish poisoning), extensive damage due to storm surges, and lowered fish production. It concludes *"managing change will be particularly critical in the area of climate change, a subject ... of immense and immediate impact on Pacific Island countries. Choosing a development path that decreases the islands' vulnerability to climate events and maintains the quality of the social and physical environment will ... be central to the future well being of the Pacific Island people."*

The Federated States of Micronesia (FSM), Kiribati, the Marshall Islands, Tokelau, and Tuvalu are among the countries predicted to suffer the greatest impact of climate change – including disappearance of some islands in the worst-case scenario. For the energy sector, where investments made today will have effects for many decades, PICs must consider carefully where to locate large petroleum storage terminals, how to dispose safely of wastes and plan for spills where coastlines may erode. They must decide whether to make large investments in hydropower or biomass energy if rainfall patterns may change or in wind energy if wind patterns might change significantly over time. They must decide how to protect expensive investments in renewable energy technologies (RETs) and best develop energy services in a changing environment.

1.1.6 Managing marine resources

The Central -West Pacific has the world's richest tuna fishery. However, during the 1990s the island states captured only 11% of US$2 billion in annual landed value (WB, 2000). Effectively managing the fish – and eventually mineral – resources of the Pacific Ocean will be a key challenge in coming decades. Determination of sustainable maximum yields, access negotiations with distant fishing nations, and assurance of good economic returns and local employment will require improved cooperation on a regional basis. If the PICs decide to invest more heavily in fishing and onshore facilities to support fishing, as several did in the 1990s, this can result in a huge increase in marine fuel use and the economic risks, storage requirements, handling and safety issues associated with increased petroleum imports.

1.1.7 Poor data

Assessing key development issues, formulating and implementing effective policies, and monitoring results require a wide range of timely, accurate and consistent data. In the PIC region, however, data – where collected at all – tend to be available years late, sometimes using second or third hand sources and are rarely checked for errors or consistency. Time-series datasets tend to be limited, inaccurate and inconsistent and not sufficient for determining trends.

For a small PIC, even good data for a specific year can be misleading. Accurate fuel imports for a single year, for example, are seldom useful for estimating future imports. The data can be misleading for calculating petroleum consumption during the year because infrequent deliveries may result in a delivery in (for example) either December or January, skewing the apparent consumption for both years.[3] In addition, the oil companies reportedly no longer consistently distinguish between inland fuel use and bunkering or re-exports. Aviation gasoline or fuel oil for ships, for example, reported as re-exports in 1995 may be considered inland consumption in 2004. That makes it difficult to determine trends over time or the amount of fuel actually consumed locally. In general, the quality of PIC energy sector data, whether for commercial energy, such as electric power and petroleum, or non-commercial, such as wood or other biomass, are poor. In general, reliability of energy data appears to be considerably lower in 2004 than ten or fifteen years ago.

In nearly all of the fifteen countries studied under PIREP, petroleum import data, both total and retained volumes, were unreliable or not available, resulting in significant uncertainties regarding the baseline commercial energy consumption against which to measure the potential for renewable energy development and reductions in greenhouse gas (GHG) emissions. The problem was made much worse by the unwillingness, in nearly all countries, of the petroleum industry to provide import or sales volume data that was requested by the PIC governments for the PIREP studies.

Improved data and time series are essential for energy sector planning, for constructing meaningful development indicators and for understanding development trends in these small states.

1.1.8 Development assistance to the Pacific

A number of the smaller PICs are highly dependent on donor assistance for developing and implementing social and economic policies. It has been stated by some officials that donors shift emphases too frequently, leading to support that is often too short-term to produce lasting impacts. Where aid is a small percentage of GDP, the volatility of aid flows and priorities may not be a serious concern but for some PICs, it can arguably undermine development efforts. The donor community is not well equipped to effectively provide the small levels of support best suited to most of the PICs. Changes in donor energy development policies have tended to result in either a feast or a famine for the region. In the energy sector, there was significant assistance to PICs during the 1980s but this dropped off rapidly by the mid 1990s as donor priorities changed, then began to increase again in the late 1990s and for several countries is currently at the highest level ever. Small countries find it difficult to quickly develop the capacity to handle rapidly increasing donor programmes. If the capacity is developed, the country often cannot maintain it when the donor support later declines significantly.

1.1.9 Population growth and poverty

Over the past decade, numerous studies have warned that population growth may be hampering the region's development efforts. The Asian Development Bank (ADB), in a series of reports, has also recently warned of growing poverty in the Pacific islands, where 43% of the population are estimated to be disadvantaged. The ADB states that the following key issues affect its "Pacific Member Developing Countries" (PMDCs): governance problems, populations growing faster than the economies, declining educational performance, weakness of the private sector, breakdown of traditional support systems, and an urban elite capturing a high percentage of the benefits of

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[3] The smaller PICs often receive fuel shipments every month or even less frequently. If end-of-year stocks in bulk storage differ substantially from year to year, retained imports during the year can differ by 10-15% or more from actual consumption during the same year.

modernisation. Development challenges, according to the ADB, include disappointing macroeconomic performance, increasing poverty, increasing environmental degradation, and limited progress in gender equality. With growing pressure for structural reform of the energy sector, including privatisation in countries where the government has been the dominant economic force, a good deal of assistance will be required if these reforms are to proceed smoothly and result in benefits to the people.

1.1.10 Political development

Although political systems differ within the region, most PICs have adopted a Westminster form of parliamentary democracy with voters electing members of parliament (or equivalent) with the head of government then chosen by parliament. The former Trust Territories in the North Pacific have adopted a form of the US system with direct elections of the President whereas Tonga is a Kingdom. There have been military and civilian coups (Fiji), civil war (Solomon Islands) and instability (Papua New Guinea). However, in 2004 most PICs appear to be relatively stable, with vibrant democratic institutions, the rule of law enforced, a strong legal/judicial system, and relatively few reports of human rights abuses.

1.2 Environmental Overview

PICs have ratified a number of important international environmental conventions including the Convention on Biological Diversity (1992), the Ramsar Wetlands Convention (1993), the United Nations Framework Convention on Climate Change (UNFCCC, 1993), the London Convention on the Prevention of Marine Pollution (1994), the Montreal Protocol on Ozone-depleting Substances (1998), the Convention on the Illegal Trade in Endangered Species (CITES), the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean and the Apia Convention on the Conservation of Nature in the South Pacific.

Table 1-2 – Key Environmental Treaties and Conventions of Importance to PICs

Convention/Treaty	Formal Title(s)	Comments
Waigani Convention	Convention to Ban the Importation Into Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Trans-boundary Movement and Management of Hazardous Wastes within the South Pacific Region	Done at: Waigani, PNG, 16 Sept. 1995 In Force: 21 October 2001 Depository: PIFS Secretariat SPREP
Treaty of Rarotonga	South Pacific Nuclear Free Zone Treaty	Done at: Rarotonga, 06 Aug. 1985 In Force: 11 December 1986 Depository: PIFS
Apia Convention	Apia Convention on Conservation of Nature in the South Pacific	Done at: Apia, Samoa In Force: 26 June 1990 Depository: SPREP
SPREP Convention	Convention for the Protection of Natural Resources	Done at: Apia, Samoa, In Force: 22 August 1990 Depository: SPREP
Key International Treaties:		
Montreal Protocol, et. al.	The international agreements to protect the ozone layer include the following set: The Vienna Convention for the Protection of the Ozone Layer (1985); The Montreal Protocol on Substances that Deplete the Ozone Layer (1987); The London Amendment to the Montreal Protocol (1990); The Copenhagen Amendment to the Montreal Protocol (1992); The Montreal Amendment to the Montreal Protocol (1997); and The Beijing Amendment to the Montreal Protocol (1999).	
Kyoto Protocol	1997 Protocol to the 1992 UNFCCC establishing, when in force, legally binding targets for reducing greenhouse gas emissions for developed countries.	

Source: SPREP and UNFCCC and UNEP websites.

These conventions bind signatory countries to observe the regulatory measures contained in them. Initial national communications to the UNFCCC, indicating GHG emission inventories, and vulnerability and adaptation to climate change, have been prepared by ten PICs with assistance from SPREP. Table 1-2 summarises some key environmental conventions of importance to PICs and Table 1-3 summarises the status for individual PICs.

Table 1-3 – Status of PICs Ratification of Environmental Treaties and Conventions (May 2004)

Country and treaty status		Protection of natural resources: SPREP Convention	Conservation of nature: Apia Convention	Hazard. wastes: Waigani Convention	Nuclear free Pacific: Treaty of Rarotonga	GHG reductions: Kyoto Protocol	Ozone depleting substances: Montreal Protocol et. al.	UNFCCC: initial national communication
Cook Islands	Signed Ratified In Force	25 Nov 87 09 Jul 89 22 Aug 90	24 Jun 87 26 Jun 90	17 Sep 95 30 Oct 00	06 Aug 85 28 Oct 85 11 Dec 86	16 Sep 98 27 Aug 01 n/a	Ac to Vienna Convention: 21 Mar 86	Yes, 1999
Fed States of Micro.	Signed Ratified In Force	09 Apr 87 29 Nov 88 22 Aug 90	No no	17 Sep 95 26 Jan 96 21 Oct 01	06 Aug 85 20 Oct 86 11 Dec 86	16 Mar 98 15 Nov 00 n/a *	– 21 Dec 92 17 June 93	Yes, 1999
Fiji	Signed Ratified In Force	– 14 Sep 89 22 Aug 90	– 8 Aug 89 26 Jun 90	16 Sep 95 18 Apr 96 21 Oct 01	06 Aug 85 04 Oct 85 11 Dec 86	17 Sep 98 17 Sep 98 n/a	Ac: 23 Oct 89 Also L & C	No, draft prepared 1997
Kiribati	Signed Ratified In Force	no no	No no	16 Sep 95 28 Jun 01 21 Oct 01	06 Aug 85 28 Oct 86 11 Dec 86	n/a	Ac: 7 Jan 93	Yes, 2000
Marshall Islands	Signed Ratified In Force	25 Nov 86 23 Jul 90 22 Aug 90	- 20 Jul 90 26 Jun 90	16 Sep 95 23 May 01 21 Oct 01	06 Aug 85 20 Oct 86 11 Dec 86	17 Mar 98 11 Aug 03 n/a	Ac: 11 Mar 93 Also L C & M	Yes, 2000
Nauru	Signed Ratified In Force	15 Apr 87 28 Aug 95 22 Aug 90	No no no	16 Sep 95 no	17 Jul 86 13 Apr 87 13 Apr 87	– 16 Aug 01 n/a	Ac: 12 Nov 00	No
Niue	Signed Ratified In Force	no no	No no	16 Sep 95 22 Jul 03 21 Aug 03	06 Aug 85 12 May 86 11 Dec 86	08 Dec98 06 May 99 n/a	Ac to Vienna Convention: 21 Mar 86	No
Palau	Signed Ratified In Force	25 Nov 86 25 Nov 86 22 Aug 90	No no	16 Sep 95 no	??	– 10 Dec 99 n/a	Ac 29 May 01 Also LCM&B	No
Papua New Guinea	Signed Ratified In Force	03 Nov 87 15 Sept 89 22 Aug 90	12 June 76 No	16 Sep 95 11 Dec 95 21 Oct 01	16 Sep 85 15 Sep 89 15 Sep 89	02 Mar 99 28 Mar 02 n/a	3 Mar 98 Also L & C	Yes, 2000
Samoa	Signed Ratified In Force	25 Nov 86 23 Jul 90 22 Aug 90	- 20 Jul 90 26 Jun 90	16 Sep 95 23 May 01 21 Oct 01	06 Aug 85 20 Oct 86 11 Dec 86	16 Mar 98 15 Nov 00 n/a *	– 21 Dec 92 17 June 93	Yes, 1999
Solomon Islands	Signed Ratified In Force	– 10 Aug 89 22 Aug 90	No no 26 Jun 90	16 Sep 95 07 Oct 98 21 Oct 01	29 May 87 27 Jan 89 27 Jan 89	29 Sep 98 13 Mar 03 n/a *	Acc: 17 June 93	To be submitted during 2004
Tokelau	Signed Ratified In Force	?	No no	??		no no n/a	Ac to C only: 4 Jun 93	No
Tonga	Signed Ratified In Force	– – –	– – –	16 Sept 95 22 May 03 22 Jun 03	06 Aug 85 16 Jan 86 18 Dec 86	Acceded 20 Jul 98	Acc: Vienna Convention, 29 Jul 98	Yes, 2004
Tuvalu	Signed Ratified In Force	14 Aug 87 14 Aug 87 22 Aug 90	No no	no 21 Sep 01 21 Oct 01	06 Aug 85 16 Jan 86 11 Dec 86	16 Nov 98 16 Nov 98 n/a	Ac: 15 Jul 93 Also L C & M	?
Vanuatu	Signed Ratified In Force	no no	No no	16 Sep 95 no n	16 Sep 95 09 Feb 96 09 Feb 96	– Ac: 17Jul 01 n/a *	Ac: 21 Nov 94	Yes, 1999

Notes: ? = Information not available or conflicting information provided by sources; Ac = acceded; n/a = not applicable;
L C M B = London, Copenhagen Montreal and Beijing amendments to Montreal Protocol
The Kyoto Protocol has been in force from 15 February 2004 for European Union members only.

Sources: 1) Kyoto Protocol from www.unfcc.int; 2) Montreal Protocol and related agreements from www.unep.org/ozone/montreal; and
3) Others from Initial Communication to UNFCCC, PIC government sources., SPREP and PIFS in early 2004

The fifteen national PIREP reports discuss key environmental issues at the national level and these are not repeated here. The region overall is quite vulnerable to environmental shocks such as tropical cyclones, flooding, drought and earthquakes. The impacts of these shocks are often increased by poorly planned land use (e.g. deforestation and uncontrolled agricultural expansion) and poor waste management that has caused damage to coral reefs. Very rapid urbanisation, particularly in the atoll island states, is causing severe, localised environmental deterioration.

1.3 Economic Overview

The constraints to development faced by PICs are well known and have been discussed in numerous studies for several decades. These include small, highly dispersed land areas and populations; distances far from world markets; narrow resource bases and primary production options, and vulnerability to natural disasters such as tropical cyclones and droughts, the last two to being especially problematic for atoll countries. In the smallest, most resource-poor PICs, a sustainable future with an improved quality of life for a growing population will be difficult to achieve.

Constraints to economic growth and poverty reduction include small markets, high cost structures, high vulnerability to shocks, and the very limited human resources available to public and private sector organisations. Combined with cultures that emphasise communal sharing of resources as a safety net strategy, these reduce incentives for individual entrepreneurship, labour, and wealth accumulation.

Significant numbers of the best educated, most skilled, and most motivated Pacific Islanders have emigrated and continue to emigrate to the USA, New Zealand and Australia. Some PICs encourage this brain drain as it increases remittances, thereby supporting the domestic economy, at least in the short term. However, emigration can also result in a downward spiral in local skills and capacity. According to the ADB (2004), reliance on remittances and trust funds will probably be insufficient to raise the living standards of local populations significantly.

The governments of most PICs have developed and adopted national development plans – influenced and often supported financially by donor agencies – that emphasise more rapid economic growth, equitable distribution of the benefits of growth, increased emphasis on the private sector as an engine of growth, and the recent recognition of poverty and gender equality as genuine problems which need to be addressed.

In a recent draft analysis[4] of development issues among its PDMCs, the ADB characterises the economic performance among them over the past decade as generally disappointing with poverty increasing. Although coverage is limited to the thirteen PDMCs, the conclusions broadly apply to PICs in general:[5]

> *"While significant variation exists in the PDMCs' circumstances and performance, the overall picture is not encouraging. The Pacific is falling behind other developing regions. Economic growth has not kept pace with high population growth rates (Table 1-4), so per-capita incomes are declining, sometimes steeply; even where per-capita growth has occurred, it is insufficient*

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[4] *ADB Pacific Strategy 2005-2009: Responding to the Priorities of the Poor* (Draft Discussion Paper; ADB, April 2004). The fourteen PDMCs are the Cook Islands, FSM, Fiji, Kiribati, Nauru, Palau, PNG, Marshall Islands, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. Timor Leste (East Timor) is also a PMDC within ADB's terminology. Two countries included within PIREP (Niue and Tokelau) are not ADB members.

[5] Similar issues have been raised in Forum Communiqués, World Bank reports, internal PIC reports, etc.

to promote real development. The private sector has been unable to lead economic growth. Job creation for young populations has been minimal. Poverty is becoming a significant issue in many PDMCs. Previously mitigated by social safety nets in rural villages, it today manifests itself most often as hardship in meeting basic needs rather than in absolute or food poverty; it lurks in unplanned and un-serviced peri-urban settlements filled with migrants seeking nonexistent jobs, and among those populations left behind on outer islands. While data are not definitive, more than 25% of the populations of Fiji Islands, Kiribati, Federated States of Micronesia, Papua New Guinea, Solomon Islands, ... and Vanuatu are believed to be living in poverty.

PDMC governments are finding it difficult to maintain fiscal discipline. Revenue collection levels are not growing, but demands for and expectations of public services financed by scarce public sector resources are. Providing infrastructure and services for education, health care, transportation, communications, energy and water, continue to be major challenges for most PDMCs. Their inability to fund maintenance programs often makes it necessary to reconstruct existing infra-structure, thus diverting funds from new development projects and programs."

Table 1-4 – Ave Annual Changes in Real GDP, Population and GDP/Capita (Local Currency Terms) 1995 - 2002

Country	Growth from 1995 – 2002 (%)		
	GDP	Population	GDP / capita
Cook Islands	3.0	-3.1	6.3
Fiji Islands	2.4	1.1	1.3
Kiribati	4.6	1.6	2.9
Marshall Islands	-2.5	2.4	-4.8
Fed States of Micronesia	-0.5	0.2	-0.7
Papua New Guinea	-0.1	3.2	-3.2
Samoa	4.4	1.0	3.4
Solomon Islands	-2.2	2.9	-4.9
Tonga	2.1	0.5	1.6
Tuvalu	4.3	1.3	3.0
Vanuatu	0.8	2.6	-1.7
PDMCs, weighted ave.	0.9	2.4	-1.2
Excl. PNG, weighted ave	2.0	1.1	0.9

Source: ADB

As ADB's Table 1-4 shows, from 1995-2002, in local currency terms, the PIC economies declined by 1.2% per capita per year overall (but grew by 0.9% annually if PNG is excluded). The ADB also reports that social indicators are declining for some PDMCs[6] and many will fail to achieve key MDG[7] targets as planned by 2015. Crime and ethnic tensions are growing in some areas, and the rule of law has come under pressure in some countries, notably PNG and the Solomon Islands. . Environment and natural resource management concerns – arising from population growth, urbanisation, and the need for cash income – threaten the sustainability of development. Fresh water resources, waste management, coastal deterioration, and forest degradation are identified by the ADB as key concerns, as well as climate change and sea level rise, especially for low-lying countries. The PICs have taken few practical

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[6] From 1994 to 2003, the UN Human Development Index for Fiji slipped from 59 of 173 countries to 80 of 175, Vanuatu slipped from 119 to 128, and PNG 129 to 132. Samoa, however, significantly improved its ranking, from 104 to 71.

[7] In September 2000, 147 countries including most PICs adopted the Millennium Development Goals (MDGs), a set of targets with quantifiable indicators, now widely used to assess development progress. The MDGs, agreed at the UN General Assembly, are to eradicate extreme poverty and hunger; achieve universal primary education; promote gender equity and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria and other diseases; ensure environmental sustainability; and develop a global partnership for development. Details of national PDMC progress towards the MDGs are discussed, where available, in the respective national reports.

steps to improve economies of scale and spread the costs of providing specialised public goods through deeper regional cooperation.

External conditions are sometimes cited as a cause of weak PIC performance, but the ADB argues that external forces have essentially been supportive, with strong growth in key trading partners and generally improving commodity prices since the mid-1990s. Reductions in concessional terms to PIC products in many markets have had a detrimental effect, but the Pacific has also benefited from cheaper imports and lower transport and communication costs. However, very low competitiveness has reduced the ability of the PICs to take advantage of external conditions and the opportunities emerging from new technologies and the growth of services in world trade. Finally the ADB argues that natural and external conditions are real constraints but are not the determining cause of weak performance and worsening situations: *"ADB believes that significant constraints to growth and poverty reduction in the Pacific lie in the area of policy and institutions, especially weaknesses of economic and social institutions ... [that] is broader than merely the organisations and structures that frame economic and social behaviour; it also encompasses the 'rules of the game' by which that behaviour is carried out. ... These include constitutions, laws and regulations as well as trust, informal rules and social norms."*

The mixed economic performance of PICs is often made worse by plans and commitments which are not reflected in the actions, decisions, resource allocations, detailed policies, and legislation required for implementation. This is as true of energy sector development as it is of overall national development.

1.3.1 Economies of individual PICs

For individual PICs, key economic features are summarised in Table 1-5. The table is from a 2001 study by the Pacific Islands Forum Secretariat (PIFS) on the investment climate in PICs and is somewhat out of date. Nonetheless, it remains useful as a summary comparison of the national economies of Forum island states. This table excludes the New Zealand dependency Tokelau, a non-Forum member.

1.3.2 Economic treaties

As shown in Table 1-6 most PICs are signatories to the three Pacific regional trade and economic trade agreements, the most important of which are the Pacific Island Countries Trade Agreement (PICTA) and the Pacific Agreement on Closer Economic Relations (PACER; between PICTA signatories and Australia and New Zealand), which the development community and PIFS have promoted as prerequisites to more sustained economic growth.[8] A number of PICs have also signed the Cotonou Agreement, providing membership in the African, Caribbean and Pacific (ACP) group of countries, and thus access to development assistance from the European Union (EU).

[8] Some analysts question whether these agreements, and PIC attempts to open their economies further, are really in the PICs' interests. See for example *Regional Consultation on Globalisation, Trade, Investment and Debt* (Pacific Islands Association Of Non-Governmental Organisations; Suva, May 2001) and *The WTO Incompatibility of the Lomé Convention Trade Provisions* (R Grynberg; Australian National University Asia-Pacific School of Economics and Management; South Pacific Working Paper #98/3; 1998. Grynberg is a former Forum Secretariat and University of the South Pacific economist.

Table 1-5 – Forum Island Countries: Summary of Key Economic Features (for most recently available year)											
Country	**Area** (km^2)	**Estimated Population** 1996 ('000)	**GDP per capita** (US$)	**Imports** (US$'m)	**Exports** (US$'m)	**Principal Import Items**	**Principal Export Items**	**Net Aid Inflows** (US$'m)	**Share of GDP (%)**		
									Primary[A]	**Manuf.**	**Tertiary**[B]
Cook Islands	240	20.6	4,186 (1995)	35.3 (1996)	2.5 (1996)	Food and live animals and machines transport and equipment	Tourism; black pearls; pawpaw	9.4 (1996-97)	18.8 (1995)	2.7 (1995)	78.5 (1995)
Federated States of Micronesia	705	110 (1994)	1,967 (1994)	164.5 (1994)	69.6 (1994)	Mineral fuels; manufactured goods; machinery; food; milled timber and building supplies	Copra; commercial fishing rights	113 (1994)	N/A	N/A	N/A
Fiji Islands	18,272	773	1,698 (1996)	718 (1996)	546 (1996)	Mineral fuels; manuf. goods; chemicals; machinery; food	Tourism; sugar and molasses; garment manufacturing; gold; lumber; fish; coconut oil, ginger	86 (1996) (net official transfers)	23 (1996)	15 (1996)	62 (1996)
Kiribati	811	78.3 (1994)	447 (1993)	22.3 (1993)	3.6 (1993)	Mineral fuels; manuf. goods; machinery; food	Copra; tuna fish; commercial fishing rights	12.5 (1993)	39.9 (1992)	10.8 (1992)	49.3 (1992)
Marshall Islands	181	56 (1995)	1,872 (1995)	75 (1995)	23 (1995)	Mineral fuels; manuf. goods; machinery; food	Coconut oil and copra; fish; handicrafts	50 (1993)	14.9 (1995)	2.6 (1995)	63.7 (1995)
Nauru	21.1	10.7	4,145 (1992)	15.4 (1996)	25.1 (1996)	Food; clothing; mineral fuel; machinery and other manuf items	Phosphate deposit	Nil	N/A	N/A	N/A
Niue	259	2.2	2,807 (1994)	3.1 (1996)	0.24 (1996)	Mineral fuel; manuf. goods; machinery; food	Handcrafts and agricultural goods; taros and coconuts	1 (1993)	19 (1991)	7 (1991)	74 (1991)
Republic of Palau	487	17.2 (1995)	8,000 (1996)	79 (1996)	14.3 (1996)	Manuf. goods, machinery, food, beverage and tobacco	Fish, garments	N/A	24.4 (1996)	0.8 (1996)	74.8 (1996)

Table 1-5 – Forum Island Countries: Summary of Key Economic Features (continued)											
Country	**Area** (km^2)	**Estimated Population** 1996 ('000)	**GDP per capita** (US$)	**Imports** (US$'m)	**Exports** (US$'m)	**Principal Import Items**	**Principal Export Items**	**Net Aid Inflows** (US$'m)	**Share of GDP (%)**		
									Primary[A]	**Manuf.**	**Tertiary**[B]
Papua New Guinea	462,840	4,200	1,263 (1996)	1,151 (1996)	1,979 (1996)	Mineral fuel; manuf. goods; machinery, capital equipment; food; consumer goods; industrial supplies; transport; equipment	Gold; copper; oil; coffee; copra; cocoa; palm oil; logs	97.4 (1996)	54 (1995-6)	8 (1995-6)	38 (1995-6)
Samoa	2,934	170	896 (1996)	110 (1996)	65 (1996)	Food; mineral fuels; manuf. goods; machinery	Coconut products; fish; beer; kava; automobile wiring harnesses	15.8 (1993)	37 (1996)	13 (1996)	50 (1996)
Solomon Islands	28,369	380	685 (1995)	120 (1996)	146.5 (1996)	Mineral fuel; manuf. goods; machinery; food	Fish; timber; copra; palm oil; cocoa	23.4 (1996)	N/A	N/A	N/A
Tonga	699	98.3	1,473 (1995)	88.5 (1996)	15.4 (1994)	Mineral fuel; manuf. goods; machinery; food	Squash; vanilla and live animals	55.1 (1994)	3.5 (1995)	5 (1995)	60 (1995)
Tuvalu	26	9.6	1,083 (1995)	8.3 (1995)	Neg	Food and beverages; crude materials; machinery and transport equipment; manufacture goods	Stamps; copra; handcrafts; garments	7.5 (1992)	21.2 (1990)	5.1 (1990)	73.7 (1990)
Vanuatu	12,190	177.4 (1997)	1,348 (1995)	94.3 (1996)	29 (1996)	Food; mineral fuels; manuf. goods; machinery	Copra; beef; cocoa; coffee; kava; timber; shells	49 (1995)	23 (1995)	13 (1995)	64 (1995)

Source: *Overview of Foreign Investment Climate: Forum Investment Climate Study* (PIFS, 2001) except Tokelau from Tokelau national PIREP report (2004).
Date from FIC Government Departments and IMF, World Bank, Asian Development Bank, National Centre for Development Studies.

Notes: A) Primary Sector includes agriculture, forestry, fishing and mining. B) Tertiary Sector includes all services and construction.

Table 1-6 – Status of Key PIC Economic Agreements				
Country		**SPARTECA**	**PACER**	**PICTA**
Cook Islands	Signed	14 July 1980	18 Aug 2001	18 Aug 2001
	Ratified	12 Nov 1980	28 Aug 2001	28 Aug 2001
	In Force	01 Jan 1981	03 Oct 2002	13 Apr 2003
Fed States of Micro.	Signed	–	no	no
	Ratified	29 Nov 1988	no	no
	In Force	29 Dec 1988		
Fiji	Signed	–	18 Aug 2001	18 Aug 2001
	Ratified	02 Dec 1980	16 Oct 2001	16 Oct 2001
	In Force	01 Jan 1981	03 Oct 2002	13 Apr 2003
Kiribati	Signed	14 July 1980	18 Aug 2001	18 Aug 2001
	Ratified	10 July 1981	04 June 2003	04 June 2003
	In Force	09 Aug 1981	03 Oct 2002	13 April 2003
Marshall Islands	Signed	14 July 1980	18 Aug 2001	18 Aug 2001
	Ratified	24 Feb 1981	10 Oct 2001	10 Oct 2001
	In Force	26 Mar 1981	03 Oct 2002	13 April 2003
Nauru	Signed	–	18 Aug 2001	18 Aug 2001
	Ratified	08 Aug 1982	14 Mar 2003	14 Mar 2003
	In Force	07 Sept 1982	3 Oct 2002	13 Apr 2003
Niue	Signed	14 July 1980	18 Aug 2001	18 Aug 2001
	Ratified	22 Jan 1981	no	26 Feb 2003
	In Force	21 Feb 1981		
Palau	Signed	–	18 Aug 2001	no
	Ratified	?		no
	In Force			no
Papua New Guinea	Signed	14 July 1980	05 Mar 2002	05 Mar 2002
	Ratified	31 Dec 1980	05 Aug 2003	05 Aug 2003
	In Force	01 Jan 1981	03 Oct 2002	13 April 2003
Samoa	Signed	14 July 1980	18 Aug 2001	18 Aug 2001
	Ratified	24 Feb 1981	10 Oct 2001	10 Oct 2001
	In Force	26 Mar 1981	13 Oct 2002	13 Apr 2003
Solomon Islands	Signed	14 July 1980	18 Aug 2001	06 Aug 2002
	Ratified	15 Apr 1980	02 June 2003	02 June 2003
	In Force	15 May 1981	03 Oct 2002	13 April 2003
Tokelau *	Signed		18 Aug 2001 ?	no
	Ratified		21 Nov 2001 ?	no
	In Force		03 Oct 2002	no
Tonga	Signed	14 July 1980	18 Aug 2001	18 Aug 2001
	Ratified	24 Dec 1980	27 Dec 2001	27 Dec 2001
	In Force	01 Jan 1981	3 Oct 2002	13 Apr 2003
Tuvalu	Signed	14 July 1980	18 Aug 2001	18 Aug 2001
	Ratified	04 May 1981	no	
	In Force	03 June 1981		
Vanuatu	Signed	no	18 Aug 2001	18 Aug 2001
	Ratified	18 Nov 1981	no	no
	In Force	18 Dec 1981	3 Oct 2002	13 Apr 2003

Source: Communications from SPREP and PIFS, 2003 and 2004 * through New Zealand
? = information not available or conflicting information provided from different sources

1.3.3 Investment Incentives

Table 1-7 provides an overview of the range of investment incentives offered by the FICs in 2001.

Table 1-7 – Forum Island Countries : Sample of Incentives for New Investments	
Country (& comment)	**Examples of Investment Incentives**
Cook Islands	• Exemptions from customs import duties • Taxation concessions • Tariff protection • Accelerated depreciation allowances
Federated States of Micronesia	• Duty free access to the US market for most categories • Import duty exemptions
Fiji (new investment legislation pending)	• Tax Free Zone/Tax Free Factory Scheme which includes: 1. Tax holidays 2. Accelerated depreciation 3. Import duty exemptions 4. Special industry related incentives 5. Carry forward of losses
Kiribati	• Case by case approach which may include: 1. Reduced company taxation 2. Depreciation allowances 3. Full or partial exemptions from customs duties 4. Direct Government investment in certain projects
Niue	• Case by case approach which may include: 1. Taxation concessions 2. Exemptions from customs import duties 3. Tariff protection
Papua New Guinea	• Taxation incentives • Special depreciation allowances • Wages subsidies • Staff training double deduction against company taxation • Contribution to costs of feasibility studies
Samoa	• Taxation concessions • Customs import duty concessions • Export Finance Facility • Access to industrial land
Solomon Islands	• Taxation concessions • Staff training double deduction against company taxation • Export promotion taxation incentives • Accelerated depreciation • Customs import duty concessions on capital equipment
Tonga	• Taxation concessions • Customs import duty concessions on capital equipment • Protection from competition for specified periods
Tuvalu	• Case-by-case approach which may include: 1. Taxation concessions
Vanuatu	• Case-by-case approach which may include: 1. Customs import duty concessions 2. Vanuatu has no company tax, no income or withholding tax, no capital gains tax nor sales taxes
Source: *Overview of Foreign Investment Climate: Forum Investment Climate Study* (PIFS, 2001)	

The individual national PIREP reports provide additional, and updated, information on incentives although they remain broadly as indicated in Table 1-7. In general, PIC bureaucracies are slow in dealing with potential investors, are often inconsistent in interpreting the rules, and are ill prepared for pending changes under WTO membership and regional economic agreements.

1.4 Institutional and Policy Context for Energy

This section summarises the PIC energy sector policies, plans and the existing institutional and legal arrangements for energy management and development. Although some changes will have occurred since this was prepared in mid 2004, the broad description of the situation is representative of energy institutions, policies and plans in the region.

1.4.1 PIC National Energy Offices

Table 1-8 provides an overview of the PIC government offices responsible for energy matters. The number of national staff dealing with energy is indicative and may not be exact. The table excludes unfilled positions, power utility staff, and staff of any government-owned renewable energy service companies.

It is clear from the table that even the largest PICs (PNG and Fiji) have relatively small government departments responsible for national energy policies and planning. Most energy offices were established as a result of a cabinet (or equivalent) decision in the early 1980s. None have been established under legislation that gives them a clear statutory or other legal mandate[9] with responsibilities and powers agreed by parliament (or its equivalent). Often the powers and responsibilities are vague and these can be removed or modified by subsequent cabinet decisions. Apparently only three energy offices (Fiji, PNG and Vanuatu) have a strategic, corporate or business plan, defining roles and medium-term goals within the public service.

In many PICs, the “energy unit” or “energy office” consists of only one or two staff, who deal mainly with the administration of donor-funded renewable energy projects, and have very little influence on broader national energy policies. In several countries, energy policy is the responsibility, formally or informally, of the electric power utility or electricity section of a public works department. A few energy units have some role in monitoring or establishing retail petroleum prices. Due to relatively rapid staff turn over and the associated need for training, often energy officers may need to spend a fifth or more of their time abroad or at home at training courses, workshops, seminars, etc., leaving limited time for substantive work.

In some PICs, *ad hoc* or semi-permanent national energy coordinating committees have been established at ministerial or official level to bring together ministries, statutory authorities, non-governmental organisations (NGOs) and private sector interests dealing with energy matters. These occasionally operate with enthusiasm and effectiveness for short periods, but tend to languish when the crisis, donor project or issue for which they were established has been resolved or completed. The committees in general do not play an effective ongoing coordinating role to help guide the PICs in implementing those policies or plans which have been formally or tacitly agreed.

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[9] Such legislative authority has been proposed for the Cook Islands and Tonga but neither has been approved by cabinet. In the PICs it is not typical for government departments to be established under legislation and this makes long term programme consistency difficult.

Table 1-8 – Overview of PIC National Energy Office Staffing and Authority (early 2004)

Country	Full-time equivalent energy staff [1]	Legal mandate or authority [2]	Policy role [3] or project implementation	Oversee [4] electric power utility	Petroleum pricing or policy role [5]
Cook Islands	3	No	Both	Indirectly	No
Fiji	25 (incl 14 support staff)	No	Both	Indirectly	No
FSM	None national level; < 1 [a]	No	Both [a]	No	No
Kiribati	6	No	Both	Indirectly	Indirectly
Marshall Islands	1 [b]	No	Both	No	No
Nauru	No energy office; < 1	No	N/A	N/A	No
Niue	No energy office; <1 [c]	No	N/A	Yes [c]	No
Palau	2 (incl unestablished)	No	Both [e]	No	No
PNG	≈ 19 [d]	No	Both	Indirectly	No
Samoa	1	No	Policy	Indirectly	Yes
Solomon Islands	3	No	Both	Indirectly	No
Tokelau	2	No	Both	Yes	No
Tonga	5	No	Both	No	No
Tuvalu	2	No	Both	No	No
Vanuatu	8	No	Both	No	Minor

Sources: Annexes of PIEPSAP Project Document (SOPAC/UNDP, Dec. 2003) updated from national PIREP reports (2004).

NOTES: FOR SPECIFIC COUNTRY DATA: N/A = not applicable ≈ = approximate

a FSM. Until about 1991, four full-time (one per state; one national). Dept. of Econ. Affairs has climate change responsibilities

b Mar. Is. Govt.-owned Marshals Energy Co. has strong energy policy role.

c Niue. Electricity utility handles energy matters overall.

d PNG. Includes four long-term casual professional staff; excludes one on overseas study and one on overseas assignment. In mid 2004, government was considering recommendations to enlarge the Energy Division.

e Palau. Technically within PWD but director reports to Minister. No consistent departmental responsibility for RE.

f. Tokelau Department of Energy includes expatriate head and trainee. When the expatriate leaves, the number drops to 1

NOTES FOR COLUMNS:

1 Approximate full time staff in the energy office, energy department, energy unit, etc of the government. Excludes any government-owned energy company (e.g. Kiribati Solar Energy Company or Kiribati national Oil Company). Also excludes staff with non-energy responsibilities (e.g. Cook Islands electrical inspectors).

2 Has an energy office, ministry, etc been established under legislation approved by parliament or congress or equivalent (and thus providing statutory responsibilities and powers).

3 Does energy office deal only with policy and planning or also have responsibility for project implementation?

4 Does energy office have a seat on the board of the power utility or renewable energy utility or petroleum company? 'Indirectly' means that the Permanent Secretary or other senior official of same ministry is a Director.

5 Does the energy office have a legal role regarding petroleum fuel pricing, product quality, safety storage, etc?

1.4.2 PIC National Energy Policies and Plans

National energy policies. In mid 2004, only three PICs (the Cook Islands, the Marshall Islands and Tokelau) had current national energy policies with some form of official endorsement by their cabinets.[10] The policies were developed through a process of considerable consultation within government and with the public. Two other PICs (PNG and Samoa) had prepared draft policies that were under review in early 2004, and one (Fiji) had been directed by government to develop a new national energy policy by 2005. Samoa's draft policy was reviewed in late 2003 through a public workshop, critiqued with UNDP assistance, and subsequently is being modified to address various views and submissions.[11] In several other PICs (Kiribati and Tonga) incomplete draft policies have recently been prepared. Table 1-9 summarises the status of national energy policies.

[10] For Tokelau, where the three island councils operate independently, all three have approved the energy policy and strategy.

[11] It is understood that Samoa's cabinet may have approved the national energy plan later in 2004.

Table 1-9 – Status of PIC National Energy Policies and Plans (early – mid 2004)

Country	National Energy Policies	Energy Plans or Energy Components of National Development Plans
Cook Islands	The govt. prepared draft energy policy (2001) reviewed internally and externally then substantially revised over the next year. Cabinet adopted a final version, similar in style to PIEPP, in April 2003.	No energy action plan has been developed but SOPAC asked in late 2003 to assist. No specific priorities, activities or budget for energy. A *National Strategic Plan* was being developed in early 2004 with limited energy coverage. Status unknown.
Fiji	Corporate Plan for the Department of Energy 2002-2006 provides guidance for DoE's work. A national energy policy is to be developed in 2005.	A *Strategic Development Plan 2003-2005* has limited energy coverage and specifies a *Sustainable Development Bill* for 2004 and a "a comprehensive national energy policy to address renewable energy, efficiency and affordability, and environmental sustainability" by 2005.
FSM	Draft *National Energy Policy* prepared in 1999. SOPAC has advised on revised policy but no recent progress. No national electrification or rural electrification policy. Energy is considered a state, not federal responsibility.	A *Strategic Development Plan* is being prepared in 2004. Drafts available in early 2004 had no appreciable energy sector content but there may be policies to address terms of petroleum product supply.
Kiribati	*Energy Policy Issues and Guidelines* (2002) not endorsed by Cabinet and no formal status. Contains broad goals and objectives, and strategies to meet them, but is unprioritised mix of outdated, current and proposed activities. Solar Energy Company may evolve into a broader rural electrification agency but there is no national electrification policy even in draft form.	A *National Development Strategy 2000-2003* was being revised and updated in early 2004. The current status and the extent of energy content are not known.
Marshall Islands	A *National Energy Policy Statement* was endorsed by Cabinet in April 2003 incorporates much from the 1994 *Outer Islands Energy Policy.* Including proven technologies, transparent subsidies and full recovery of operational costs,	A set of strategies to implement the policy, developed with SOPAC assistance, was discussed in April 2003. Additional public consultations are reportedly planned. There is a *Strategic Development Plan Framework 2003-2018* ('Vision 2018') with some energy content.
Nauru	There is no national energy policy. A 2005 EU project with RE focus being handled mainly by environment division	A draft *Nauru Development Plan: 2002-200*6 was apparently never finalised and planning remains haphazard. The extent of energy content is not known.
Niue	The government adopted an energy policy in 1995 but it has no status. There is no overall energy coordination or regulation.	A *Niue Integrated Strategic Plan 2003-2008* includes provision of reliable energy supply to all residents and completion of an EU energy efficiency/RE project.
Palau	There is no national energy policy or plan.	The *National Master Development Plan 1996-2020* includes a goal of complete electrification
PNG	*National Energy Policy Statement* and *National Energy Policy Guidelines* of 2001 being revised following AusAID national energy policy review *of 2004. There is a draft Five-Year Strategic Plan for Department of Petroleum and Energy: 2004-2008*	The *Medium Term Development Strategy for 2003-2007* and a *Medium Term Fiscal Strategy for 2003-2007* have very little energy content except petroleum and gas development policy.
Samoa	Draft *National Energy Policy* prepared in 2003, reviewed at a stakeholders meeting, critiqued with UNDP assistance, and is being finalised. Samoa has a well-developed national petroleum fuel policy.	The *Strategy for the Development of Samoa: 2002-2004* has some limited coverage of energy, mainly power sector corporatisation plans.
Solomon Islands	Draft *National Energy Policy Guidelines* and *National Energy Policy Statement (*1995) prepared with PIFS assistance but never finalised. The Japanese govt. developed power sector master plan (2001). These have no formal status.	SI is emerging from several years of conflict and there has been little planning. A national economic development plan is to be prepared in 2004. The proposed energy content is not known.
Tokelau	Draft energy policy (2004) by UNESCO consultant approved by each island council Aug. 2004. Focus is desire for energy self-reliance in through RE and energy efficiency	There are concept papers for individual departments but no overall plan. Each island council is essentially independent.
Tonga	Draft *Tonga National Energy Policy* (2002) is essentially an incomplete and slightly edited form of PIEPP. There is no national electrification policy or plan.	Str*ategic Development Plan 7* is valid until July 2004. Cabinet approved an Economic and Public Sector Reform Programme in 2002. Energy coverage in both is minimal.
Tuvalu	A *Tuvalu National Energy Policy Statement* (1995), prepared with PIFS, was approved by Cabinet in 1997 but never really used. Preliminary work has begun on a new policy but it is a low priority for the government.	The *National Development Strategy 1995 – 1998* is apparently the most recent national plan. There is limited energy coverage but it is very much out of date.
Vanuatu	An *Energy Unit Business Plan for 2000-2004* provides some guidance but there is no national energy plan. A draft 1996 energy policy prepared with PIFS assistance was apparently 'adopted' but is effectively defunct.	*Priorities and Action Agenda: Supporting and Sustaining Development (2002)* is to be updated in 2004. The current status of the new plan and its energy coverage are unknown.

Source: Annexes of PIEPSAP Project Document (SOPAC/UNDP, Dec. 2003) updated from national PIREP reports (2004).
Notes: PIEPP is the *Pacific Islands Energy Policy and Plan*; RESCO is Renewable Energy Service Company; RE is renewable energy; WB is World Bank.

To some extent, policies under development or recently completed have been influenced by the content and format of the 2002 *Pacific Islands Energy Policy and Plan* (PIEPP), discussed below in section 1.6. Some PICs (Niue, Solomon Islands, Tuvalu and Vanuatu) sometimes rely for guidance on generic draft plans developed in the mid-1990s through the former Forum Secretariat Energy Division (FSED) energy advisory service and subsequently, SOPAC advice. In most PICs, there has been some external assistance since 2001 during the policies' drafting, reviewing or consultation process, with inputs from the German technical co-operation agency (*Deutsche Gesselschaft für Technische Zusammenarbeit*, GTZ), the Japan International Cooperation Agency (JICA), SOPAC, UNDP, GEF, UNESCO, ESCAP, the World Bank, ADB, the US National Association of State Energy Offices, and probably other organisations.

In some PICs there have been recent reviews of some aspects of rural energy policy including rural electrification (Fiji through ESCAP/SOPAC and separately through ADB in 2003/04; PNG through the World Bank in 2003/04) and renewable energy (Fiji through a UNDP/GEF national project on barriers to renewable energy in 2002-2003; and possibly Tonga through a Japanese mission on hybrid renewable/conventional energy systems commencing in late 2003. In most PICs, the development of a practical energy policy is a low priority by the government. Even where policies have been formally adopted, these tend to have limited impact, are often ignored when decisions related to energy are made, and often require substantial revision if they are to be practical.

National energy plans. Those PICs that have developed, or nearly finalised, recent national policies are generally beginning to think about specific plans to enable these policies to be implemented. Several follow the broad format of the PIEPP. Some drafts include specific activities and a timeframe. However, they tend to lack clear priorities and budgetary provisions required to implement the activities, except where the funds are provided by development assistance agencies. Most PICs have some form of national strategic plan or socio-economic plan, often donor driven. These tend to have some limited coverage of energy issues but usually this emphasises power sector investment needs, not policy, renewable energy utilisation or planning matters. A frequent exception, however, is a policy statement regarding the intended commercialisation and/or eventual privatisation of selected government functions, usually including the electric power utility. In addition to energy policies, Table 1-9 summarises the status of national energy plans within the PICs and to a lesser extent energy coverage within national socio-economic plans. This status is likely to change somewhat by 2005, by which time the Danish (DANIDA)/UNDP 'Pacific Islands Energy Policy and Strategic Action Planning' project (PIEPSAP) at SOPAC will have advised a number of countries.

Rural electrification policies. All PICs have at least an implicit electrification policy and national and/or state/provincial electric power utilities that are usually government-owned, exceptions being Tonga and Vanuatu where utilities are under private ownership. A number of PICs need improved guidelines for commercialisation and effective regulation in the interest of consumers. Urban electrification and main island grid systems function reasonably well. However, in many PICs rural electrification lacks clear policies and the quality of service is often poor. Where explicit policies do exist, there are often ambiguities regarding the role of the national utility. Subsidies for rural electrification tend to be high but typically are not explicit or often even recognised by officials. Policies regarding customer charges for rural electrification are often *ad hoc*, with communities or households in the same geographical area experiencing very different costs and standards for similar electrical services. In many PICs, the provision of rural electrification to islands and remote communities throughout the country has been an explicit policy objective for several decades. In some PICs the percentage of households electrified exceeds 90% (e.g. Cook Islands, Nauru, Niue, Palau, Samoa, Tokelau, Tonga and Tuvalu). However, in others (Solomon Islands, Vanuatu, PNG), less than 10% of households in remote islands or away from the utility grids are electrified and the growth in rural electrification has been slow. Clear policies, better institutional arrangements, consistent and transparent subsidy arrangements and reconsideration of tariff policies could improve the rate of rural electrification substantially in some PICs. Table 1-10 summarises the status of rural electrification policies within the region.

Table 1-10 – Status of PIC Rural Electrification Policies (early – mid 2004)

Country	Status
Cook Islands	There is no national rural electrification policy. In effect, RE policies and pricing differ island-by-island. The government is considering developing a national RE policy.
Fiji	A *Rural Electrification Policy* (REP) endorsed by Cabinet in 1993 is still operational but has not been as effective as hoped in substantially increasing RE to off-grid and island communities. ESCAP reviewed the REP in 2003, DoE considering report and recommendations to go to Cabinet in 2004. Cabinet has endorsed a charter for Renewable Energy Service Companies (RESCOs). Draft RESCO legislation prepared (2003) through UNDP/GEF and being reviewed in late 2004 by UNDP/GEF.
FSM	SOPAC has planned a review of solar electrification policy since 2002. An ADB 'Omnibus Infrastructure Project' is looking to some extent at RE policy and investment needs but apparently not policies. There is no national rural electrification policy and none is being developed.
Kiribati	There is no formal rural electrification policy though an informal policy making renewable energy the priority for outer island electrification has been consistently applied for at least 20 years. Rural electrification is effectively all under the Solar Energy Company though Island Councils typically operate small grids near their offices for their own use.
Marshall Islands	An *Outer Islands Electrification Feasibility Study for the Republic of the Marshall Islands* (ADB, 1995) is in effect the current national rural electrification policy, favouring solar PV where feasible.
Nauru	Nauru is a single island with the population around its perimeter. There is no RE policy and no real need for one except for renewable energy initiatives, particularly implementation guidelines.
Niue	Same as for Nauru above
Palau	Nearly 100% of households are electrified and a separate RE policy is not necessary
PNG	World Bank prepared a *Rural Electrification Policy and Strategy to Improve Energy Access for Rural Services Delivery* in 2004. In 2004, recommendations were being considered by the government.
Samoa	The draft national energy policy has an objective that all Samoans are to have access to electricity within five years. Samoa is over 90% electrified and probably does not require an explicit RE policy.
Solomon Islands	Draft *Rural Electrification Policy* (1996) prepared with German assistance. There is no policy on electrification beyond the Solomon Islands Electricity Authority's urban and provincial centres. In 2000, Japanese power sector analysts recommended a rural electrification policy and establishment of a Rural Electrification Advisory Committee to guide of rural hydro and PV implementation. This has not eventuated.
Tokelau	Tokelau has no 'rural' population. Almost 100% of households are electrified.
Tonga	Different regulations and inherent policies apply to rural electrification provided through the power utility (Shoreline), diesel systems operated by island cooperatives, and PV systems operated by local committees. Tonga has reportedly prepared a draft RE policy but there was no consistent policy in early 2004.
Tuvalu	SOPAC reviewed RE through the (now defunct) Tuvalu Solar Energy Cooperative in 2003. There is no regulation of the power sector and there is a need for a consistent policy covering small diesel-based and renewable systems used in rural areas.
Vanuatu	There is no formal rural electrification policy (or national electrification policy). The government prepared a *Revised Rural Electrification Policy* (2000) and a *Draft Electricity Supply Act (2002)*, which remain in draft form. From 2001-2003, a number of reports were prepared by Japanese JICA advisers stressed the need for an RE policy framework.

Source: Annexes of PIEPSAP Project Document (SPREP/UNDP, Dec. 2003) updated from national PIREP reports (2004).

1.5 Data for Energy Policies and Planning

There has been little systematic collection and analysis of energy data in most PICs, in part due to the limited staff who are responsible for a wide range of activities. However, there is also often limited appreciation of the practical use of good data for policy development. Where data are available, they tend not to be much used for analysis. In the early 1980s there was an extensive one-off data collection effort as part of the Forum Secretariat (now PIFS)/Australian National University (ANU) studies and a joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP). Similar, but more extensive data-collection efforts were made for twelve PICs a decade later through the *Pacific Regional Energy Assessment* (PREA).

Table 1-11, based on information provided by SOPAC, provides a brief summary of the status of energy data in the PICs.

Table 1-11 – Summary of Energy Data in the PICs

Country	Status of Database (data for 1990-99)	Status of Data Return to SOPAC
Cook Islands	Completed except for renewable energy but major gaps and inconsistencies	Data for 1990-1999 is with SOPAC
Fiji	Energy Statistics Yearbook through 2000 completed	Data book provided to SOPAC
FSM	ESCAP advised Dept. of Energy on energy data needs in late 2001. Very little data collection by national government.	FSM is difficult as there are four largely autonomous states with varying degrees of data collection and no aggregation
Kiribati	Completed for the period 1990-99 but many gaps and inconsistencies. There is a draft Energy Statistics Yearbook for 2002	Not all data are with SOPAC
Marshall Islands	Data collection is slow but proceeding slowly	Data are to be returned to SOPAC
Nauru	Data collection is slow but proceeding	Limited data at SOPAC
Niue	Data collection is slow but proceeding	Limited data at SOPAC
PNG	Data collection is slow but proceeding. No systematic collection and analysis of energy data since 1980s.	Limited data at SOPAC
Palau	Data collection is slow but proceeding	Limited data at SOPAC
Solomon Islands	Data collection is slow but proceeding	Difficult due to considerable loss of data and lack of collection during the recent civil conflicts
Samoa	Data collection is slow but proceeding	Limited data at SOPAC
Tokelau	Not covered by SOPAC	Not covered by SOPAC
Tonga	Completed for the period 1990-99 but some gaps and inconsistencies	Data are being returned to SOPAC
Tuvalu	Data collection is slow but proceeding. There are serious gaps and major inconsistencies.	Limited data at SOPAC
Vanuatu	Data collection is slow but proceeding	Limited data at SOPAC

Source: Annexes of PIEPSAP Project Document (SPREP/UNDP, Dec. 2003) updated from national PIREP reports (2004).

The Forum Secretariat developed a spreadsheet-based energy database system about 1996, which was supposed to provide the PICs with a standardised system for the regular collection of energy sector data in a format that would be comparable among the countries. SOPAC took over this work in 1998 and simplified the spreadsheet, which PICs reportedly had found difficult to use. Assumptions regarding the availability of disaggregated data in most PICs were optimistic. The current system in principle includes all key data for commercial, non-commercial and traditional (biomass) energy sources and develops a national energy balance. In practice, however, only two - three PICs have provided reasonably accurate time-series data and there reportedly is little ongoing data collection between visits of SOPAC staff. The *Pacific Rural Renewable Energy France-Australia Common Endeavour* (PREFACE; 2000-

2003) under the Secretariat of the Pacific Community (SPC) collected a good deal of data on RET installations in the four countries (Cook Islands, Marshall Islands, Tonga and Vanuatu) where it was active. In mid 2004, the information could still be accessed at the SPC website. Two PICs (Fiji and Tonga) have produced occasional or annual energy data reports or yearbooks. There is reportedly some power utility data at the Pacific Power Association (PPA) but this is for internal use only and is not available to regional organisations.

In general, the data available for energy policy and planning are very poor. In most PICs there are data with major inconsistencies, and gaps and errors in even basic data such as (as noted earlier) the volume and value of petroleum imports and the amount of electricity generation and sales. It is difficult or impossible to obtain reasonably accurate data from the PICs on the costs of rural electrification or reliable information on the history of RET installations or on the effectiveness of past RE installations. In many PICs, national census reports include information on the number of households reporting the use of a particular fuel or energy form for cooking or lighting, though often confusing since households may use several fuels at the same time and these combined uses are typically not reported separately. The results are indicative but do not provide quantities of fuels such as LPG, kerosene or fuelwood consumed. As far as the PIREP missions could determine, there have been no large-scale surveys with actual physical measurements of actual household energy consumption since the 1980s[12] although there have been small surveys in Fiji, Kiribati, FSM and probably elsewhere. Thus the PIREP estimates of household energy use, particularly biomass energy, are only approximate. As biomass constitutes a large percentage of gross energy consumption in most PICs, the national energy balances provided in several national reports are no more than roughly indicative.

It is not uncommon for several people to request the same data from the same individual, utility or agency, and receive substantially different replies. Receiving quite different data for the same subject is typical when different agencies respond to the same data request. The unavailability or unreliability of energy and economic data in most PICs was the major obstacle to the timely and accurate preparation of the national PIREP assessments and is itself a significant barrier within the countries to making informed decisions regarding the costs and applicability of renewable energy compared to conventional energy technologies.

1.6 Institutions and Programme Initiatives at the Regional Level

At the regional level, the key institutional structure for energy matters in the Pacific is the Energy Working Group (EWG) of the Council of Regional Organisations of the Pacific (CROP). The EWG was formed in 1999 to coordinate the energy work of the regional organisations and to advise CROP on energy sector priorities. It was chaired by the PIFS until mid 2004 when SOPAC assumed responsibility for a two-year period or until further review. In addition to SOPAC and PIFS, the membership includes SPREP, the University of the South Pacific (USP) and UNDP, the last as an observer. The PPA is not a CROP member but does have a full voice in the EWG. In early 2004, Greenpeace Pacific, the Worldwide Fund for Nature (WWF) and the Pacific Concerns Resource Centre (PCRC) are NGOs that have acted as observers. The SPC is an inactive member, as it no longer has an energy programme. Although the EU, ADB,

[12] PNG carried out a large household energy survey in the 1990s but the data were only partly analysed and no report was completed.

JICA and French governments all have offices in Suva and are major players in PIC energy matters, particularly for renewable energy, none have been invited to participate in the EWG.

The EWG has developed the *Pacific Islands Energy Policy and Plan*. As the title suggests, PIEPP contains both energy policy and planning components. The policy component was “affirmed” by government energy officials in 2002 as a guideline for regional organisation energy policy and for developing PIC national energy policies, with adaptation to the circumstances of each country. PIEPP has a vision of “available, reliable, affordable, and environmentally sound energy for sustainable development for all Pacific islanders.” Within PIEPP, sustainable development is defined as “a process of change in which the exploitation of resources, the directions of investment, the orientation of technological change, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations.” Although PIEPP has no binding force on governments, it is nonetheless a consensus agreement among PICs, and between the PICs and the CROP regional organisations in the Pacific involved in various aspects of energy development.

In 2003, through the Forum Communiqué, PIC political leaders directed the EWG to review the PIEPP in light of a request from Palau to strengthen the renewable energy components of its strategic plan. PIEPP has been reviewed by members, revised in October 2004, and was presented for consideration by national energy officials during a Regional Energy Meeting (REM) in November/December 2004.

The PIEP organises the energy sector according to six themes: 1) Regional energy sector coordination; 2) Energy policy and planning; 3) Petroleum; 4) Renewable energy; 5) Electric power; and 6) Energy use in transport. There are also four cross-cutting issues, which apply to all six themes: a) Energy for rural areas and remote islands; b) Environmental aspects of energy use; c) Energy efficiency and conservation; and d) Human and institutional capacity development in the energy sector. For the above topics, there are specific overall themes and goals.

- *Regional coordination*: Cooperative sectoral co-ordination that maximises the impact of regional resources and capabilities.
- *Policies and planning*: Open and consultative cross-sectoral policy development and integrated planning to achieve sustainable supply and use of energy.
- *Power*: Reliable, safe and affordable access to electric power for all rural and urban Pacific Islanders.
- *Transportation*:Environmentally clean, energy efficient, and cost effective transportation.
- *Renewable energy*: An increased share of renewable energy in the region’s energy supply.
- *Petroleum*: Safe, reliable, and affordable supplies of petroleum products to all rural and urban areas.
- *Rural and remote islands*: Reliable, affordable, and sustainable energy for social and economic development of rural areas and remote islands.
- *Environment*: Environmentally sustainable development and use of energy resources.
- *Efficiency and conservation*: Optimised energy consumption in all sectors of the economy and society.

- *Human and institutional capacity*: Adequate human and institutional capacity to plan, manage, and develop the energy sector.

To achieve these goals, policies are to be supported by PIEPP's detailed strategic plan for implementation (which was not formally endorsed by governments), organised as follows:

- *Policies*. Policies for each goal establish rules by which specific strategies and actions are to achieve the goals. They are long-term, but may be reviewed and changed every 3-5 years if necessary.
- *Strategies*. There are strategies for each policy, i.e. the means by which goals will be reached. They are medium-term, but may be reviewed and changed on a 1–3 year cycle as required. There are supposed to be specific activities under each strategy by which strategies are implemented. They should be monitored continually and modified annually if needed.

Table 1-12 – Proposed Informal Allocations of Strategic Planning Responsibilities Among EWG Members

Topic	Main responsibility	Other responsibilities
Regional energy sector coordination	SOPAC as chair and for mobilising development assistance for national energy strategies	SOPAC and PPA newsletters NSAs [d] for wide stakeholder participation
Energy policy and planning	Generally SOPAC [a] PIFS for model legislation and regulations SPREP on barriers to RETs PIFS on social aspects of energy policy	PPA regarding private sector PPA re. legislation/regulation n/a The EWG
Electric power	PPA PIFS on regulatory environment SOPAC/USP on tech working papers	Electric power utilities n/a n/a
Energy use in transport	USP R&D; information dissemination SPREP emissions and efficiency; PIFS for policy mechanisms	SOPAC n/a
Renewable energy	SOPAC everything except barriers to RETs SPREP for barriers to RETs	n/a n/a
Petroleum	PIFS generally USP for independent testing SPREP,SOPAC, USP, PIFS on alternatives to petroleum WWF and SPREP on waste disposal [b] SOPAC on exploration for oil	Govts and private sector n/a n/a n/a n/a
Energy for rural and remote areas / islands	SOPAC	n/a
Environmental aspects of energy use	SPREP in general PIFS and SPREP on EIAs for petroleum [c] SPREP on standards and regulations including environmental inputs to energy planning PIFS, NSAs, SOPAC for opposition to nuclear energy	CROP EWG CROP EWG; private sector PPA on power sector standards n/a
Energy efficiency and conservation	SOPAC in general PPA and SOPAC on demand side management	PIFS on taxes, duties and tariffs and financial implications
Human & institutional capacity development	Broadly shared between USP and SOPAC	CROP EWG

Sources: *Pacific Island Energy Policy and Plan* (CROP, Oct. 2002) and discussions with SOPAC, PIFS and SPREP

Notes: a) Also USP on evaluation of RETs; b) WWF is Worldwide Fund for Nature; c) Environmental Impact Assessment; d) NSA is Non State Actor, basically Non Governmental Organisation (NGO) n/a = not applicable

The draft PIEPP strategic planning component provides an allocation of energy sector responsibilities among the regional organisations of CROP.

SOPAC clearly has overall responsibility within CROP for energy sector coordination. Table 1-12 also shows that the EWG – pending revision to and finalisation of the plan component – agrees that SOPAC has primary responsibility within CROP for energy policies and planning, but that others have important roles for economic, legislative, regulatory, social and environmental aspects of energy planning in general, and for petroleum and electric power issues in particular. Recently, the heads of SOPAC and SPREP have agreed that SPREP is the lead agency for climate change issues while SOPAC has overall energy sector responsibility. As regional initiatives on renewable energy (and energy efficiency) are SOPAC responsibilities, but renewable energy and energy efficiency offer the best opportunities for greenhouse gas abatements, factors within SPREP's mandate regarding climate change, the two organisations will have to cooperate closely in order to provide consistent and coordinated services to the region.

The EWG is an important mechanism for effective coordination among regional agencies. However, discussions during the PIREP missions[13] and observations by PIREP international consultants suggest that the EWG has an unclear mandate, outdated terms of reference, in effect several categories of participation and influence, no budget for its meetings (which therefore tend to be held only in Suva), and institutional concerns which can appear to override a genuine spirit of cooperation. The EWG should be more proactive in engaging the ADB, the EU and the French and Japanese governments in the primary funding agencies for the programmes being considered. The EWG should be strengthened if the energy sector issues facing the PICs as a region are to be effectively addressed.

The Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP) is a GEF proposal under development by SPREP (2004) and is aimed at reducing the growth rate of GHG emissions from fossil fuel use in the PICs through the widespread and cost effective use of their renewable energy (RE) resources. It consists of various types of activities whose outputs are meant to contribute to the removal of the major barriers to the widespread utilisation of RETs. The project is intended to bring about in the PICs: (1) increased number of successful commercial RE applications; (2) expanded market for RET applications; (3) enhanced institutional capacity to design, implement and monitor RE projects; (4) availability and accessibility of financing to existing and new RE projects; (5) strengthened legal and regulatory structures in the energy and environmental sectors; and, (6) increased awareness and knowledge on RE and RETs among key stakeholders.

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[13] When discussing regional programmes for energy, in several PICs, senior government officials expressed concerns regarding the EWC to the PIREP team. Though concerns varied according to experiences, in essence it was felt by the officials that member organisations do not always cooperate well and sometimes ignore agreed upon allocations of work responsibility agreed upon within the EWC. At an August 2003 PIREP planning meeting held in Nadi, Fiji, the keynote speaker, the chair of the Fiji Electricity Authority, spoke on experiences and barriers to renewable energy. He stated that in his view the activities and interactions among organisations present (which included UNDP, UNDP/GEF, SOPAC and SPREP) constituted significant barriers to the use of renewable energy in the region.

2 Energy Supply, Demand and the GHG Inventory

2.1 Commercial Energy Supply and Demand

The PICs are overwhelmingly dependent on imported petroleum fuels for commercial energy for transport, electricity, business and households though hydropower has been a significant contributor in the larger countries. Biomass is widely used for cooking and agricultural drying (especially copra) but as a percentage of gross energy consumption it varies considerably by country. Other renewable energy resources are a small percentage of supply in most of the region, although important for some locations.

2.1.1 Petroleum

Petroleum supply

As noted in chapter 1, statistics on recent retained petroleum imports to PICs are generally incomplete and unreliable. Table 2-1 summarises available information. Despite inaccuracies, it provides a reasonable overview of the volume of fuel imports and recent annual growth rates.

Table 2-1 – PIC Petroleum Fuel Imports (Retained) and Recent Growth Rates

Country	Volume		Year	AAGR	Comments
	ML	L / capita			
Cook Islands	19	~ 1,000	2003	?	Data appear to be inconsistent ; growth trends uncertain
Fed States of Micronesia	~ 60	~ 600	2003	?	Very poor data; None at all by volume and dollar values of imports appear inconsistent.
Fiji Islands	> 320	~ 400	2000	~2 % ?	Inconsistent 2000 data from 1999-2003; 250 ML in 1990
Kiribati	16	~ 200	2003	3.9 %	AAGR is from 1990 - 2003
Marshall Islands	127	~ 2,300	2003	?	Includes substantial re-exports; no data for 1995-2002
Nauru	~ 15	~ 1,500	2003	?	Large year to year variation, no trend visible
Niue	1.6	~1,000	2002/3	5.5 %	AAGR for past 4 years
Palau	~ 111	~ 5,800	2002	28 %	AAGR for 1999-2002 is very high but no clear reason found.
PNG	~ 780	~ 150	2000		Poor time series data; considerable annual fluctuation
Samoa	78	~ 400	2003	6%	AAGR 1998-2003
Solomon Islands	72	~ 150	2002	1.8%	AAGR 1990-2002 (sharp decline during civil conflicts)
Tokelau	~ 0.4	~ 300	2003	–	Fairly static demand
Tonga	~40	~ 400	2000	~ 1.5	AAGR for 1990-2000 but data are unreliable
Tuvalu	3.8	~ 400	2003	?	Data before 2001 are not reliable
Vanuatu	41	~ 200	2003	3.6	AAGR 1994-2003, with considerable annual fluctuation

Source: National PIREP reports (2004) Note: ~ is 'approximately' AAGR = average annual growth rate

Four PICs use 200 litres or less per capita of petroleum fuel per year (Kiribati, PNG, Solomon Islands, and Vanuatu), a number are in the 300 700 litre range (Fiji, FSM, Samoa, Tokelau, Tonga and Tuvalu) and several consume 1000 litres or more (Cook Islands, Marshall Islands, Nauru, Niue), with Palau having by far the highest consumption, about 5800 litres/person. Because of the unreliability or lack of disaggregated data, no comparisons could be made on petroleum fuel consumption for power, transport or other sectoral use.

Petroleum storage facilities vary considerably, with a typical small country facility shown in Figure 2-1.

Figure 2-1 – Petroleum and LPG storage facilities, Tuvalu

Photograph, Herb Wade, Funafuti, 2004

Petroleum Pricing

The PIFS provides price trends for petroleum products marketed in the PICs. For the August 2004 PIFS *Pacific Fuel Price Monitor*, prices are shown in Table 2-2 and Figures 2-2 through 2-5. Although the "average" prices of the table conceal considerable differences among the countries, typically petrol is taxed more than Automotive Diesel Oil (ADO), which is taxed more than kerosene that is used largely by households. The mark-up between wholesale and retail prices averages slightly more than US7¢/litre for petrol (i.e. gasoline or mogas) and kerosene, and US8.6 ¢ for ADO.

Table 2-2 – Pacific Wide Fuel Prices, mid 2004 (US ¢ / litre)

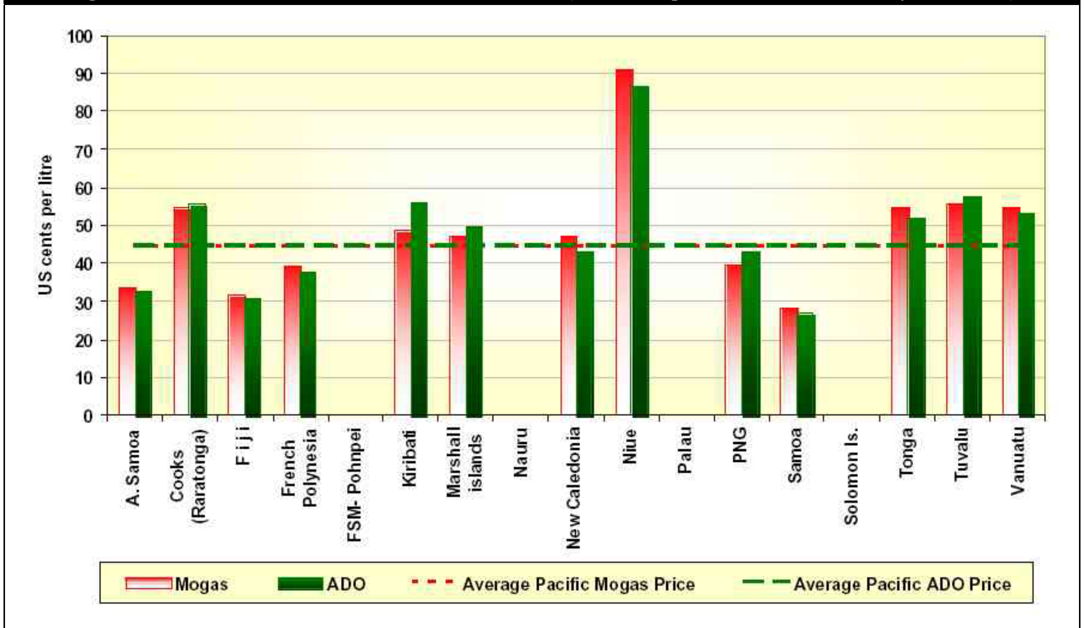
Fuel	Excluding all taxes:		Including all taxes:	
	Wholesale	Retail	Wholesale	Retail
Petrol	44.5	55.2	72.8	80.1
ADO	44.8	55.5	63.4	72.0
Kerosene	46.2	53.8	58.1	65.2

Source: *Pacific Fuel Price Monitor*, Edition 8 (PIFS; 24 August 2004)

Figure 2-2 shows wholesale prices of petrol and ADO, excluding all import duties and taxes. It is notable that Samoa has lower prices in Apia than those of the capital cities of much larger PNG and Fiji, even though Samoa's products are largely sourced through Fiji. Samoa has had a consistent and aggressive approach to fuel acquisition and pricing for nearly two decades. Unlike most PICs, Samoa owns the petroleum storage facilities and tenders for its national fuel supply. Niue, struggling to recover from the effects of a catastrophic hurricane in early 2004, has extremely high fuel prices.

Comparative data are only available for the main islands of the PICs, which are covered in the PIFS pricing service. In remote areas, fuel is generally more expensive, often double the main port price, even when shipping is subsidised. In most PICS fuel supply to remote islands can also be irregular with long periods when fuel is unavailable.

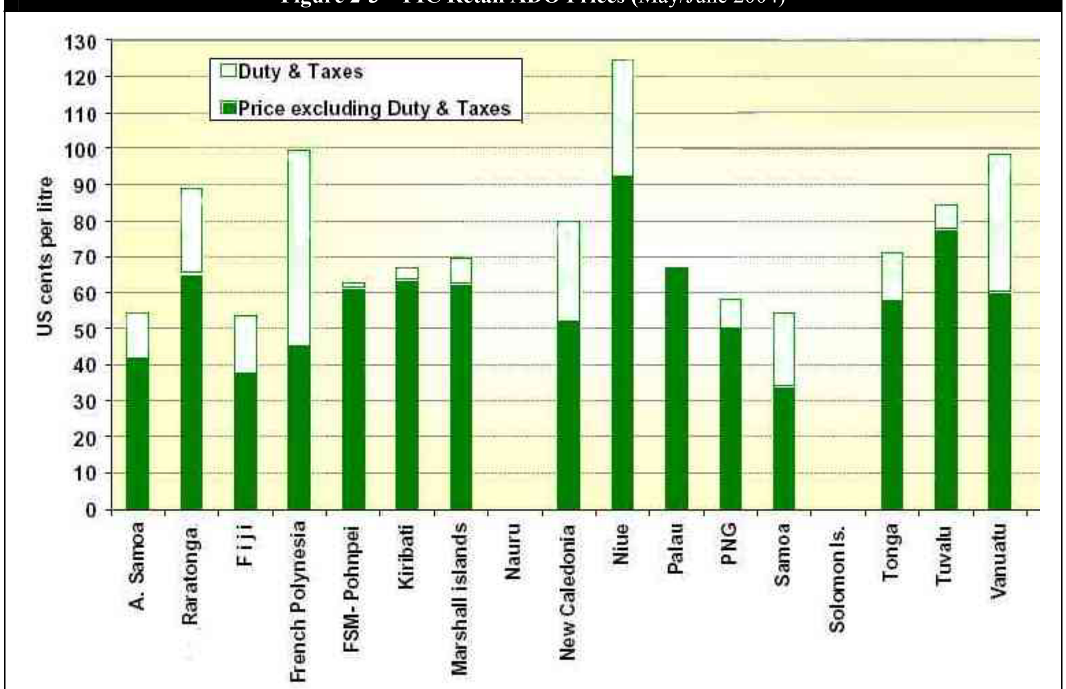
Figure 2-2 – PIC Wholesale Petrol and ADO Prices (without import duties and taxes; May/June 2004)



Source: *Pacific Fuel Price Monitor*, Edition 8 (PIFS; 24 August 2004)

Figure 2-3 illustrates the wide range of taxes and duties imposed by PIC governments on distillate. There is no tax in Palau and low taxation in FSM, Kiribati, PNG and Tuvalu. Excluding French Polynesia and New Caledonia, which were not part of the PIREP exercise, the highest taxes are in the Cook Islands, Niue and Vanuatu. For petrol (not illustrated), the pattern is broadly the same.

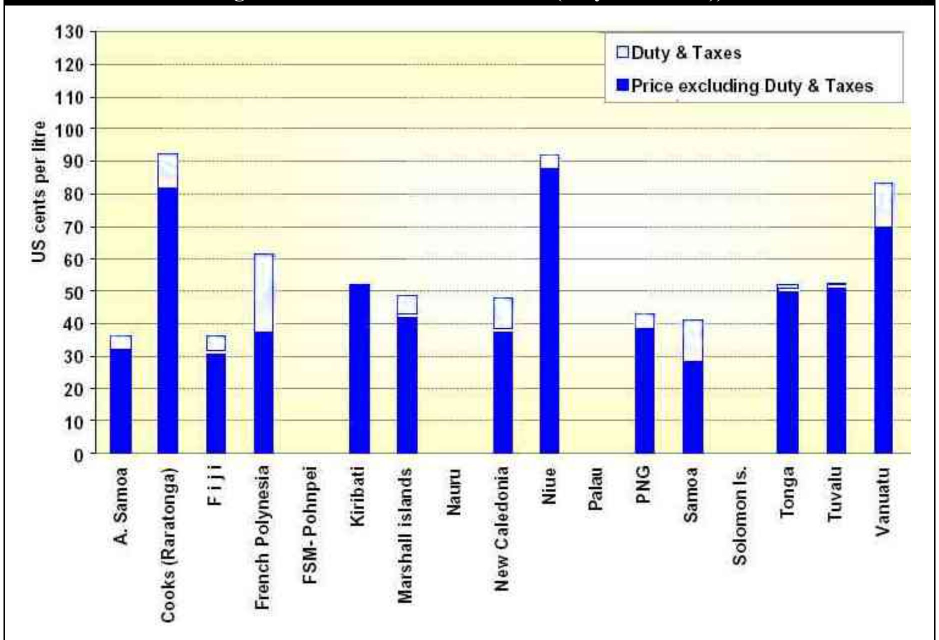
Figure 2-3 – PIC Retail ADO Prices (May/June 2004)



Source: *Pacific Fuel Price Monitor*, Edition 8 (PIFS; 24 August 2004

For kerosene (Figure 2-4) pre-tax prices in Fiji and Samoa are the lowest in the region and, as for other fuels, taxation varies considerably by country.

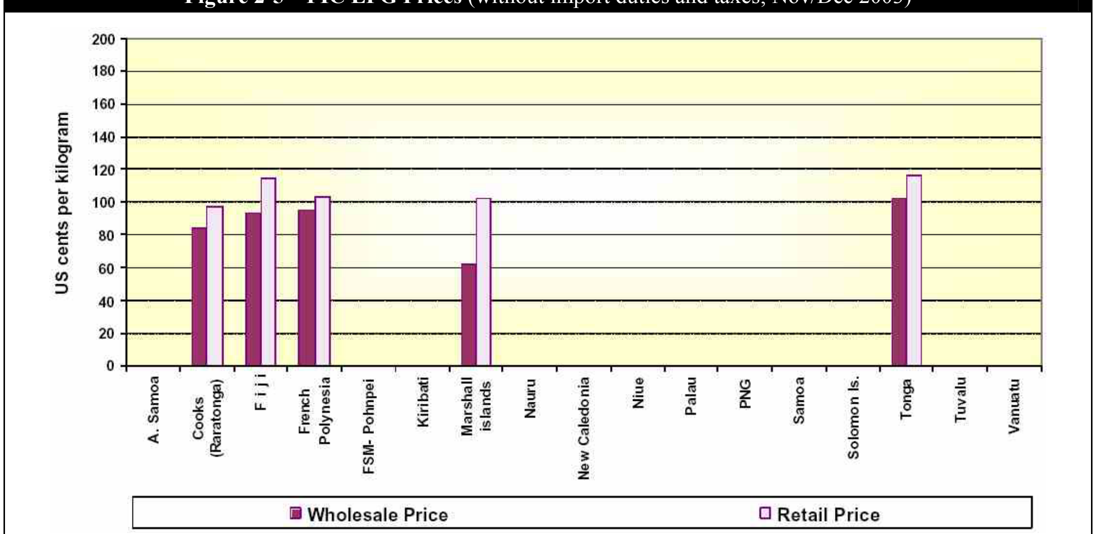
Figure 2-4 –Retail Kerosene Prices (May/June 2004))



Source: *Pacific Fuel Price Monitor*, Edition 8 (PIFS; 24 August 2004)

The most recent PIFS price monitor does not include liquid petroleum gas. For late 2003, based on a relatively small number of PICs reporting prices, LPG prices are shown in Figure 2-5. The wholesale price in the Marshall Islands was far lower than elsewhere but the retail mark-up was considerably higher.

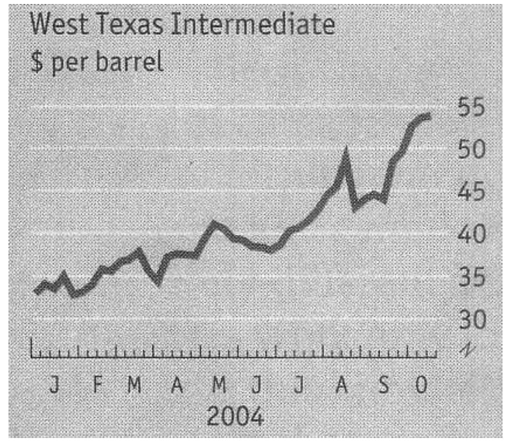
Figure 2-5 – PIC LPG Prices (without import duties and taxes; Nov/Dec 2003)



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

During 2004, world crude oil prices have risen dramatically, about 67% for West Texas Intermediate (Figure 2-6) from January to mid October 2004, when prices reached US$55 per barrel.[14] This will result in considerably higher product prices in PICs after a lag of several months. In real (inflation adjusted) terms, however, the cost of crude oil in October 2004 of crude oil is about 70% of the peak price of 1980.

Figure 2-6 – Crude Oil Price Rises, 2004



Source: The Economist, October 2004

2.1.2 Electric Power

Table 2-3 summaries the electricity supply arrangements within PICs, provides an overview of costs and services, and estimates the percentage of households electrified in 1994 and for the most recent year available. The table was updated and expanded from a 1999 ADB study. The most recent estimates of household electrification include electric power supply from the utilities as well as self-generation, PV cooperatives or other sources, generally as reported in national population census reports. Some ADB estimates of electrification in 1994 seem far too low (e.g. the Cook Islands) or far too high (e.g. PNG).

In brief:

- most PIC utilities were formerly government departments, often attached to the public works department, but many have become corporatised state-owned enterprises within the last decade or so. In principle, they establish their own tariff levels but in practice, the cabinet (or equivalent body) must approve increases;
- except for the privatised utilities (UNELCO in Vanuatu; Shoreline in Tonga), most utilities do not cover their true costs through charges to the consumer and are subsidised by the government or donors. Utilities selling electricity below cost tend to have inadequate funds for maintenance and expansion, and high generation and transmission losses;
- only a few utilities (other than those countries with a single island) serve all or a large number of populated islands. These include the SIEA in the Solomon Islands and TEC in Tuvalu;
- in most PICs, there is no true national utility but rather independent supply arrangements for different states or island groups (e.g. FSM with four state utilities, the Marshall Islands with two utilities and some provision by public works), although some utilities have recently expanded to provide service to smaller islands particularly where the tariffs are sufficient to cover costs (UNELCO in Vanuatu; Shoreline in Tonga);
- in several PICs, the utility focuses on the main island or several of the largest islands with island councils, public works departments, cooperatives or others providing power elsewhere (Cook Islands, Fiji, Kiribati);

[14] There are 159 litres per barrel so $55 per barrel is equivalent to about 35 cents per litre of crude oil.

- the percentage of households electrified ranges from under 20% (PNG, Solomon Islands, Vanuatu) to close to 100% (Cook Islands, Nauru, Niue, Samoa, Tonga, Tokelau,Tuvalu)); and
- many utilities are required to have a national tariff structure (e.g. Fiji, PNG, Samoa, Solomon Islands) which results in high levels of cross subsidies from the main urban areas or the main island to other electricity consumers. In at least one utility (PUB of Kiribati), electricity revenue heavily subsidises the provision of water supply. In one utility (Tuvalu), consumers pay less in outer islands, where supply costs are far higher, than on the main island.

Table 2-3 – Overview of electricity utilities in PICs

Country	Utility organisation and reforms	Cost of services	HH electrified: * 1994 and recently	Quality of Service
Cook Islands	TAU is govt owned utility. Privatisation attempted in 1990s, but unsuccessful. Bids were much lower than govt had expected. 13 outer island systems run by island councils	Costs are high in Rarotonga and very high elsewhere. ADB unsure how prices are to be regulated	35 % in 1994; 99% in 2004	Generally OK in Rarotonga. Generally poor O&M elsewhere
Federated States of Micronesia	All four state utilities are govt-owned and corporatised: CPUC, KUA, PUC and YSPSC). ADB currently advising FSM.	Historically, free or supplied at very low cost. Even after corporatisation, prices do not fully cover costs	30% in 1993; 54% in 2000 (46% via utilities)	Ranges from generally OK (Pohnpei and Yap) to very poor (Chuuk) on main islands of all states
Fiji Islands	FEA corporatised and fully govt. owned. Serves only islands of Viti Levu, Vanua Levu and Ovalau. Considering various private proposals for supply.	ADB says relatively high charges but stable for 10 years. National tariff with heavy subsidies from Viti Levu to other two FEA islands.	50% in 1994; 67% in 1996 (57% via FEA)	Generally acceptable but some outages.
Kiribati	PUB is govt owned and supplies only South Tarawa. ADB has advised on restructuring. and Japan is assisting major refurbishment and expansion	Tariffs raised in 2000 and 2001. Large, cross-subsidy from electricity to water and sewerage is long-standing financial drain.	29% in 1993; not available for recent years	Generally poor (Table excludes SEC)
Marshall Islands	MEC is SoE operating on Majuro, Jaluit and Wotje, with govt meeting revenue shortfalls outside Majuro. KAJUR operates only in Ebeye	MEC is profitable; no longer receives govt subsidies for Majuro. Dispersion of islands over large distances means high cost for outer islands	50% in 1994; 63% in 1999 (only 13% away from Majuro and Ebeye	MEC well managed with good electricity standard in Majuro; KAJUR well-managed until recently by ASPA but quality may be declining.
Nauru	NPC is govt owned and supplies the entire island.	A9¢/kWh (domestic) and 13¢ (other) is far lower than cost. No govt or hh bills paid since 2002.	unknown in 1994; nearly 100% in 2003	Demand ≈ capacity and outages frequent. Most cooking is electric and heavy use of air conditioning.
Niue	NPC is govt-owned corporation reporting to Secretary for Govt.	NZ 30¢/kWh (48¢ for air con). This is heavily subsidised	unknown in 1994; ~ 100% in 2003	Good
Palau	Supplies Koror, Babeldaob, Kayangel, Peleliu and Angaur	Complex national tariff with urban consumers subsidising rural islands	unknown in 1994; ~ 97% in 2004	Generally OK in recent years
Papua New Guinea	Elcom corporatised into govt. owned PNG Power. Responsible for power throughout PNG.	Complicated tariff structure. Large tariff increases since 2000 but PNG Power under considerable financial stress	22% in 1994: < 10% in 2003 (P Moresby ~ 63%)	Unreliable. High and growing losses. Frequent breakdowns

Table 2-3 – Overview of electricity utilities in PICs (continued)				
Country	**Utility organisation and reforms**	**Cost of services**	**HH electrified: * 1994 and recently**	**Quality of Service**
Samoa	EPC is govt-owned and corporatised. ADB advising on staff and finance	Charge is well below cost and gap is widening; Upolu subsidises Savaii	90% in 1994; 93% in 2001	Generally OK; about four outages per month
Solomon Islands	SIEA is govt owned. No corporatisation plans yet formulated.	High cross subsidies from Honiara to all other areas. Charges do not cover costs.	15 % in 1994; 16 % in 1999 (11% via SIEA)	Power supply unreliable; Honiara peak demand exceeds capacity by ~20%; many businesses self-generate.
Tokelau	Power separate for each of three islands. Procedures and structure being developed	Charges of NZ 30-50¢/kWh but costs NZ$1.0 - 1.8 excluding capital costs.	unknown in 1994; ~ 100% in 2003	Currently being upgraded by late 2004 to high quality
Tonga	Shoreline private utility serves Tongatapu and main islands of Ha'apai, Vava'u and' Eua. In principle,TEPB regulates.	Charges cover costs and differ by island. Tariffs rose at AAGR of 11% mid 1998 - mid 2003	unknown in 1994; ~ 79% in 1996 80 % in 1999 estimated ~ 90% 2004	High quality and reliability in areas served by Shoreline. Electrified HH include those using solar.
Tuvalu	TEC is govt-owned and corporatised; serves nearly all islands	Tariffs below full cost on Funafuti and much below cost away from Funafuti. In real terms, charges far less than in 1982	unknown in 1994; > 95 % in 2003	Generally reliable on Funafuti until recent rapid growth
Vanuatu	UNELCO is private sector monopoly operating on Efate, Santo Tanna and Malekula islands	ADB describes charges as among highest in world (but actually comparable to many PICs).	unknown in 1994; 19% in 1999 (61% of urban hh)	Service quality away from Efate has improved under private sector operation.

Sources: *Improving Provision of Utility Service* (ADB 1999) for PMDCs, revised, updated and expanded with Niue, Palau and Tokelau added by PIREP team

Notes: * 1994 ADB estimate; latest year from national PIREP reports hh = houshold ~ is 'approximately'
SoE = state owned enterprise

Utilities: *Cook Islands*: TAU = Te Aponga Uira, *FSM*: CPUC = Chuuk Public Utilities Corporation, KUA = Kosrae Utilities Authority, PUC = Pohnpei Utilities Corporation and YSPSC = Yap State Public Service Corporation); *Fiji*: FEA = Fiji Electricity Authority; *Marshalls*: MEC = Marshalls Energy Company; KAJUR = Kwajalein Atoll Joint Utility Resource and ASPA = American Samoa Power Authority; *Kiribati*: PUB = Public Utilities Board and SEC = Solar Energy Company. *Nauru*: NPC = Nauru Phosphate Corporation. *Niue*: NPC = Niue Power Corporation, *Palau* PPUC = Palau Public Utilities Corporation; *PNG* Elcom = Electricity Commission. *Samoa*: EPC = Electric Power Corporation, *Sol Isl* SIEA = Sol Islands Electricity Authority, *Tonga*: TEPB = Tonga Electric Power Board *Tuvalu*: TEC = Tuvalu Electricity Corporation; *Vanuatu*: UNELCO = Union Electrique de Vanuatu.

The PIC utilities vary enormously in size from tiny systems with less than 0.25 MW of capacity and a few hundred customers to fairly large systems with 100,000 or more customers. Most are entirely diesel-based. The Solomon Islands generates about 1% of its electricity from hydro, Vanuatu 7%, PNG 35%, and Fiji and Samoa about half or more. Except for geothermal production in PNG and biomass in Fiji, there is no other significant electricity production from renewable resources other than small-scale solar PV and several small wind systems. Table 2-4 summarises power statistics.

Table 2-4 – PIC Electric Power Statistics (latest year)						
Country	**Year**	**Capacity (MW)**	**MD (MW)**	**GWh***	**Customers**	**Generation mix and AAGR (%)**
Cook Islands	2002	~ 7	4.4	~ 25	4,400 3,800 hh **	All diesel; Generation AAGR 9% 1997-02; demand 5% 1985-2002
Fed States Micronesia	2001	25.5	15.3	~ 84	n/a ~9,300 hh **	All diesel as Pohnpei hydro damaged; Declining or flat in recent years.
Fiji Islands	2003	194	?	~300	125,000	53% hydro, 42% diesel and 5% biomass Gen demand AAGR ~6.5% 1997-2003
Kiribati	2003	7.7	3.1	15.9	4,520	All diesel; AAGR ~ 8% 1998-2003
Marshall Islands	2002/03	~ 29	~15	~ 97	~4,600 6500 hh (1999)	All diesel. MEC 2003: 24.4 MW firm, 81 GWh generated and 2500 customers. Totals include KAJUR, etc.
Nauru	2003	~ 6.5	~ 6	> 44	~ 2,000 1677 hh	All diesel. Declining overall due to low phosphate production and economic crisis
Niue	2002/03	~ 1.6	~0.7	3.5	1453 (984 hh)	All diesel; AAGR 3.8% past 4 years
Palau	2003	~ 20 MW	?	104	~ 5,500 4300 hh	All diesel; AAGR 4% 1996-2003
PNG	2001	~ 600	?	~2,600	73,000 (2002) ?	39% fuel oil, 35% hydro, 26% natural gas; PNG Power accounts for 300 MW & 665 GWh.
Samoa	2003	29 (wet[a]) 22 (dry[a])	16	93	20,500 (2002) ?	49% hydro; 51% diesel; AAGR in generation 5.2% 1994-2003 [a] = season (as most hydro is run-of-river)
Solomon Islands	2003	7.5 Honiara	9 Honiara	< 50	9,200 ~ 7,000 hh	~ 99% diesel; ~1% hydro. SIEA data only as private generation unknown
Tokelau	2003	<< 1	<< 1	~ 0.3	~ 340	All diesel.
Tonga	1999	n/a	6	30	14,000 (in 2000 / 01)	All diesel. Shoreline does not release any public data
Tuvalu	2003	~ 1	~ 0.8	4.7	892	All diesel. Data for Funafuti only, with 46% of all customers.
Vanuatu	2002	21.6	9.5	47	8,550	93% diesel and 7% hydro; Gen AAGR 3.9% 1992-2002

Source: National PIREP reports (2004) Note: ~ is 'approximately' n/a = 'not available' [a] = season of year
Notes: Capacity is MW available, not name-plate; MD = maximum demand hh = households
* Generation unless noted otherwise ** hh = national total electrified, not just via utility (census data)

The magnitude of current electricity production from renewable sources is summarised in Table 2-5 .

Table 2-5 –Electricity Supply from Renewable Energy Technologies in MWh (2003 or latest year)						
Country	**Year**	**Hydro**	**Solar PV**	**Other RE**	**Wind**	**Comments**
Cook Islands	2002	0	~15	0	<< 1	Wind on line in '03 but data incomplete
Fed States Micronesia	2003	0	~10	0	0	PV=SHS, Telecom and water pumping
Fiji Islands	2003	~ 160,000	~ 45	~ 15,000	<< 1	2003 worst hydro year ever; Other = biomass (bagasse and wood)
Kiribati	2003	0	~25	0	0	PV will increase to ~150MWh/yr. in 2005
Marshall Islands	2003	0	~8	0	0	PV=SHS and telecom
Nauru	2003	0	0	0	0	
Niue	2003	0	0	0	0	
Palau	2003	0	~15	0	0	PV for telecom and SHS
PNG	2001	~ 910,000	n/a	n/a	~0	2003: geothermal 10,000-20,000 MWh
Samoa	2003	~46,000		0	0	
Solomon Islands	2003	< 300	~3	0	0	PV = telecom and SHS
Tokelau	2003	0	0	0	0	
Tonga	2003	0	~55	0	0	Assumes all installed SHS are operational
Tuvalu	2003	0	<1	0	0	
Vanuatu	2003	3,200	~4	0	0	

Source: Estimated from National PIREP reports (2004)
Notes: < = 'less than' << = 'much less than' ~ is 'approximately' n/a = not available SHS = solar home systems

For consumers connected to the utility grid, domestic consumers (i.e. households) are by far the largest category but account for well under half of consumption. For some utilities, it was possible to obtain data on household electricity consumption. Table 2-6 summarises consumption levels and costs to the consumer in U.S dollars per month.

Table 2-6 – Typical Household Electricity Consumption and Cost from Utility Grid (latest year)						
Country	**KWh / customer / month ave.**			**Cost US$ / month ***		**Year and comments for cost**
	Overall	**Urban**	**Rural**	**60 kWh**	**100 kWh**	
Cook Islands	n/a	n/a	n/a	10.56	23.21	2004, Rarotonga (incl. 12.5% VAT)
Fed States.	n/a	n/a	n/a	10.20	17.10	2004, Chuuk (incl. fuel surcharge?)
Fiji	n/a **	n/a	n/a	7.78	12.97	2004. (Includes 12.5% VAT)
Kiribati	n/a	n/a	n/a	16.43	27.38	2004, S Tarawa (Excl VAT, if any)
Marshall Ils	~ 720 (2003) ~ 600 (1990)	n/a	n/a	7.20 9.30	12.00 15.50	2003, Majuro 2003, Ebeye (1990 from PREA)
Nauru	915 (2002)	915	none	4.00	6.66	But not collected since July 2003
Niue	~220	~ 220	none	11.52	19.20	2002/03 (Cost assumes no air con)
Palau	~ 545	n/a	n/a	11.00	13.00	2003 (incl. fuel price adjustment)
PNG	166 (2002)	200	70-180	6.14	11.26	2004 (lifeline tariff ≤30 kWh/m)
Samoa	104 (2002)	n/a	n/a	10.85	19.25	2004. (No VAT on electricity)
Solomon Isl	132 (2002)	n/a	n/a	15.55	29.37	Late 2003 (10.1¢/kWh fuel surcharge)
Tokelau	n/a	n/a	none	11.34	18.90	2003 Atafu (Fakaofo is 67% higher)
Tonga	81 (2001)	n/a	n/a	14.20	23.66	2004. Tongatapu ('Eua 13% higher)
Tuvalu	150 (2003)	180	45	15.10	25.16	2004, Funafuti ; ~ 1/3 of true cost
Vanuatu	n/a	n/a	n/a	11.61	23.21	2004 Vila and Santo

Source: National PIREP reports (2004) Note: ~ is 'approximately' n/a is 'not available'
Note: * Exchange rate from national reports. Prices include Value Added Tax (VAT) if applicable.
** About 63% of household consumers use about 108 kWh per month or less.

In most PICs where data are available, household consumption is in the range of about 100-200 kWh/m although some (Marshall Islands, Nauru, Palau) are far higher. A household consuming 100 kWh/m would pay under US7¢/kWh in Nauru (if charges were collected), 11-13¢ in Fiji, Majuro, PNG and Palau, 17-19¢ in Chuuk, Niue, Samoa and Tokelau, 23-25¢ in the Cook Islands, Tonga, Tuvalu and Vanuatu, and 27-29¢ in Kiribati and the Solomon Islands.

In some PICs, Value Added Tax is charged for electricity sales (e.g. Cook Islands, Fiji) and for others there is no VAT or it does not apply to electricity (e.g. Palau, Samoa). Some tariff formulas include minimum monthly charges (e.g. Fiji, FSM, Palau) and several (e.g. Solomon Islands, FSM, Palau) have complicated fuel adjustment cost surcharges. Although fuel surcharges (that sometimes change every month) are confusing to the consumer,[15] this is often the only practical way utilities can adjust tariffs from time to time during periods of rapid changes in fuel prices as the governments are unwilling to increase the base tariff even annually. In one country (Nauru), a low domestic tariff is imposed but has not been collected since mid 2003 due to a financial and economic crisis. Several countries (Cook Islands, PNG, Palau, Samoa) have "lifeline" tariffs that are meant to assist low-income customers by providing an initial block at low subsidised rates. In PNG this is 30 kWh per month, in Samoa 50 kWh and in Rarotonga 60 kWh, which are sufficient for basic services. In September 2004, Fiji's FEA sought a tariff increase of 20% (domestic) to nearly 30% (commercial) offset by a proposed lifeline tariff at current domestic rates for consumers spending F$25 per month or less, about 108 kWh.

Table 2-6 allows a comparison of electricity charges to domestic consumers, but it does not show the actual costs of supply. Although a few estimates have been carried out, they vary considerably in accuracy. Table 2-7 summarises some estimated costs of power supply to the main urban area or the main island, compared to remote islands or other rural areas that are also grid-connected. These should be considered no more than indicative. Despite the limited data, the table shows clearly the much higher cost of supply to remote and rural grid-connected communities in the Pacific compared to the main urban system.

Table 2-7 – Estimated Cost per kWh of Grid-based Electricity Supply

Country	Year	Currency	Main island or urban area	Outer island remote grid	Comments
Cook Islands	1998	NZ $	~ 0.30	0.58 *	10 islands arrange from $0.43 – 1.00; ADB study
Fiji Islands	FEA 2001	F $	Viti Levu urban 0.19	0.38 * – 1.88	Ovalau urban 0.38, rural 1.88; Vanua Levu urban 0.40, rural 1.22; Viti Levu rural 0.51. For 5 PWD mini-grids in 2002, average cost ~ F$2.44 and range $1.07 - $4.63
Tokelau	2003	NZ $	Not applicable	~ 1.50	For three islands cost (*excluding* capital amortisation) ranges from $1.2 - $1.83 for village grid systems
Tonga	1999	T $	~ 0.30	~1.50	Four village grids in Ha'apai range T$1.36 - 1.93
Tuvalu	2000	A $	>0.34	~ 1.50	Outer island costs *exclude* capital amortisation.

Source: National PIREP reports (2004) ~ is 'approximately' * relatively large rural grids

Because the data of Table 2-7 were spread over a five year period and are approximate, no attempt has been made to convert these into a common currency. Without more

[15] Fuel surcharges also reduce the utility's incentive to lower operating costs by negotiating for better fuel prices.

accurate and up-to-date information on costs of electricity supply through conventional diesel systems, it is meaningless to estimate the relative economics of electricity supply from diesel and renewable energy. In any case electricity costs from renewable sources are highly site-specific so generic comparisons of diesel versus renewable energy costs for PICs are not very useful. In remote areas of the Pacific relying on small diesel generators, the diesel system cost data are even less accurate and almost always underestimated.

Table 2-8 shows the source of electric power supply to households from national census reports. In most PICs where data are available, about 85-90% of electrified households are served through the state or national utilities. In the Solomon Islands, only 70% of electrified households receive their supply from the utility.

Table 2-8 – Source of Electricity Supply to Households (census year)

Country	Year	Electrified (% of hh)	% electrified by: *			Comments
			utility	self	other	
Cook Islands	Dec. 2001	98.8%	94.4	3.2	7.9	'Other" is solar PV, Total >98.8% as some have more than one source
Fed States Micronesia	Early 2000	53.6%	45.7	4.0	3.9	Utility connection 19.0% Chuuk, 87.8% Kosrae, 63.4% Pohnpei & 56.7% Yap. PV 5.4% Chuuk, 0% Kosrae, 3.6% Pohnpei & 1.5% Yap.
Fiji Islands	Aug. 1996	67.0	57.4	4.8	4.8	'Other' = village 3.6%, PWD 0.4% and company supply 0.8%. Viti Levu 73% electrified; other islands 47%
Marshall Islands	1999	63.3	—— 58.1 ——		5.2	Electrification on Majuro 88.3%, Ebeye 89.8% and rural 13.4%
Solomon Islands	1999	15.7%	10.8	2.3	2.7	Honiara 70% electrified; most provinces are 3-14% but some under 1%
Tonga	1966	78.6%	73.7	2.2	2.7	'Other' is solar PV

Source: National PIREP reports (2004) ~ is 'approximately'
Note: * May not add to same percentage as totally electrified because some respondents do not answer all questions

According to a recent World Bank report (*Results From a Survey of International Investors in the Power Sector*, 2003), electricity demand in developing countries overall is expected to grow by four percent per annum over the next twenty years but international investment in the power sector in these countries has been dropping since 1997. Reportedly countries with smaller power systems do not seem to be at a disadvantage in securing investment.[16] The findings of the survey suggest the following priorities for governments seeking to attract and retain international investment in the electric power sector:

- ensure adequate cash flow in the sector through adequate tariff levels and their collection;
- maintain the stability and enforceability of laws and contracts;
- improve the response times and generally assure administrative efficiency in responses; and
- minimise government interference in utility operations, management and regulatory authorities.

[16] 'Smaller systems' were not defined but even the smallest countries surveyed (Jamaica, Panama and Costa Rica with 2.7-3.7 million people) have larger populations than all PICs except Papua New Guinea, and the larger ones (e.g. Kenya and Morocco) have about 26-30 million people, far larger than Australia with about 20 million.

Investors give relatively low priority to the status of transition from a government owned utility to a competitive market structure, as long as there is independent regulation. If the survey results are applicable to PICs, the findings appear to suggest that private investors might generally prefer to invest elsewhere, whether for conventional energy or renewables, unless these perceived barriers are addressed.

2.2 Household and Biomass Energy

For a number of PICs, there is limited information from census reports on household energy. Census questionnaires frequently ask respondents to identify the main fuel or energy source used for lighting and cooking. This provides a rough indication but cannot be used to quantify energy use. Often the percentages exceed 100% as more than one energy source is reported. In some countries (e.g. the Cook Islands) where most weekday cooking is with kerosene or LPG, but the traditional Sunday *umu* (earth oven) uses a considerable amount of wood, the census surveys do not provide an accurate picture of fuelwood consumption.

Although a few household energy surveys have been carried out, most date back to the 1980s, are based on very small sample sizes, and/or rely on questionnaires and observations rather than field measurements. The bulk of biomass energy use in most PICs is for household cooking but it is not possible to accurately estimate the fuel wood demand without recent household energy surveys that include measurements of the weight or volume and the type of fuel consumed.

Tables 2-9 summarises the available information from census reports on the main household energy source for cooking and Table 2-11 for lighting.

Table 2-9 – Main Energy Source for Cooking by Percentage (census years except PNG)

Country	Year		Elec	LPG	Kero	Wood	Other	Comments
Fiji	1996	national	3	28	21	48	<1	Fiji data not separated into urban & rural
Marshall Islands	1999	national rural	26 6	2 1	40 11	30 79	1 3	'Other' is mainly charcoal
Palau	2000	national	23 *	21 *	22 *	-	-	* These are *exclusive* use of the fuel
PNG	1996/97	Moresby national	29 3	19 3	37 7	13 87	< <1 <1	Survey of 22,156 households nationally (about 2% of total).
Samoa	2001	national	11	12	14	62	-	For wood, Apia area 24%, Savaii 85%
Solomon Islands	1999	Honiara national	1 <<1	67 10	6 2	25 89	- -	Honiara accounts for nearly 11% of all households
Tonga	1996	national	11	55	23	74	-	Appears to be all fuels used to cook
Vanuatu	1999	national rural	<1 <<1	12 4	<1 <<1	83 95	<<1 <<1	Urban cooking 51% LPG and 42% wood Households are 77% rural and 23% urban

Source: National PIREP Reports (2004) Note: Rounded off to nearest whole number

There have been other small-scale surveys or estimates of cooking fuel used in PICs:

- in the Cook Islands (2001 census), wood is still the main cooking fuel for about 11% of all households (Rarotonga 0.6%, southern group 29% and northern group 34%);
- in Kiribati, several outer island surveys carried out by the energy unit in the early 2000s suggest that biomass is used exclusively in about 55-60% of households, whereas about 30% use wood and kerosene, and 10-15% use mainly kerosene. There seems to be no biomass shortage for cooking except in South Tarawa;
- in Nauru in 2004, most cooking is with (free or very inexpensive) electricity although LPG use is increasing due to frequent power outages;

- in Niue (2001), over 50% of households use LPG for cooking (19% as the main fuel, 28% some of the time) with wood less than four percent;
- the Palau census is the only one distinguishing between exclusive use of one fuel and the actual pattern of using several fuel types for cooking. In addition to the exclusive usages shown in Table 2-8, about 10% of households use electricity and LPG, about 10% use LPG and kerosene and about 5% use electricity and kerosene;
- in Tokelau (2003), cooking is largely with kerosene but LPG use is increasing;
- in Tuvalu, (2002), 90% of Funafuti homes have kerosene stoves. Kerosene is the main cooking fuel but about half of the households use LPG some of the time; and
- although data from earlier census reports are not shown in this report, there has generally been a shift from fuelwood to kerosene over time. In the more affluent PICs, there has been a further shift to LPG for cooking and not only in urban areas.

A rural household energy use survey in Fiji in 2003 – covering 271 households with electrification from stand-alone diesel generators and 542 households without electricity – is summarised in Table 2-10. It illustrates the obvious point also shown in the Palau and Kiribati PIREP reports: people may use one type of fuel much of the time but cook with a combination of fuels.

Table 2-10 – Cooking Fuel in Rural Fiji Households, 2003

Fuel	Electrified hh (%)	Unelectrified hh (%)
Wood (including agr. wastes)	35	67
Wood and LPG	34	25
Wood and kerosene	22	6
Wood, LPG and kerosene	7	2
LPG only	2	0
Total	*100*	*100*
Sample size	271 hh	542 hh
hh with income <F$3,000/year	51 %	74 %

Source: Fiji National PIREP Report (2004)
Note: Electrified is from stand-alone diesel gensets, not FEA

Table 2-9 and 2-10 and the above bullet points for other PICs confirm that fuelwood is still a commonly used cooking fuel in the region but that accurately estimating the national consumption requires more data than small-scale surveys and census reports can provide.

Table 2-11 summarises the data from PIC census reports on household energy use for lighting, with clear differences between urban and much less-electrified rural households. In PNG, in 1996/97, a quarter of rural households were estimated as using wood fires as the main source of lighting.

Table 2-11 – Main Energy Source for Lighting by Percentage (census years except PNG)

Country	Year	Elec	Wick lamp	Pressure lamp	Other	Comments
Fiji	1996	62	29	8	1	
Marshall Islands	1999 national rural	63 13	— 31 kerosene — — 78 kerosene —		5 15	'Other' is solar PV
Palau	2000	~100	0	0	0	
PNG	1996/97 Moresby national	76 12	18 57	4 4	- 28	See PNG note for Table 2.8 'Other" is mostly open fire.
Samoa	2001	93	- 7 kero or benzine -		0	
Tonga	1996	79	36	4	7	'Other' includes solar 3% and genset 2%
Vanuatu	1999 national rural	19 7	— 74 kerosene — — 85 kerosene —		6 7	'Other' is mostly wood and coconut waste; Households are 77% rural and 23% urban

Source: National PIREP Reports (2004) Note: Rounded off to nearest whole number

There have been several other small-scale surveys or estimates of lighting fuel used in PICs:

- in Kiribati, households using kerosene for lighting typically consume about one litre per week, more for wick-type lamps, and less for pressure-type lamps. (This increases to nearly five litres per week for households using kerosene for both lighting and cooking);and
- In Nauru, Niue, Tokelau and Tuvalu, nearly all lighting is electric, except for kerosene during outages or (Tokelau) when the genset is turned off.

2.3 Energy Balances and Greenhouse Gas Emissions

Most national PIREP reports include estimates of biomass energy use. It is clear from the previous section that these are crude estimates. In the absence of recent survey data (except small-scale surveys in several PICs), biomass energy for cooking was estimated based on information from a series of household energy surveys carried out in six PICs in the 1980s.[17] PIC economies have changed considerably in the past two decades and both urban and rural energy patterns have changed as well but no reliable recent data are available. Estimates of biomass energy use for industry and agricultural processing (mostly copra drying PICs) are explained in national reports.

Table 2-12 summarises findings from energy balances for PICs where these could be developed. It was anticipated at the beginning of the PIREP exercise in late 2003 that the biomass energy use estimates would be very approximate. Much more surprising was the generally poor quality data available on petroleum fuel imports and consumption, whereas the PREA analyses of the early 1990s[18] were able to rely on reasonably accurate information provided by the petroleum industry or otherwise obtained by the petroleum experts from the Forum Secretariat (i.e. PIFS) and UNDP regional energy programmes. In addition, information on petroleum imports available from government agencies was considerably more accurate and complete than is the case today. For the PIREP analysis, it was necessary for petroleum use for some national reports to be estimated based on several inconsistent sources. In other PICs, trend lines over a number of years were used to estimate recent or current use.

Table 2-12 also provides estimates of GHG emissions for a baseline year, varying by country depending on the most recent year for which more-or-less acceptable petroleum data were available. The purpose of the GHG estimates was to establish a baseline from which future GHG reductions (or reductions in growth rates) could be estimated for new renewable energy or energy efficiency investments, which might occur if barriers to these investments were removed. Accordingly, baseline GHG emissions were calculated only for petroleum or other thermal energy use, so inaccuracies in estimated biomass consumption do not affect the results.

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[17] From 1982-1987, 14 household energy surveys were carried out in rural and urban communities in six PICs through the UNDP/ESCAP Pacific Energy Development Programme (PEDP) and Fiji surveys funded by the Canadian International Development Research Centre (IDRC). For six rural surveys, households typically used 4,000 – 6,000 kg of wood per year (wet basis) with a gross energy content of 60–90 Gigajoules (GJ). Urban households in two Fiji surveys (i.e. a relatively high income PIC) used 580–850 kg of wood (8.7–12.7 GJ). Results are summarised in the papers of the Pacific Household and Rural Energy Seminar (World Bank/UNDP Energy Sector Management Assistance Programme and PEDP; Port Vila, Vanuatu, November 1990).

[18] Two of the three PIREP international consultants also participated in the PREA and are well aware of the data differences between then and now.

As Table 2-12 shows, most PICs (Fiji, Kiribati, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu and Vanuatu) annually emit between about 0.5 and 1.2 tonnes of CO_2 equivalent GHGs per capita. PNG is the lowest at 0.3 tonnes, the Cook Islands and FSM emit about 1.6-1.8 tonnes, the Marshall Islands, Nauru and Niue about 4-6 tonnes, and Palau well above the others at 15 tonnes.

For comparative purposes, Australia, New Zealand and the USA are in the 20-24 tonne per capita range, the EU overall averages about 11 tonnes and China 3.9 tonnes[19] but growing rapidly. A number of other island states are in the range of 2.5-6.5 tonnes (Bahamas, Barbados, Jamaica, Maldives, Mauritius, and Seychelles) with oil-producing Trinidad and Tobago highest at 16.5 tonnes. A number of African states are in the range of 0.5-1.8 tonnes (Ghana Kenya, Lesotho, Liberia, Malawi and Rwanda).

2.4 Future Growth in Energy Demand and GHGs

Table 2-13 is indicative of the likely maximum reductions in annual GHG emissions through very optimistic investments in renewable energy (and aggressive but perhaps more realistic investments in energy efficiency) after a decade if key barriers were removed. This does not seriously consider practical social, economic, physical or technical constraints, any of which could be considerable, although obvious constraints such as very remote locations with no demand or extremely high development costs were taken into account. This is not a forecast; actual savings will probably be much less.

For several PICs, the estimated GHG abatement potentials of Table 2-13 are impractical for another reason: they assume the development of too much renewable energy, i.e. the assumed investments could displace *more* petroleum fuel than the projected fuel demand. In Table 2-14, therefore, the investments in renewable energy have been reduced to a level sufficient to displace 100% of the projected demand for petroleum fuels for electricity generation and most fuel for ground transport.[20] The potential reductions in GHG emissions are adjusted accordingly.

There is a wide variation in opportunities for reduced emissions in 10 years time, ranging from under 10% to about 60% of the business-as-usual magnitude (i.e. projecting current patterns of energy use), through investing in renewable energy technologies and improved efficiency of energy use. The magnitude of potential savings in Gg is probably considerably more useful than the estimated percentage savings since the baseline data for 2000-2003 are poor. Of course any projections of fuel use (and potential GHG reductions) over a decade are bound to be inaccurate. The PREA, which had far more resources[21] for national energy assessments than PIREP, was often very inaccurate in estimating growth in fuel use in the PICs during the decade from 1990. The PIREP estimates are unlikely to be better.

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[19] For non PICs, the year is 2000. The source is the *Climate Analysis Indicator Tool* Excel® spreadsheet (WRI, 2003) freely available from the World Resources Institute at www.wri.org.

[20] It has been assumed that any use of ethanol for ground transport could replace about 15% of gasoline use the bulk of gasoline imports would not be displaced by renewable energy within a decade.

[21] PREA resources for 12 country reports plus a regional overview were roughly ten times the PIREP resources for 15 reports plus an overview.

Table 2-12 – Overview of PIC Energy Supply by Source in 1990 and Latest Available Year

Country	—— Energy Use in kTOE (1990) ——					% from:		—— Energy Use in kTOE (2002 unless noted) ——						% from:		GHGs latest year (Gg)	GHGs per capita (kg CO_2)
	Oil	Bio-mass	Hydro	Solar etc.	Total	Oil	Bio-mass	Oil	Bio-mass	Hydro	Solar	Total	Year	Oil	Bio-mass		
Cook Islands	14.3	2.3	0	–	16.6	86%	14%	9.4	0.8	0	–	10.2	2003	92	8	28.5	1,580
Fiji Islands	209.7	532.7	94.8	–	837.1	25.1%	63.6%	298	n/a	113.5	<<1	n/a	2000	n/a	n/a	897	1,080
FSM	49.3	6.2	0.6	–	56.1	88%	11%	73	12	0	–	85	2002	86	14	~ 200	1,820
Kiribati	8.5	15.4	0	–	23.9	36%	64%	16.2	3.9	0	0.1	18.5	2003	80	20	49.7	560
Marsh. Is.	23.5	6.6	0	–	30.1	78%	22%	81.8	7.6	0	–	89.4	2003	91	9	245.6	5,665
Nauru	n/a	n/a	n/a	N/a	n/a	n/a	n/a	15.0	0	0	0	15.0	2003	100	0	45.3	4,500
Niue	n/a	n/a	n/a	N/a	n/a	n/a	n/a	2.3	low	0	0	2.3	2002	100	~ 0	6.9	~ 3,800
Palau	22.2	0.3	0	–	22.5	98.7 %	1.3 %	93.6	~0	0	–	< 94	2003	~100	0	286	~ 15,000
PNG	627	693	126	21	1,477	42%	47%	493	947	80	25 ?	1545	2001	32	61	1470	277
Samoa ('89)	35.2	63.1	5.1	–	105.2	35%	60%	73.2	73?	?	–	> 147	2003	50?	50?	187.2	1,046
Sol. Is. ('89)	59.3	117.9	<< 0.1	–	177.1	33%	67%	68.4	109.8	1.8	–	180	2001/02	38	61	206	476
Tokelau	n/a	n/a	n/a	N/a	n/a	n/a	n/a	0.34	0	0	–	0	2003	100	0	1.1	724
Tonga ('89)	23.7	26.9	0	–	50.6	47%	53%	34.2	20.3	0	< 0.51	55	2000	62	37	104.3	1,043
Tuvalu ('89)	1.26	2.06	0	–	3.32	38%	62%	3.4	n/a	0	<<1	< 4	2003	90?	10?	10.8	1,160
Vanuatu	22	42	–	–	64	34 %	66 %	37	37?	small	–	> 74	2003	50 ?	50 ?	110.4	534

Sources: 1990 is from PREA series (Cook Islands, Fiji, FSM, Kiribati, Marshall Islands, PNG, Palau, Solomon Islands, Samoa, Tonga, Tuvalu and Vanuatu); Latest year is from PIREP national reports (2004)

Notes: Oil = petroleum fuel except PNG includes natural gas (144 ktoe) for 2001. – is 'minimal' ~ is 'approximately' n/a is 'not available' or 'unknown' GHG emissions are from commercial energy use only
No wind electric systems or geothermal energy output in PICs in 2000-2002. Hydro ktoe based on fuel savings compared to petroleum fuel use.

Countries: **Fiji.** High biomass use in 1990 due in part to use of bagasse as fuel for sugar cane processing. Petroleum use in 2000 is questionable; GHG emissions in 2000 could be of by 20% or more.
FSM. Data for 2002 are rough estimates only and are subject to change. **Marshall Islands**: Inconsistencies in petroleum data so GHGs may be too high.
PNG. Solar in 1990 = solar 28 ktoe and ethanol fuel 3 ktoe. PNG economy is volatile. Data show high year-to-year variation in fuel use so 2001 is not necessarily a typical year for PNG. Geothermal began in 2004.

Table 2-13 – GHG Emissions and Potential Savings After a Decade: Gross Estimates														
Country	Petroleum Use AAGR (%)			Projected GHG emissions in 10 years, BAU		Potential GHG Savings with Renewable Energy and Energy Efficiency Investments: (Gg per year, 10 years from the baseline year)								
	– 1990-2000 (or latest year) –		Projected: next 10 years											
	Predicted (PREA)	Actual		CO_2 (Gg)	Year	Total	Energy Efficiency	Geo-thermal	Hydro	Bio-diesel	Ethanol	Other biomass	Solar PV	Wind
Cook Is.	4 %	~ 0 %	4.2 %	42.9	2013	13.1	2.1	0	0	2.6	0	0	2.1	6.3
Fiji	4.8 %	~ 2 %	~ 5 %	1487	2010	966	37	43	818	4	27	17	1	19
FSM	4.5%	~0	2 %	168	2012	23.9	7.1	0	14.2	2.3	0	0	0.3	0
Kiribati	4.5	3.9	3.8	72.2	2013	26.5	2.0	0	0	20.8	0	0	—— 3.7 ——	
Marsh. Is	4.0	3.7	5.0	400	2013	22.3	14.3	0	0	7.6	0	0	0.4	0
	n/a	n/a	0.4%	46.9	2013	16.6	13.8	0	0	0	0	0	2.8	0
Niue	n/a	n/a	2.3 %	8.7	2012	1.08	0.44	0	0	0	0	0	—— 0.64 ——	
Palau	4.8 %	?	4.4 %	441	2013	49	37	0	0	0	0	0	12	0
PNG	+ 9.6 %	- 1.7 %	3%	2056	2011	1586	0 *	333	691	113	430	Very small	9	10
Samoa	4.6	7.3 %	6.7 %	357.3	2013	96.1	12.2	12.8	40.2	27.0	0	0.3	2.5	1.1
Sol. Is.	2.2	1.8 %	4.2 %	313	2012	~121	10.7	Low	31	75	0	<2	3	<1
Tokelau	n/a	n/a	1.7 %	1.3	2013	0.22	0.07	0	0	—————— 0.15 ——————				0
Tonga	5.5 %	~ 1.5 %	1.5 %	121	2010	34.5	3.3	0	0	27	0	0	1.4	2.8
Tuvalu	4.2 %	~ 4.3	1.9 %	13.0	2013	2.2	1.4	0	0	—————— 0.8 ——————				0
Vanuatu	3.6 %	3.6 %	3.5 %	155.7	2013	~109	1	17	14	75.6	0	< 1	< 2	<<1

Sources: PREA series included Cook Islands, Fiji, FSM, Kiribati, Marshall Islands, PNG, Palau, Solomon Islands, Samoa, Tonga, Tuvalu and Vanuatu; Projections and potential savings from PIREP national reports (2004).
Notes: BAU = Business as usual, i.e. no new RE or EE investment ' ~ is 'approximately' n/a is 'not available' or 'unknown' AAGR = average annual growth rate; NE = not estimated.
PNG * Efficiency savings shown as zero because all fuel saved replaces renewable energy so there are no additional GHG savings.

For four of the PICs (Fiji, PNG, Tonga and Vanuatu), very aggressive development of renewable energy could displace more than the projected business-as-usual demand for petroleum fuel required for electricity generation, for transport, or for both so renewable energy development has been limited to projected fuel use since that is all that will impact GHG emissions.

Table 2-14 suggests that the PICs may fall into three broad categories regarding oversell potential for reducing emissions compared to the business-as-usual projections.

- 11±5%. Relatively small island countries, most of which are relatively resource poor with relatively high per capita energy use (Marshall Islands, Niue, Tokelau, Tuvalu) plus Palau with substantial opportunities for improved energy efficiency,
- 30±5%. The Polynesian islands, generally with a wider range of resources than the first group (Cook Islands, Samoa, Tonga) plus Nauru with limited resources but ample opportunities for efficiency savings; and
- 50±10%. The resource-rich Melanesian countries with a large land mass and a wide range of options for developing renewable energy (Fiji, Papua New Guinea, Solomon Islands, Vanuatu).

Table 2-14 – GHG Emissions and Potential Savings After a Decade: Adjusted to Projected Energy Demand

Country	Projected baseline emissions in 10 years, BAU		Potential Annual GHG Savings			Relative Savings from Renewable Energy and Energy Efficiency			
	CO_2 (Gg)	Year	Gross (Gg)	Adjusted (Gg)	Adjusted as % of baseline	RE (Gg)	% of total	EE (Gg)	% of total
Cook Islands	42.9	2013	13.1	13.1	31%	11.0	84%	2.1	16%
Fiji	1487	2010	966	504	52%	467	93%	37	7%
FSM	~ 168	2012	23.9	23.9	14%	16.8	70%	7.1	30%
Kiribati	72.2	2013	26.5	26.5	37%	24.5	92%	2.0	8%
Marshall Is.	400	2013	22.3	22.3	6%	8.0	36%	14.3	64%
Nauru	46.9	2013	16.6	16.6	35%	2.8	17%	13.8	83%
Niue	8.7	2012	1.08	1.08	12%	0.64	59%	0.44	41%
Palau	441	2013	49	49	11%	12	24%	37	76%
PNG	2423	2011	1586	1013	42%	1010	> 99%	3	< 1%
Samoa	357.3	2013	96.1	96.1	27%	83.9	87%	12.2	13%
Sol. Islands	313	2012	121	121	39%	108.8	90%	12.2	10%
Tokelau	1.3	2013	0.22	0.22	17%	0.15	68%	0.07	32%
Tonga	121	2010	34.5	31.6	26%	28.3	90%	3.3	10%
Tuvalu	14.0	2013	2.2	2.2	16%	0.8	36%	1.4	64%
Vanuatu	155.7	2013	109	93.6	60%	108	99%	1	1%

Note: RE = renewable energy and EE = energy efficiency

Since the region as a whole is dominated by the large resource-rich countries, the regional potential for GHG reduction heavily favours renewable energy but on an individual country basis, that is not the case.

- 16% or less. Large resource-rich countries (Fiji, PNG, Solomon Islands, Vanuatu), and smaller Polynesian countries (Cook Islands, Samoa, Tonga).
- 36±5%. Small countries with relatively high per capita energy use (Niue, Tokelau)

- 60% or more. Countries with very inefficient use of commercial energy (Marshall Islands, Nauru, Palau, Tuvalu).

As discussed in chapter 5, the table probably underestimates the potential role of energy efficiency in reducing GHGs.

3 Technical Potential for Renewable Energy Technologies and their History in the Pacific

3.1 Biomass

3.1.1 Biomass combustion

Technology Description

Biomass combustion for the production of steam to run an electric generator is a technology more than 100 years old. Although it is certainly possible to use small-scale biomass combustion systems to produce steam for plantation or village electrification, the operation of steam power systems for electricity generation can be complicated and is potentially dangerous so the technology requires well-trained operators and regulation by government to ensure that operators are qualified and proper maintenance is carried out. Also, steam power systems benefit from economies of scale with the cost per kWh of power generation decreasing as the size of the plant increases. The economies of scale for more economically viable systems extend well beyond the range of power required by any of the PICs. For village scale systems, the capital cost may exceed US$10,000 per kW of capacity, making its life cycle cost higher than diesel even though the biomass for fuel is assumed to be free. In fact the fuel is not free even if it is a waste product because there are transport, storage and handling costs involved that can be substantial. There can also be processing costs.

Past Pacific Experience

Small scale agricultural drying – notably for copra – has long used biomass as fuel. Biomass combustion is also a traditional energy source throughout the Pacific for cooking in rural areas. Institutional woodstoves have been used in PIC schools (Figure 3-1) since the early 1980s. Many hundreds of household wood burning stoves, and far fewer charcoal stoves, were developed, tested and trialed in numerous PICs including Kiribati, Tonga, Fiji and PNG throughout the 1980s. In Fiji, over 600 household stoves were constructed with EU support and provided to low-income rural families. One outcome of the programme was its catalytic role in leading Fiji to establish a woodstove working group (officials, academics, donors, users, NGOs, etc.), that better defined the goals of stoves programmes and appropriate stove designs for Fiji and the wider Pacific.

Figure 3-1 – Energy Officer Winnie Veikoso with woodstove at Queen Salote College, Tonga

Photograph: Peter Johnston Nuku'alofa, 2003

In the early 1980s, the Samoan government promoted an "improved charcoal stove project" to replace earlier designs that cracked easily. The new portable stoves were made from concrete and retailed for about WS$5.

Within a year, more than 4000 stoves were sold in the Apia area and production was passed to the private sector. The programme was apparently short-lived as less than one percent of Samoa's households reportedly cooked primarily with charcoal in 2001. There is little evidence anywhere in the Pacific that improved household wood or charcoal stove programmes have in practice reduced fuelwood consumption, although they can have health benefits such as reduced eye inflammation and less emphysema or lung irritations.

On a larger scale, agricultural wastes – notably sugar processing waste (bagasse), rice husks, coconut husks, coconut shells, forestry waste, and the waste from palm oil production – have been burned for process heat or electricity generation using steam generated from the heat. The technology has been commercially available for decades and hardware is readily available. It has been used successfully in Fiji at a coconut plantation on the island of Taveuni continuously for over 25 years. In 1979 a small wood/coconut waste-fuelled steam power system was installed to provide heat for copra drying and electricity and it is still operating though much modified over the years. Two 10 kW steam engines operate on an alternating basis, switched every two weeks, reportedly saving about 27 litres of diesel fuel per hour relative to a diesel genset.

In 1987 a similar but smaller system was commissioned at a nearby village. Using 500 kg of wood and coconut husk/shell over eight hours, the boiler was intended to provide heat for copra drying and steam for the 10 kW steam engine, supplying electricity to 47 homes for 4-8 hours daily. The community was not seriously committed to the project and the project failed due to institutional issues.

The PIREP studies found no small steam systems elsewhere in the region. Under the EU's Lomé II Pacific regional energy programme, which ran from 1982–1994, two systems of about 100 kW each were planned for Kiribati (fuelled by senile coconut stems on Kiritimati) and Tonga (coconut waste from a mill on Tongatapu). In both countries, costs were considerably higher than expected. In Kiribati, access to the old trees was uncertain, available fuel costs were unknown, no operator was identified, and there were serious technical difficulties in integrating the plant into a mixed 50 Hz/60 Hz distribution system so that installation was never made. In Tonga, the mill closed down for reasons unrelated to the steam plant.[22]

In Samoa, a much larger 2.5 MW turbo generator at a sawmill in Asau, Savai'i produced electricity from excess steam from a wood waste fuelled boiler in the early 1980s. Power that was surplus to the mill's requirements was distributed to consumers in Asau village and by the Samoa Electric Power Corporation (EPC) through the grid to northwest Savai'i. However, the facility was inefficient and frequently shut down due to insufficient timber waste or mechanical failure. It continued to operate for some years but was eventually closed.

Potential

The estimate of the potential biomass resource has to consider replacement in real time, that is, the biomass used must be replaced at the same rate that it is used, otherwise it cannot be considered a sustainable renewable resource. Therefore the use of biomass for energy implies a replanting rate that is sufficient to ensure that the resource is never

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[22] Details of this experience, and the Lomé II programme overall, are from *An Evaluation of the European Community's II Pacific Regional Energy Programme* (P Johnston/Forum Secretariat, August 1994).

depleted. Economically and institutionally, this resembles a big plantation, even if the resource originally comes from uncultivated lands held communally or by many small land holders. In theory such virtual biomass plantations can fuel biomass power generation plants but trials elsewhere in the world have not been promising in terms of either sustainability of the resource or economics. In the Pacific, even if the process were economic and sustainable, several megawatts of sustained power production requires hundreds of hectares of land, and assured long term access to the fuel supply would probably be difficult. Most land owners could find productive uses for their land providing more income than fuel production.

An important characteristic of biomass based power production is the large volume of fuel required. Biomass in general is a low-density fuel so transport and logistics problems can be considerable. This is one reason why most biomass fuelled power production is based on waste products produced near the plant. If the plant depends on fuel from a large surrounding area with many land owners providing the supply, the power producer loses control of the fuel supply and the risk of failure is greatly increased. Where power plants have been designed to operate from a standing crop of trees or other biomass rather than agro-industrial waste, the plant is usually in a fuel plantation controlled by the power plant owners, not reliant on the provision of fuel from a large number of distant, individual holdings.

A possible exception to this generality is use of senile coconut trees which are being replaced as coconut plantations are renovated. For best coconut production, trees should be replaced on about a 30-year cycle. In those PICs with a large economically productive coconut tree population, maintaining high production requires a continuous process of removing old trees and planting new ones. If a biomass fuelled power plant is located where the cost of transport of the cut trees is reasonable, it may in theory be possible to sustainably fuel a power plant of 100 kW or more. However, the cost of transport and handling can be prohibitive, particularly on atoll islands where trees are distributed along a narrow strip of land or in very hilly areas of larger islands. Also there may be more profitable uses for the cut trees including milling for construction, specialty furniture and export. If large-scale biofuel use requires highly productive, large scale coconut or palm oil plantations, then the senile palm waste from the continual replanting over the years may be an interesting by-product to benefit the energy supply system.

In most cases, the main potential for biomass combustion is for use at agricultural and forestry processing facilities to produce process heat and electricity and to help reduce the accumulation of waste products. The biomass potential therefore is directly related to the extent of the agro-forestry industry and the market for its products.

3.1.2 Biomass gasification

Technology Description

When most carbon based materials, such as wood and plastics, are heated to a high temperature with restricted access to air, a burnable gas called producer gas (consisting largely of carbon monoxide) is generated. The gas can be burned directly in spark ignition engines or, with some adaptation, in diesel engines if well filtered and cleaned before introduction into the engine. The technology is not new. Industrial scale gasifiers for process heat are commercially available and a few are used in the region.. Gasifiers for power production generally require constant attention and skill for both operation and maintenance. Therefore small-scale gasification for remote areas has not generally been successful. There are no commercially proven small-scale (1 MW or less) gasifiers that are technically appropriate for electricity generation or other engine operation in rural areas. However companies in the USA and Europe are developing designs specifically for developing country electricity generation at a community level, and these may become practical for PIC use within the next decade.

There is potential for environmental damage due to the production of tars and other somewhat toxic waste products. Environmental issues must be carefully considered in the design of a gasifier installation and its operation.

Past Pacific Experience

Over 80 New Zealand-made Waterwide[23] gasifiers were used in the Eastern Highlands of PNG from the early the 1980s to replace diesel fuel burners for commercial copra, cocoa, coffee and tea drying. In late 2002, there were reportedly 52 gasifiers still in use by coffee processors in PNG. Waterwide systems were also used successfully for a time in Samoa.

In the early 1980s, highly-efficient Samoan-designed and constructed Brugger hot-air gasifiers/dryers were used for crop drying. In 1984, with Commonwealth Secretariat support, three diesel-fired boilers and driers were retrofitted with Brugger systems (Samoa Tropical Products, a soap factory, and the Cocoa Board), reportedly resulting in substantial fuel savings. They have apparently not been used for some years.

In 1983, the Cook Islands Electric Power Supply (EPS) tested a small sawdust fuelled gasifier for running a small generator but there were numerous problems and the tests were short-lived. A small gasifier was also installed and briefly tested at Atiu in the Cook Islands about the same time but results were not sufficiently promising to continue.

Under the EU's Lomé II Pacific regional energy programme, which ran from about 1982 – 1994, 17 power gasifiers of varying designs and sizes were originally planned in five PICs (Fiji, PNG, Solomon islands, Samoa and Vanuatu), later reduced to eleven and then seven systems. Only two were built and installed: a 25 kWe wood-fuelled system at Onesua Presbyterian College, a secondary school in north Efáte, Vanuatu commissioned in late 1986; and a smaller 15 kW charcoal-fuelled system completed in late 1987 at Batuna sawmill, at Vangunu Island in the Solomon Islands. The Batuna system worked periodically with mediocre performance (1500 hours of operation) before closing down in early 1990. It was of limited financial value to the sawmill operators, labour costs were high, spare parts were hard to obtain, power demand was four times the consultant's estimates, and the system did not fully meet specifications. The slightly larger Onesua system from the same manufacturer required a great deal of modification during the first year of operation and required several throat replacements over its life. Nonetheless, it operated regularly from late 1987 until July 1993 eventually reaching 9000 operating hours, a total far exceeding all other power gasifiers tried in the region since 1980. The Onesua success was due to the diligence, enthusiasm and competence of a highly-skilled operator. The poor experience elsewhere had various causes: poor tender documents (PNG); technical unsuitability Fiji, PNG, Solomon Islands); prices far exceeded budgets (all countries); the biomass fuel resource required was uncertain, inadequate, unavailable, or too costly (Solomon's, Samoa); the

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[23] The Waterwide gasifier is essentially a close-coupled two-stage combustion system. Biomass is first gasified in up-draft conditions and the hot dusty, and tarry fuel gas is immediately burned in a cyclonic combustion system.

organisation which was to operate the system backed out, closed down or lost interest due in part to the time required to finalise arrangements (Fiji, Samoa); gasifiers of the size or type specified were unavailable (Fiji); and as time dragged on, governments decided gasification appeared to be uneconomic so alternative energy sources were decided upon (Fiji).

Potential

There is some potential for industrial scale use in the agricultural and forest industries for process heat or power production where direct burning is not practical or appropriate due to air quality problems or where the flexibility of gas as a fuel is needed.

3.1.3 Biodiesel

Technology Description

Vegetable oils of various types have long been used as fuels in diesel engines. Many PICs have experimented with coconut oil as a diesel replacement both with the raw oil and with chemically modified oil. Although the energy produced from coconut oil is somewhat less per litre than diesel fuel, it is generally satisfactory as a direct replacement for diesel fuel. If the raw oil is used, it must be kept at a temperature above 22°C since the oil turns into a waxy solid at colder temperatures. To avoid this problem the coconut oil may be blended with diesel fuel, the fuel heated when ambient temperatures are below 22° or the oil chemically modified to prevent solidification at normal ambient temperatures.

Figure 3-2 – Jatropha intercropped with coconut trees

Source: Fiji Coconut Industry Development Authority, 2004

Besides coconut oil, palm oil may also be used as a diesel fuel replacement. Since the production of palm oil tends to be simpler and lower in cost than the production of coconut oil, if new planting of palms for fuel production is necessary, consideration probably should be given to planting for the production of palm oil rather than coconut oil. It is noted, however, that all the research in the Pacific on vegetable oil as a diesel replacement has been with coconut oil and if palm oil is to be considered, further application oriented research needs to be carried out. In Fiji, the Coconut Industry Development Authority (CIDA) is considering intercropping coconut trees with *Jatropha Curcas* (Figure 3-2), or other long-lived plants that produce seeds with a high oil content suitable as a possible source of biodiesel.

Past Pacific Experience

In the early 1980s it was generally expected that coconut oil in the region would continue the previous trend of declining value, whereas diesel fuel prices would increase in real terms. In 1982, the United Nations Industrial Development Organisation (UNIDO) financed a study in Fiji that confirmed that coconut oil was technically viable as a distillate substitute and possibly economically feasible to develop as a fuel. However, the price differential over the next few years shifted in favour of diesel making locally produced coconut oil economically unattractive as a fuel.

There was some testing of coconut oil, or chemically modified coconut oil, as a fuel in a number of PICs in the 1980s and early 1990s. EPC in Samoa, for example, used coconut oil on a small scale as a partial substitute for ADO about 1981-1982. However, it was never a high priority considering other heavy commitments requiring skilled manpower and alternative remunerative uses for coconut oil.

Under the Lomé II energy programme, trials of coconut oil as a fuel were planned in Fiji and PNG. In Fiji, FEA planned a series of trials on coconut oil and coconut/diesel blends in an existing engine. Due to unexpectedly high coconut oil costs and a surplus of hydro capacity, FEA lost interest. A replacement project was planned using esterified (chemically changed) coconut oil as a fuel through the National Marketing Authority. The project was cancelled in 1987 for unknown reasons. In PNG, a demonstration was planned of coconut oil in diesel engines for both electricity generation and vehicle use at a rural site near Wewak. The system used esterified oil and reportedly produced usable fuel for a year or so until late 1987 when the project closed for financial reasons related to the high cost of coconut oil.

One of the authors of this report (Wade) used filtered, unmodified coconut oil in Tahiti from 1989 to 1992 to fuel a standard diesel automobile with no operational problems, although distillate would have been cheaper. There have been similar experiences in Vanuatu, PNG, RMI, Fiji and elsewhere.

Potential

Vegetable oils are among the few renewable energy sources practical for replacement of fuels used for transport that are even close to being economically competitive with imported petroleum products. The large inventory of coconut and palm oil trees in the Pacific has the potential for a significant, although not complete, replacement of fossil fuel for marine transport and diesel based land transport. Air quality also would benefit since particulate emissions from vegetable oils are much lower than petroleum and engine exhaust does not have the foul smell associated with diesel fuel combustion.

The real potential for the use of coconut or palm oil as a replacement for diesel fuel is determined by the cost of production. Since vegetable-oil based fuels have a large labour and transport component, they are more likely to be economically competitive at current petroleum prices in countries with a relatively low rural labour cost (Fiji, Kiribati, PNG, Solomons andVanuatu). Also, in most of the PICs, the low market price for copra has tended to discourage the upkeep of coconut plantations and the tree stock tends to have low productivity due to a high average tree age. Finally, issues of land tenure often keep plantations small and inefficient.

However, despite these limiting factors, the use of coconut or palm oil as a diesel fuel replacement has considerable potential and is one of the few renewable energy technologies that can have a substantial impact on transport while providing direct economic development in rural areas. Where PIC governments are serious about reducing rural-urban income differentials, vegetable oil fuel production offers real opportunities for improvement.

3.1.4 Ethanol

Technology Description

Ethanol can be produced by the fermentation of solutions containing sugars such as wastes from fruit processing or from sugar cane processing. The technology is well developed and widely known since ethanol is the alcohol found in alcoholic beverages. Ethanol can be used as a petrol replacement in spark ignition engines, although its energy production per litre is not as great as petrol unless engine fuel intake systems are significantly modified. Burning pure ethanol requires modification of petrol engines that would prevent reverting to petrol without re-modification, but it blends well with petrol allowing direct use in unmodified petrol engines while reducing the volume of petrol that needs to be imported.

Several countries, notably Brazil and the USA, have incorporated large-scale ethanol production into their energy economies with apparent success. Large expanses of agricultural land are essentially fuel farms. Criticisms of these programmes include questions about the overall energy balance of ethanol production – some claim it takes more energy to produce the ethanol than you get from the fuel – and the effect large-scale conversion of agricultural land to fuel production could have on food production. In Brazil, there have been environmental issues (land degradation and effluents) associated with some poorly-planned and operated ethanol production systems.

Past Pacific Experience

Although many PICs produce ethanol in various beverage forms, only PNG has manufactured it commercially as a fuel. A sugar mill in PNG's Ramu valley produced about four million litres per year from molasses for several years from the mid-1980s. At the time of the 1991 PREA mission, the ethanol was still being blended with motor spirit for sale primarily within the valley. At that time the commercial value of molasses at Ramu was low but the cost of petroleum fuels was high due to poor transportation including very poor roads. In 1995, by which time transportation infrastructure had improved, the distillery was upgraded to produce high-value potable-grade alcohol, mainly for export. Ethanol in PNG is no longer used as a fuel and the economics of doing so are now unattractive.

Potential

In the sugar producing countries, notably Fiji and PNG, it is possible to shift from producing sugar to using the cane to produce ethanol for fuel on a large scale. Both countries have periodically investigated this but the economics have been marginal at best. In Fiji, and PNG, molasses, a relatively low value by-product of sugar production, is currently used for high-value potable ethanol production. The pulp waste from fruit juice production can also be a feedstock for ethanol. However, the economics are not favourable, even at existing prices of fossil fuels, and the ethanol would cost substantially more than the petroleum it replaces.

Other feed stocks have also been considered for ethanol production in the Pacific. Around 1980, Fiji seriously considered production of fuel ethanol from sweet sorghum in uncultivated areas of the second largest island of Vanua Levu. Although two oil companies expressed interest in a joint venture investment with the government, the economics, as with sugar cane, were marginal and the idea was abandoned.

3.1.5 Methanol

Technology Description

Methanol, commonly called wood alcohol, can be produced from wood waste. Although lower in thermal value than petroleum fuels, it can be used to replace petrol in spark ignition engines or, to a limited extent, blended with petrol. It is a particularly attractive fuel for use in fuel cells, a technology that holds great promise for the future. However, the technology used for its production from wood waste is relatively complex and not suitable for small-scale production so a methanol production facility would need to be developed in conjunction with the availability of a fairly large volume of convertible wastes on a continuous basis.

Past Pacific Experience

There has apparently been no experience with methanol as a fuel in the region.

Potential

Methanol production is generally a less energy efficient use of wood waste than direct combustion or gasification for power generation. However using the waste to produce methanol has the potential for reducing petrol use for transport. When fuel cells become economically attractive for isolated electricity production, using methanol would allow their operation from a renewable energy source. At the present time, however, the potential for the development of methanol in the PICs appears to be small.

3.1.6 Municipal solid wastes

Technology Description

Where urban solid wastes are collected, separated into combustible materials and other matter, and transported to landfill sites, the combustible wastes can be incinerated using a range of commercially available technologies. Incineration is widely used in Europe, China, Japan and elsewhere and can produce hot water for process heat or steam for industrial use or electricity production. The World Bank (WB, 2000) characterises municipal solid waste (MSW) incineration as highly expensive in terms of investment and operating costs, requiring highly skilled personnel and careful maintenance. Although operations can be clean and a well-managed facility can reduce net GHG emissions, in developed countries air pollution remains a major problem. In general, the economically viable size is a unit (preferably two units allowing for down time) burning 10-20 tonnes of material per hour, with a supply of at least 50,000 tonnes per year of suitable material. The lower calorific value must average at least 7 MJ/kg and not fall below 6 MJ/kg in any season. A mature and well-functioning waste management system should be in place for a number of years before incineration is considered.

Past Pacific Experience

There has been no experience with MSW incineration for energy production in the region.

Potential

The mission does not have information on the production of combustible MSW from PIC urban areas or their energy value. It is likely that the greater Suva area in Fiji and greater Port Moresby in PNG could produce sufficient MSW for incineration to be a technical option. However, neither currently has a mature and well-functioning waste management system which has been in place for a number of years.

3.2 Hydro

Technology Description

Hydro energy may be used directly for mechanical energy but most applications are for electricity production. The amount of energy available is directly proportional to the flow rate (m^3/sec) times the distance the water drops vertically (metres). To increase power production it is necessary to either increase the rate of water flow or the distance it falls. Most hydroelectric systems in the Pacific rely on the water falling from a considerable height with a modest flow rate rather than a short distance of fall and a high flow rate, because the size of the installation (and therefore its cost) is largely a function of the amount of water that passes through it, i.e. the flow rate. A high head (distance of fall) low flow site can be developed for a given power output more cheaply than a low head high flow site.

Although classification can be vague and can seem arbitrary, the following range is often used when describing small hydro sites: picohydro for outputs below 1 kW, micro-hydro for output between and 1 kW and 300 kW, and mini-hydro for output greater than 300 kW but less than about 1500 – 2000 kW (1.5 to 2 MW).

Seasonality of flow due to distinctive rainy and dry seasons is a problem for most of the Pacific for hydro development, as the amount of energy available from the flow may vary widely over the year. Installations at small streams are more vulnerable to varying flow rates, sometimes experiencing extreme differences, up to 500 to 1, between maximum and minimum flows. Accordingly, the design of micro-hydro installations for small Pacific streams is difficult, requiring local experience and a good understanding of the unusual conditions that exist in the islands.

Hydroelectric installations have the advantage of being a renewable energy resource capable of providing continuous power on demand up to the limit of the stream energy resource. If sufficient water storage can be provided in a large head pond or reservoir, then combining a small hydro installation with a variable energy source (e.g. solar or wind) allows the use of smaller streams. Solar energy matches particularly well with small hydro: when it is raining there is sufficient water for power but little solar energy and when it is dry there is increased solar availability but reduced energy from hydro. No hybrid hydro-solar systems have been installed in the Pacific region but several have been used with reasonable success in Asia, although trials have not been running long enough to determine sustainability.

Past Pacific Experience

There is extensive experience in the high islands of the region with hydroelectric systems, ranging from household level pico scale, through village micro/mini-hydro to large-scale utility-run systems. Details are provided in the national reports, with a brief summary in this regional overview. Hydro systems under construction or planned are discussed in the next chapter.

- **PNG**. PNG's power utility (PNG Power) commissioned 162 MW of hydro at 11 locations between 1957 and 1989, distributed among three systems: Port Moresby (63 MW), Ramu in the highlands (87 MW) and the Gazelle system in New Britain

(12 MW). Including private industrial systems above 2 MW, there are about 220 MW of installed capacity. Between 1988 and 1992, the government commissioned three micro-hydro systems: i) the 300 kW Tari scheme (Southern Highlands) in 1988 with the EU financing 80% of construction costs and the government the remainder; and ii) the 60 kW Woitape scheme (Central) and the 100 kW Telefomin project (West Sepik) completed in 1991 and 1992 respectively, both with GoPNG funds. The Woitape project (installation, commissioning and site supervision) cost about US$1.4 million, or US$23,000 per kW. The Telefomin system cost US$2.4 million or US$24,000 per kW.

Numerous micro and mini hydro installations exist in PNG, but documentation is poor. A 1984 study identified 55 microhydro schemes installed since 1960, of which 40 were operational at that time. An earlier estimate suggested about 100 small schemes built by 1976. Other estimates suggest more than 45 microhydro plants had been installed between 1960 and 1989, few of which were operational, mainly due to poor maintenance. Certainly dozens of small systems have suppled electricity to rural communities and institutions, over half of which were established by missions and church organisations, some of which have been in operation for over 25 years.

- **Fiji**. The FEA commissioned an 80 MW hydro system at Monasavu in the interior of Viti Levu in 1983 and a 0.8 MW scheme at Wainikeu in Vanua Levu in 1992. Between 1930 and 1999, seven small hydroelectric systems (3-100 kW), two of which were at church missions, were built in four islands.
- **Samoa**. Eight hydro systems (Figure 3-3) have been built at five locations in Upolu between 1959 and 1992, with a total capacity of 12.2 MW. All but the largest system (Taelefaga with two 2 MW turbines) are run-of-river.

Figure 3-3 – Cleaning and Repairing 1959 Alaoa Hydro Intake, Samoa

Photo: ADB following Cyclone Heta, 2004

- **FSM.** At Nanpil in Pohnpei, a highly automated 2.06 MW hydro facility, limited to 1.8 MW due to intake restrictions, was constructed in 1988. It was damaged during flooding several years ago and is not currently operational. A microhydro system was constructed in Kosrae some years ago but has never operated.

- **Solomon Islands**. The Solomon Islands Electricity Authority (SIEA) had commissioned two microhydro schemes by 1996. In 1986, a 32 kW system was built on the Malu'u River in Malaita to supply a health centre, a store and several homes. Funded by New Zealand Aid, it was closed due to local land disputes and the current status is not known. A 185 kW scheme was constructed at Buala on Santa Isabel in 1996 supplying a hospital, school, store, fish storage and houses. It was part of a GTZ-funded and PIFS-managed project. In 1983 and 1994 two small (10-12 kW) microhydro schemes were built in Kolombangara in the Solomon Islands, at Iriri (Figure 3-4) and Vavanga villages respectively, through an Australian development organisation, APACE. A 75 kW microhydro Pelton turbine was installed in 1976 serving a church mission and health centre at Atolifi on Malaita. The PIREP team has no information on its status or the extent to which other church organisations have installed hydro plants in the Solomon's. It seems likely, however, that others have been built.

Figure 3-4 – Iriri Hydro Penstock, Solomon Islands

Source: www.apace.uts.edu.au

- **Vanuatu**. Vanuatu's only experience with hydropower has been the JICA-built, government-owned and UNELCO-operated Sarakata system, consisting of 2 x 300 kW turbines which have been used for baseload at Espiritu Santo island and produced on average about 4.5 GWh per year since early 1995.

Potential

Hydropower can operate as base load generation if the stream capacity is high or if there is large enough storage. The potential exists in the larger mountainous countries, particularly Fiji, PNG, Solomon Islands, Vanuatu, and to a lesser extent Samoa. Some potential exists in FSM, Cook Islands and Tonga but not sufficient to play a significant role in national energy production. The fact that most sites suitable for hydroelectric development are in remote, mountainous areas makes many of them economically unattractive. As the population in those remote areas increases or the cost of conventional energy increases, many presently uneconomic sites may become reasonable for eventual development.

Estimates of technically and economically attractive hydro potential in the region are only approximate as there has been very limited hydrological (stream gauging and rainfall) data collection and analysis:

- PNG probably has over 4,000 MW of economically attractive hydroelectric potential for hydro systems of about 1 MW or above and vast potential for micro/mini hydro;
- Fiji has roughly 200 MW of large-scale hydro potential which may be economically viable, and perhaps 40 attractive undeveloped micro-mini schemes totalling under 3.5 MW;

- Vanuatu may have several MW of mini hydro potential. The government has investigated microhydro potential for 13 sites on six islands. Preliminary results suggest about 1.5 MW of available power ranging from 15 - 350 kW per site;
- in the Solomon Islands, JICA has identified nearly 330 MW of hydroelectric potential at 130 sites on seven islands. 73% of the total is on Guadalcanal, possibly because the resource has been more thoroughly investigated on the island with the bulk of national electricity demand;
- in Samoa, JICA experts note that there has been no systematic water gauging since the mid 1980s. Nonetheless, a reasonable potential exists for a 4.6 MW three-phase cascade development in the Sili River basin of south Savai'i. The average output would be about 24 GWh per year;and
- elsewhere, hydro potential is very small.

3.3 Geothermal

Technology Description

Geothermal energy relies on the heat found deep in the earth's interior. Although theoretically any site can access geothermal energy simply by drilling deep enough, only those locations where the hot rock lies close to the surface can be economically tapped for energy. In the Pacific, PNG, Fiji, Vanuatu and Samoa have known geothermal resources and the Solomon Islands probably does as well. Tonga has a geothermal resource but not in a populated area where power could be put to economic use.

Two basic types of geothermal energy production are common: i) those sites where natural steam or very hot water can be used directly for power generation; or ii) sites where the rock is hot but dry and a heat exchange fluid, usually water, must be used to extract energy from the rock. The steam or hot water systems are cheaper to develop but often have environmental problems due to sulphur dioxide and other toxic gas emissions that accompany the steam or hot water. Dry rock installations generally have low environmental impacts but are more expensive to develop.

Past Pacific Experience

The first geothermal system in the PIC region was commissioned in PNG in 2003 and is discussed in the next chapter.

Potential

Geothermal provides base load generation possibilities for PNG, Fiji, Vanuatu, Samoa and possibly the Solomon Islands. The resource has not been well determined for any of the PICs. No deep boreholes have been drilled to provide reasonable data on the magnitude of the resource.

3.4 Wind

Technology Description

Wind energy has been used for mechanical power, notably for water pumping, for centuries. During the past century it has also been used for electricity generation but only within the past twenty years has there been a serious interest in wind power to supplement grid-based power systems. Energy is usually extracted from the wind by means of propeller type turbines, although there are other technologies available. Wind energy technologies have developed rapidly, approaching US$9 billion in sales in 2003, when 8344 MW of new capacity were added. Although globally, capacity has grown by 26% per year for the past five years, wind still accounts for under 0.5% of total installed electricity generation capacity.[24] During the past two years, manufacturers have emphasised systems rated at 2-3 MW and higher (up to 5 MW), far too large for PICs. However, smaller commercial systems remain available

Past Pacific Experience

There have been small trials and demonstrations of wind power systems in most of the PICs, and several private users of wind power in several countries. Although a number of wind generators have been installed in the Pacific over the years, only a few very small privately owned or Telecom owned units have remained in service more than four or five years.

Potential

With rapidly increasing investment in grid connected wind power in Germany, Denmark, Spain, the Netherlands, USA, India and China – and recently in Australia and New Zealand – the interest in wind power development for the Pacific has also increased. The Pacific wind energy resource varies from virtually non-existent in most of the equatorial regions to moderately good in the higher latitude islands such as the northern islands of the Marshall Islands and those at higher latitudes of the south Pacific such as Niue, Cook Islands, Tonga and Fiji. In all cases, the Pacific wind resource tends to be seasonal and variable so the reliability of power from the wind is low and is not useable for base load generation, or even to reduce required generation capacity, only for supplementation of existing generation for fuel savings. If combined with expensive energy storage, wind can be used as a base load source but the cost of storage usually results in an overall system cost which is prohibitively high, except for some small scale, remote power generation requirements.

Because wind energy changes as the cubic power of the wind speed, accurate knowledge of wind speeds is critical. A site with 6 metres/second winds will have eight times the energy potential of a site with an average speed of 3 metres/second. Also, the wind resource is greatly affected by land contours and tree cover so it is vital that resource assessments be taken at actual prospective sites before designing the system or analysing the economics. Fortunately, meteorological and satellite data can be used to model landmasses to indicate likely locations for good quality wind energy sites, and this has been done in the Pacific. However, only a well-designed wind resource assessment focused on the specific sites will provide the actual resource availability. Since the winds are seasonal, a full year, and preferably two or more years, of data need to be collected and analysed to fully characterise a wind power site.

A particular problem for the atoll islands is the small land area available and the concentration of economically valuable coconut trees over most of that land. Wind power systems must be placed well above nearby treetops, both to avoid turbulence that can damage the turbines and to access the highest wind speeds available at the site. The tall stature of coconut trees implies a tower height in excess of 50 metres, a height that is difficult to achieve with the construction equipment available on atolls, especially

[24] This overview draws from the Review Issue: 2004-2005 of Renewable Energy World (volume 7, number 4, July/August 2004)

cranes to install the tower. Thus for atoll wind power systems, placement in the lagoon or on the reef well away from coconut trees may be the only recourse for economic development of wind energy. This approach increases the cost of attaching the tower (submarine cabling is expensive) and of maintenance. Therefore the atoll requires a good, well-researched wind resource before seriously considering wind power.

To date, wind resource assessments in the Pacific have been limited to a regional programme by the Forum Secretariat that carried out a preliminary assessment of the wind regime in the Cook Islands, Niue, Fiji, Tonga and Vanuatu in the 1990s and national assessment programmes such as those of the Fiji Department of Energy and the Fiji Electricity Authority. UNELCO in Vanuatu is assessing the Efate wind resource at one prospective site. Some preliminary assessments were done for the former Trust Territories of the Pacific and in PNG, both in the 1980s, mostly through analysis of meteorological records rather than the use of specific resource assessment instrumentation.

Without the addition of very expensive power storage banks, it is unlikely that wind can provide more than about 20% of the grid power anywhere in the Pacific and the energy will only serve to save fuel (or water in the case of connection to a hydro-dominated grid such as Viti Levu in Fiji). It will not offset capacity. Given the generally modest wind resource available in the Pacific, this means that the economics of wind power are very dependent on fuel prices and on proper siting of wind machines to obtain the maximum wind resource possible.

3.5 Solar

3.5.1 Solar Thermal

Technology Description

Solar energy falling on a black surface generates heat that can provide hot water for domestic, commercial and industrial use or hot air for agricultural drying and space heating. The technology has been used for centuries and is well developed both technically and commercially.

Typically temperatures up to 120°C are available from solar thermal devices though most systems operate best in the 50° to 70° range. Higher temperatures may be generated from devices that use focusing lenses or mirrors to concentrate the solar energy into a small, very hot area but they require mechanical systems to track the movement of the sun and only work when there is bright sunshine with no cloud cover. For the Pacific region, these concentrating type devices are not reliable and frequent cloud cover prevents consistent heat production.

Figure 3-5 – Local Manufacture of Solar Water Heaters in Tonga

Photograph: Peter Johnston, Nuku'alofa, 2003

Past Pacific Experience

The primary use of solar thermal systems in the Pacific is for water heating and for crop drying. Crop drying typically is very low tech – the produce is simply laid out in the sun to dry. Water is typically heated in commercial solar water heaters that use blackened metal plates to collect the energy and pipes behind the plates to transfer the energy to water, that is then stored in an insulated tank for later use. Domestic solar water heaters (SWH) have been manufactured in Tonga (Figure 3-5), Fiji and PNG and are widely imported from New Zealand and Australia as well. All PICs have used SWH to some extent for years although – except for Rarotonga in the Cook Islands, where they are widespread in private homes – most are in tourist facilities and commercial establishments, with low penetration into the domestic market.

Potential

The potential for installation is every house in the region plus all hospitals and tourist facilities. However, as there is little piped hot water in most PIC homes at present, there is little opportunity for significant reduction in petroleum fuel use.

3.5.2 Solar Photovoltaics

Technology Description

Solar photovoltaics (PV) directly converts solar energy to electricity, with approximately 15% of the solar energy falling on a PV panel, converted to direct current (DC) electricity. The most common use of PV is for remote power applications for telecommunications, water pumping and rural electrification using stand-alone solar home systems (SHS). PV panels can also provide grid power through the use of electronic converters that input DC and output alternating current (AC). For stand-alone electrification, battery storage is needed, except for some types of water pumping systems. For grid connected PV, a higher percentage of power input can be managed with batteries but due to the high cost of battery storage, most installations directly connect the PV panels to the grid through their inverters. The PV market globally has been expanding by 30-40% per year for the past seven years, due in part to government subsidies and other support from major manufacturing countries, particularly Japan and Germany.

Past Pacific Experience

Solar PV first was used for telecommunications power in the late 1970s and continues to be used throughout the Pacific for powering remote repeaters and island telephones. By the 1980s, the cost of solar panels had fallen to the point where lighting could be provided in remote homes at an acceptable cost. In the Cook Islands, largely through the efforts of the late Stuart Kingan and his staff, trials of small PV lighting were carried out from the late 1970s, through the 1980s and into the 1990s. The projects were small and essentially experimental but yielded valuable technical and social information for later projects.

Figure 3-6 – PV system operating since 1994, Fiji

Photograph: Herb Wade, Namara, Kadavu, 2004

The first village scale trials of solar PV began in Fiji in 1983 and by 1984 Tuvalu and Kiribati had established rural electrification programmes using solar PV as the power source. The TTPI also used solar PV for school and clinic electrification and carried out small-scale trials of village electrification with PV in the 1980s. Although the early trials had a very low long-term success rate, partly because of poor technical designs and partly because of inadequate provision for long term maintenance, by the 1990s technical designs had become reliable and institutional designs had evolved to better provide for the long term sustainability of PV based rural electrification. By 1995, Fiji (Figure 3-6), Tonga, Tuvalu and Kiribati each had their own style of PV based rural electrification incorporating over 1000 SHS altogether. PNG has several thousand SHS, mostly through private suppliers, and there may be several hundred in the Solomon Islands.

Potential

As with wind power, solar PV is unlikely to successfully provide more than 20% of peak power but unlike wind power, PV always has long periods without power every day so the energy provision is unlikely to be greater than about 5% of the energy provided through the grid. The primary potential for PV in PICs is for off-grid electrification to households requiring electricity to operate basic lighting and entertainment services.

3.6 Ocean

3.6.1 Ocean Thermal

Technology Description

Energy will flow between any two objects of different temperature. The greater the temperature differential, the higher the energy flow. In tropical oceans, the surface temperature is typically 15° to 20° warmer than the bottom so if a mass of bottom water could be brought to the surface, energy would flow from the warm surface water to the cold bottom water and that can be used to turn a turbine or other conversion device and produce electricity. Since the volume of ocean water is essentially infinite, the energy flow is continuous by pumping the hot and cold water continuously through the energy converter. Since the temperature difference does not vary much, more energy flows require increasing the mass of water moving through the converter system.

This is the operating principle of Ocean Thermal Energy Conversion (OTEC). Given the ability to continuously circulate both warm and cold water through the plant, continuous electricity generation is possible and the OTEC generator can be used for base load energy production.

OTEC power plants are rated according to either gross or net energy production. Gross energy is the total amount generated but because of the large power requirements for the huge pumps needed to move large quantities of sea water through the plant, much of the energy is used to operate the plant never becomes available to the grid.

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 commercialization 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 commercialized, proposed installations in independent island states must be implemented without any financial responsibility assumed by their governments.[25]

Past Pacific Experience

In 1981 and 1982, the Tokyo Electric Power Company (TEPCO) in association with Toshiba installed and began technical trials of a mini-OTEC facility at the west coast of Nauru near the Civic Centre in Aiwo. The gross continuous power rating was 100 kW with anticipated net output of around 15 kW. The design was of the closed cycle low-pressure turbine type using Freon 22 as the working fluid. Very expensive titanium heat exchangers were used to provide high efficiency heat exchange at the low temperatures used in the plant.

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

The Nauru installation was the first land based OTEC plant in the world to produce net power; it was the highest power OTEC plant ever operational and the first to feed power to an operating commercial grid. It was known that it would not be a cost effective power supply for Nauru when it was installed and the system was not intended as a permanent installation, only as a technical trial. It fed the Nauru grid for only 240

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

hours, a record for OTEC at the time. (A 50 kW Hawaii mini-OTEC built about the same time ran only 110 hours). The cost is not known but estimates exceed US$1 million, paid by TEPCO and Toshiba.

Potential

The potential is great for most countries of the Pacific. A steep drop off down to 700 metres or more and tropical latitudes provide the basic conditions needed for the most economical form of OTEC facility: one located on land. Probably the greatest developable potential can be found in the atoll islands since steep drop offs to great depths are common and because lagoon water temperatures tend to be several degrees warmer than the surface water temperature on the open ocean. The narrow landmass of many atolls would allow construction of an OTEC installation that draws cold water from the open ocean depths and warm water from the surface of the lagoon. This would provide a higher power potential for the same size installation as one that could only operate using the difference between the open ocean surface and deep water.

A 1 MW (gross) floating plant is being constructed in India for engineering trials but no OTEC plant has ever been built for commercial power production. New designs promise more net power output per gross kW rating, with theoretically as much as 70% of gross power production available to the grid.

Although there is considerable potential for large-scale continuous energy production from OTEC in some PICs, it is unlikely that electricity can be generated economically within the next decade or more.

The environmental effect of moving huge quantities of cold nutrient rich water from the sea bottom and dumping it on the surface is not known and must be determined before a multi-megawatt OTEC plant is installed in a PIC. This could be a serious issue.

3.6.2 Wave Energy

Technology Description

Ocean waves carry substantial energy in their movement. In the Pacific, wave energy is typically 10-30 kW/metre of wave front. However, no commercially practical wave energy conversion device has been developed and until that occurs, wave power for the PICs is not practical. In general, the resource increases with distance from the equator, so higher latitude PICs tend to have a greater wave energy resource. However, these countries also tend to experience more frequent typhoons/hurricanes/cyclones, which are a serious problem for wave conversion devices.

There are four prototype wave energy systems currently undergoing trials in Europe,[26] a 500 kW ‘Wavegen’ system in Scotland, a 20 kW ‘Wavedragon’ in Denmark, a 2000 kW Dutch ‘Archimedes wave swing’ in Portugal and 400 kW Pico Plant in the Azores. The Scottish and Azores system are based on an oscillating water column and exploit near-shore waves. The Danish system is an overtopping device (riding over the waves) and the Dutch prototype is an oscillating submerged buoy, both of which are designed for off-shore waves. Several 3-5 MW systems are currently in the feasibility study phase.

[26] See Renewable Energy World, July/August 2004.

Past Pacific Experience

SOPAC undertook a Norwegian funded wave measurement programme in the Cook Islands, Fiji and Tonga; but there has been no other wave energy experience in the Pacific.

Potential

Wave energy, like wind energy, is variable (although to a lesser extent) but the variations extend over hours rather than minutes. Wave energy can be considered a base load generation technology similar in character to a run-of-the-river hydro system using all the available river water. The available power changes slowly as the volume of river flow changes and the wave energy changes slowly as the sea conditions change. Nonetheless, calm seas provide no energy so there needs to be sufficient generation capacity additional to the wave energy system to provide power needed for the grid.

3.6.3 Tidal Energy

Technology Description

Tidal energy uses the same concept as hydropower: a volume of water flows through a turbine driven by a difference in height of the source and outlet. For most hydro installations, the power is largely provided by a large difference in inlet and outlet height (head) but in tidal flows, the height difference is usually only a few metres so the power is provided by large water flows through the turbine. To obtain a difference in water height, a large reservoir connected to the sea is dammed so that all the water going in and out during tidal changes must pass through a turbine. Tidal power cannot be a base load generator since the tides reverse twice a day and there are two times daily when the inlet and outlet heights are the same. Tidal power also changes with the tide level since power is proportional to the difference between the inlet and outlet height of the turbine. However, tidal power has the advantage of being highly predictable.

Despite technical differences, wave and small tidal energy systems are at a similar stage of development and face broadly similar challenges. Other than several large tidal barrage systems (which rely on a dam or channel built in the watercourse to increase depth or divert flow), such as the 240 MW La Rance system in France and a smaller system in Canada, only three tidal energy devices have been built and are currently being tested. These are in the 150-300 kW range in Scotland, Norway and England. The Scottish system uses an inflow plane device and the other two are underwater turbines, conceptually similar to wind turbines. Tidal energy systems suitable for PICs are unlikely to be commercially practical for some years and sites suitable for their installation uncommon.

Past Pacific Experience

There has been no tidal energy experience in the region.

Potential

In the PICs, the tidal range is small, usually less than two metres maximum, so a very large mass of water must pass through the generating turbine to generate useful power. Only in a few places are there opportunities to block off a large water area from the sea and force large volumes of tidal flows through a turbine. One such area is in Vava'u, Tonga and others may be some lagoons in the atoll islands. However, the required capital investment would be very large and there would have to be a careful environmental impact assessment, since there could be changes in marine life inside the enclosed bay area due to restricting its water interchange with the open sea.

3.7 Hybrids

Technology Description

Combining two or more types of generation technologies technically creates a hybrid system. This is common with large grid systems such as in Fiji where hydro, diesel and biomass electricity production feed into the same grid. In the context of this report, the term hybrid system means a generation scheme specifically designed to combine more than one type of generation technology in a single location.

Most common are hybrids of renewable and conventional energy such as diesel and solar generation or diesel and wind. Also of interest are combinations of several renewable energy technologies with generation characteristics that complement each other, notably micro hydro and solar.

Hybrid systems are inherently more complex than single source generation and as a result have been harder to keep operating reliably in the PIC context than systems using a single generation technology. Not only must operating and maintenance staff be familiar with two or more different generation technologies, but also the interface between the technologies (needed to combine their outputs into a single power stream) is complex. To date, no hybrid system using PV or wind power combined with diesel power has operated in the Pacific for even five years successfully. Elsewhere, such hybrid systems have suffered from ‘diesel creep’, where the diesel component provides an increasingly higher percentage over time of the total energy provided by the hybrid scheme, and progressively less is contributed by the renewable energy component(s), with the system ultimately becoming essentially a fully diesel operation.

Past Pacific Experience

The only installation in the Pacific designed specifically as a hybrid and intended for power generation is the Nabouwalu wind / PV / diesel system which is still operating (mainly as a diesel plant) and is described in the next chapter.

Potential

The potential for hybrid systems depends largely on the ability of the PICs to develop the technical competence necessary to simultaneously operate and maintain a system that involves the use of multiple generation technologies tied together by a complicated electronic interface. The potential appears to be low since these types of systems tend to be principally used for isolated grids in rural areas, and it is unlikely that the technical competence to operate and maintain them can be made available and retained over time in rural areas of the PICs.

4 RECENT EXPERIENCE WITH RENEWABLE ENERGY TECHNOLOGIES IN THE PACIFIC

This chapter covers recent or current experience with renewable energy technologies in the Pacific and notes plans for near-term development.

4.1 Biomass

4.1.1 Biomass combustion

As described earlier, biomass has been used for power generation in Fiji, PNG and Samoa. In Fiji the Fiji Sugar Corporation has a long history of generating electricity from bagasse and has plans for providing FEA with power from a new 25 MW bagasse/wood system on Viti Levu supplemented as necessary by imported coal. Tropik Woods in Fiji produces about 3 MW of power from wood waste and this is expected to expand. Throughout the Pacific, biomass continues to be used extensively for cooking (Figure 4.1) though there has been insufficient data collected in recent years to allow a good estimate of current usage.

4.1.2 Biomass gasification

There has apparently been no recent experience with biomass gasification in the region. Trials for large-scale use (3 MW) for electricity power generation are being considered in Samoa. Telesource, the American contractors who operate and maintain all of the Fiji Electricity Authority's (FEA) diesel systems, have been investigating possible gasification trials in some of FEA's older units. If such trials in Samoa or Fiji are successful, the potential for gasification technologies may shift from almost solely for process heat at industrial facilities to electricity production.

Figure 4-1 –Typical wood burning oven, Solomon Islands with PIREP national consultant and PIREP Coordinator

Photograph: Peter Johnston, Honiara, 2004

4.1.3 Biofuels

Presently, only Fiji and Vanuatu have significant activities that use biofuels in other than an experimental or demonstration context. In the Solomon Islands, coconut oil has begun to be used on a small scale for vehicle and electricity use but has not yet developed beyond a trial level. Several vehicles are being operated on coconut oil in the RMI as a demonstration. There is strong interest in further developing biofuels in many of the PICs to rejuvenate the ailing coconut industry, to increase the security of fuel supply and to lower the economic effect of price increases for petroleum products.

Vanuatu

On Efate, Motor Traders (MT) and Vanuatu Sea Transit (VAST) operate as small biofuel producers. Both have specialised in the production of coconut oil as a substitute for diesel fuel, either for use in power generation or transport. In the production process, coconut oil is cleaned and stripped of solids and free fatty acids and then filtered. The two processes differ in the quantity and type of additives that are blended. MT blends coconut oil with diesel. VAST includes an additive to the coconut oil but did not discuss its composition. For more than a year COPV tested different mixtures of coconut oil and kerosene or diesel in its Blackstone generator and in its trucks. Use in the generator has ceased (for unknown reasons) but the COPV boilers continue to be run on exclusively pure on coconut oil (Temakon, 2004). VAST plans to use coconut oil biofuel in a catamaran planned for ferrying copra from outer islands.

MT's owner Tony Deamer has experimented for many years using different coconut oil blends as fuel. He converted numerous rental cars to run on coconut oil, resulting in greatly increased local interest in its potential. Early in 2002, over 50 mini-buses were running on coconut oil blends and MT sold 2000 litres weekly. When VAST started selling a similar coconut oil based fuel, the number of mini-buses using it daily rose to 200. Another dozen or so vehicles ran on cold pressed coconut oil with very little or no diesel or kerosene added (PEN, 2002 and One Country, 2003). In general, there have not been serious technical difficulties in using coconut oil as a fuel in Vanuatu to replace distillate although there are differences of opinion on the need for blending with kerosene, diesel or other products for ease of starting in cooler weather or for smoother operations.

Fiji

Coconut oil has been used as an alternative to diesel fuel to operate diesel generators at SPC funded DoE pilot projects in two rural locations: i) an 80 kVA generator installed in May 2000 provides electricity for 198 households in three villages in Vanuabalavu, Lau; and ii) a 45 kVA generator installed in July 2001 electrifies 60 households in Welagi in Taveuni. Preliminary indications are that the technology is probably viable but there are difficulties with the local management required for operations as well as on site production of copra oil (as fuel).

Figure 4-2 –
Coconut Oil Production, Vanuatu

Photograph: John Vos, Port Vila, 2004

Figure 4-3 –
Tinytech Coconut Oil Expeller, Solomon Islands

Photograph: Peter Johnston, Honiara, 2004

4.1.4 Ethanol

In August 2003, an agreement was signed between the PNG government and a Korean company to develop cassava as a commercial crop. Initially, it is to be exported to Korea for ethanol production, with an ethanol distillery later planned at Kwilila, about 100 km from Port Moresby, assuming the economics are favourable. However, this may be used for edible products rather than fuel.

4.2 Hydro

On a world scale, nearly all the PIC hydro installations would be considered micro or mini schemes. All but the largest are "run-of-the-river" designs with no more than a few hours of water storage available. However, in terms of renewable energy, the hydro installations of the larger, mountainous PICs are major renewable energy sources and have the potential for providing a high percentage of the electricity supply for national utilities.

Figure 4-4 –2.5 kW microhydro system for sale in Papua New Guinea

Photograph: Peter Johnston, Port Moresby, 2004

There is also considerable development potential for village scale mini-grids using hydropower and a number have been constructed in PNG, Fiji, Vanuatu and the Solomon Islands. Unfortunately, village installations have not generally been reliable power sources due to the inability of the villages to access the technical support necessary. Problems have been primarily with the electrical components, particularly turbine speed controllers and alternators. Designs that have inadequately addressed flooding have also contributed to the problem.

Figure 4-5 – 200 watt household picohydro, Bougainville

Photograph: Andrew Mears

In addition to the past experiences of chapter 3:

- PNG Power has prepared a list of nine mini/small hydro projects to replace diesel systems for funding consideration by the World Bank. Five schemes in five provinces with a total capacity of 11.2 MW are planned for completion between 2004 and 2010. Numerous microhydro systems have been installed in PNG privately (Figure 4-4). About 30 community-owned self-built micro- and picohydro schemes (Figure 4-5) were built during and since the civil conflicts near Arawa in Bougainville, some operating for over six years.
- Additions to Fiji's hydro capacity have been completed or are underway in Viti Levu (6 MW Wainikasou scheme completed in 2004; 3 MW Vaturu scheme due for 2005 completion). Prefeasibility studies have been carried out for four microhydro projects with 220 kW of total capacity and FEA hopes to add an additional 40 MW or so of large system capacity by 2007 or 2008.
- The Solomon Islands Electricity Authority (SIEA) hopes to develop a baseload hydro scheme of about 7 MW at Komarindi on Guadalcanal. There has been renewed interest in a 20 MW scheme at Lunnga, also on Guadalcanal, in part to serve the needs of the Gold Ridge gold mine, if and when a decision is made to re-open it. SIEA is also considering four new small schemes with a total capacity of 720 kW. From 1997-1999, APACE has developed four microhydro projects ranging

from 12-50 kW in capacity. The Solomon Islands Village Electrification Council has surveyed at least 18 new sites for potential microhydro development.

- For Samoa, a third ADB-funded 2.0 MW turbine will be installed by late 2004, with reservoir capacity expanded by 50 percent. ADB has approved a loan for several MW of hydro in Savai'i. By mid 2004 the site and details were not yet finalised due to social concerns in the area.
- In Vanuatu, there have been plans to expand the Sarakata hydro project on Santo from 600 to 1200 kW if the Japanese government is willing to provide support. A JICA expert has recommended four sites for further study of micro-mini potential (Lowanau in Tanna, Mbe Tapren in Vanua Lava, Waterfall in Pentecost and Anivo in South Santo) where long-term water flow and rainfall monitoring and more detailed investigations are needed to confirm the hydro potential. A 75 kW project designed by APACE (Maewo Island, Penama Province, central Vanuatu) would provide electricity to 361 houses in several villages and a school and may be implemented with government support in 2005.

Table 4-1 summarises the hydro installations in the Pacific.

Table 4-1 – Overview of PIC Functioning Hydroelectric Capacity (2003)

Country	Utility Based:		Micro / mini:		Comments
	MW	GWh / yr (ave)	No.	KW (total)	
Cook Islands	None	n/a	None	n/a	Very small run-of-river resource on Rarotonga
Fed States of Micronesia	~ 2	0 in 2003 design: 4	1	~ 25	Nanpil (Pohnpei) damaged by floods; Kosrae microhydro late 1980s never commissioned
Fiji Islands	~ 86	~ 450	8	985	Monasavu (1983: 80 MW); Wainikasau (2004: 6 MW)
Kiribati	None	n/a	n/a	n/a	No hydro resource
Marshall Isl	None	n/a	n/a	n/a	No hydro resource
Nauru	None	n/a	n/a	n/a	No hydro resource
Niue	None	n/a	n/a	n/a	No hydro resource
Palau	None	n/a	n/a	n/a	No hydro resource
PNG	~ 220	> 600	~ 50	?	Perhaps 25% of 200+ pico/micro/mini systems working
Samoa	12	~43	None	n/a	~ 4 MW dry season capacity
Solomon Isl	0.2	?	2 ?	~ 40	Apparently only two of seven microhydro functioning mid 2004
Tokelau	None	n/a	n/a	n/a	No hydro resource
Tonga	None	n/a	n/a	n/a	No hydro resource
Tuvalu	None	n/a	n/a	n/a	No hydro resource
Vanuatu	0.6	4.5	None?	n/a	Sarakat constructed in 1995 on Santo island

Source: National PIREP reports (2004) Note: n/a is 'not applicable' ~ is 'approximately' ? is unknown

4.3 Geothermal

Figure 4-6 – 6 MW Geothermal Plant, Lihir, PNG

Source: PNG Chamber of Mines and Petroleum

Only PNG has an operating geothermal facility. In early 2003, Lihir Gold Ltd. commissioned a 6 MW geothermal plant on Lihir Island (see Figure 4-6) and an additional 20-30 MW of capacity is expected to be completed during 2004. The site has a natural steam source and serves not only to generate electricity but also to help control conditions in the mine by diverting the naturally occurring steam away from mining areas. PNG Power is considering exploring the geothermal potential in both East and West New Britain.

In 1999, the Vanuatu government signed a joint venture agreement providing exclusive rights to a geothermal concession on Efate Island. A feasibility study has recommended construction of a 3 MW geothermal plant, followed by subsequent units (tentatively 1 MW each) as demand increases. Partly through GEF support, a power purchase agreement (PPA) was negotiated in 2001 between the development partners and the power utility (UNELCO) but negotiations have been halted since 2002, as the parties cannot agree on a mutually acceptable power purchase price. The investment of US$10-15 million may also be high risk as there has been no deep drilling to substantiate the magnitude of the resource.

In 2004, the Fiji Electricity Authority requested expressions of interest from companies interested in developing the geothermal resource on Fiji's second largest island, Vanua Levu and also hopes to develop one or more geothermal sites on the main island of Viti Levu, each of roughly 5 MW capacity. As in Vanuatu, drilling is necessary to quantify the resource. The economics are uncertain.

4.4 Wind

Figure 4-7 - Wind energy, Mangaia, Cook Islands

Photograph: Tangi Teriapi November 2003

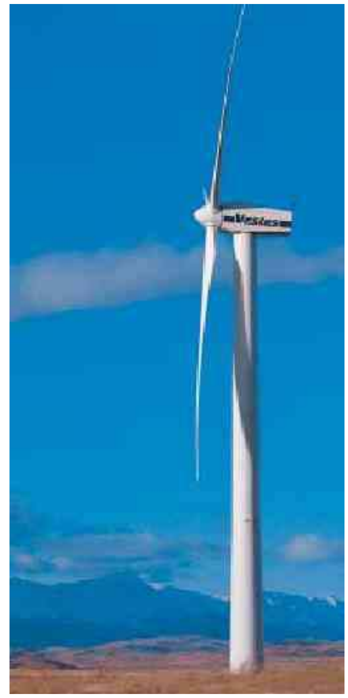
Currently, three wind installations are generating electricity to a grid, one in Mangaia, the Cook Islands (Figure 4-7), one in Fiji at Nabouwalu in Vanua Levu and a small training installation at SOPAC in Suva. The Mangaia installation includes two 20 kW Vergnet (French) turbines funded by the PREFACE project (French/Australian funding) that feed into a small grid. Fiji's Nabouwalu installation combines wind, PV and diesel generation, and is discussed in section 4.6 on hybrid systems. A 20 kW Vergnet wind turbine has been installed at SOPAC for training and demonstration purposes, with energy fed into the grid, but no operational data are yet available.

In PNG, small 0.5 kW Chinese wind systems are being tested by the Department of Petroleum and Energy (Figure 4-8). As most of these are components of small hybrid systems, they are discussed in the next section.

Figure 4-8 – Nat. Consultant, John Wilmot with 0.5 kW Chinese Wind System, PNG

Photo: Peter Johnston, Waigani, 2004

Figure 4-9 – 660 kW Vestas Wind Turbine



Source: www.vestas.com

The Nabouwalu (1998), Mangaia (2002) and SOPAC (2004) systems have not been used long enough to conclude if they are successful or suitable for economic replication. The Nabouwalu turbines have had maintenance problems with some turbines out of service for extended periods awaiting repair. Both electrical and mechanical problems have occurred, although electrical problems seem to be the primary cause of turbine outages. At Mangaia, the turbines have not been completely commissioned. Although they have been feeding power to the grid for several months, the units are not yet considered fully operational and some technical problems remain.

In late 2004, Fiji's FEA signed an IPP agreement with a private company, Pacific Free Energy Limited, to supply 180 kW of electricity from wind into the grid. The expected completion date is not known. FEA is also intends to install about 6 MW of wind turbine capacity at Butoni near Sigatoka on Viti Levu's south coast, with possible subsequent wind farms feeding each of the three island grids it serves. The initial systems may be Danish Vestas turbines (Figure 4-9), for which FEA's joint venture partners Pacific Hydro have the Australian distributorship, or possibly smaller Vegnet systems. The unit illustrated, which is probably considerably larger than FEA will install, has a rotor diameter of 47 m, about half a football field in length, and requires a tower height of at least 40 metres.

In the Cook Islands, a feasibility study in 1997-1998 by COWI/Risoe National Laboratory of Denmark located three sites on Rarotonga at which they estimate an average wind resource of 7 m/s or more. They proposed a 300 kW wind turbine at one of the sites to be financed by Denmark (the turbine) and the government (installation). The cost estimate was about NZ$1 million and no further action has been taken.

Table 4-2 summarises the wind installations and status of monitoring in the Pacific.

Table 4-2 – Overview of PIC Installed and Planned Wind Electric Capacity (2003)

Country	KW installed	KW planned	Wind Monitoring and Comments
Cook Islands	40	None currently	PIFS; One 20 kW damaged in early 2004. Vernet (1999) est. 9 m/s at 30 m at Ngatangila Pt; other studies suggest 6-7.5 m/s elsewhere Rarotonga.
Fed States Micro.	None	None	Small systems installed by US$. In 1980s?
Fiji	54	~ 6,000	Eight Bergeys at PWD Nabouwalu but few now functioning. Nabouwalu Excludes 20 kW SOPAC. Monitoring by DoE & FEA at several sites.
Kiribati	None	None	NOAA may have long-term data suggesting ave 6.0 m/s at Kiritimati
Marshall Isl	None	None	Brief trials of small system in Majuro by USDOI in 1980s
Nauru	None	None	No known wind energy measurements
Niue	None	None	No experience with wind electric systems
Palau	None	None	Inadequate Met station data suggest low resource of ~ 2.5 m/s
PNG	> 25	?	50 x 0.5 kW systems being installed. PNG Power may consider wind farm at Moresby mountain ridge, possibly PNG's best resource but no monitoring yet done. 1970s CSIRO studies suggest good resource.
Samoa	None	None	Apparently trials of small systems in 1980s
Solomon Islands	None	None	Apparently no wind energy assessments
Tokelau	None	None	Possible study for Atafu some years ago. No details available
Tonga	None	None	PIFS results show modest resource which could be viable for Ha'apai and Vava'u considering high diesel costs.
Tuvalu	None	None	Met data suggest seasonal, highly irregular winds below 5-6 m/s
Vanuatu	None	None	PIFS measurements on Efate suggest winds below 6 m/s. UNELCO monitoring north of Port Vila. Prelimi results (4.2 m/s) disappointing

Source: National PIREP reports (2004) Note: n/a is 'not applicable' ~ = 'approximately' ? = unknown
Note: PIFS = participated in Forum's Southern Pacific Wind and Solar Monitoring Project in early 1990s

4.4.1 Solar Thermal

Solar water heaters for domestic, commercial and industrial use are commercially available in the PICs. Tonga, Fiji and PNG have small manufacturers of solar water heaters and large numbers have also been imported from Australia, notably the Solar Edwards and the Solahart brands. The most common use for solar water heaters is to provide piped hot water for hotels and guest houses. A few countries, notably the Cook Islands, have many domestic installations as well but since piped hot water has not been a common component of housing in the Pacific, solar water heating has not had a strong market in most of the PICs.

Large scale solar thermal power systems have been installed in desert environments of North America and the middle-east that produce electrical energy at a cost substantially lower than solar PV. Unfortunately, in the PICs the resource is not technically suitable for reliable power generation from solar thermal systems. Achieving the high temperatures needed by solar thermal power generation requires the concentration of solar energy using mirrors or lenses plus tracking of the sun as it moves across the sky. Therefore, reliable power is dependent on having essentially clear skies for a high percentage of the time. Any cloud passing in front of the sun turns off the heating source completely since the concentration of solar energy requires a clear view of the sun's disc. Solar PV systems continue to provide reduced power even in cloudy conditions. Since partly cloudy conditions dominate the weather patterns in the PICs, the resulting frequent total interruptions in power generation makes the energy from solar thermal power generators more costly per kWh produced than an array of PV panels with similar rated capacity. FEA in Fiji is considering a trial of a small solar thermal electricity system in 2005 or 2006.

4.4.2 Solar Photovoltaics

From 1995 to the present, the growth in number of installed systems has been rapid and by 2006 several thousand homes in the PICs will have been electrified using solar PV. Kiribati (Figure 4-10), RMI and Fiji have long range plans for further large-scale expansion of SHS for rural electrification, which could result in over 20,000 more installations over the next 10 years. The largest potential market for SHS is in those countries with large numbers of un-electrified households, notably PNG, Solomons and Vanuatu. To develop that market, there will need to be the development of culturally appropriate institutional models to provide for maintenance, the development of financing mechanisms that permit rural households to have access to systems, risk abatement mechanisms to lower the risk both to households for getting proper service and for service providers to be able to recover their costs.

Figure 4-10– School Solar Pump: Kiribati

Photograph: Herb Wade, North Tarawa, 2004

Development of solar PV for rural electrification in French Polynesia paralleled that in the PICs with nearly 4000 SHS installed in the 1980s. Many of those PV systems have been replaced by the grid since then but there still are over 1000 SHS installations operational and new installations are continuing to be made. The main difference between the French Polynesia and PIC programmes has been the size of the individual installations. In French Polynesia, system size is determined by the needs of the customer, not the needs of the project. Typically no less than 200 Wp of panel is installed and over 1 kWp with an inverter is relatively common. This allows the use of major appliances such as a refrigerator or colour TV and brings electrification to a level comparable with urban use.

In most of the PICs, village water supply and small scale water pumping for schools, clinics and houses has been a useful application of photovoltaics. Success has been variable but well designed systems using simple technology have operated successfully for decades and clearly have been cost effective. More complex installations, notably those using positive displacement pumps with associated electronic controls, have had lower reliability and a higher maintenance requirement but, if maintenance is properly carried out and pumps used that have had good prior Pacific experience, those installations can also provide good economic value.

There have been trials of “focal point” electrification using solar PV, that is, electrification of community facilities only, without extending electrification to homes. That has not been widely accepted and maintenance of the systems has generally been poor since it has proven difficult to get communities to accept the financial responsibility for battery replacement and other repairs and to have sufficient technical capacity for general preventive maintenance and service of the systems.

Figure 4-11 - Failed batteries at Namukulu village, Niue: still good for recycling after 10 years of storage

Photograph: Herb Wade, 2003

Most of the PICs have at one time or another been the recipient of a programme for the electrification of health clinics, usually with the inclusion of a vaccine storage refrigerator, power for lights and for a communications radio. Abuse of the systems, poor maintenance and lack of a financial commitment by the agencies responsible have caused the systems to provide unreliable service and to typically have a short life. Some PICs have, over a 20-year period, received donor assistance to electrify the same clinics as many as three times because earlier systems were not maintained and had failed. An exception has been Kiribati where the Department of Health has contracts with the Solar Energy Company for maintenance and has made the necessary financial commitment to maintenance and repair.

Figure 4-12 – 2002 PV Installation, Marshall Islands

Photograph: Marion Ferguson

Figure 4-13 – Solar PV Panel, Namukulu Community Hall, Niue

Photograph: Herb Wade, 2003 Note corrosion and delamination of the lower panels

Table 4-3 Estimated renewable energy capacity available to offset conventional energy used for electricity generation (2003)

Country	Solar (SWH in estimated electricity capacity offset; PV in Wp)				Biomass			Hydro kWe	Wind kWr	Geothermal kWe	Total
	SWH kWe	SHS (kWp)	Community kWp	Comm. kWp	Agriculture kWe	Forestry kWe	Biofuel kWe				
Cook Is.	2,000	50.7		49.1					40		2,140
Fiji	3,000	33.1	8	70	11000	3000	125	90,185	75		107,496
FSM	750	41.9	7.8	n/a				2060			2,860
Kiribati	50	49*	34	10							143
Nauru	15										15
Niue	20		2								22
Palau	500	20	9								529
PNG	15,000	525	380	200	n/a	n/a		222,000	n/a	6,000	238,105
RMI	75	21	38	2.5							137
Samoa	150							11,060			11,210
Solomon Is.	150	9	1	25				455			640
Tokelau	10			21.5							31.5
Tonga	1,000	83.5		20							1,104
Tuvalu	75	2.5	5.6	32							115
Vanuatu	225	26.5	36.5	30			N/a	600			918
Totals	20,020	862	522	460	11,000	3,000	125	265,120			365,349

*When the existing EU project is completed in 2005, total PV capacity will rise to about 200 kWp of installed PV capacity

Notes: SWH capacity is based on assumed numbers of SWH installations each offsetting 1,500 W of electricity capacity; Comm. = communications; only Biomass for electricity generation is included; kWr = rated capacity of wind machine; n/a = probably substantial use but data was not available.

4.5 Ocean

4.5.1 Ocean Thermal

There has been no OTEC experience in the PICs since the 1981 Nauru project. However, discussions were held several years ago between the Cook Islands government and staff of Saga University of Japan regarding the possibility of developing an OTEC system for the Cooks using the proprietary Uehara Cycle for the technical design. In 2003, a Japanese company, Xenesys (holder of the Uehara patent rights) approached the government offering to obtain funding from Japan for a feasibility study. In May 2003, Cabinet supported the concept, agreeing that Xenesys could develop a feasibility proposal and seek its funding. The plan is reportedly for one 3 MW Uehara OTEC plant for Aitutaki and two 3 MW plants for Rarotonga. No further progress has been reported. Palau is also considering a 3 MW Xenesys OTEC plant. Before any PIC government makes any commitments, there should be careful evaluations of any prior Uehara Cycle OTEC installations and the specific plans for PIC installations. These should be undertaken by an independent organisation competent in OTEC engineering. Environmental impacts should be assessed. The Pacific should not become an engineering trial site for an unproven OTEC technology.

Commercially practical OTEC systems are not expected to be available for a decade or more and PICs are cautioned not to invest significant time or money on OTEC development as any installations in the near term will be experimental in nature. Any OTEC development in the PICs over the next five or more years should include all capital investment by the proposing organisation. Operation and maintenance should also be paid for by the proposing organisation, with any payment from the recipient PIC only for the actual energy generated.

4.5.2 Wave and Tidal Energy

SOPAC undertook a Norwegian funded wave measurement programme in the Cook Islands, Fiji and Tonga; but there has been no PIC experience with wave or tidal energy.

4.6 Hybrids

Fiji. Fiji has installed several hybrid generation systems. Fiji Telecom installed a wind/diesel hybrid at a site on Viti Levu and has used small wind/PV hybrid systems for charging backup batteries at several remote sites. The Viti Levu wind/diesel hybrid has been dismantled but the battery charging systems have been satisfactory and some continue in use.

Figure 4-14 – Wind / PV / Diesel Hybrid, Nabouwalu, Fiji

Photograph: Jens Merten, 2002

The only installation in the region designed specifically as a hybrid and intended for grid-linked generation of electricity is the Nabouwalu wind/PV/diesel installation (Figure 4-14). It includes eight 6.7 kW rated wind turbines made by Bergey (USA), 37.44 kW of solar PV and 200 kVa of diesel generation. The system includes battery storage for the PV to eliminate the rapid power fluctuation from the PV panel in partly cloudy conditions and to help serve the peak demand time, which is in the evening after sun set.

Designed energy delivery is 720 kWh/day, around 60% of the total from renewable sources. However, over five years, energy from renewables fell from 60% to less than 15% due to technical problems, the complexities of the system and the lack of training and/or qualified staff to replace those originally trained under the project. The system is now operated essentially as a diesel plant but in late 2004 a GEF-funded team is expected to assess the practicality of rehabilitation.

PNG. In PNG, a hybrid wind-solar energy system of unknown size has reportedly (UNESCO website) provided power to a highlands school but no details were available. In June 2002, China donated 50 sets wind generators (see Figure 4-8) coupled with PV panels, to the PNG government. The hybrids were reportedly valued at US$236,000 though that appears to be very expensive. Each system includes a 500 watt wind turbine and two 50 Wp solar PV panels with installation underway in provincial centres at coastal locations. The first six hybrid systems were installed in East New Britain in 2002. Chinese experts provided training in installation and maintenance. Further units have been installed in rural districts in Central Province at Bereina Health Centre in the Kairuku/Hiri District and at Kapari in the Rigo District. Installation costs were kina 4500 (about US$1400) per system. The long-term viability of these hybrid systems is doubtful, as they have been provided to users for free and for which reportedly no operational or maintenance mechanism has been put into place. The electronics in several of the hybrid systems reportedly failed shortly after installation.

In the broad sense, the power grids of PNG, Vanuatu, Solomon Islands, FSM, Samoa and Fiji are hybrids with components of both conventional (diesel) and renewable (hydro and biomass). Those hybrids have worked well since each of the individual technologies has a large enough scale installation to warrant specialist technical staff and the training necessary for competent operation and maintenance. In the case of a "packaged" hybrid such as in Nabouwalu where the entire system is small and the renewable energy and conventional energy generation must be operated and maintained simultaneously by a small staff at a remote site, it is much more difficult to make available the skills needed to operate and maintain several generation technologies simultaneously and the relatively complex interface that ties their generation together. If hybrid systems are to be practical for remote sites, simpler designs will need to be developed to better fit the capabilities of remote site operators and maintenance personnel.

5 Energy Conservation and Efficiency

5.1 Introduction to Energy Conservation and Efficiency

The terms energy conservation, demand side management, demand management and energy conservation and are often used loosely. Before discussing opportunities for more efficient use of energy, and its relationship to renewable energy in the PICs, these terms need to be explained.

- Energy conservation simply refers to steps that can be taken to reduce energy consumption. This can include encouraging people to invest in capital improvements (e.g. more energy-efficient appliances) or changing energy consumption behaviour (e.g. adjusting thermostats in air-conditioned offices, changing from electric to LPG cooking). The value of these efforts can be measured by kWh of electricity or litres of fuel saved in the past or the savings potential for the future.
- Demand Side Management (DSM) refers to the planning, implementation, and monitoring of activities, often by a power utility, designed to influence a customer's use of electricity in ways that will produce desired changes in the utility's load shape (i.e. change in the time pattern and magnitude of a utility's load in kW). Utility DSM programmes can include load management, load reduction, time shifting of loads from peak demand to low demand periods, energy conservation and innovative rates that affect demand. DSM includes only deliberate interventions to alter the load shape producing benefits to both the utility and its customers.
- An energy efficiency programme is typically a DSM programme aimed at reducing kWh, but often without regard for the time during the day of the savings. Such savings are generally achieved by substituting more efficient equipment to produce the same level of end-use services with less electricity. In the case of transport, an energy efficiency programme is generally meant to reduce fuel use per vehicle and could involve more efficient vehicles, activities which improve the flow of traffic or increase the number of persons per vehicle.
- Load management refers to the reduction of electric energy demand (kW or MW) during a utility's peak generating periods. Load management differs from conservation in that load management strategies are designed to either reduce or shift demand from peak to off-peak periods, while conservation strategies may primarily reduce consumption (kWh) over a period of time. For a utility, load management can reduce capital expenditure, circumvent capacity limitations, provide for more economic energy dispatch, reduce the cost of service, or improve system efficiency or reliability.
- Supply side efficiency management (SSM) efforts are intended to increase the kWh delivered and billed to consumers per unit of fuel used. Utilities can reduce the fuel used per kWh delivered to consumers by investments that reduce losses during generation, transmission and distribution of electricity.
- An energy audit is a review of a facility's energy usage, generally including recommendations to reduce energy usage and often indicating the cost of doing so.

Most of the easier short-term opportunities in the PICs involve DSM to improve the efficiency of electricity end-use and efforts to improve the efficiency of ground transport fuel use. In some power utilities, there are also significant opportunities for improved SSM. In this chapter, any of these are referred to as energy efficiency efforts.

5.2 The Importance of Energy Efficiency in PICs

The PIREP national studies have concentrated predominantly on opportunities for PICs to reduce barriers to the development, use and commercialisation of renewable energy technologies. In chapter 2 of this overview, it was concluded (Table 2-14) that though regional benefits would be largest from renewable energy implementation because of the large opportunities for renewable energy in PNG, the Solomon Islands, Vanuatu and Fiji – the countries that represent most of the land and population of the region – nearly half of the participating countries could achieve about a third or more of their potential GHG reductions (i.e. annual reductions by about 2013 relative to a business-as-usual approach in which barriers were not removed) from improvements in energy efficiency and some, like Nauru, could benefit far more from energy efficiency measures than from available renewable energy resources. Table 5-1 lists opportunities for efficiency improvements.

Table 5-1 – GHG Emissions and Potential Savings from Energy Efficiency

Country	Projected baseline emissions in 10 years, BAU		Total Potential Annual GHG Savings		Savings from Energy Efficiency	
	Gg	Year	Gg	% of baseline	Gg	% of total savings
Cook Islands	42.9	2013	13.1	31%	2.1	16%
Fiji	1487	2010	504	52%	37	7%
FSM	184	2012	23.9	17%	7.1	30%
Kiribati	72.2	2013	26.5	37%	2.0	8%
Marshall Is.	400	2013	22.3	6%	14.3	64%
Nauru	46.9	2013	16.6	35%	13.8	83%
Niue	8.7	2012	1.08	12%	0.44	41%
Palau	441	2013	49	11%	37	76%
PNG	2423	2011	1013	42%	3	< 1%
Samoa	357.3	2013	96.1	27%	12.2	13%
Solomon Islands	313	2012	121	39%	12.2	10%
Tokelau	1.3	2013	0.22	17%	0.07	32%
Tonga	121	2010	31.6	26%	3.3	10%
Tuvalu	14.0	2013	2.2	16%	1.4	64%
Vanuatu	155.7	2013	96	60%	1	1%

Note: RE = renewable energy and EE = energy efficiency BAU = Business-as-usual

Estimated savings potential are only indicative. However, there are several reasons to believe that the percentage savings from energy efficiency in Table 5-1 are underestimated relative to potential renewable energy savings:

- because PIREP has focussed overwhelmingly on renewable energy, and energy efficiency is largely outside the project's scope, there was only a modest effort to consider efficiency during national assessments, and this was restricted to ground transport and electricity end-use measures that can be applied almost immediately;

- the opportunities considered in national assessments for renewable energy are those that appear to be technically viable but are upper estimates, not limited to those which are likely to be practical;
- efficiency opportunities were assessed after the renewable energy technologies were assumed to be in place. Many of the efficiency improvements would thus save both fuel and money, but not result in further GHG emission reductions, as these would already have been achieved as a result of the RET investment. It was assumed that any efficiency improvement that "displaced" a renewable energy source would be GHG-neutral.[27] If efficiency opportunities had been assessed before considering new generation from renewable energy, the GHG savings from improved efficiency would have been considerably higher in every country but particularly in Fiji and PNG; and
- There are numerous opportunities for immediate significant cost-effective energy efficiency investments in the region. Although efficiency programmes are skill intensive, it is usually considerably less expensive to save energy through DSM or SSM efforts than to expand energy output, whether through conventional or renewable technologies.

Where energy use is inefficient, it does not make economic sense to invest in expensive new sources of energy without also including concurrent programmes to improve the efficiency of energy use. It appears (Table 5-1) that there are six or seven PICs for which any programme of significant renewable energy expansion should only be considered in conjunction with a simultaneous effort at improved efficiency of energy use.

5.3 Past Energy Efficiency Efforts in the Region

In every PIC there have been efforts to improve energy efficiency through energy audits and subsequent investments. These have included government and commercial buildings (often very wasteful of electricity), hospital boilers (to reduce fuel use), water pumping stations (electricity use reductions), businesses, factories, and transport. From the 1980s to the present, there have been hundreds of audits carried out through numerous donor-funded efforts including: i) an Australian-funded CHOGRM energy programme for Commonwealth island countries in the 1980s, ii) US Department of Energy and Department of Interior efforts for the (then) TTPI in the 1980s, iii) the UNDP's Pacific Energy Development Programme (PEDP), iv) the Lomé II Pacific Regional Energy Programme and increased energy efficiency efforts under Lomé III (both with EU support), and v) more recently SOPAC (with UN and other support). In at least Fiji and PNG, government energy departments have also arranged energy audits since the early 1980s and in a few cases, such as FEA in recent years, utilities have carried out customer audits as well.

Although there are dozens of reports on individual audits suggesting substantial energy savings for modest investments, there is no overview of results indicating the actual impacts and the value of investments made as a result of audits. Many tourist complexes have carried out and partly implemented audits but results are not generally available.

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[27] In fact, an efficiency investment which saves a kWh of generation or a litre of fuel will generally have a more positive impact than an equivalent investment in renewable energy as RE systems are not truly zero emission technologies.

As long ago as 1985, five PIC utilities participated in an ADB seminar on power efficiency and load management, reporting on some ongoing efforts. The Pacific Power Association (PPA) has had a SSM programme to improve supply side efficiency of its utilities for several years but results are only available to members.

The PIREP consultants are only aware of two past Pacific studies that looked at energy efficiency opportunities at a regional level, and these are not recent.

5.3.1 1993-96 UNDP/Forum/PPA DSM Study in ten PICs

In the mid 1990s, a PIFS effort, funded by UNDP and working closely with PPA, assessed the DSM potential within ten PIC power utilities. Results (Table 5-2) suggested typical overall demand savings (kW peak) of 17% with a range of 8-28% and typical energy savings (kWh) of 17% with a range of 6-27%, even though not all options were investigated. The assumed benefits were confined to reduced energy consumption and deferred capital expenditure. Therefore the analysis excluded other possible benefits such as reduced GHG emissions and any indirect gains to the economy.

Table 5-2 – Forum/PPA DSM DSM programme: potential results from 1994-2013

Measure of programme effectiveness	Fiji	PNG	Sol Isl	Samoa	Cook Isl	Marsh Isl	Tonga	Palau	Kiribati	Tuvalu
1) DSM savings										
Demand (% of installed MW)	8	13	16	10	19	24	28	13	25	17
Energy (% of MWh generated)	6	13	13	13	16	22	27	16	18	13
2) Cost effectiveness (1994 m):										
Currencies used	F$	Kina	SI$	Tala	NZ$	US$	T$	US$	A$	A$
NPV (utility perspective)	-12.9	-18.7	-12.5	-0.2	-4.8	-1.4	-3.8	1.0	-0.8	-0.3
NPV (TRC perspective)	26.5	33.1	24.4	24.0	4.1	10.3	8.6	9.5	1.5	0.4
3) Life cycle costs (levelled)										
Rate impact (respective currencies ¢/kWh)[c]	0.35	0.51	0.96	0.03	1.68	0.11	0.34	-0.08	1.67	1.62
TRC (respective currencies ¢/kWh)[d]	5.35	4.00	10.0 8	9.03	5.84	2.75	4.35	3.45	2.60	5.04

Source: Conway & Johnston, 1995 (based on work of Felix Gooneratne of Forum Secretariat

Notes: NPV = net present value. Discount rates were 10% for the utility and consumer; six percent for total resource costs and savings (TRC) to the utility and participants.
Levelled life cycle costs = average cost of programme per kWh saved;
Rate impact = one-time change in customer tariff (¢/kWh) for the utility to recover the full cost of DSM programme.

One of the barriers to implementation was that net benefits overall were significant but the value to the utilities was negative, so mechanisms needed to be developed so they could share in savings. Although there were some follow-up activities, the PIREP team found no reports of the actual subsequent results. For the individual national PIREP reports, more modest savings were assumed, as actual benefits are often less than expected and costs more than expected.

5.3.2 Energy Conservation for Ground Transport in the PICs

About a decade ago, the East-West Center commissioned an overview of opportunities for energy conservation within ground transport for the region (Johnston, 1993). PREA data indicated that in the early 1990s, transport typically accounted for half of petroleum fuel use in PICs. For seven of the twelve countries covered, transport accounted for over 70% of petroleum fuel, and thus was an appropriate target for energy conservation efforts. Typically, fuel for road travel was 64% of total transport fuel use, sea 28% and air 7%. Within ground transport, fuel efficiency for cars, buses, and trucks depends upon a number of factors including road conditions, maintenance standards, vehicle age, vehicle size, engine size, driving patterns, type of fuel used, fuel cost, and others. Tests in 1992, for example, indicated that gravel roads typically impose a 22% fuel penalty compared to good-quality sealed asphalt roads. Studies in Asia showed that a well-designed traffic signal network can reduce vehicle energy consumption by 9-17%, depending upon vehicle type and the time of day. Improved traffic management schemes and better bus services could yield even higher savings, sometimes at fairly low costs. Tests in Japan, Australia and the US showed that the most efficient cars typically used one-third less fuel than the least efficient models of comparable size, and this was before the widespread use of fuel-hungry sports utility vehicles. In Japan, driver training reportedly improved fuel efficiency by 20% without reducing average speed. As vehicles age, poor maintenance will increase fuel use considerably. Even simple maintenance can make a big difference: a very dirty air filter can increase fuel use by 20% and under-inflated tires by 10 percent. Diesel fuelled cars offer considerably higher fuel efficiency: tests in Australia and Japan indicated about 30-40% better efficiency for new diesel cars of the same engine size as petrol-fuelled cars.

Although there are apparently no recent studies of transport energy efficiency options in the region, this earlier report suggests that the assumed potential savings for the PIREP national reports, 5-10% reduction of transport fuel use in 10 -years compared to a business-as-usual approach, is reasonable.

5.4 Current Energy Efficiency Efforts in the Region

The PIREP Team is aware of a few activities currently underway or proposed at the regional level to improve energy efficiency, and these involve only several countries.

- The Asian development Bank's Renewable Energy and Energy Efficiency Project (REEP) is assessing opportunities for at least one renewable energy investment project and one energy efficiency project each for Fiji and Samoa. The efficiency project will emphasise institutional and capacity development.
- SOPAC, with support from the United Nations Department of Social and Economic Affairs (UNDESA) is undertaking a programme of energy audits and training with the governments and power utilities of Fiji and Samoa.
- SOPAC has approached the GEF in 2004 for regional project support for "Promotion of Environmentally Sustainable Transportation in the Pacific Islands" initially covering Fiji, Samoa and Vanuatu.
- A PPA SSM programme continues with its member utilities but no details are available.

The Australian economy is far bigger and more complex than those of any PIC but nevertheless recent analyses there[28] suggest the magnitudes of energy efficiency savings that may be practical. Detailed analyses of energy use in the commercial sector and government, mostly electricity consumption, considered potential savings

[28] See Australian government, 2003; EMET, 2004;

from all improvements which (when combined would achieve a payback of under four years). This is shown in Table 5-3 as 'raw' savings. However, many efficiency improvements would take place even without any government initiatives to remove barriers. The raw savings were reduced to account for trends already underway, resulting in the net savings of the table. Excluding communications services, net savings were in the range of 20-26% compared to a business-as-usual approach and average payback was about a year or less (i.e. it would take a year for benefits to equal the amount invested). It is likely that cost-effective net savings of 20% or considerably higher are potentially achievable in at least half of the PICs.

Table 5-3 – Annual Potential Savings by Government and Commercial Sector

Subsector	Savings (%)		Average Payback (years)
	Raw	Net	
Wholesale and retail sales	36%	26%	0.92
Accommodation, cafes and restaurants	37%	25%	1.19
Communication services	22%	14%	1.05
Finance, insurance and business services	30%	20%	1.04
Government administration, education and health	30%	18%	0.64
Culture, recreation and personal services	36%	22%	1.01

Source: Energy Efficiency Improvements in the Commercial Sub-sector (EMET Consultants Ltd for Sustainable Energy Authority of Victoria; Australia; 2004)

The actual savings achieved by non-transport energy efficiency programmes tend to be considerably less than potential savings. At the national level, the Australian government has estimated that an achievable programme (50% penetration over 12 years of practical measures currently available with four year payback) could reduce net energy use and GHG emissions by about 10% while increasing both GDP and employment. For the national PIREP reports, 10% was generally the potential savings assumed. The PIREP team has not seen similar recent studies for achievable savings in the transport sector.

5.5 Barriers to Energy Efficiency in the Pacific

Barriers to renewable energy are considered in the next chapter. This section briefly lists some barriers to energy efficiency in the region.

- Relevant cost-benefit information for energy efficiency measures is often unavailable to decision makers.
- Policies and programmes that only provide information may have some positive effect but do not address or overcome behavioural barriers and inertia.
- Energy is often a small proportion of expenditure so potential savings aren't believed to justify the investment in time and effort necessary to determine and implement energy efficiency improvements.
- Organisations do not have easy access to the expertise or tools to identify or take advantage of available energy efficiency opportunities.
- Studies in several countries suggest that organisations often appear to require a higher return for energy efficiency investments than other investments.
- Often (as for PIC utilities in Table 5-2) the incentives are split: the organisation that invests in energy efficiency improvement is not the one that gains the most from resulting reductions in energy use.

- Governments tend to begin programmes (such as. DSM support) but are seldom consistent in terms of policies and resources over the long-term.
- Architects and builders in the region seldom receive training in energy efficiency or designs appropriate to the climate and often construct buildings that are energy intensive (Figure 5-1).
- There is a lack of clear evidence of achievements within the region from energy efficient applications and government measures because of poor measuring, monitoring and reporting of past efforts.
- There is very limited information about quantities and patterns of current energy use within government and commercial buildings within the PICs so planners often don't realize how much is being spent on energy services.

Figure 5-1 – The New Government Building, Tuvalu

Photograph: Herb Wade, Funafuti, 2004

- There are very few local companies or individuals with the skills to carry out good energy audits and recommend cost-effective investments to reduce energy use.
- Finance institutions are not familiar with energy efficiency investments and may consider them as risky.

6 Barriers Identified in Development & Commercialisation of Renewable Energy Technologies in the Pacific

Barriers that can be considered regional and are discussed in this overview are those that apply to more than three countries. The country reports indicate additional, specific barriers that apply individually to a PIC but are not considered a barrier of regional scope. The placement of barriers into categories to aid the reader but categorisation is somewhat arbitrary since in many cases barriers affect several categories.

6.1 Fiscal and Financial Barriers

- Subsidies for electricity supply and in some cases for petroleum products often exist in the PICs but are rarely transparent and therefore difficult to evaluate. Subsidies should always be transparent. Renewable energy should be allowed to compete on the basis of the real economic cost of using conventional electricity supply processes and fossil fuels.
- The real economic cost of electricity and other energy is not known. Few PICs have the information or capacity to determine the real cost of energy. Most PICs have a reasonable understanding of the financial cost of O&M but few consider capital costs and even fewer consider non-financial economic costs such as environmental costs, opportunity costs, the cost of depletion of foreign currency reserves for petroleum purchase, the cost associated with the risk of petroleum supply interruption or a dramatic change in petroleum cost, etc.
- Inadequate funding is allocated to energy offices to monitor pilot projects and to correct problems that occur in those projects. Since pilot projects are intended to provide information regarding how installed technical and/or institutional systems work, it is vital that there be good quality monitoring and analysis for a sufficient time, usually at least five years, to obtain that information. When pilot projects are clearly facing a serious technical or institutional problem, a shift in the installed technology or institution is called for and sufficient funding needs to be present to make that shift.
- Although it is presently relatively easy to develop large-scale renewable energy projects using donor funding, there is inadequate access to finance for small projects and to rehabilitate failing projects. Donor finance is not as readily available for small (under $100,000) renewable energy projects or for the rehabilitation of failing projects as for large new projects. This has made it generally impractical to attempt focused development of rural productivity projects where a very specific activity in a specific community can use renewable energy for productive uses. It also has also made worse the tendency to develop new projects and abandon old ones that have failed.
- Import duties on energy producing and using equipment in some PICs are not applied uniformly. Some utilities get fuel tax-free but there may be tax on RETs.
- Tariff policies that force providers of rural power to adhere to a low "national" tariff makes it impossible for the private development of rural power systems.
- Rural credit for the purchase of rural power systems, particularly solar home systems, is generally not available in those countries where there is the biggest potential market: PNG, Solomon's and Vanuatu.

6.2 Legislative, Regulatory and Policy Barriers

- Although most of the PICs have drafted energy policies, in general the policies do not clearly define the role of renewable energy in the national energy economy or establish responsibility for carrying out that policy. As a result, implementation of renewable energy projects is usually *ad hoc* and there is no responsibility on the part of implementers to follow any renewable energy development guidelines or to ensure that projects consider the experience of earlier implementations of the same technology. This has resulted in many projects being implemented that repeat the same errors of design and operation as earlier projects in the same country. Also, without a policy that is accepted at all levels of government, policies will change with changes in government so consistency in long-term project goals cannot be achieved.
- Except in Palau, no power sector legislation in the PICs requires the utility to consider RE or EE measures or otherwise encourages them. When utilities develop expansion plans, there is seldom (if ever) any attempt to consider the relative merits of investing in EE or alternative energy generation
- Much of the power sector legislation is 30 or more years old and needs to be revised to encourage utilities to utilise renewable energy, encourage power purchase from IPPs, provide a fair price for purchased energy, etc.
- PICs are slowly commercialising or privatising power utilities without first establishing a regulatory framework that protects the public interest.

6.3 Market Barriers

- Although not applicable to Niue and Nauru as single island states, the rest of the PICs include remote islands and areas that have poor shipping, that have small populations, are expensive to access and have little technical capacity. That makes delivery of services difficult, maintenance of installed facilities costly and requires the installation of high cost, high quality energy systems if a reliable energy supply is to be provided. In particular the provision of fuel and of spare parts for energy systems has been a problem that has contributed significantly to lowered reliability of installed energy systems using both conventional and renewable technologies.
- The failure of renewable energy projects has often prejudiced government officials and recipient groups against renewable energy technologies. By failing to fix problems in projects and allowing them to fail, the confidence in renewable energy technologies in those PICs where there have been failures has been eroded and acceptance of renewable energy as a viable national energy source has generally been lowered.
- The small market size of most PICs is a barrier to companies for establishing a local presence for spare parts, repair, and training for most RETs.
- Limited private sector knowledge of opportunities for renewable energy in rural areas, a lack of understanding of the needs of the market and of how to market the appropriate products.

6.4 Knowledge and Information Barriers

- Information about the costs and benefits of renewable energy has not been well disseminated in most PICs. Both public leaders and private citizens have too limited an understanding of renewable energy to be able to make informed decisions about renewable energy technologies. An exception is Kiribati where there has been an extensive public information programme by the SEC to public officials and to rural households regarding solar energy for electricity production.

- Inefficient distribution of information about experiences with renewable energy technology applications between PICs and sometimes within a single PIC. Many renewable energy projects have used components, institutional systems and system designs shown in other PICs to be failure prone and have failed to replicate successful projects. Although this is partly due to the "not invented here" problem where each agency wants to put their own individual stamp on their projects, it is also a result of not effectively communicating lessons learned throughout the region.
- Limited capacity and funding for training institutions to improve knowledge and information about RE. Neither RE nor EE is normally part of the curricula in technical training institutions.
- The very poor information within nearly all PIC governments about the volume of petroleum sales, the trends in sales, and the sectoral end-use for various petroleum products is a barrier to understanding where RE and EE might make a significant difference.

6.5 Institutional Barriers

Figure 6-1 – Battery testing training.

Photograph: Herb Wade

Poor understanding of the needs, resources and abilities of rural communities to sustain renewable energy installations. The resulting institutional systems established for renewable energy use in rural areas are either excessively costly or simply do not work. This lack of understanding includes: (1) incorrectly assuming rural areas to be able to maintain and repair unfamiliar technologies when such capacity does not exist and cannot be readily developed; (2) heavily subsidising O&M costs by assuming that cash available to rural households is so low that they cannot pay the full cost of operating and maintaining renewable energy installations – when in fact they are typically already paying as much for kerosene, benzine and dry batteries as the cost of renewable energy systems to replace those conventional energy sources; (3) the assumption that all households will be happy with the same capacity installation. In rural areas as in urban areas some households are quite poor and can afford only minimal electrification while others have the resources to make good use of a much larger energy supply. The provision of a single electrification capacity to all households makes it too costly for the very poor to have access and does not provide satisfaction to the wealthier household with a greater expectation of energy services.

- There is inadequate capacity to design and implement renewable energy projects both in government and the private sector. All the PIC governments have done relatively poorly in the local design of projects, depending largely on external consultants who may not be familiar with conditions in the country and who may not share the same project goals as government and the recipients. As a result projects often use equipment poorly suited to the PIC environment, excessively complex systems that are beyond the ability of local personnel to operate and maintain, and installations that do a poor job of providing the services desired by the recipients. The private sector has been better at meeting the needs of recipients since their livelihood depends largely on customer satisfaction but there are also many examples of poor technical designs and inadequate provision for after market support by the private sector.

- Most PICs have not provided for project support for the long term including adequate spare parts arrangements, training for new operating and maintenance personnel that replace those originally trained at the time of installation, lack of a commitment to the collection of money from recipients sufficient to pay for operating and maintaining the installations and poor monitoring of projects so that problems are not recognised until they become so serious that their solution requires a major rehabilitation effort or project abandonment. Exceptions include Kiribati SEC projects, the Fiji Vanua Levu household solar projects, the Ha'apai PREFACE solar project of Tonga and the Namdrik PREFACE solar project of RMI that all appear to address these problems adequately.
- The lack of technical standards that focus on sustainability and reliability of installed renewable energy systems has resulted in the repeated use of components and installation methods already known to result in poor performance in the PICs. A lack of certification requirements for technical labour associated with renewable energy systems has been a major factor in allowing the existing low standard of maintenance for most rural development projects to continue. An exception is Kiribati where the SEC has specific component standards and training standards for maintenance personnel. The MEC in RMI is also expected to develop internal standards for installations and for personnel training for the renewable energy projects they will manage.
- Intellectual inertia in utilities and energy delivery institutions makes it difficult for them to accept new technologies and operational structures. There is a strong tendency for utilities to focus on grid delivery systems and on generation technology that has been successful in the past. Taking on new delivery mechanisms (such as RESCOs providing individual household solar power systems) or using new generation technologies is not likely to be done properly without strong incentives for successful implementations. There is also a tendency for implementers of renewable energy projects to fail to use unfamiliar technologies such as wind or biofuels and to promote the use of less appropriate but more familiar technologies such as solar PV.
- There is a tendency for regional and multilateral donor organisations to patronise PICs and develop programmes that are intended to be "good for the countries" instead of responding to the needs of the countries as perceived by the countries themselves. This tendency results in programmes being received with little enthusiasm or feeling of ownership and as a result projects have a hard time achieving their goals.
- The long time, often five years or more, needed to develop donor projects prevents addressing immediate issues and creates expectations on the part of government and recipients that cannot be fulfilled for an extended period. This

tends to lock out private development of the market that is to be addressed by the donor project since even though the demand is strong, recipients expect the donor funded project to provide subsidised services while private companies will require full cost recovery.

- A relatively frequent turnover of energy office personnel requiring extended training periods and resulting in low work efficiency.

6.6 Technical Barriers

- Poor technical or institutional designs for some renewable energy projects has resulted in poor quality of service. The confidence of potential recipients of new renewable energy projects that they will receive adequate energy service is therefore low. Communities have been known to reject solar PV electrification even when offered as an outright gift because they anticipated poor service and accepting PV meant rejecting the possibility of receiving another electrification technology in the future.
- Some renewable energy technologies, such as wind power systems, have not yet had a sufficiently strong experience base in the PICs to determine which component specifications are critical for long term reliability and cost effective service. Therefore each project tends to be a test bed for the installed components with component failure more common than success.
- Incorporating energy sources that may have a rapidly varying power output into a grid system is technically difficult and there are limits to the extent that such sources – notably solar PV and wind energy – can be integrated into a grid system unless complex power control systems are involved or unless the variations can be damped out by using energy storage systems.
- The lack of commercially proven ocean energy technologies is a huge barrier to the use of OTEC and seawave resources, which are abundant in many PICs. Land tenure and access to project sites is can also be problematic.

6.7 Environmental and Social Barriers

- Due to relatively high income expectations by rural dwellers, in most of the PICs, the production of copra at prices that allow biofuel production to be competitive with imported diesel fuel is difficult to achieve without a major restructuring of the supply mechanisms. Exceptions are Kiribati, PNG, the Solomon Islands, Vanuatu, and possibly RMI.
- Many of the PICs have a relatively high frequency of cyclones/typhoons. This makes wind and ocean energy installations more risky for large-scale investment. Biomass and biofuel production also are seriously reduced for months by a major storm. Solar PV installations also are at risk though installation methods that take storm passages into consideration have been shown to keep that risk to a minimum.
- The physical environment of the PICs is harsh for mechanical and electronic systems. There need to be special designs for mechanical systems and electronic components that prevent the high temperature, high humidity and salt laden environment of the PICs from shortening their service life or dramatically increasing maintenance costs.

- The development of large scale biomass energy projects requires a reliable and predictably priced supply of raw material. That is very difficult to achieve in many PICs because of fragmentation of land ownership into small individual holdings and/or land tenure issues. This is made worse by the failure of some governments to deal fairly and adequately with past land access issues for large scale energy projects.

7 Other Implications of the Widespread Use of Renewable Energy in the Pacific

7.1 Positive Implications

Less reliance on fossil fuel imports. The PICs can regain some control of their economies by increasing the use of renewable energy and through energy efficiency measures. This means that the PICs may be able to reduce the risk of economic disruption due to major fuel price changes or supply problems.

The use of biomass or biofuel replacements for imported fuel will mean that investments will increase in rural areas and there will be a steady transfer of cash from urban areas to rural areas instead of from the country to external oil suppliers.

Lowered GHG emissions relative to the use of conventional fuels will result. Although in the world context the emissions from the PICs are exceedingly small, on a per-capita basis many of the PICs are substantial emitters. Given the major problems that will result from GHG induced climate change, it behoves the PICs to attempt to minimise per-capita GHG production and to encourage other, larger countries to follow their example.

7.2 Negative Implications

Large scale implementation of any technology for energy production introduces environmental problems. The large scale use of each renewable energy technology can create its own set of environmental problems, discussed in section 7.3, that need to be addressed.

While the large scale use of biomass and biofuel technologies can benefit PIC economies, they also can create problems and induce economic instability. When energy resource suppliers in rural areas realise that the national economy relies on their product, there may be a tendency to raise product prices well in excess of real production costs and force the return to imported fuels. Careful development of price control systems and regulation of the raw material supply side of biomass related energy production, while assuring fair incomes to rural suppliers, should be considered to avoid returning to a situation where the nation has lost control of fuel pricing.

Very large capital investments will be needed to implement large scale renewable energy systems. There will be substantial opportunity costs involved and other developmental investments may have to be delayed or avoided. Renewable energy investment must always be made in the full national development context.

7.3 Environmental Implications of Widespread Use of Renewable Energy

For GHG emissions and energy production from renewable energy, the biggest impact in larger PICs could come from investments in large hydropower. Ethanol as a fuel, geothermal, biodiesel, small hydro, biomass and waste could all contribute as well. Any of these, if poorly planned, could have significant environmental impacts, as discussed below.

7.3.1 Large hydro (over 10 MW)

The International Rivers Network (IRN), an NGO which generally lobbies against hydro projects above 10 MW, alleges that major hydro expansion harms: i) efforts to move toward sustainable development, ii) people and ecosystems, and iii) energy security. Among other dangers, IRN lists increased vulnerability to climate change (due to changes in rainfall patterns and quantities) and the emission of significant amounts of GHG from large reservoirs (due to rotting organic matter) (IRN, 2003).

While some feel that IRN is alarmist, there has been a history of poorly designed and implemented large hydropower developments throughout they world. There can be significant and irreversible effects on surface water, groundwater and other aspects of water transfer within the hydrological cycle during project construction, project operation and maintenance, and decommissioning. In some cases, there are impacts during the planning phase, probably indirect off-site effects as materials are mined or fabricated in preparation for plant construction. For hydropower, the area of influence is very wide, extending from the upper limits of the watershed catchment to the valley below the dam and as far downstream as the estuary and off-shore zones. The most severe direct hydrological impacts are likely to result from the impoundment of water, flooding of land to form a reservoir, changes in flow characteristics downstream and the redirection of water flows. Potential indirect effects can be caused by construction and operation of work camps, access roads, and power transmission facilities, for example soil erosion affecting surface and ground water. The potential hydrological effects of the environment on the dam depend on land and water use in the watershed area upstream of the reservoir. Often relocations of population from the inundated reservoir area can increase pressures within the watershed resulting in changed land use patterns which increase erosion and subsequently sedimentation in the reservoir. The main hazard risk is a failure of the dam resulting in a sudden and massive flow of water downstream (Johnston, 1994).

The World Bank (1991) lists the following potential, and often real, hydrological impacts of large hydro dams:

- decomposition of trees in flooded land, causing nutrient enrichment in the reservoir and increased water loss through transpiration as well as increased methane (a potent greenhouse gas) generation;
- creation of reservoir dramatically changes water flow (quantity and timing), water quality, and sedimentation within river basin;
- disrupted water flow to downstream communities, initially with greatly increased sedimentation and later reduced quantities of water;
- loss of wetlands downstream of reservoir;
- sedimentation in reservoir reducing storage capacity and lifetime, reducing nutrient-rich silt downstream, increasing riverbed scouring downstream;
- altered water table upstream and downstream plus resulting salinisation;
- reduced flow of water at times to communities downstream;
- reduction in fish production (and catches) downstream;
- increased pressure on upstream land due to resettlement followed by poor watershed control (agriculture in steep areas, grazing, deforestation,) causing erosion and increased sedimentation in the reservoir;
- deterioration of water quality in reservoir;
- sedimentation at reservoir entrance causing waterlogging and flooding upstream;
- decrease in water for floodplain agriculture. Floodplain salinisation;

- chemical contamination of water during maintenance of transmission lines and towers;
- released water from lower portion of reservoir for power is high in pH, low in oxygen, high in hydrogen sulphide and is cold, all affecting animal and plant communities downstream;
- seismic events causing catastrophic dam collapse with sudden massive water flow downstream; and
- conflicting demands for water uses.

Some potential sites for large-scale hydro development could, and probably would, be developed as run-of-river systems, greatly reducing potential impacts. In general, any large hydro developments in the region should be planned, built and operated in accordance with the recommendations of the World Commission on Dams (WCD; available from www.dams.org explained in a *Citizen's Guide to the World Commission on Dams*, available from www.irn.org).

7.3.2 Small hydro (under 10 MW)

The International Association for Small Hydro, the European Small Hydro Association and the International Energy Agency's Renewable Energy Working Party all define small hydro as less than 10 MW. The IRN says, "*small hydro can, if responsibly implemented, be environmentally and socially low-impact. ... To ensure that small hydro projects have low impacts and meet community priorities it is imperative that all small hydro schemes are planned, built and operated in line with the recommendations of the World Bank/IUCN-sponsored World Commission on Dams"* (IRN, 2003).

7.3.3 Ethanol

Portions of PIC land are subject to strong erosion, inundation or regular flooding. Substantial areas have been cleared for agriculture. Environmental issues regarding the production of ethanol as a fuel are essentially those of biomass energy use in general: conversion of forests to biomass plantations, encouraging clear cutting, nutrient draining, use of toxic chemicals, increased erosion, and possibly loss of wetlands. Ethanol or other fuels made from sugar cane would probably have no more environmental impact than sugar cane farming (Fiji, PNG) at present.

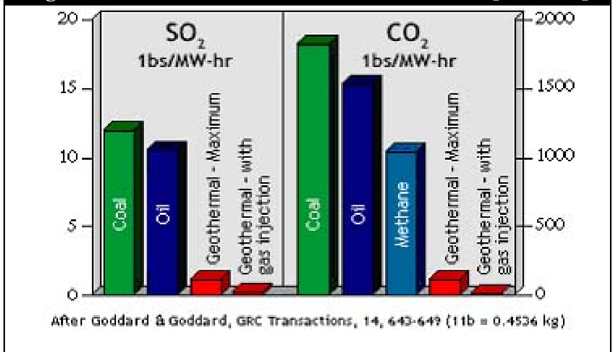
7.3.4 Other biofuels

In most PICs a relatively small percentage of coconut oil production might be used for fuel so the impact should be no more severe than current coconut harvesting practices. In terms of use, biodiesel fuels from coconut, oil palm or other vegetable oils are very low in emissions, as they contain almost no sulphur or hazardous materials. In case of spillage to the ground or marine environment, they biodegrade readily and do not normally cause contamination.

7.3.5 Geothermal

Although geothermal has not always traditionally been considered as renewable (as reservoirs eventually deplete, at least temporarily) or benign (due to hydrogen sulphide – H_2S – and other toxic emissions), it is now often accepted as an environmentally friendly energy technology. Typical emission levels of geothermal compared to other energy sources are shown in Figure 7-1. According to the US Department of Energy *"geothermal power plants easily meet the most stringent clean air standards because they emit little carbon dioxide (fossil-fuel power plants produce roughly 1000 to 2000 times as much), no nitrogen oxides, and very low amounts of sulphur dioxide (SO_2). Steam and flash plants emit mostly water vapour. Binary power plants run on a closed-loop system, so no gases are emitted." For [plants containing H_2S], the sulphur can be "separated, dewatered, and recycled as feedstock for sulphuric acid production. Future technology will use microbial processes to extract metals contained in the sulphur, allowing further reuse. At most geothermal hot-water power plants, H_2S is present in such low concentrations that it requires no special controls to comply with environmental regulations. ... A typical geothermal plant requires several wells. Although drilling these wells has an impact on the land, using advanced directional or slant drilling minimizes that impact. Several wells can be drilled from one pad, so less land is needed for access roads and fluid piping"* (USDoE website, undated).

Figure 7-1 – Geothermal Power Emissions of SO_2 and CO_2



Source: www.eere.energy.gov/geothermal/environ_impacts.htm

7.3.6 Wind

The key issues regarding wind energy in countries where it has been adopted on a large scale are related to noise and damage to the bird population. Noise can be reduced by siting wind systems several hundred meters from habitations and new lower noise designs are available. Any individual turbines likely to be installed in the PICs in the next decade are likely to be under 0.5 MW in rated capacity, and relatively quiet, whereas current installations in Europe, the US and elsewhere are typically several megawatts, and up to 5 MW, which can be far noisier. There have been reports of birds being killed as they fly into rotors but mostly of classes of birds not commonly found in the region.

8 Implementation of Pacific Capacity Development Needs & Co-Financing Opportunities

8.1 Past Regional Capacity Building and Support Programmes

8.1.1 Pacific Energy Development Programme (PEDP)

The PEDP was a regional energy outreach programme from 1983-1992 managed by ESCAP with funding mainly from UNDP. The programme provided energy advisory services and capacity building programmes on demand to PICs. It also assisted multinational and bilateral donors in the development of programmes and projects intended to benefit the PICs. It maintained a staff of local and expatriate experts with specialties in energy policy and planning, biomass and biofuel energy development, solar energy and small hydro energy development and in petroleum supply, standards and pricing. The programme carried out numerous training programmes, energy use and resource surveys, and assisted PICs in project design, feasibility studies and project analysis.

8.1.2 South Pacific Institute for Renewable Energy (S.P.I.R.E.)

S.P.I.R.E. operated from about 1984 -1996 with funding initially from both the French and the territorial governments and in later years only by the territorial government. S.P.I.R.E. developed technical designs, created and managed pilot and demonstration projects and tested renewable energy components for their applicability to the Pacific Island environment. Although initially established to provide technical support for the large and evolving renewable energy rural electrification programme of French Polynesia, the S.P.I.R.E. shared its knowledge with the PICs and in the later years provided outreach to the PICs in the form of advice, project development, technical training and project management.

8.1.3 Lomé III Pacific Regional Energy Programme (PREP)

The PREP operated from about 1994-1998 with EU funding. It was designed principally to provide capacity development to the PICs particularly the national utilities. Some renewable energy capacity development was included but it tended to be unfocused and limited to a few classroom type training programmes.

8.1.4 Forum Secretariat

Between the early 1980s - mid 1990s, the PIFS (then known as the Forum Secretariat) included an energy office, and later an energy division, that provided a regional interface with multilateral donors for project development and implementation and included some direct advisory and capacity development services to the PICs. The long-running (designed in 1980-81; operating from 1982-1995) Lomé II Pacific Energy Programme was managed by the Forum Secretariat and numerous trials of various renewable energy technologies were carried out under that programme. In the late 1990s, the Forum Secretariat reorganised and divested itself of several technical programmes, including energy (except for petroleum advisory services), and those were either abandoned or shifted to another regional organisation. Energy moved to SOPAC where regional energy programmes are currently located.

8.1.5 The Secretariat for the South Pacific Community (SPC)

Originally the South Pacific Commission, the SPC has the largest regional membership of all regional organisations as it includes both the PICs and the French

Territories. Until 2002, it had a rural development programme that included renewable energy and a number of small scale renewable energy programmes were carried out by the SPC including the PREFACE project of 2000-2003 that was jointly funded by Australia and France and managed by SPC. In 2002 the SPC energy programmes were turned over to SOPAC and currently the SPC has no energy programme though there remains a forestry and agriculture programme that could be of benefit to the region in developing biomass and biofuel production.

8.1.6 Other Organizations with a Pacific Energy Programme

In the former TTPI countries (RMI, FSM and Palau) the United States Department of Energy (USDOE) and Department of Interior (USDOI) had a number of renewable energy development programmes with an emphasis on small scale demonstrations of solar, wind, biogas and biomass technologies.

The East-West Center (EWC) in Hawaii had a very active Pacific Islands Energy Programme from the mid 1980s until the mid 1990s. The focus was largely on petroleum issues and conventional energy (training and workshops) but the EWC programme offered several opportunities to discuss a wide range of energy policy issues at ministerial level.

The Pacific International Center for High Technology Research (PICHTR) has provided some energy services to the region and in particular has been a centre for research and demonstration of OTEC technology. PICHTR has also provided assistance to the Fiji Government for RESCO and hybrid power development.

SPREP has been active regionally in environmental capacity building which includes some energy issues, particularly within its climate change programmes and is developing future programmes for renewable energy capacity building that will be focused on carbon emission reduction.

8.2 Characteristics of Required Regional Capacity Building and Support

8.2.1 Technical Support

Technical feasibility studies

Few PICs have the technical capacity to do detailed feasibility studies of proposed renewable energy projects. Assistance is needed in the carrying out of these feasibility studies to bring their quality to a level acceptable by international funding agencies.

Technical design assistance

Most of the PICs have inadequate technical capacity to develop renewable energy system designs that are specific to the needs of recipients. Most designs being used are copies of prior project designs that often were intended for a recipient group that had different needs than those for the current project. Assistance is needed in developing the capacity to provide specific system designs to meet specific energy production requirements.

Technical specification assistance

Component specification has generally been more the result of vendor recommendations than experience with components in the field. Because of the difficult environment faced by renewable energy systems in the PICs, it is vital that specifications be provided that specifically include components known to be reliable in similar projects. Assistance is needed for the development of standards and specifications for renewable energy systems and their components that rely on field experience in the region rather than on equipment vendors.

Tender evaluation assistance

Although simple in concept, tender evaluation processes can be quite complex especially for renewable energy systems where there are few vendors and vendors tend to be small and relatively new companies. Assistance is needed to develop tender evaluation procedures specifically for renewable energy tenders and direct assistance may be appropriate in the independent evaluation of tenders for renewable energy equipment and services.

Technical training

Training cannot be a one-off activity at the time of project installation. There is a continuing need for training of new personnel and retraining of the old. None of the PICs have long term training available for renewable energy related personnel. Training systems need to be developed in the PICs and at the regional level for the long term provision of training in management of projects, development of projects, analysis of projects, monitoring of projects, maintenance of projects and installation of projects. If the private sector is to become involved in renewable energy development the above trainings need to be open to them and additional training in financial management, renewable energy marketing, financial analysis and operational practices needs to be made available for the long term.

8.2.2 Policy and legislation Support

Development of general and specific policies

Although there have been several attempts by regional organizations to assist countries to develop national policy, they have not been successful. However there is still a need for regional support for national policy development but to be effective it has to be personalised to fit the needs of each PIC, not developed generically for acceptance by the PICs. The SOPAC administered PIEPSAP project is expected to address this issue and provide the needed assistance at the individual PIC level.

Standards for hardware

There is sufficient experience in the PICs with most renewable energy systems to allow the development of equipment standards appropriate to the specific needs of the islands. As there is little experience in the development of technical standards in the PICs, external support for developing that capacity is needed. The REEP project is expected to provide a model for such development in Samoa and Fiji.

Standards for activities

Installation

For there to be consistently reliable service provided by renewable energy systems, they must be installed in the proper manner. Standards and procedures to be followed for renewable energy system installation need to be developed and external assistance is needed for their preparation.

Maintenance

Maintenance procedures appropriate to the technology installed need to be developed and assistance is needed for their preparation.

Monitoring

Frequent and appropriate monitoring of projects is necessary if problems are to be caught and solved in a timely manner. There need to be standards and procedures developed for renewable energy project monitoring, analysis and record keeping. External assistance is generally needed to help their development.

Financial aspects

There are many different methods commonly used for financial and economic analysis. For such analysis to result in easily comparable figures, it is vital that a standardised procedure be used. In most PICs there are no standard procedures for financial and economic analysis. Since financing applications for renewable energy projects are evaluated largely on the basis of financial and/or economic analysis, it is important that standard procedures are imposed on analysts that result in evaluations that are consistent between projects and consistent with the needs and requirements of international financing institutions.

Certification of personnel

To help ensure reliable and consistent service provision from renewable energy systems, personnel responsible for operation and maintenance of those systems need to have a background of experience and training that is sufficient to meet the tasks assigned. Development of a technical certification process can help achieve the goal of increased average competence and a more consistent quality of operating and maintenance personnel than is presently the case. External assistance is generally required to develop certification procedures. The REEP project is expected to provide a model that will be developed for Fiji and Samoa.

8.2.3 Business Support

Management advice and training

Renewable energy systems, particularly stand-alone energy delivery systems for rural electrification, require specialised management procedures and processes that are not generally used for other businesses. For businesses to rapidly develop the capability to manage rural electrification projects, training and support needs to be made available.

Accounting and record keeping training

Small businesses that are involved in renewable energy service delivery and equipment sales have been found to be generally weak in record keeping and financial accounting. Training needs to be made available for the long term for these businesses to help them maintain control over finances and over the projects they may manage.

Business forecasting

Although commercial finance for small business development is generally available in the PICs, it cannot be accessed quickly and the need for finance must be understood and acted upon well in advance of the time when the finance will be needed. Forecasting of financial needs for capital requires analysis and prediction of cash flows well into the future and good quality analysis of business factors that will cause variations in sales and in the availability of money to the company. Training in financial forecasting and analysis needs to be made available for the long term to aid businesses in developing financial skills and to access finance from local sources.

Marketing training

Marketing of renewable energy systems and services is not a field well developed in the PICs. Specific marketing techniques relating to rural markets and renewable energy markets need to be communicated to the PIC businesses attempting to sell renewable energy products and services in the PICs.

Assistance in locating finance

Many technically oriented small businesses are unfamiliar with the requirements and procedures appropriate to accessing finance from banks and other financial institutions. Assistance needs to be available to help those businesses develop the necessary business plans, analyses and applications for finance.

Assistance in locating external expertise

Specialised knowledge may be required for the design and application of renewable energy systems. Assistance needs to be provided to locate and engage the necessary renewable energy specialists required.

Assistance in locating hardware sources

There are many sources, often obscure, of renewable energy components and services. PIC businesses need assistance in locating and accessing suppliers of equipment appropriate to the Pacific environment and meeting the technical needs of the applications being supported by the businesses.

8.2.4 Project Development Support

Project concept assistance

Some of the PICs do not yet have the capacity necessary to develop renewable energy project concepts without external assistance. Assistance needs to be made available to those countries to develop that capacity and to provide direct assistance in the development of renewable energy projects appropriate to the needs of the individual PIC.

Feasibility studies

Feasibility studies require skills in conceptualisation, operational forecasting, financial forecasting and comparative financial analysis that are often lacking in the PICs. Training to develop those skills and assistance in the preparation of renewable energy feasibility studies are needed in most PICs.

Project design assistance

Renewable energy project design needs a clear understanding of the effects of various institutional arrangements and of the technical systems that are being installed. That understanding only comes from long experience with renewable energy projects under differing technical and institutional arrangements. Most PICs do not yet have that experience. Assistance in achieving that understanding as based on project experience in other countries will be needed until there is sufficient local experience.

Assistance in locating project finance

Both the private and public sectors often find locating funding for renewable energy implementation difficult and complex. External assistance in preparing the necessary documents for application and in locating potential funding sources could make this process both faster and more likely to develop the necessary finance for projects.

8.2.5 Data and Analysis Support

Surveys

Although field surveys appear simple in concept, many energy surveys that have been carried out are strongly biased, incomplete or simply inaccurate. Survey design and implementation requires specific knowledge and techniques not generally available to PIC energy offices. Capacity building efforts should include training and assistance in the development of survey procedures and analysis processes that provide useful and accurate date for planning purposes.

Data collection

The PIREP survey found that most PICs' energy data, particularly electricity production and use data and petroleum import and use data, to be out of date, inaccurate or simply not available. If those responsible for energy planning and analysis are to do their jobs properly, accurate and up to date energy supply and use data are vital. Since a number of obvious errors were found in the data that has been collected, the capacity to understand the meaning of the data also needs to be strengthened. Collecting data that cannot be properly analysed and put to good use is not the intent. Although there have been regional programmes directed toward data base development, clearly they have not been sufficient and further support is needed, particularly support that addresses the development of procedures to verify data accuracy and consistency and that emphasises the use of that data for planning and project design purposes.

Forecasting

Development and energy planning are dependent on forecasting of energy needs and the availability of energy delivery systems. Many PIC energy offices do not have the skills to develop forecasts that are more complex than extrapolating trend lines. Assistance is needed in developing the needed statistical and analysis skills for producing forecasts with a higher probability of accuracy. A better understanding of factor sensitivity analysis and the development of alternative scenarios are also needed.

Economic Analysis

All project development requires skill in economic and financial analysis. Many PIC energy offices do not have the skills needed to include the time value of money, depreciation, residual values, and internal rates of return in their economic analysis. Procedures for including non-financial factors in economic analysis are not generally known and analysis tends to focus only on financial matters ignoring many non-financial components that are important to economic analysis including such things as environmental cost, opportunity cost and the value of energy as a driver of development. Further training and support in the preparation of quality economic analyses is important for decision making and vital to successfully access funding for projects.

8.3 Recommended Programme for Meeting These Needs

It is clear that for capacity support and development to be effective three conditions must be simultaneously be met.

1. The effort must reach the right people. It is unfortunately common for regional training programmes to have participants who have little likelihood of using the information provided. For example sending a participant from an atoll country to China for small hydro training is not a good use of regional resources. All too often, overseas training is viewed more as a privilege than as capacity building and participants are selected on the basis of "whose turn it is to travel" than on capacity development.
2. It must be at the right time so that it is immediately useful. Providing training for processes that will not be used for months or years in the future is of little real value. There is little value, for example, in providing technical training in wind technology until there is a wind power project underway. Training is rapidly lost if not used, so to be effective training efforts must be timely and fit into activities where that training will be immediately of use.
3. It must have content that matches the need. Providing highly theoretical training to maintenance personnel is not very useful. Providing training of field technicians in English rather than the local language greatly reduces its value since understanding often is poor. Training must be of a nature that specifically fits the need and the conditions that are faced by the activities for which the training is being provided.

Although SOPAC, has had capacity development programmes, they have generally been *ad hoc* rather than planned as a long term capacity development process since there is no long term training plan with an associated budget.

This has resulted in the timing of trainings not being well coordinated with PIC activities and the subjects being taught not always relevant to the tasks at hand. While this approach is better than no training availability at all, the trainings provided have often not met the three conditions for successful training and training effectiveness would be improved if training processes could be developed in a logical and long term manner that better fit the specific needs of the individual PICs.

The existing approach also makes it impossible to obtain training on demand. For example, Tonga has expressed a need for training four field technicians to support its growing solar PV projects for some time but none can be provided and none is scheduled.

If renewable energy implementation is to grow rapidly and become a sustainable part of PIC energy economies, training processes that allow capacity to grow with the growing deployment of renewable energy systems are essential. However, it must be realised that most of the PICs are simply too small to support highly trained renewable energy specialists in design, engineering and project development and training people to that level takes a long time and the probability of losing them to Australia, New Zealand or the USA is high. Yet each of the PICs will need the services of people with those skills immediately upon embarking on renewable energy deployment activities and the organizations supporting those activities will need to make those skills available as an integral part of their support.

Annex - References

For references that are country-specific, see the national PIREP report for that country.

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