SPREP

Pacific Islands Renewable Energy Project

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

GEF

UNDP

PIREP

our islands, our lives...

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

FEDERATED STATES OF MICRONESIA National Report Volume 3

SPREP IRC Cataloguing-in-Publication Data

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

xiii, 42 p. : figs., tables ; 29 cm. – (Pacific Islands
Renewable Energy Project. Technical report ; no. 03)

"This report is based on data gathered by a
PIREP team consisting of John Mooteb, Peter
Johnston and Herbert Wade".

ISBN: 982-04-0290-5

1. Energy development – Federated States of Micronesia.
2. Energy sources, Renewable - Federated States of Micronesia.
3. Energy research – Federated States of Micronesia. 4.
Conservation of energy resources – Federated States of
Micronesia. 5. Conservation of natural resources – Federated
States of Micronesia. 6. Energy consumption – Climate factors
- Federated States of Micronesia. I. Wade, Herbert. II. Mooteb,
- John. III. Pacific Islands Renewable Energy Project (PIREP).
- VI. Secretariat of the Pacific Regional Environment Programme (SPREP)
- VII. Title. VIII. Series.

333.79415966

Currency Equivalent:	FSM uses the US dollar as its national currency
Fiscal Year:	October 1 – September 30
Time Zone:	Pohnpei and Kosrae are GMT+11 Chuuk and Yap are GMT+10

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

Mr John Mooteb, FSM National PIREP Coordinator;

Mr Peter Johnston, International PIREP Consultant; and

Mr Herbert Wade, International PIREP Consultant/Team Leader

Mr Johnston visited Kosrae and Pohnpei and Mr Wade visited Chuuk, Pohnpei and Yap states in February - March of 2004. Although a national consultant was appointed, he resigned after several days of work to accept a position elsewhere. Though repeatedly contacted, both officially by government and unofficially by members of the PIREP team, the international oil companies failed to provide any information on their product sales, and therefore basic data needed for energy balance and forecasting was not available. The lack of up-to-date petroleum data and not having a national consultant for local support seriously hindered data collection. Much of the local effort in data gathering was assisted by the staff of the national Department of Economic Affairs and officials in each of the four states who were all very supportive of PIREP efforts.

A July 2004 draft of this report was reviewed by the FSM National PIREP Committee, Secretariat of the Pacific Regional Environment Programme (SPREP), United Nations Development Programme and others. However, the contents are the responsibility of the undersigned and do not necessarily represent the views of the above organizations, the Government of the Federated States of Micronesia, the state governments of Chuuk, Pohnpei, Kosrae or Yap, or any other individuals or organization who provided information or comments.

Peter Johnston

Herbert Wade

October 2004

ACRONYMS

AAGR	Average Annual Growth Rate
AC	Alternating Current
ACP	African, Caribbean, Pacific countries
ADB	Asian Development Bank
ADO	Automotive Diesel Oil
BFSM	Bank of the Federated States of Micronesia
CCA	Common Country Assessment (of the UN)
CIA	Central Intelligence Agency (USA)
CIF	Cost+insurance+freight
CPI	Consumer Price Index
CPUC	Chuuk Public Utilities Corporation
CROP	Council of Regional Organisations of the Pacific
DANIDA	Danish International Development Agency
DC	Direct Current
DEA	Department of Economic Affairs (FSM national government)
DPS	Division of Planning and Statistics (Kosrae)
DRC	Kosrae State Development Review Commission
DSM	Demand Side Management for efficient electricity use
EC	European Community
EDA	Economic Development Authority (Pohnpei state)
EDF	European Development Fund
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENSO	El Niño/El Niña oceanic climate cycle
EPA	Environmental Protection Agency
ESCAP	Economic and Social Commission for Asia and the Pacific (UN)
EU	European Union
EWG	Energy Working Group of CROP
FSM	Federated States of Micronesia
FSMDB	Federated States of Micronesia Development Bank
FY	Fiscal Year
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GMT/UTC	Greenwich Mean Time/Universal Time Coordinate
GNP	Gross National Product
GoC	Government of the state of Chuuk
GoFSM	Government of the Federated States of Micronesia
GoK	Government of the state of Kosrae
GoP	Government of the state of Pohnpei
GoY	Government of the state of Yap
HIES	Hawaii International Environmental Services, Inc.
Hp	Horsepower
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
KORDI	Korea Ocean Research and Development Institute
KUA	Kosrae Utilities Authority
kV	Kilo-Volts (thousands of volts)
kVA	Kilo-Volt-Amperes (Thousands of Volt Amperes of power)
kW	Kilo-Watt (Thousands of Watts of power)
kWh	Kilo-Watt-Hour (Thousands of Watt Hours of energy)
kWp	Kilo-Watts peak power (at standard conditions) from PV panels
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
MOMI	Mobil Oil Micronesian Islands
MPC	Micronesian Petroleum Corporation (Kosrae state)
NASA	US National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration

OTEC	Ocean Thermal Energy Conversion
PACER	Pacific Agreement on Closer Economic Relations
PEDP	Pacific Energy Development Programme (UN 1982-1993)
PIC	Pacific Island Country
PICCAP	Pacific Islands Climate Change Assistance Programme (GEF/UNDP)
PICTA	Pacific Island Countries Trade Agreement
PIEPSAP	Pacific Islands Energy Policies and Strategic Action Planning
PIFS	Pacific Islands Forum Secretariat
PIREP	Pacific Island Renewable Energy Project (GEF/UNDP)
PPA	Pacific Power Association
PREA	Pacific Regional Energy Assessment (1992)
PSRP	Public Sector Reform Program
PUC	Pohnpei Utilities Corporation
PV	Photovoltaic
PWD	Public Works Department
RET	Renewable Energy Technology
RFP	Request for Proposals
SHS	Solar Home System
SDC	Sustainable Development Council
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Communities
SPREP	Secretariat of the Pacific Regional Environment Programme
SWH	Solar Water Heater
SWOT	Strengths, Weaknesses, Opportunities and Threats
TNC	The Nature Conservancy
toe	Tonnes of Oil Equivalent
TTPI	Trust Territory of the Pacific Islands
ULP	Unleaded Petrol
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USP	University of the South Pacific
V	Volts
WB	World Bank
Wh	Watt hours of energy
YSPSC	Yap State Public Service Corporation

Energy Conversions, CO_2 Emissions and Measurements

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

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

Diesel Conversion Efficiency:

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

Area: 1.0 km^2 = 100 hectares = 0.386 $mile^2$ 1.0 acre = 0.41 hectares

Volume 1 US gallon = 0.833 Imperial (UK) gallons = 3.785 litres 1.0 Imperial gallon = 4.546 litres

Mass: 1.0 long tons = 1.016 tonnes

Energy: 1 kWh = 3.6 MJ = 860 kcal = 3,412 Btu = 0.86 kgoe (kg of oil equivalent)
1 toe = 11.83 MWh = 42.6 GJ = 10 million kcal = 39.68 million Btu
1 MJ = 238.8 kcal = 947.8 Btu = 0.024 kgoe = 0.28 kWh

GHGs 1 Gg (one gigagramme) = 1000 million grammes (10^9 grammes) = one million kg = 1,000 tonnes

CO_2 equiv CH_4 has 21 times the GHG warming potential of the same amount of CO_2; N_2O 310 times

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

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

EXECUTIVE SUMMARY

1. Country Context

Physical Description. The 607 islands of the Federated States of Micronesia, north-northeast of Papua New Guinea, extend east to west and north to south over 1500 miles and 600 miles respectively. The land area is 271 square miles with an exclusive economic zone exceeding one million sq. mi. distributed over the four states of Yap, Chuuk, Pohnpei and Kosrae. The islands vary geologically from high and mountainous to low coral atolls. Strong northeast trade winds prevail from December through April and periods of weaker winds occur from May to November. Rainfall is extremely high on the volcanic islands (Kosrae, Pohnpei and Chuuk) sometimes exceeding 400 inches per year. Storms and typhoons are generally more severe in the west.

Population. In April 2000, the last census, FSM had a population of 107008, an annual average growth rate since the 1994 census of only 0.2% due largely to free access to the United States. Fifty per cent of the people live in Chuuk, 32% in Pohnpei, 11% in Yap and 7% in Kosrae. The census does not distinguish between urban and rural areas but suggests that Chuuk and Kosrae are the most urbanized states. If current trends continue, the population in 2020 will be slightly less than 110000.

Environmental Commitments. The FSM is party to various treaties and conventions related to environmental protection, including the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, both with energy implications.

Political Development. The FSM was part of the Trust Territory of the Pacific Islands (TTPI) until independence within a Compact of Free Association with the USA in 1986. An American-style constitution was adopted in 1979 with a legal system based on TTPI laws, acts of the legislature, and municipal, common, and customary law. Each of the four states has an elected governor and a unicameral legislature. The National Congress is also unicameral with 10 members elected for two-year terms from districts in each state apportioned by population, and one member from each state elected for four year terms. The president and vice-president are elected by the congress from among its four-year members, both serving a four-year term. Elections for two-year seats are due in March 2005 and for four-year seats in March 2007.

Economic Overview. Economic development has been highly variable and extremely dependent on the Compact, which provided large financial transfers over 17 years, varying over time but accounting for the bulk of gross domestic product (GDP). A step-down in Compact funding after five years (FY1992) was relatively painless but a larger step-down in 1997 required painful adjustment, including an Asian Development Bank (ADB) public sector reform program that reduced the public service work force by 23% and wage bill by 29%, with real GDP declining 3.9% per year from 1995-1999. Overall, from Independence through 2003, GDP grew only 1.6% per year. The FSM is a federation with considerable state autonomy. Pohnpei with 32% of population accounts for 45% of GDP whereas Chuuk, with 50% of the population has only 30% of GDP. Economic performance has varied considerably by state, partly reflecting differences in policies and responses to external developments. Pohnpei and Yap grew the most rapidly at 2% per annum from 1987-2003. Kosrae and Chuuk each grew about 0.6% per year. In 2000, the FSM adopted the Millennium Development Goals, a set of targets with indicators to assess development progress. The ADB concluded in 2003 that FSM *"shows little progress towards meeting the MDGs by 2015. Poverty incidence is estimated to be high with approximately 40% of the population falling below the national poverty line in 1998 and there are signs of increasing*

inequalities." Key issues were poor delivery of basic social services, poor health indicators, and limited access to clean water and sanitation.

Economic growth. A new Compact signed in 2003 provides grants of $76.2 million per year and contributions to a trust fund of $16 million per year from 2004-2006, about $850 per capita. Thereafter, grants drop as contributions to the trust fund increase. Compact funding will continue to dominate the FSM economy. The ADB estimates real GDP growth of 0.1% in 2003, a decline of 1.5% in 2004 and moderate growth of 2.2% in 2005. Over the long term, the five FSM governments face the major fiscal challenges of managing the adjustment to a decline in sector grants and placing government revenues on a sustainable basis.

Energy planning. From about 1981-1991 there was a national energy planner within the federal government, initially financed by the US Department of Energy (USDOE), and an advisor on fuel contracts and pricing. There is currently no effective national energy planning, as Congress decided that energy should be dealt with at the state level. From the late 1990s to 2004, national energy matters were handled on a part-time basis by staff of the Department of Economic Affairs (DoEA). There is no clear energy role for DoEA and no formal links between the office and the four states on energy matters.

The USDOE also financed state energy planners from about 1981-1991. By 1992, funding ended, the position was left vacant in Chuuk, was abolished in Yap, and continued for a time in Kosrae. Pohnpei continues to have positions of Chief of Energy and Energy Technician, but with no energy planning responsibilities beyond renewable energy implementation.

Electric power. Each state has a state-owned and controlled power utility. Compact funds have been the main source of funding for both capital replacement and expansion. There is no national utility and no national standards, utility laws or regulation. The Kosrae, Pohnpei and Yap utilities operate semi-autonomously but still rely on state governments to cover deficits. In Chuuk, the utility is more heavily subsidized and revenue collection is low. All utilities have statewide mandates but provide services primarily to the main island or islands.

Petroleum. Refined petroleum products are supplied to Chuuk, Yap and Pohnpei by Mobil Oil from Guam. Kosrae is supplied by the state-owned Micronesia Petroleum Corporation, which operates a bulk terminal. There is no control of fuel prices except for state use in Kosrae.

Energy policy. In 1999, the DoEA prepared a draft National Energy Policy, but there has been no further work since 2000. The overall objective is to promote sustainable social and economic development through cost effective, safe, reliable and sustainable energy services. In 2002, the government listed five areas where energy policies and related strategies are needed: 1) an effective and coordinated energy sector; 2) safe, reliable, cost effective and sustainable energy; 3) restructuring the power utilities and petroleum industry and promotion of energy service companies; 4) diversification of FSM's energy resource base; and 5) environmentally appropriate and efficient use of energy. The draft energy plan identified four constraints and deficiencies to be addressed: 1) institutional issues (small fragmented energy sector, environment not conducive to private sector; no oversight or regulation, insufficient capacity to coordinate, plan and manage); 2) power sector (highly subsidized, no standards; 3) petroleum supply and pricing (limited competition, no responsibility for waste disposal); and 4) renewable energy (solar electrification unsustainable, little experience, no monitoring of RE potential). These issues are still not being addressed. There are statements in state plans regarding energy but apparently no budgets or specific activities.

Energy related legislation and legal tools. There is no national electricity or petroleum legislation. In addition to state laws establishing the four power utilities and Kosrae's Micronesia Petroleum Corporation, there are state and national environmental laws that could

affect energy investments although there are no specific requirements (i.e. environmental impact statements) for energy except for pollution control and waste management.

Inter-ministerial Energy Committees. There is no permanent interdepartmental or inter-ministerial energy committee. The Sustainable Development Council, chaired by the vice president with representatives from the states and government offices, meets monthly and reportedly includes energy in its deliberations as it relates to sustainable development.

2. Energy Supply, Demand and the GHG Inventory

Energy Supply and Demand. The FSM is overwhelming dependent on imported petroleum fuels for commercial energy. Approximately 86% of gross energy supply is from petroleum and 14% from biomass for cooking. The Nanpil hydro system previously provided several percent of electricity but is not now operating. Solar energy provides considerably less than 1% of the total.

Petroleum. According to DoEA, data on the volume and value of fuel imports are very unreliable for the period 1991-2000. Data on fuel use by state for 2001 and 2002 are only available as customs data stated in dollar value. No data was provided by the petroleum companies despite repeated official and unofficial requests. Accordingly, there are no accurate data in this report on either recent fuel use or trends. Similarly, the FSM does not provide information to the Pacific Islands Forum Secretariat on fuel prices so the FSM is not included in the region's regular fuel price monitor. Therefore the PIREP team cannot comment on prices of petroleum fuels in the FSM relative to other Pacific Island countries.

Biomass and household energy. A joint UNDP, World Bank, Forum and ADB study, the Pacific Regional Energy Assessment (PREA) estimated that in 1990, 20% of FSM households cooked entirely or primarily with biomass, accounting for 4100 tonnes of oil equivalent (toe), about 11% of total energy supply. The 2000 national census reports that over 50% of all households use wood as their main fuel, ranging from 8% in Kosrae to 71% in Chuuk. This suggests that perhaps 12,000 toe of biomass was used in 2000 for energy. It seems likely that the PREA, with no recent census data, underestimated the percentage of FSM households that cooked with biomass.

Electricity supply. There are electric power systems on the principal islands of all four FSM states, and much smaller systems on some outer islands of Chuuk and Yap states. The Pohnpei Utilities Corporation is the largest power utility in FSM with six Caterpillar diesel generators with an effective (derated) capacity of 4.9 MW and four newer Daihatsu units with an effective capacity of 10 MW. A 2 MW hydro plant is not currently operational. The Pohnpei power distribution system reaches nearly all inhabited areas of the main island. The Yap State Public Service Corporation serves Yap Proper and has four operational generators effectively rated at 7.6 MW. The network reaches 98% of Yap Island's population and, in 2000, 57% of the state's households. The Chuuk Public Utilities Corporation serves the main island of Weno with 5 MW of effective capacity, 4 MW of peak load and 2.9 MW of base load. Because of the small margin of capacity over peak load, all generators regularly operate, resulting in frequent outages. In 2000 only 19% of the state's households were electrified through the utility. The Kosrae Utilities Authority has an effective capacity of 5.4 MW, peak of 1.2 MW and base load of just 0.7 MW. 98% of Kosrae's households were electrified through the grid in 2000. Nationally, generation is roughly 90 GWh, nearly half in Pohnpei. In 2000, about 54% of all households in the FSM had electrification from some source ranging from 33% in Chuuk, to 59% in Yap, 68% in Pohnpei and 100% in Kosrae. Overall, 46% of FSM's households were electrified through a state utility, varying from a low of 19% in Chuuk to a high of 98% in Kosrae.

Electricity customers and pricing. There were 2150 Chuuk utility consumers in 2003. Commercial customers were 17% of the total but accounted for half of sales compared to 24% for government and 26% for residential consumers. Charges rose from 10 ¢/kWh in the mid-1990s to 17-21¢ in 2003. The utility received an annual Compact energy grant of about $1 million from 1988-2002, without which revenue would only have covered 75% of costs. The Kosrae utility appears to be technically sound and financially well managed. 79% of customers are residential (accounting for 43% of sales), 12% are commercial (22%), 7% are state government (21%) and 2% are NGOs (9%). The Compact energy grant accounted for nearly half of electricity revenues in 2002 and was sufficient to cover operating deficits. Tariffs in Kosrae need to increase substantially as there is no longer a Compact energy grant.

Energy Balance and Greenhouse Gas Emissions. As discussed, there are no data available to indicate the demand for petroleum products overall or distribution among government, commerce and industry, domestic households or transport. However, the team did make rough estimates of greenhouse gas (GHG) emissions. The government reports that, apparently in 1994, the FSM emitted 146 Gigagrams (Gg) of GHGs from energy use. This is more-or-less consistent with PREA data that suggest 1990 emissions of about 151 Gg. It is likely that growth in petroleum fuel consumption has been low, although in the absence of data this is clearly a guess. This study assumes relatively low economic growth of about 1.8% per annum over the next decade, with petroleum fuel growing about the same amount in the absence of investment in either renewable energy or energy conservation (i.e. a 'business-as-usual' approach). This would result in GHG emissions of around 170 Gg by 2012.

The main opportunities for GHG reductions appear to be hydropower and improved energy efficiency. With the removal of barriers to renewable energy and energy efficiency, and an aggressive investment program, emissions could be reduced by roughly 24 Gg per year, perhaps 14% of the business-as-usual emissions in 2012. Of the total, about 70% would be from renewable energy (hydro, some biodiesel and a small amount of solar) and 30% from efficiency gains.

3. Potential for Renewable Energy Technologies

Biomass – A resource assessment is being carried out at the time of writing but results were not yet available. Environmental issues make the harvest of indigenous forests for energy unlikely so the resource that can be made available is dominated by existing economic tree crops, primarily coconut. The coconut resource would be best utilized for biofuel production and a potential production of around 6500 tonnes per year of copra appears possible. To achieve that level renovation of plantations, improved efficiency of production and increased payment to copra producers appears necessary.

Biogas – No resource assessment available but some urban waste and possible farm waste could make small-scale development possible.

Solar – Good to very good resource with an average around 5.5 kW/m^2/day insulation (horizontal surface), sufficient for cost effective photovoltaic and solar water heating use.

Wind – No wind resource assessment has been carried out. Based on weather measurements, the resource appears poor but there may be areas of good resource.

Hydro –Pohnpei and Kosrae have an estimated 6.9 MW of developable hydro potential (mostly on Pohnpei) though development cost would be high.

Wave – Moderate resource present but not developable with current technologies.

OTEC – Large resource present but not developable with current technologies.

Geothermal – There is no known resource that is developable.

4. Experiences with Renewable Energy Technologies

Many small scale "demonstrations" of various renewable energy technologies were carried out during the TTPI years. However most were not sustained for more than a short time and none have survived to the present as operating facilities.

Solar Photovoltaics. Considered the result of poor water sanitation, a cholera epidemic in 1982 caused Chuuk State to provide over 200 small solar pumps to residents for pumping ground water for flushing newly constructed water seal toilets. The units were well received and even in 2000, pump repair parts were being purchased by owners.

In Pohnpei state trials of solar energy for village electrification in Mwoakilloa were carried out in the late 1980s. Though the project was not sustained, the experience led to the development of improved technical and institutional arrangements for new installations in Mwoakilloa, Pingelap, Sapwuhafik and other Pohnpei State outer islands totaling nearly 500 installations. Yap state also has had village electrification projects using solar power with the most recent a French funded project for 50 Satawal homes. A number of private installations exist but no survey has been carried out to determine their characteristics or number.

Solar Thermal. Solar water heating has been used for hotels, hospitals and guest houses for many years. In urban areas of FSM an increasing number of private homes are using imported solar water heating but the percentage of homes with installations is still quite low.

Wind Power. Though wind energy has been used for water pumping, using the American style multibladed windmills common in the USA central plains states, there have been only small scale demonstrations of electricity generation that have not been considered technically or economically successful.

Biofuels and Biomass. Though biomass combustion remains a major energy source for rural cooking, development of biomass or biofuels for commercial energy has not been significant though the potential for biofuel use appears good.

Hydro. During the years of Japanese occupation, several small hydro installations were developed but after WWII they were not maintained and provided little energy in the postwar years. Increasing demand for electricity and increasing costs of production led to renewed interest in hydro development. In 1988 the Nanpil river hydropower system was commissioned near the site of an earlier Japanese installation. A real capacity of 1.8 MW was possible but stream flows are widely variable and the installation cannot be considered as firm capacity for the power system. The installation is not currently working due to penstock damage. The Malem River in Kosrae was proposed as a site for development f a 35 kW hydro plant but plans were stalled by land tenure issues and the project never began construction.

Biogas. Only small scale trial units have been installed and even in those, the gas produced has not been used for energy due to cultural issues.

European Union Renewable energy and Energy Efficiency project. €4.08 million has been allocated for FSM renewable energy and energy efficiency development under the Coutonou Agreement. The financial agreement should be signed in late 2004 and initiation of feasibility studies for project development is expected in 2005. Solar energy and biofuel energy appear likely to be the focus of renewable energy development under the program.

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

Barriers to Renewable Energy Development are known to include:

- heavily subsidized electricity tariffs making conventional power appear much lest costly than renewable alternatives;
- poor collection of electricity utility charges making it difficult to collect charges for renewable energy used for electricity production;
- no incentives for RET development at state or national level;
- state subsidies to state owned petroleum companies;
- lack of energy policies and legislation encouraging renewable energy use;
- lack of national energy officers, planners and regulators in state and national government;
- no state energy planners, policies nor are there budgets for renewable energy development;
- no coordination of energy matters though they spread over several ministries;
- lack of institutional arrangements suitable for renewable energy operations;
- poor understanding of opportunities and obstacles to renewable energy development;
- limited knowledge of renewable energy resources;
- individual states are too small to develop the needed skills for large scale project design and implementation;
- small dispersed population;
- lack of up to date, reliable energy data;
- low level of public awareness regarding energy issues and options;
- lack of RET and EET training capacity;
- land tenure issues; and
- vulnerability to cyclone damage.

6. Capacity Development Needs for Removing the Barriers

Each of the four States have different capacity development needs. The following list combines the needs of states and for national development.

- Data collection and analysis capacity building
- Utility planning and forecasting capacity development
- General RET training development
- Project design capacity development
- Technical capacity building
- Decision maker information provision
- State energy policy development

7. Implications of Large Scale Use of Renewable Energy

Solar Energy. Large scale use of photovoltaics for rural electrification implies the large scale use of lead-acid batteries and an environmentally acceptable means of disposing of failed batteries. Recycling arrangements with manufacturers will be important to arrange at the time of purchase of batteries for projects. Social and economic benefits of rural electrification are expected to be delivered by large scale renewable energy use for rural electrification notably quality of life improvements, improvement in education and in health care.

Biofuels. Significant economic benefit for rural areas can result from large scale use of biofuels. Urban areas also benefit from a more stable cost of fuel and increased security of supply.

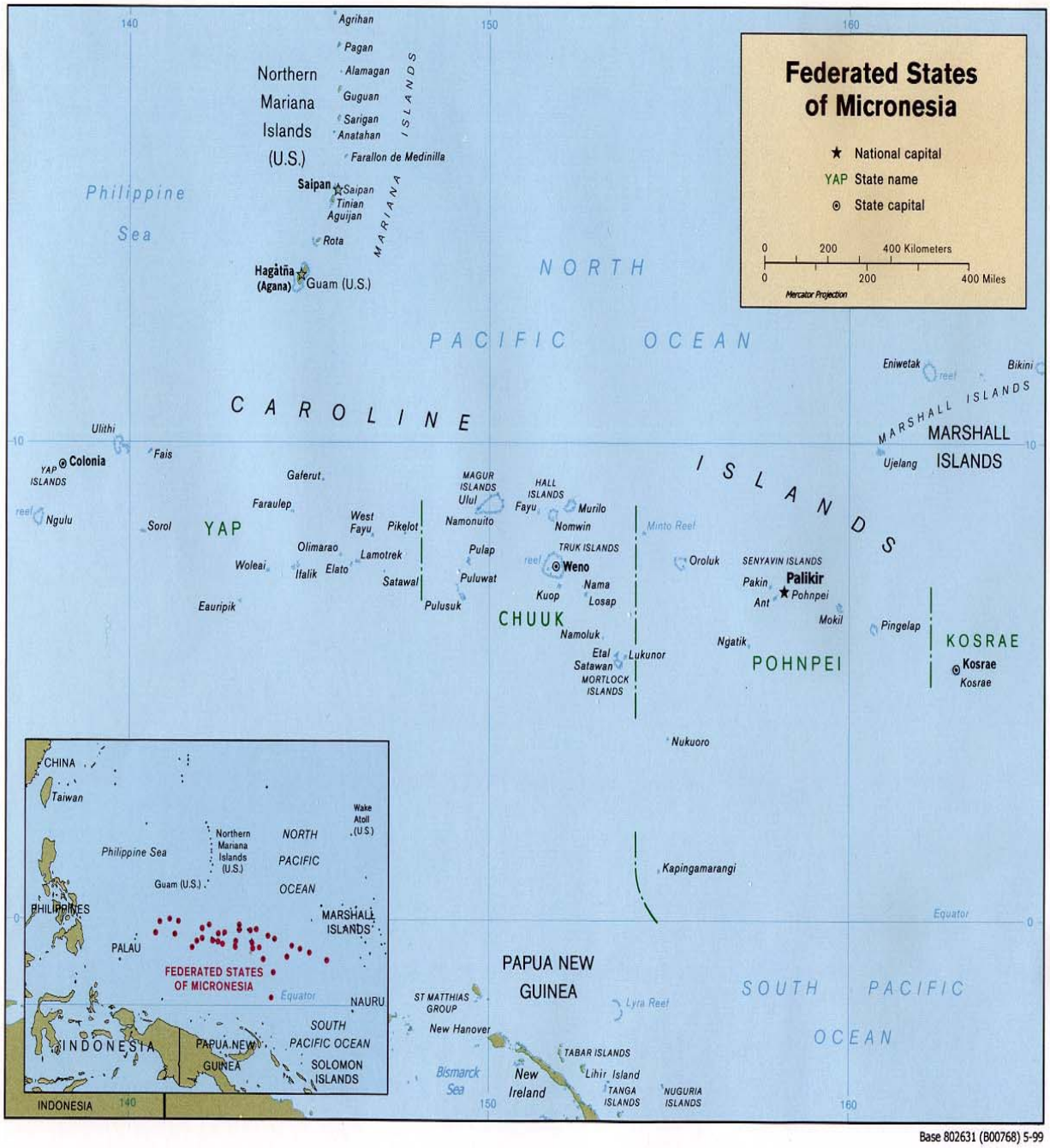
8. Implementation of the Capacity Development Opportunities

The EU project for FSM offers the only significant opportunity for co-financing of capacity development activities at the present time. Capacity development for state utilities through various regional and local programs may also provide co-financing opportunities.

TABLE OF CONTENTS

1 COUNTRY CONTEXT 1
1.1 PHYSICAL DESCRIPTION 1
1.2 POPULATION 2
1.3 ENVIRONMENTAL COMMITMENTS 2
1.4 POLITICAL DEVELOPMENT 3
1.5 ECONOMIC OVERVIEW 4
1.6 INSTITUTIONAL AND LEGAL ARRANGEMENTS FOR ENERGY 8
2 ENERGY OVERVIEW: SUPPLY, DEMAND AND THE GHG INVENTORY 14
2.1 ENERGY SUPPLY AND DEMAND 14
2.2 ENERGY BALANCE AND GREENHOUSE GAS EMISSIONS 19
2.3 FUTURE GROWTH IN ENERGY DEMAND AND GHGS 20
3 POTENTIAL FOR RENEWABLE ENERGY TECHNOLOGY USE 22
3.1 THE RESOURCE 22
4 EXPERIENCE WITH RENEWABLE ENERGY TECHNOLOGIES 25
4.2 OPERATIONAL RENEWABLE ENERGY SYSTEMS 26
4.3 FUTURE RENEWABLE ENERGY PROJECT PLANS 29
5 BARRIERS TO DEVELOPMENT AND COMMERCIALIZATION OF RENEWABLE ENERGY TECHNOLOGIES 30
5.1 FISCAL AND FINANCIAL BARRIERS 30
5.2 LEGISLATIVE, REGULATORY AND POLICY BARRIERS 30
5.3 INSTITUTIONAL BARRIERS 31
5.4 TECHNICAL BARRIERS 31
5.5 MARKET BARRIERS 31
5.6 KNOWLEDGE AND PUBLIC AWARENESS BARRIERS 32
5.7 ENVIRONMENTAL AND SOCIAL BARRIERS 32
6 CAPACITY DEVELOPMENT NEEDS FOR REMOVING THE BARRIERS 33
6.1 ELECTRICITY 33
6.2 RENEWABLES 33
6.3 POLICY AND REGULATION 34
7 IMPLICATIONS OF LARGE SCALE USE OF RENEWABLE ENERGY 35
7.1 SOLAR PV 35
7.2 BIOFUELS 35
THE IMPLEMENTATION OF CAPACITY DEVELOPMENT NEEDS AND CO-FINANCING OPPORTUNITIES 36
7.3 EXISTING OPPORTUNITIES 36
7.4 FUTURE OPPORTUNITIES 36
8 ANNEXES 37
ANNEX A – PERSONS INTERVIEWED BY THE LOCAL AND INTERNATIONAL CONSULTANTS FOR PIREP 37
ANNEX B – REFERENCES 40

Map of the Federated States of Micronesia



Source: www.lib.utexas.edu/maps

1 COUNTRY CONTEXT

1.1 Physical Description

The 607 islands of the Federated States of Micronesia (FSM), located north-to-northeast of the island of Papua New Guinea, extend east to west over 1500 miles (2500 kilometers), and over 600 miles (1000 km) from north to south. The total land area is 271 square miles (702 km^2) with an Exclusive Economic Zone (EEZ) exceeding one million sq. mi. (2.6m km^2) distributed over the states of Yap, Chuuk, Pohnpei and Kosrae, as shown in Figure 1.1. The islands vary geologically from high mountainous islands (the highest point being 791 meters) to low, coral atolls with volcanic outcroppings on Pohnpei, Kosrae, and Chuuk. Northeast trade winds heavily influence the tropical climate of the FSM with strong trade winds prevailing from December through April and periods of weaker winds and doldrums occurring from May to November. Rainfall is extremely high on the high volcanic islands (Kosrae, Pohnpei and Chuuk) and can exceed 400 inches (1016 cm) per year. The FSM is affected by storms and typhoons that are generally more severe in the western islands (e.g. Typhoon Sudal which caused severe damage to Yap in April 2004), and by periods of drought and heavy rainfall associated with the El Ninõ southern oscillation (ENSO). A 1997-1998 drought was especially severe with groundwater sources greatly reduced, agricultural systems damaged and coral bleaching events recorded. Table 1.1 shows the distribution of the 271 sq. mi. (702 km^2) of land and 2776 sq. mi. (7190 km^2) of lagoon.

Table 1.1: Physical Features of the Federated Sates of Micronesia

State	Islands and land area	Landforms and comments
Chuuk	Land: 49 mi^2 (127 km^2) Lagoon: 823 mi^2 (2132 km^2) Islands: 7 main groups	Chuuk lagoon includes 98 islands (14 mountainous and volcanic), surrounded by a lagoon of 800 sq. mi. Mixed broadleaf forests comprise the dominant vegetation of the high islands. Lowland vegetation is dominated by mangrove and swamp forest, with large portions disturbed by human activity.
Kosrae	Land: 43 mi^2 (111 km^2) Lagoon: none	Tropical moist forests. Rainfall averages 252 inches per year. Vegetation as above. Montane cloud forests thrive in parts of Kosrae.
Pohnpei	Land: 132 mi^2 (342 km^2 Lagoon: 297 mi^2 (769 km^2) Islands: 6 main groups	Tropical moist forests. Rainfall averages 200 inches per year (lowlands) up to 400 inches (mountainous interiors). As above, mixed broadleaf forest is dominant and montane forests thrive but 2/3 of native forest has been lost in past 20 years.
Yap	Land: 46 mi^2 (119 km^2 Lagoon: 405 mi^2 (1050 km^2) Islands: 12 are inhabited	Tropical dry forests. Dominant vegetation types are mixed broadleaf forest, swamp, mangrove, savanna and agroforests. Rainfall averages 120 inches per year with a distinct dry season.

Sources: A Blueprint for Preserving the Biodiversity of FSM (The Nature Conservancy, 2002); and FSM National Biodiversity Strategy and Action Plan (Govt. of FSM, 2002)

1.2 Population

In April 2000, the date of the last national census, the FSM had a population of 107,008, an annual average growth rate (AAGR) since the previous 1994 census of only 0.2%. Of the total 50% were in Chuuk, 32% in Pohnpei, 11% in Yap and 7% in Kosrae. Population changes by state from 1980– 2000 are shown in Table 1.2. FSM's median age of 18.9 years was among the youngest in the Pacific. There were 6.2 persons per household in 2000. The census does not distinguish between urban and rural areas except to suggest that Chuuk and Kosrae are probably the most urbanized states.

Table 1.2: Population by State and Annual Average Growth Rates

	Census Population:				Average annual growth rate (AAGR):		
	1980	1989	1994	2000	1980-1989	1989-1994	1994-2000
Chuuk	37,488	47,871	53,319	53,595	2.7%	2.2%	0.1%
Kosrae	5,491	6,835	7,317	7,686	2.4%	1.4%	0.8%
Pohnpei	22,080	30,669	33,692	34,486	3.7%	1.9%	0.4%
Yap	8,100	10,365	11,178	11,241	2.7%	1.5%	0.1%
FSM total	*73,159*	*95,740*	*105,506*	*107,008*	*3.0%*	*1.9%*	*0.2%*

Source: National Census Report May 2002

The FSM's crude birth rate, 29.1 per thousand of population, is high. From 1970-1994, FSM had one of the fastest growing populations in the Pacific, averaging 2.6% per annum. Since 1994, the AAGR has dropped due to migration to Guam, Hawaii and the continental United States of America (USA). As FSM citizens have the right of access to the USA, population growth is expected to remain low. If current trends continue, the population in 2020 will be slightly less than 110,000.

Figure 1.2 Shows population by state since 1920 and illustrates the low growth rates of the past decade.

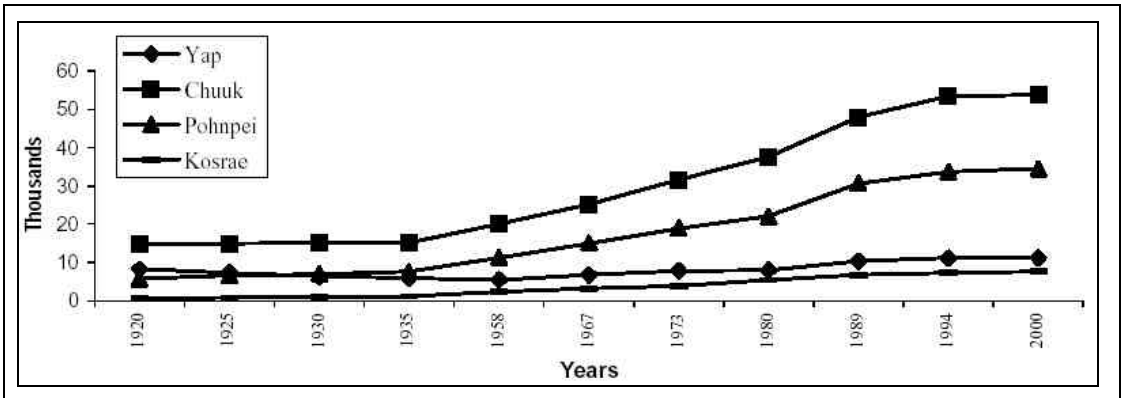


Figure 1.2: FSM Population from 1920 – 2000 (*Source*: 2000 National Census Report, 2002)

1.3 Environmental Commitments

The FSM is party to various treaties and conventions related to environmental protection, including the United Nations Framework Convention on Climate Change (UNFCCC), the

Kyoto Protocol, the Convention to Combat Desertification, and the Convention on Biological Diversity. The initial national communication to the UN FCCC, indicating greenhouse gas emissions, and vulnerability and adaptation to climate change, was submitted in 1999. Table 1.3 summarizes the status and date of signing of some key environmental conventions.

Table 1.3: Status of Ratification of Environmental Treaties and Conventions by the FSM

Status in FSM	Protection of Resources (SPREP Convention)	Conservation of nature (Apia Convention)	Hazardous wastes (Waigani Convention)	GHG reductions (Kyoto Protocol)	Ozone depleting substances (Montreal Protocol, et. al.)
Signed	9 Apr '87	no	17 Sept '95	17 Mar 98	6 Sep '95 (ac)
Ratified	29 Nov '88	no	26 Jan '96	11 Aug 03	
Entered into force	22 Aug '90	26 June '90	21 Oct '01	n/a	

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

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

Sources: Websites for conventions, and communications from Pacific Island Forum Secretariat (PIFS) and Secretariat for the Pacific Regional Environment Programme (SPREP, between January and March 2004)

1.4 Political Development

The FSM is an independent country in a Compact of Free Association (the Compact) with the USA, which entered into force on 3 November 1986. The FSM has an American-style constitution adopted in 1979which provides for a government composed of executive, legislative and judicial branches. The legal system is based on adapted TTPI laws, acts of the legislature, and municipal, common, and customary laws.

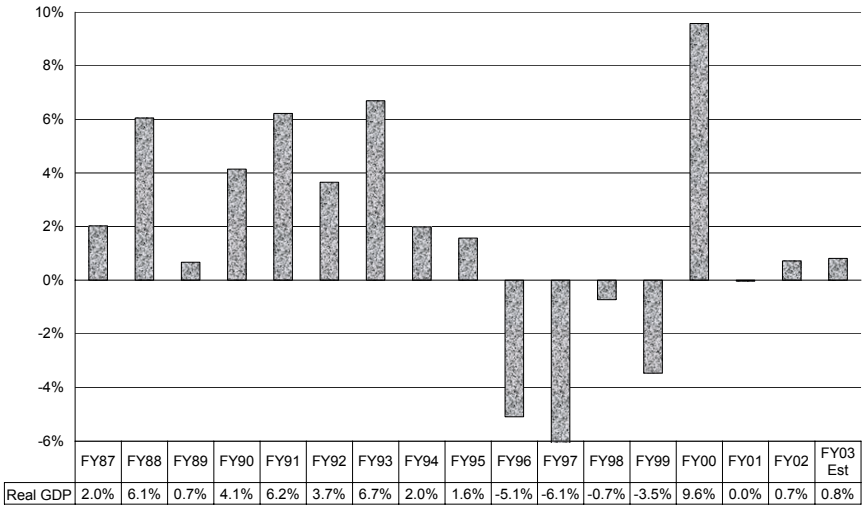
Each of the four states of the Federation (Pohnpei, Chuuk, Kosrae and Yap) has an elected governor, a lieutenant governor and a unicameral legislature. The National Congress is also unicameral and consists of 10 members elected for two year terms from congressional districts in each state apportioned by population, and four members (one from each state) elected for four year terms. Both the president and the vice-president are elected by the Congress from among its four-year members and both serve a four-year term. Joseph Urusemal of Yap State was elected to the presidency by Congress on 11 May, 2003, in the first regular sitting of Congress following national elections on 4 March. Redley Killion, of Chuuk State, was elected to a second four-year term as vice-president, a position he has held since 1999. Elections for two-year term seats are next due in March 2005 and elections for four-year terms in March 2007.

The Compact leaves the FSM in control of domestic and foreign policy except defense and security issues, for which the USA is responsible. The Compact also provides considerable direct financial assistance for the development of the FSM. A second Compact was signed on 14 May 2003, with less generous funding, but still equivalent to US$1.8 billion over twenty years, including contributions to a trust fund which will replace direct financial assistance in 2024. As well as financial assistance, the Compact also grants FSM citizens access to US federal programs, and favorable provisions for traveling to and working in the USA.

1.5 Economic Overview[1]

1.5.1 The national economy

Economic development in the FSM needs to be analyzed in the context of the Compact which has provided large external financial transfers to support the operations of the Government of the FSM (GoFSM) and substantial public sector investment. Compact economic assistance, initially meant to last 15 years until 2001, was front-loaded with reductions in grant funding of 15% after 5 years and 22% after 10 years. Transfers were partly indexed to US inflation, resulting in an overall average real decline in resource flows of 4% per year. The Compact was extended for a further two years through fiscal year (FY) 2003 during renegotiations, with additional transfers at the average level of the first 15 years. The original Compact period thus incorporated three distinct fiscal shocks and challenges to the economy: two negative shocks requiring substantial downward financial adjustments and a third "bump-up" in resources, requiring measures to limit unsustainable increases in public expenditures.



	FY87	FY88	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03 Est
Real GDP	2.0%	6.1%	0.7%	4.1%	6.2%	3.7%	6.7%	2.0%	1.6%	-5.1%	-6.1%	-0.7%	-3.5%	9.6%	0.0%	0.7%	0.8%

Figure 1.3: Real GDP Growth in FSM: FY1987-2003
Source: *Economic Developments: 1987-2003* (GoFSM, 2003)

In 1987 the economy was already heavily dominated by Compact flows, representing 88% of gross domestic product (GDP). The economic structure was simple, with a private sector dominated by non-traded goods production, virtually no exports, and a nascent tourism sector. Against this background, developments in the economy can be divided into three periods: 1987-1995, 1995-1999, and 1999-2003. During the initial period, real (i.e. inflation adjusted) GDP grew at an AAGR of 3.9% (see Figure 1.3) with a modest government contribution of 1.4% per year and private sector growth of 6.5%, although without significant growth in exports. The FY1992 step-down was relatively painless as expenditures had not fully adjusted upward to available funding levels. In addition borrowings against future Compact flows for public enterprise fisheries sector investment enabled expenditure levels to

[1] This section is largely based on *Economic Developments: 1987-2003*, a draft chapter of the forthcoming FSM Strategic Development Plan, prepared by the Department of Economic Affairs in December 2003 (GoFSM, 2003). More recently, the ADB (2004) estimated real growth in 2003 of only 0.1%, not 0.8% as shown in Figure 1.3.

be maintained through much of the second five-year period of Compact assistance. However, the second step-down in FY1997 was larger in magnitude and required painful adjustment. Supported by an Asian Development Bank (ADB) Public Sector Reform Program (PSRP) loan, an Early Retirement Program reduced the public service work force by 23% (against a target of 27%) and the wage bill by 29% (target of 35%). The PSRP helped avoid a potentially destabilizing financial situation, with Compact revenue and expenditure balanced by the end of FY1998. However, the adjustments had a significant economic impact, with real GDP declining by 3.9% annually between FY1995 and FY1999.

The shock imposed by the second step-down in Compact funding was exacerbated by events in Chuuk State, where poor fiscal management and increasing expenditure overruns led to arrears to domestic and international creditors, and undermined economic stability. By FY2000 the Chuuk crisis was resolved for a time and GDP grew by 9.6%, further buoyed by airport reconstruction in Chuuk. However, state GDP grew at an AAGR of only 0.5% from FY2000-2003. With pending Compact negotiations, the resulting uncertainty in the medium term, and the return of financial crisis in Chuuk, the private sector took a "wait and see" attitude regarding investment.

Overall, from Independence through FY2003, the private sector grew at an AAGR of 2.9% and GDP by 1.6%, a low rate of economic growth but broadly consistent with other Pacific Island Countries (PICs). The national FSM Department of Economic Affairs (DOEA) draws two lessons from economic experience during the original Compact period: 1) economic growth supported by large government is not sustainable; impetus for growth must lie with the private sector; and 2) despite inheritance of a weak policy regime and a poorly-designed Compact, resulting in recurring shocks and a continuing reduction in demand through the first 15 years, the private sector has demonstrated capacity for economic growth.

As shown in Table 1.4, the FSM is signatory to the three Pacific regional trade and economic trade agreements, the most important of which are the Pacific Islands Trade Agreement (PICTA) and the Pacific Agreement on Closer Economic Relations (PACER; between PICTA signatories and Australia and New Zealand). The GoFSM has also signed the Cotonou Agreement, providing membership in the African Caribbean Pacific (ACP) group of countries, and thus access to further development assistance from the European Union. In 2003, the government endorsed the funding proposal for the new Pacific ACP states that provides 4.08 million Euro (approximately US$5 million) for renewable energy development through the four state electric power utilities under the ninth European Development Fund (EDF).

Table 1.4: FSM and Regional Economic Treaties

Status	SPARTECA	PACER	PICTA
Signed	–	no	no
Ratified	29 Nov 1988	no	no
Entered into force	29 Dec 1988	03 Oct 2002	13 April 2003

Source: Source: Discussions with Pacific Islands Forum Secretariat, late 2003

1.5.2 The state economies

The FSM is a federation with considerable state autonomy. As shown in table 1.5 Pohnpei, with the national government, accounts for only 32% of FSM's population but 45% of GDP. Chuuk, with half of the population has 30% of GDP. Economic performance has varied considerably (Table 1.6), partly reflecting differences in policies and responses to external developments. Pohnpei and Yap grew the most rapidly at 2% per annum from FY1987-2003. In Kosrae, GDP grew at a modest 0.6% per year, with Chuuk only marginally better at 0.7%.

Table 1.5: % of Population and GDP by State, 2003

State	GDP	Population
Pohnpei	45%	32%
Chuuk	30%	50%
Yap	17%	11%
Kosrae	9%	7%

Sources: ADB, 2004 and 2000 Census

Table 1.6: Average Real GDP Growth by State and Economic Sector [1]												
State	Full Compact Period FY1987-FY2003			Early Compact Period FY1987-FY1995			Adjustment Period FY1995-FY1999			Final Compact Period FY1999-FY2003		
	GDP	Gov	Prv[3]	GDP	Gov	Prv[3]	GDP	Gov	Prv[3]	GDP	Gov	Prv[3]
Chuuk	0.7	-1.3	1.8	2.5	1.6	4.2	-6.0	-12.3	-7.8	4.0	4.6	7.5
Kosrae	0.6	-0.6	0.5	1.6	-0.6	0.2	-2.8	-6.3	-1.0	2.0	5.5	2.4
Pohnpei[2]	2.2	0.2	3.2	5.4	2.3	8.7	-4.4	-4.4	-7.0	2.6	0.9	3.1
Yap	2.4	-1.3	5.8	3.8	-0.5	8.9	1.0	-6.5	4.7	1.1	2.6	1.0
FSM	*1.6*	*-0.6*	*2.9*	*3.9*	*1.4*	*6.5*	*-3.9*	*-7.4*	*-4.6*	*2.7*	*2.7*	*3.7*

Source: Economic Developments: 1987-2003 (draft; GoFSM, 2003)

Notes 1) Growth rates computed using end points. 2) Pohnpei inclusive of national government.
3) Private Sector, excludes public enterprises, NGOs, and households

Yap had the highest economic growth in FSM during the original Compact period. The state also achieved the best outcome in the PSRP, meeting its targets and anticipated cost-savings. Yap state government has been fiscally prudent, opting to set aside rather than spend the "bump up" funds. However, economic performance during the last four years of the Compact was disappointing, reflecting the inability of the private sector to sustain growth and poor results of the state-owned purse seining company. Chuuk has suffered from several financial crises and has not yet made the adjustments necessary to repay debts, which were equivalent to 30% of state GDP at the height of the crisis in FY1996. Large inflows of funds to assist Chuuk recover from Typhoon Chata'an in 2003 helped stimulate economic growth. In Pohnpei, substantial investment in unprofitable public enterprises contributed for a time to economic stagnation. Recently, fiscal policy has been moderate, and the state economy has benefited from a return of private investment. Kosrae, the smallest and most remote state and with limited natural resources, is the most dependent of FSM's states on public sector activity and has failed to generate a buoyant private sector. In FY2003, Kosrae embarked on an expansionary fiscal policy, rapidly expanding the public sector and stimulating the economy, but only temporarily.

Table 1.7 shows GDP per capita at the beginning and end of the first Compact for the FSM overall and the states. Some differences are due to the structure of the Compact and larger per capita shares for the smaller states. However, much reflects state policies and performance. In FY1987 Yap's per capita income was double that of Chuuk and similar to those of Pohnpei and Kosrae. By 2003, per capita income in Yap was nearly 2.5 times the level of Chuuk and a third greater than Kosrae. Over the period, real per capita income grew by about 15% in Pohnpei and 27% in Yap but declined by nearly 6% in Chuuk and 10% in Kosrae. Annual improvements in Pohnpei and Yap averaged 0.9% and 1.5% respectively.

Table 1.7: Real GDP Per Capita (US$ 1998 Constant Prices)				
State	FY1987	FY2003	Growth FY1987-2003	AAGR FY1987-2003
Chuuk	1,255	1,182	- 5.8%	- 0.4%
Kosrae	2,551	2,307	- 9.6%	- 0.6%
Pohnpei	2,358	2,718	15.3%	0.9%
Yap	2,464	3,133	27.1%	1.5%
FSM	*1,829*	*1,966*	*7.5%*	*0.5%*

Source: Economic Developments: 1987-2003 (draft; GoFSM, 2003)

1.5.3 Millennium development goals

In September 2000, FSM was among 147 countries which adopted the Millennium Development Goals (MDGs), a set of monitorable targets with measurable indicators, to assess development progress. In 2003, the ADB reported on the progress of its PIC members toward meeting MDGs and concluded that FSM:

"Shows little progress towards meeting the MDGs by 2015. Poverty incidence is estimated to be high with approximately 40% of the population falling below the national poverty line in 1998 and there are signs of increasing inequalities. One of the key issues is delivery of basic social services, which often fail to reach the poorer strata of society, the outer islands and rural areas. There are significant differences in the poverty situation between the various states but little disaggregated data is available. FSM not only faces the challenge of increasing enrolment rates at all levels but also of improving the quality of education, retention rates and access in the outer islands. FSM has poor health indicators. Although maternal mortality rates have fallen significantly, FSM still has a relatively high maternal mortality rate and a rapidly increasing incidence of non-communicable diseases. Child mortality rates have decreased slightly. Available data suggest that only 41% of the population has access to an improved water source and about 45% to improved sanitation." (ADB, 2003)

1.5.4 Future development and economic growth

The government's internal economic review (GoFSM, 2003) expresses concern about the impacts of economic declines since the second Compact step-down, which resulted in large-scale migration to the USA to seek employment. In the short-run, migration improves average incomes for those remaining. However, migration will reduce the long-run productive potential of the FSM economy if, as seems to be the case, migrants are mainly those who are economically skilled and active.

The new 2004-2023 Compact agreement provides the FSM with grants of $76.2 million per year and Trust Fund contributions of $16 million per year from FY2004-2006, about $850 per capita excluding various other US federal funds that FSM can access. Thereafter, grants drop by $0.8m per year as US contributions to the Trust Fund increase by the same amount plus partial adjustments for inflation. Despite the decline in grants, Compact funding will continue to dominate the FSM economy and provide a large percentage of funding for infrastructure. The GoFSM is required to prepare and maintain an official overall strategic national development plan which is to be continuously reviewed and updated through the annual budget process. It is hoped by the GoFSM that the periods of shock experienced during the first Compact period will be reduced by the steady annual declines in funding levels (rather than several steep step-downs), the steadily growing Trust Fund, and the more stringent rules regarding expenditures and monitoring.

The ADB (2004) has estimated real GDP growth of only 0.1% in FY2003 with considerable variation by state, expects a decline of 1.5% in 2004 as FSM adjusts to the new Compact, and projects moderate growth of 2.2% in 2005. According to the ADB:

"Over the long term, the five FSM governments face the major fiscal challenges of managing the adjustment to the decline in sector grants and of placing government revenues on a sustainable basis. In FY2007, the reduction in real official transfers is estimated to be equivalent to 0.6% of GDP, and the national Government's economic modeling suggests that during the amended Compact period a compensatory rise in taxation revenues from the present level of about 12% of GDP to over 16% is needed. A comprehensive reform of taxation and tax collection is required but faces strong opposition. Sizable budget surpluses will be needed into the future to build up the Compact Trust Fund to the required level, with the completion of contributions to the fund scheduled for 2004 representing a major initial test of the national and state governments' commitment."

1.5.5 Investment and banking

Following the withdrawal of the Bank of Hawaii in late 2002, only two commercial banks operate in the FSM. Total deposits in commercial banks at the end of FY2003 were 7% higher than the previous year. Commercial loans fell by 52% as the banks restricted lending in response to accumulating arrears on commercial loan repayments, reflecting deterioration in the timeliness of both state and national government payments. Consumer lending fell by 23% because of a similar arrears problem and declining government employment levels. According to the International Monetary Fund (IMF, 2003), the banking system in the FSM is well regulated and supervised.

1.6 Institutional and Legal Arrangements for Energy

1.6.1 National energy planning

For about ten years from the 1981 there was a national energy planner position within the federal government, initially financed by the US Department of Energy (USDOE). From the early to mid-1990s there was also a petroleum advisor who advised the national and state governments on fuel contractual and pricing matters. There is no longer a national energy planning position, apparently as Congress felt that energy should be addressed and coordinated primarily at the state level. That means that each state must somehow maintain the capacity for energy tariff analysis and development, preparing standards for renewable energy system specification and operations, preparing operational and safety standards for electric supply systems, doing project development and the economic analysis of energy development proposals. Donors also must deal with each state individually making project management more difficult and expensive.

From the late 1990s to mid- 2004, national energy matters were being handled as a low priority matter on a part-time, *ad hoc* basis by staff of the DoEA.[2] There is no clear energy sector role for DoEA and no formal links between the DoEA and the four states on energy matters.

1.6.2 State energy planning

The USDOE also financed an energy planner for about a decade within each state from 1981, primarily to coordinate USDOE's own activities. By 1992, USDOE funding had been discontinued. The energy planning position was left vacant in Chuuk, was abolished in Yap, and continued for a time in Kosrae. Despite the loss of specific energy planning positions, Yap, Chuuk and Kosrae have government staff dealing part time with energy matters, generally within a planning agency and/or the state electric power utility.

Pohnpei continues to have the positions of Chief of Energy and Energy Technician. However, they do not have energy planning responsibility beyond renewable energy implementation. The energy office has no responsibility for regulating or regarding the development of the conventional energy systems that provide over 99% of Pohnpei's energy use. They do have responsibility for doing solar installations, renewable energy proposals and the technical support of renewable energy projects. Even in that limited areas of responsibility, budgetary restrictions has limited the ability of the Pohnpei energy office to implement and support renewable energy projects.

---

[2] The official who dealt with energy issues in the late 1990s estimates that he spent only 2% of his time on energy matters (source: draft National Energy Policy, GoFSM, 1999).

1.6.3 Electric power

Each state has a state-owned and controlled power utility, established in the late 1980s shortly after independence, all of which inherited the power generation and transmission networks of the respective public works departments. Compact funds have been the main source of funding for both capital replacement and system expansion. There is no national utility and no national standards, utility laws or regulation of the management, finances or technical performance of the utilities.

In the early 1990s, the US Department of Interior (USDOI) assisted the utilities to evolve into state-owned corporations through its Operation and Maintenance Improvement Program (OMIP). The Chuuk and Yap utilities were corporatised in 1995-1996 respectively, Kosrae and Pohnpei slightly later. In 2004, the Kosrae, Pohnpei and Yap utilities operate semi-autonomously but still rely on the state government to cover deficits. In Chuuk, the utility is more heavily subsidized than elsewhere as revenue collection is low. All utilities except Kosrae are also responsible for water and sewerage, which are provided below cost and subsidized by electric power operations, imposing serious financial burdens. The government-appointed boards of directors generally include some private sector representation. The power utilities have state wide mandates but provide services primarily to the main island or islands, although some have involvement in more remote islands. Table 1.8 summarizes the arrangements in each state.

Table 1.8: Electric Power Responsibilities in FSM

State	Chuuk	Kosrae	Pohnpei	Yap
Utility	Chuuk Public Utilities Corporation (CPUC)	Kosrae Utilities Authority (KUA)	Pohnpei Utilities Corporation (PUC)	Yap State Public Service Corporation (YSPSC).
Structure	Corporatised	Corporatised	Corporatised	Corporatised
Responsibility	Power, water, sewerage	Power	Power, water, sewerage	Power, water, sewerage and solid waste
Main coverage	Weno and Tonoas	Kosrae state	Pohnpei island	Yap Proper (4 islands)
Comment	15 of 17 inhabited islands in Chuuk lagoon have no electric power	Single island with power extending to most areas	Limited electrification away from Pohnpei island	Several communities in Ulithi and Woleai atolls have limited electric power

Source: FSM Infrastructure Development Plan: FY2003-17 (GoFSM, 2002)
Notes: corporatised = state-owned corporations

1.6.4 Petroleum

Refined petroleum products are supplied to Chuuk, Yap and Pohnpei by Mobil Oil Micronesian Islands (MOMI) from Guam. Mobil owns bulk fuel storage facilities in these three states. Kosrae is supplied by the Kosrae state-owned Micronesia Petroleum Corporation (MPC) which operates a bulk terminal. MPC also has small bulk storage facilities in Yap where it competes with MOMI. There is no control of the wholesale or retail prices of petroleum fuels in FSM except in Kosrae where price increases of fuel supplied for use in the state by the MPC must be approved by the governor and legislature. Although there is no national ministry formally responsible for petroleum supply, in June 2004 the DoEA was directed to look into the contractual terms of supply of MOMI.[3]

[3] In May 2004, the FSM Economic Policy Implementation Council (EPIC) resolved to "further negotiation of the FSM's fuel supply contract with Mobil. The EPIC directed the formation of a high-level negotiation team to facilitate the negotiations."

1.6.5 Energy policy

There is no formal national energy policy but various policy statements appear in GoFSM reports. The *National Climate Action Plan* (GoFSM, 1997) aims to "continue to promote renewable energy alternatives, especially solar PV power in the outer islands and other insular areas of the nation" but this is only a "suggested mitigation measure" to reduce greenhouse gas (GHG) emissions. Perhaps more important is the statement of then-President Falcam before the United Nations General Assembly in September 2002 regarding FSM's commitment to replace fossil fuels:

"We have become far too dependent on imports of fossil fuels during the past half-century; even so, our contribution to global emissions of greenhouse gases is negligible. Looking to the future, we have committed to a reduction and eventual elimination of fossil fuel for energy production. But we must rely on western technologies if we are to move in the direction of renewable sources of energy. Thus, we are disturbed by the policies of developed countries that give little more than lip service to development of renewable energy technologies."

The DoEA has prepared a draft National Energy Policy (GoFSM, 1999) and held workshops and meetings to discuss it, but there has apparently been no work to further develop or finalize it since 2000. The overall objective is to promote sustainable social and economic development through cost effective, safe, reliable and sustainable energy services. According to the *National Assessment Report* prepared for the World Summit on Sustainable Development (WSSD) (GoFSM, 2002j), five areas have been identified through the draft energy plan and other GoFSM deliberations where energy policies – and related strategies, programs and activities – are needed, and are required to be implemented: 1) an effective and coordinated energy sector; 2) safe, reliable, cost effective and sustainable energy supply; 3) restructuring the power utilities and petroleum industry and promotion of energy service companies; 4) diversification of FSM's energy resource base; and 5) environmentally appropriate and efficient use of energy. These are all reasonable, if vague, aspirations.

The draft energy plan identifies four areas of constraints and deficiencies which need to be addressed before an effective sustainable energy program can be developed and implemented.

1. Institutional issues:
    - a relatively small but fragmented energy sector;
    - an environment not conducive to competition and private sector participation;
    - absence of effective oversight and coordinating mechanisms between the governments and between energy sector partners; and
    - insufficient capacity at all government levels to coordinate, plan and manage energy sector activities.
2. Power sector:
    - highly subsidized power sector operation; and
    - absence of any standardized technical and operational procedures.
3. Petroleum supply and pricing:
    - limited competition for the supply of petroleum fuels and products;
    - fuel and lubricant supply companies should take responsibility for collection, removal and disposal of used and waste petroleum products; and

- oil companies should ensure that adequate fire fighting capability is available in terminals and the general community to cope with worst-case disaster scenario.

4. Renewable energy:
    - existing solar electrification programs are not sustainable;
    - absence of any long-term experience with renewable energy; and
    - lack of monitoring of the nation's renewable energy potential.

The draft plan adequately identifies the key areas which need to be further addressed.

From about 2000-2002, the Washington Cooperative Extension Energy Program *"conducted an energy efficiency program development initiative and assisted in the development of a sustainable energy strategy for Micronesia. Washington officials have worked with officials in Micronesia for about two years on clean energy projects and efficiency aspects of electricity production and transmission."* This was carried out through the National Association of State Energy Offices (NASEO). No further information on any energy programs or strategy developed with NASEO or other assistance is available to the PIREP team.[4]

1.6.6 Energy policies at the state level

The *Kosrae State Action Plan 2003-2007* (GoK, 2002) includes 'Policy and Strategy Number 3, reduced petroleum dependence." Within the plan, KUA is mandated to " *encourage use of solar and other alternative energy sources; and b) encourage energy conservation programs …"* There is apparently no budget or specific activities. Other states may have plans containing similar statements of intent but the team has not seen them.

1.6.7 Energy related legislation and legal tools

There is no national legislation regarding electricity production or use and no statutes specifying petroleum fuel quality, its storage, transport and disposal. In general energy sector legislation is considered and enacted at state level.

- *Public utilities (Yap).* Yap State Code Title 14 Public Utilities established the Yap State Public Service Corporation which is headed by a board of seven directors, at least two of whom are to be from the private sector and two from outer islands, appointed by the Governor with state legislature approval. There is provision to encourage the efficient use of electricity: *"The rate schedule for each category of utility consumption shall be uniform within each island, except that the schedule may provide for increasing marginal rates as the consumption of a person increases."* The tariff can be revised annually, can include a separate fuel adjustment charge, and is supposed to meet the full costs of supply: YSPSC *"shall charge all consumers an amount at least equal to the marginal costs of providing them utility services."* It is not clear whether YSPSC has the sole right of electricity supply in the state.
- *Public utilities (Kosrae).* Chapter 12 of Kosrae state law established the Kosrae Utilities Authority *"to provide to the public electric power" and "operate and manage the State's electric power, on the basis of commercially accepted practices."* There are four directors appointed by the governor with the advice and consent of the

[4] The information is from *State and Territory Energy Office Clean Energy Peer Exchange Partnerships—Market-Based Solutions to Sustainability and Export Promotion* (NASEO, 2003) from www.naseo.org.

legislature. There is no discussion of tariffs or tariff policy. KUA is exempt from taxes. It is not clear whether KUA has the sole right of electricity supply in the state.

- *Public utilities (Pohnpei and Chuuk)*. Legislation for the other two state utilities is not available on-line and has not been seen by the PIREP consultants Both are understood to be broadly similar to Chuuk and Kosrae.

- *Petroleum (Kosrae)*. Kosrae State Law 13 established the Micronesia Petroleum Corporation that is responsible for operating, expanding and improving the state-owned fuel storage facilities, buying and selling petroleum products, and transporting fuel to and from Kosrae and other locations in the Pacific region. There are five appointed board members nominated by the governor, with the advice and consent of the Legislature. MPC can increase the cost of diesel fuel or gasoline sold for domestic use in Kosrae *"only after exhaustive consultations with the governor and Legislature, and they have concluded that such increases are not unreasonably high, restrictive or discriminatory due to the abuse of the corporation's dominant position in the industry."* There is a maximum fuel charge for the KUA, the actual purchase price for the fuel at the refinery plus $0.40 per gallon. There is no control of aviation fuel pricing.

- *Environment (national)*. According to the newly agreed revised Compact, *"the Government of the United States ...shall apply the National Environmental Policy Act of 1969, 83 Stat. 852, 42 U.S.C. 4321 et seq., to its activities under the Compact, as amended, and its related agreements as if the Federated States of Micronesia were the United States. ... The Federated States of Micronesia, taking into account its particular environment, shall continue to develop and implement standards for environmental protection substantively similar to those required of the Government of the United States."* According to the FSM report to the WSSD (GoFSM, 2002i), *"the regulatory responsibility for the management of the environment within the nation has been unclear in the past and has been a source of confusion between the national and state governments. This confusion has lead to jurisdiction disputes, lack of cooperation and poor environmental management in some circumstances. Recently, both regulatory and departmental confusions have been discussed and the nation has made clear progress to coordinate programs to encourage sustainable development and management of the environment."* There are no apparent national regulations that would affect energy use.

- *Environment* (Yap). The Yap State Code Title 18, Conservation and Resources, includes chapter 14: Environmental Quality Protection. It establishes a Yap State Environmental Protection Agency which can require permits for activities which may result in the discharge of any pollutant and requires Environmental Impact statements for development proposals. There are no specific requirements for energy sector investments.

- *Environment* (Chuuk). The Chuuk Sate Code, Title 22, Environmental Protection and Preservation, Chapter 1 is the Chuuk State Environmental Protection Act. It establishes a Chuuk State Environmental Protection Agency which can regulate pollution discharge and require Environmental Impact statements for development proposals. There are no specific requirements for energy sector investments

- *Environment* (Kosrae). The Kosrae State Code Title 11, Land and Environment, Chapter 13, Protection of Environment deals with waste management.

1.6.8 Interministerial Energy Committees

There is no permanent interdepartmental or interministerial energy committee. Temporary or *ad hoc* committees linked to particular donor-funded activity have been established to deal with issues with a strong energy component, e.g. climate change through the Global Environment Facility (GEF) / SPREP Pacific Islands Climate Change Assistance Programme (PICCAP) and currently PIREP.

A Sustainable Development Council (SDC) was established in the mid-1990s, chaired by the vice- president with representatives from each state plus nine national government departments and agencies. The SD Council includes energy topics as they relate to sustainable development. The Council is active, meeting monthly, and is an advisory council to the president on all sustainable development activities in the FSM. The Council discusses current energy projects, such as the ACP/EU Cotonou Agreement project, Draft Energy policy, the new SOPAC PIEPSAPP project and other energy related topics that relate to sustainable development.

2 Energy Overview: Supply, Demand and the GHG Inventory

2.1 Energy Supply and Demand

The FSM is overwhelmingly dependent on imported petroleum fuels for commercial energy used for transport, electricity, business and households. Hydropower has been a minor contributor. Biomass is widely used for cooking but is a smaller component of energy supply than in many PICs. Approximately 86% of gross energy supply is from petroleum and 14% from biomass. The Nanpil hydro system previously provided several per cent of electricity supply but is not currently operating. Solar energy provides well under 1% of the total.

2.1.1 Petroleum

The most recent overall national energy sector assessment for the FSM is the joint World Bank, United Nations Development Programme (UNDP), PIFS and ADB Pacific Regional Energy Assessment (PREA, 1992) which predicted that petroleum fuel use would grow at an AAGR rate of 4.7% from 1990-2000. Actual growth from 1990 -2002 has been far lower.

The GoFSM has not routinely collected or analyzed data on petroleum fuel imports and data from individual states are not available by product. According to DoEA, reliable data on the volume and value of fuel imports are unavailable for the period 1991-2000. Therefore, it is not possible to provide any useful information on trends in fuel use over time. However, customs data does provide dollar value of imports that allow rough estimates for 2000 - 2002 by product and by state as are summarized in Table 2.2. In 1990, Chuuk and Pohnpei accounted for about 37% each of petroleum fuel imports, followed by Yap (17%) and Kosrae (9%). Little change was seen in 2002 with, Chuuk at 39% followed by Pohnpei (34%), Yap (15%) and Kosrae (12%). The total volume of petroleum imported in 2002 appears little different from that estimated by PREA for 1990.

Table 2.2-Megaliters of petroleum imports

Product	2000	2001	2002
Chuuk			
Gasoline	6.85	8.70	8.61
Jet Fuel/Kero	2.64	3.25	3.32
Diesel	10.19	8.03	8.94
LPG	0.00	0.08	0.09
Kosrae			
Gasoline	1.19	2.73	2.20
Jet Fuel/Kero	1.17	1.46	1.17
Diesel	3.07	4.50	2.67
LPG	0.01	0.00	0.00
Pohnpei			
Gasoline	5.46	11.17	7.15
Jet Fuel/Kero	2.94	1.88	1.90
Diesel	11.99	15.24	8.83
LPG	1.91	0.10	0.19
Yap			
Gasoline	2.34	1.64	1.93
Jet Fuel/Kero	1.34	1.66	0.71
Diesel	6.20	6.58	4.74
LPG	0.16	0.68	0.67

Source – Volume estimated from dollar value of imports shown by FSM customs data. Accuracy is dubious, figures are indicative only.

Liquid Petroleum Gas (LPG) is imported from Guam and distributed in Pohnpei (with minor sales to Kosrae) by Pohnpei LP Gas Distribution Company. The annual volume for Pohnpei is about 191 kilolitres.[5] Yap imports around 670 kl with Chuuk importing only about 90kl. Less than 2% of households cook with LPG (Table 2.3). The main LPG consumers are households, restaurants and fishing fleets.

In 1992, the PREA concluded that the landed prices of petroleum fuels were reasonable for the FSM considering the small market. However, there was some concern regarding the ineffective contracting, contract implementation and price monitoring. Retail prices, especially of gasoline) were quite high compared to some other PICs because of very high

[5] According to the chief executive, Mr Willy Hawley, LPG imports have been fairly steady for some years: nine 5,600 US gallon tanks per year.

retail margins (four times as high as those in Fiji, for example). The PREA recommended a national tender for fuel that would consolidate the volumes imported by each state into a larger volume that should result in considerable savings. Although the PIFS prepares a regular fuel price monitor with information on landed, wholesale and retail fuel prices (including and excluding taxes and duties) and price trends, as shown in Figure 2.1, this does not include FSM which presumably has not provided the requisite information to PIFS. Accordingly, the PIREP team cannot comment on prices of petroleum fuels and LPG in FSM relative to other PICs. Similarly, there is insufficient information to judge the success of the MPC in financial terms.

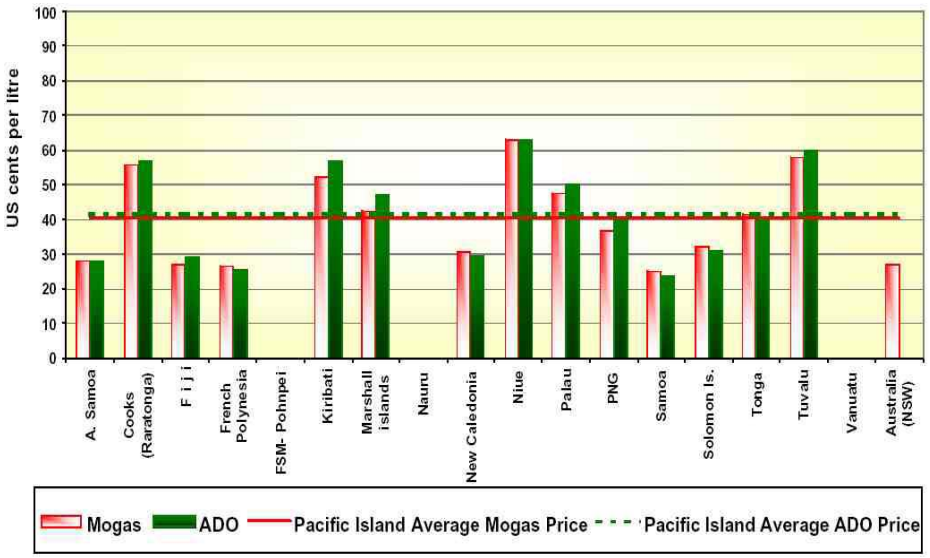


Figure 2.1: PIC Wholesale Petrol & ADO Prices (excluding import duties and taxes; Nov/Dec.03)

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

2.1.2 Biomass and household energy

According to the *National Assessment Report* prepared for the WSSD (GoFSM, 2002j), *" Traditionally, energy requirements of the nation were limited and restricted to wood; wood products and other vegetable matter to fire household cooking needs. The utilization of wood from forests is a nationwide concern and management plans are being developed that limit the area and amount of wood that can be cleared for such purposes. Special restrictions are being developed on the use of mangrove and remaining native forests."* The 1992 PREA estimated that in 1990 only 20% of FSM households cooked entirely or primarily with biomass, cooking accounting for 4,100 tonnes of oil equivalent (toe) of a total 6,100 toe of biomass energy, or about 11% of total energy supply.[6]

[6] From Annex 1 (Statistical Tables), the PREA assumed 1.6 kg/household per day of biomass for cooking x 20% x 100,789 people or 11,772 tonnes of biomass. Of this, 20% (2,335 tonnes) was assumed to be wood at an energy content of 0.42 toe/t and 80% (9419 tonnes) was assumed to be coconut husk and shell at an average energy content of 0.33 toe/t for a total of 4100 toe for cooking. It was also assumed that 2,500 tonnes of copra required 2.4 tonnes of husk/shell for open air drying, an additional 1,980 toe of biomass for a total of 6,080 toe. The biomass energy conversions used by PREA are the same as those of Annex 2 of this report. The biomass used for cooking was based on surveys carried out in the 1980s in other PICs, not the FSM.

As far as the PIREP team is aware, there have been no surveys of household energy use in the FSM. The 2000 national census did, however, report on household energy use for cooking. As shown in Table 2.3, over 50% of all households reported that their main cooking fuel was wood (presumably including other biomass), either burned in fires or wood stoves,[7] ranging from a low of 8% in Kosrae to a high of 71% in Chuuk. Assuming that those who cook with biomass require the same amount of fuel on a per capita basis as the PREA estimated a decade earlier, about 12,000 toe of biomass were required in 2000 for energy use.[8] It seems likely that the 1990 PREA, which had no access to recent census data, may have underestimated the percentage of FSM households which cooked with wood or other biomass, and consequently underestimated the contribution of biomass to overall energy supply and use.

Table: 2.3: Household Energy Use for Cooking (%, 2000)

Energy Source	Total	Yap	Chuuk	Pohnpei	Kosrae
Electricity	7.2	7.3	3.5	9.4	15.3
Kerosene	33.6	37.6	21.9	38.8	74.0
LP Gas	1.7	3.3	0.7	2.6	0.3
Microwave only	0.6	0.6	0.3	0.9	0.9
Wood / biomass	51.4	47.0	70.5	38.4	8.0
of which, stove	10.9	1.5	8.0	18.8	2.5
of which, fire	40.5	45.5	62.5	19.6	5.5
Other	1.2	0.3	1.8	0.9	0.1
None	4.2	2.6	1.1	8.9	0.1
Total (rounded)	99.9	98.7	99.8	99.9	98.7

Source: 2000 national census

2.1.3 Electricity supply

There are electric power systems on the principal islands of all four FSM states, and much smaller systems on some outer islands of Chuuk and Yap states.

Pohnpei

The Pohnpei Utilities Corporation (PUC) is the largest power utility in FSM. PUC has a number of diesel plants at Nanpohnmal 8 km from Kolonia, a hydropower plant at Nanpil (not presently operational) and a barge with old diesel plants that have not been operational for some years. At Nanpohnmal there are six Caterpillar generators installed in 1978 and 1989 with a total installed capacity of 5.79 MW (derated capacity 4.89 MW) and four newer Daihatsu units installed between 1992 and 1994, with a rated and effective capacity of 10 MW (2.5 MW each). The hydro plant has two generators with a combined capacity of 2.06 MW but hydro is not currently operational due to penstock problems. The power distribution system reaches nearly all inhabited areas of the main island. At the time of the census in April 2000, 63% of the state's households were connected to the PUC grid. It is understood that a new 8 MW diesel power plant facility is being developed in Dekehtik that includes a fuel farm and a 4 MW waste oil recycling plant.

Yap

The Yap State Public Service Corporation (YSPSC) serves the four closely grouped islands that includes Yap Island (called Yap Proper as opposed to Yap State). YSPSC has four operational generators rated at 7.9 MW (derated to 7.6 MW): two 3.2 MW Deutz generators

[7] Of 17,299 households, 31% reported indoor kitchens and of these 4.4% cooked with a wood stove or open fire. 65% reportedly had outdoor kitchens and of these 65% cooked with wood, mostly on open fires. (4% of households reported that they had no kitchen facilities. The total percentage of those cooking with wood (i.e. biomass) was 51.4%. See Table 2.3. The source is Table H04 of the national census report.

[8] 51.4% x 107,008 x 1.6 kg/capita/day x 365 days = 32,121 tonnes. If cooking fuel consists of 20% wood and 80% coconut waste, it accounted for 11,178 toe. Assuming (Coconut Development Authority, 2002), about 600 tonnes of copra, this would add 480 toe for copra drying for a total of 11,658 toe. This may well be an underestimate as the ratio of 20% wood and 80% waste coconut husk and shell seems to underestimate the percentage accounted for by wood.

installed in 1995 and two 0.75 MW White Superior (0.6 MW derated). Usually only one Deutz generator is required with one White Superior to meet the peak demand of about 3 MW (between 1800 and 2100 hours). YSPSC also has two 1970s ALCO generators and two 0.8 MW Caterpillars, all of which have been out of operation since 1996. The distribution network reaches 98% of the Yap Proper population. In 2000, 57% of Yap State's households were electrified by YSPC.

Four islets of the 49 at Ulithi Atoll, located 160 km northeast of Yap island, are inhabited. Two, Falalop and Mogmog, have diesel generators. Falalop's three Deutz generators have a combined capacity of 475 kW and were installed in September 2000. The peak demand is 85 kW at night and 72 kW during the daytime. Mogmog's two Deutz 25 kW generators were also installed in September 2000, and the peak is only 12 kW. Woleai Atoll east of Yap Proper has 22 islets of which five are inhabited. There are two Caterpillar generators of 180 kW and 80 kW generating capacity. It is not known if the smaller system is functioning. Peak demand is about 80 kW.

The YSPSC has consistently operated at a loss with billed revenues of about $2.7 million but operational costs about $3.1 million. With the increased diesel fuel cost, the operating cost is rising and a shift to a tariff that includes a fuel cost adjustment is being proposed. YSPSC provides water, sewage and sold waste disposal services as well as electricity and wishes to separate the functions, making each of them a separate cost center that has charges sufficient to meet all costs.

Chuuk

The Chuuk Public Utilities Corporation (CPUC) serves the main island of Weno. There are four Caterpillar generators, three rated at 2.0 MW (derated to 1.5 MW) and a 0.8 MW unit (derated to 0.5 MW). Total effective capacity is 5.0 MW. Peak demand is 4 MW and base load is 2.9 MW. Because of the small margin of effective capacity over peak load, all four generators operate about 6,000 hours per year resulting in frequent outages. In 2000, only 19% of the state's households were electrified through CPUC. There have been proposals to electrify the outer islands through a combination of underway cables, small diesel systems and solar photovoltaics.

Tonoas Island in Chuuk lagoon has a 250 kW Cummins generator which operates from 1800 to 0600 hours, a 50 kW back-up system, and a 125 kW system which has apparently been out of operation for some years. Although the circumferential distribution system could serve most households, many are not connected.

According to current ADB studies,[9] the condition of CPUC's assets is poor, threatening workers and public safety. Staff have done a reasonable job of "making do" to keep operations going but the utility has had chronically insufficient resources for timely maintenance, has reached a crisis in asset management, requires a thorough overhaul of operations and needs much more expenditure on new or rehabilitated plant.

Of the 2150 CPUC electricity consumers in Chuuk in 2003, 52% used conventional meters, 42% pre-paid meters and 6% were unmetered, paying a flat monthly rate of $75 (residential) or $325 (commercial). Commercial customers were only 17% of the total but accounted for half of sales compared to 24% for government and 26% for residential consumers. Charges rose from 10 US cents per kilowatt hour (kWh) in the mid-1990s to 17-21¢ in 2003. In 2002 revenue (including grants) probably covered CPUC's electricity supply and distribution costs

[9] The source is discussions with ADB consultants working in Chuuk and Kosrae , March 2004.

but there were large losses for water supply and both maintenance and investment were badly neglected. The utility received an annual Compact energy grant[10] of about $1 million from FY1988 through 2002, without which the electricity operations of the utility would have had a loss equivalent to about ¼ of its revenue. CPUC will require a significant tariff increase to cover costs, improve safety and maintenance, and invest in badly needed new equipment.

Kosrae

The Kosrae Utilities Authority (KUA) at Tofol has six Caterpillar generators, four 0.74 MW units, one 1.5 MW and one 1.65 MW. The two largest were installed in 1996 (1.65 MW) and 1990 (1.5 MW) and have not been derated. The older generators have been derated so total effective capacity is 5.4 MW. Peak load is 1.2 MW and base load is just 0.7 MW so KUA operates the two largest units on a three-months-on/three-months-off cycle. The distribution system extends along the circumferential road, reaching most of Kosrae except the village of Walung. Ninety eight percent of all Kosrae households were electrified through the grid in 2000.

Table 2.4: Electric Power Overview in FSM (latest year available)

Indicator	Chuuk (2003)	Kosrae (2001)	Pohnpei (2003)	Yap (2001)
State Utility	CPUC	KUA	PUC	YSPSC
Source of electricity *	Diesel	Diesel	Diesel, hydro	Diesel
Effective Capacity (MW)	5.0	5.4	7.55	7.6
Peak demand (MW)	4.2	1.5 in '03	6.6	3
Generation (GWh, 1997 or as indicated)	21	7.2 in '03	39.3	18.4
Energy 'sold' (GWh, year indicated)	20.2	7.1 ('00)	37.6	17.4
Generation efficiency in kWh/liter of fuel (2002)	3.7 ('97)	3.6	3.3	3.53
Estimated fuel used (Millions of liters)	5.7	2.0	11.9	5.2
Power bill collection (1997 data, similar today)	61 %	100 %	91 %	100 %

Source: Kosrae data is from KUA and 2002 Statsitcs, Pohnpei data from PUC, Yap data from YSPSC, Chuuk data from CPUC
Note: * Hydro is inoperative at present so 100% of supply is diesel-based. MW = million watts; MWh = MW hours

Table 2.4 summarizes data on the four state electric power utilities. The comparisons should be considered indicative only as data are not up-to-date, sources vary, and the years vary for different indicators. Electrical energy sold (or consumed) in the early part of the millennium is roughly 90 GWh, nearly half of which is accounted for by PUC of Pohnpei. Although the table does not show this, there are no clear generation trends. Generation and sales dropped in all states for several years in the mid-1990s.

KUA appears to be technically sound and financially well managed. 79% of customers are residential (accounting for 43% of kWh sold), 12% are commercial (22%), 7% are state government (21%) and 2% are non-government organizations (NGOs, 9 %). There are seven industrial consumers (5%). In 2003, prepayment-type meters were progressively introduced to households and some small commercial and NGO customers. As a result, there have been dramatic reductions in residential customer arrears. The KUA energy grant of about $0.5 m per year accounted for nearly half of electricity revenues in FY2002 and has been sufficient in recent years to cover operating deficits. Although KUA has accumulated cash reserves, tariffs will have to be raised substantially to eliminate future deficits and maintain reserves for when there is no longer a Compact energy grant.

[10] Section 214 of the Compact specified that FSM would receive a grant of $2 million annually for 14 years commencing on the first anniversary of the effective date of the Compact *"as a contribution to efforts aimed at achieving increased self-sufficiency in energy production."*

Electricity coverage

The PREA (WB et. al., 1992), which put a considerable effort into studying each state's power sector, estimated that only 27% of FSM households were electrified in 1990, rising to 40% for the main islands of each state. However, census data suggest that electrification was far higher, about 51% in 1994, as shown in Table 2.5. Although the percentage of households reporting to be electrified grew modestly between 1994 and 2000, those connected to the state grids decreased slightly, with electrification from solar photovoltaic (PV) systems increasing.

Table 2.5: Household Electrification by Source of Electricity (%; 1980 - 2000)

	FSM Overall:			By State in early 2000:			
Source	**1980**	**1994**	**2000**	**Chuuk**	**Kosrae**	**Pohnpei**	**Yap**
	19.4	*46.4*	*45.7*	19.0	97.8	63.4	56.7
Diesel generator	*8.9*	*4.1*	*4.0*	*8.2*	*2.2*	*0.8*	*0.4*
Solar photovoltaic	–	*0.6*	*3.9*	*5.4*	*0.0*	*3.6*	*1.5*
Total % with electricity	28.3	50.6	53.6	32.6	100.0	67.9	58.6

Source: National Census Report: 2000 FSM Census of Population and Housing *(GoFSM, 2002g)*

Table 2.6 – State utility customer base and tariffs

Characteristic	**Chuuk**	**Kosrae**	**Pohnpei**	**Yap**
residential	1,673	1,163	798	n/a
commercial	372	172	293	n/a
government	105	102	212	n/a
industrial	In commercial	7	3	n/a
other	–	30 NGOs	4261 prepaid meters	n/a
Total	2,150	1,474	5,567	1765
Tariff level (¢/kWh)				
Residential (¢/kWh)	17	8.0 (0-100 kWh) 15.0 (101-1000 kWh) 17.5 (over 1,000 kWh)	10+fuel adjustment	13 0-100 kWh/mo 15 101-1000 kWh 17 1000 or more
Commercial (¢/kWh)	Same as residential	Same as residential	10 + fuel adjustment, $10 minimum	17.0.....(0-5000 kWh) 20.0....(>5000 kWh/mo)
Government (¢/kWh)	21	17.0 (0-1000 kWh) 19.0 (1001-10000 kWh)	Same as commercial	Same as commercial
Large & industrial (¢/kWh)	Same as residential ?	16.0 (0-100 kWh) 17.0 101-999 kWh) 17.5 (over 1,000 kWh)	8 + fuel cost plus $8.10/kVA	Same as commercial
Fuel adjustment?	None	Additional charge		none
Connection (res)	$50 (<100 ft)	$100 (<100 ft)		n/a
Reconnection (res)	$100	$25		n/a
Minimum charge?	No	No	$4.00/month	$2.50/month
Compact energy grant	≈ $1 m	≈ $0.5 m		≈ $0.5 m

Source: Utility discussions, ADB consultants.Note: prepaid meters in Pohnpei are mainly residential.

In 2000, nearly 54% of all households had electrification from some source ranging from 33% in Chuuk, 59% in Yap, 68% in Pohnpei and 100% in Kosrae. Overall, 46% of FSM's households were electrified through the state utility in 2000, varying from a low of 19% in Chuuk to a high of 98% in Kosrae.

2.2 Energy Balance and Greenhouse Gas Emissions

2.2.1 Petroleum

There are no reliable or accessible data to indicate the demand for petroleum products among various economic classifications such as government, commerce and industry, domestic households or transport. Jet fuel is split between aviation use and household kerosene use. Gasoline is used for both ground transport and outboard motor use on boats. Diesel fuel is used for marine and land transport and power generation. LPG is used for both household

cooking and commercial cooking in hotels and restaurants. Thus without sales data from petroleum suppliers, sector use cannot be determined except for the power sector.

The initial *National Communication Prepared Under the United Nations Framework Convention on Climate Change* (draft, GoFSM, 1997), states that the FSM emitted 146.0 Gg of carbon dioxide, presumably in 1994, from the energy sector. There was no estimate of other emissions (N_2O, CH_4, etc.) or their CO_2 equivalent. Because the report contains no information on the volume of petroleum fuel imported or consumed, the 1994 data may not be directly comparable to those estimated in this report.

2.3 Future Growth in Energy Demand and GHGs

Small economies tend to have highly variable economic growth and – as shown in Section 1.5 – this has certainly been the case for FSM since independence. From 1986 - 2003, GDP grew by only 1.6% per annum with considerable variation by state. The ADB anticipates an AAGR in GDP of 1.8% for 2004-2005. Considering the relatively poor performance in meeting MDGs, the likelihood of very low population growth with a high migration rate for skilled workers, and the lack of resolution of Chuuk's debt problems, this study assumes a relatively low growth of about 1.8% per annum over the next decade. From 1990-2002, the rate of growth in commercial energy use appears to have been lower than the rate of economic growth. For the future, in the absence of investment in either renewable energy or energy conservation (i.e. a "business-as-usual" approach), it is assumed that commercial energy use (i.e. petroleum fuels) will grow at about the same rate as the economy. Because energy use data for FSM are incomplete and inaccurate, and recent trends are unclear, there is little point in attempting a detailed projection with differing rates of growth for each fuel. Instead, it is assumed that all petroleum fuels grow by 2% per annum. The results are indicative only but nonetheless provide a reasonable estimate of fuel use and GHG emissions in a decade's time. This is summarized in Table 2.7.

Table 2.7 – Projections of fuel use and GHG production 2002-2012

	2002							2012	
Fuel	**ML**	**KT**	**TOE**	**GHG (tonnes)**	**GHG (Gg)**	**% of GHG**	**AAGR**	**GHG (Gg)**	**% of GHG**
Motor Spirit	20.0	14,599	15,912	50,000	50.0	*36.2%*	2%	60.9	*36.2%*
Jet fuel	7.1	5,635	6,142	18,460	18.5	*13.4%*	2%	22.5	*13.4%*
Distillate Fuel	25.2	21,176	22,871	68,040	68.0	*49.3%*	2%	82.9	*49.2%*
LP Gas	.95	485	567	1520	1.5	*1.1%*	3%	2.0	*1.2%*
Total	*53,250*	*41,895*	*45,492*	*138,020*	*138.0*	*100.0%*		168.4	100.0%

For conversions used in all PIREP reports, see page iv

2.3.1 Opportunities for GHG reduction

The main opportunities for GHG reductions in the FSM are likely to be through hydropower development and improved efficiency of energy use, particularly in electricity generation, transmission and end-use. Even if a transport energy efficiency program were introduced, energy savings would likely be small. It is possible that an energy efficiency effort could reduce petroleum use within the electric power sector by 8% without compromising the quality of services. The electrification of outer islands through solar PV would provide quite modest GHG benefits. Development of biofuel production on a large scale could have impact but the cost of diesel fuel will have to increase dramatically to make it economically reasonable. For large-scale production renovation of plantations will be needed along with

major investment in processing facilities. Even if development of the resource commenced today, it would be a number of years before full production could be reached. Therefore is not expected that biofuel will be likely to provide significant offset of GHG by 2012 even if diesel fuel cost does rise dramatically over the next several years.

Table 2.8 summarizes possible options for GHG reduction which are technically viable. These are based on the analyses of renewable energy in Chapter 3 and energy efficiency in Chapter 4 but do not take social, financial or economic constraints into account and therefore represent a reasonable upper limit of approximate potential savings.

Table 2.8: Indicative Energy and GHG Savings in FSM from Renewable Energy, 2012

Technology	Potential fuel savings, energy or power production	Potential CO_2 savings (Gg / year)	Comments and assumptions
Hydro [1]	5.25 ML of distillate for electricity production	14.2	6.9 MW of hydro developed in Pohnpei & Kosrae
Other ocean	Zero	0	No *commercial* OTEC or seawave systems are yet available
Geothermal	Zero	0	No known or likely resource in FSM
Bio-diesel [2]	0.87 ML of ADO	2.3	Copra used for coconut oil fuel production
Other biomass	Zero	0	No likely viable biomass candidates
Solar PV [3]	0.11 ML of ADO	0.3	Assumes that ¼ of all households (about half of unelectrified homes) receive solar PV instead of diesel gensets
Solar thermal	Very small	0	Hotels already have solar water heating; limited scope for expansion
Wind	Zero	0	Unlikely to be viable near any appreciable load
Efficiency	2.64 ML of diesel fuel through demand-side and supply side electricity savings.	7.1	
Total		23.9	*Total saving of 14% of projected 2012 GHG levels*

Source: PIREP team estimates; See Annex 2 for conversions.

1) If the 1990 PREA estimates (based on 1980s USDOE studies) are accurate, there is potential for 6.9 MW of hydro in FSM, 6.4 in Pohnpei and 0.5 in Kosrae, capable of producing 17,500 MWh of electricity per year. If this replaced diesel systems using 0.3 l/ kWh, hydro would displace 5.25 ML of distillate

2) Maximum copra production in FSM was less than 6,000 tonnes in 1985 dropping to only 600 tonnes or so at present and never above 1,500 tonnes during the 1990s. Assume optimistically that 1200 tonnes of copra is available to produce oil as a fuel. 1200 tonnes x 0.7 = 840 tonnes of oil, equivalent to about 0.87 ML of diesel fuel which can be used for power generation or transport.

3) In 2000, there were 17,299 households in the FSM of which 46.4% or 8,027 were not electrified. If households increase by 0.2% per annum, there will be about 17,650 households in 2012. Assume ¼ of these, or 2,000 households, are reasonable candidates for solar PV and are provided with 150 Wp solar home systems producing 0.37 kWh/day each for 300 days per year, a total of 222,000 kWh per year. If these replace small gensets which use 0.5 l/kWh, the savings are 110,000 liters of ADO, equivalent to reductions of 300,000 kg of CO_2 emissions or 0.3 Gg.

Table 2.8 suggests that GHG emissions could be reduced by roughly 24 Gg of CO_2 equivalent (14% reduction of projected 2012 CO_2 emissions), mainly through the development of small-scale hydropower and improved efficiency in electricity use. These are not meant to be recommendations or goals but are only indicative of the order of magnitude of practical savings. The table suggests that the impact on emissions of developing biodiesel from copra or rural electrification through solar PV are likely to be small.

3 POTENTIAL FOR RENEWABLE ENERGY TECHNOLOGY USE

3.1 The resource

3.1.1 Estimates of RE in 1990

There has never been a comprehensive assessment of the potential or exploitable renewable energy (RE) resource in the FSM. In 1992, the PREA provided a summary of the knowledge at that time of the indigenous energy resource, since available resources have not changed since 1992, these are shown below as table 3.2. In 1990, there were 90 PV systems with about 7 kW of peak output, one functioning hydroelectric system and, as far as the PREA team could determine, no biomass energy systems.

In the 1980's Peace Corps Micronesia did a biomass (cooking with wood) study in the FSM but the data could not be located by the team. The PREA made no estimates of the biomass energy resource. Other resources listed by the PREA are summarized below.

Table 3.2: Renewable Energy Resources in FSM

Resource		Chuuk	Kosrae	Pohnpei	Yap	Total
OTEC [1]	Temperature differential (°C)	n/a	n/a	n/a	n/a	23-24
	Distance offshore (km)	n/a	n/a	n/a	n/a	1-10
Tidal	Mean range (meters)	n/a	1.6	1.0	0.6	0.6-1.6
Solar	Insulation (kWh/m^2/day)	n/a	n/a	5.5	n/a	5.5
Hydro	Potential (MW)	none	0.5	6.4	none	6.9

Sources: PREA (WB, et. Al., 1992) with some data from *Territorial Energy Assessment* (USDOE, December 1982) and *Ocean Energy Guide* (ESCAP, 1990) n/a = information not available

Notes: 1) Temperature difference between sea level and 1 km depth, estimated

The remainder of this chapter updates available information on the potential for energy production from renewable energy technologies (RETs) from local resources in the FSM and the experiences with RETs since 1990. Geothermal, hydropower, ocean based energy, wind, solar and biomass for liquid fuels (coconut oil) and combustion (forest resources) are discussed below. It appears that there is not a great deal of information available today beyond what was known in 1990.

3.1.2 Geothermal Energy

There is no known geothermal resource in the FSM.

3.1.3 Hydropower

Pre-feasibility studies carried out some years ago in all rivers of Pohnpei and Kosrae suggested a significant potential for run-of-river systems (Table 3.1) which could reduce fuel use and GHG emissions significantly. However, the costs per kW installed and kWh produced would be high.

3.1.4 Ocean Based Energy

The sea wave energy potential of a number of PICs was assessed in the early 1990s through a Norwegian-funded regional wave energy resource assessment program at the South Pacific Applied Geoscience Commission (SOPAC, 1993). The aim was to map the resource (wave height, wave periods and wave energy), through data buoys moored off the shores of various islands. No measurements were carried out for the FSM or any locations sufficiently close to draw useful conclusions. The team could find no data on the seawave potential of any state of the FSM. There is apparently no data on ocean energy potential in FSM more recent than that in the PREA.

3.1.5 Wind Energy

Although there are wind measurements by the meteorological service, they are not very representative of the energy resources. Wind systems installed by the TTPI in the 1980s did not include a resource assessment. All those systems failed due to lack of maintenance and the corrosive environment. Also in the 1980s, an anemometer was installed on Pingelap with a wind data recorder. Data was recorded and then forwarded to the University of Hawaii but that data was not located and made available to the PIREP team. No data are available which would allow an assessment of the likely wind energy potential of the FSM.

The KUC in Kosrae is understood to be interested in small wind energy systems but no details are available.

For wind energy to be considered, a resource assessment specifically for energy development needs to be carried out on each of the four main islands where wind development could impact on fuel used for electricity generation.

3.1.6 Solar Energy

Solar energy has been used for water heating and electricity generation with success for over 20 years. The solar resource varies somewhat over the country and, in the case of the larger mountainous islands, from site to site but in general the horizontal radiation ranges from 5.2-5.6 kWh/m^2/day and is suitable for the cost effective implementation of both solar water heaters and solar photovoltaics throughout FSM. However, if large scale grid based systems are proposed, it will be advisable to do at least a one year solar resource survey at the proposed site, particularly if it is on one of the larger mountainous islands where there can be substantial variation in solar resource from site to site.

3.1.7 Biomass Energy

Around 1990, Dr. Jim Rizer from the University of Hawaii did a biomass survey in Pohnpei but the data was not available for examination by the PIREP team. A biomass survey is being done in 2004 under the Persistent Organic Pollutant Substance (POPS) program but no data is yet available for publication.

The GoFSM, with support from UNDP, recently developed a *Biodiversity Strategy and Action Plan* (GoFSM, 2002c) for the conservation and sustainable use of the FSM's terrestrial and marine biodiversity resources. The plan advocates the development of renewable energy – particularly solar, wind and hydro – but does not suggest the use of biomass resources for energy with one exception: the development of a management plan for sustainable use of forests, particularly mangroves, for energy for household cooking. Otherwise, biomass is not considered a suitable resource for energy production.

According to the Coconut Development Authority (CDA, 2001), the FSM could produce over 6500 tonnes of copra annually from 16500 hectares of land planted with coconuts. However, most trees are beyond their economic bearing age and copra production has fallen from a peak of 5800 tonnes in 1985 (Figure 3.1) to about 600 tonnes from 1997-2000. Considering the age of the trees and the infrequent and unreliable shipping from outer islands to main islands, a considerable investment would be required to produce coconut oil as a fuel at an appreciable scale. This is unlikely considering that the CDA has performed poorly for some years despite considerable levels of subsidy. In principle, there should be significant quantities of old trees available for use as a high-quality biomass fuel for power production but most would be very costly to transport to areas of sufficient electricity demand to warrant the capital investment in wood-fuelled power.

Under the TTPI, a number of small scale renewable energy "demonstrations" were carried out in the areas of biogas, biomass, biofuels, small hydro, wind and solar energy. None of those demonstration systems appears to have resulted in replication and none have survived to the present.

The 1992 PREA provided a list of all known RE installations in 1990, these are shown in table 4.1. The team notes that PV installation numbers shown in the table are known to be substantially understated.

Table 4.1: Renewable Energy Systems in FSM in 1990

Systems Installed	Chuuk	Kosrae	Pohnpei	Yap	Total
Photovoltaics [1]					
Number	50	0	22	18	90
KW peak	3.5	0	2.4	1.3	7.1
Hydroelectric [2]					
Number	0	1	1	0	2
KW	0	35	2,000	0	2,035
MWh generated	0	0	2,487	0	2,487
Biomass					
Number	n/a	n/a	n/a	n/a	n/a
KW	n/a	n/a	n/a	n/a	n/a

Source: PREA (WB, et. Al., 1992) n/a = information not available

Notes: 1) Excludes about 2 kW of systems then planned for installation. There were 30 telecommunications systems in Chuuk in 1990 but the percentage operating was unknown.

2) The Kosrae hydro system never operated. Pohnpei is 1990 data.

4.1.1 The "WERI Wells", Chuuk

In 1982 Chuuk State experienced a cholera outbreak. Close to 20 people died and many others became seriously ill. As a result of the outbreak, measures were taken to improve sanitary conditions. One of them was the introduction of pour-flush toilets and the destruction of over water "benjos" that resulted in human waste being deposited in the inter-tidal zone. The introduction of pour flush toilets created another problem, however. Especially in inland areas, there was no water to flush them. Thousands of ferro-cement rainwater storage tanks were also built in the wake of the cholera epidemic but use of scarce rainwater for toilet flushing was discouraged so groundwater was the main candidate.

To meet the need for ground water pumping, over 200 solar powered pumps were installed all over Chuuk State. The University of Guam Water and Energy Research Center (WERI) developed a simple "package" system that consisted of two Solar Power Corporation 30 watt modules that powered a cheap (US $15) Rule 500 marine diaphragm type bilge pump. The package also included a pole mount for the modules, a piece of 6" PVC pipe that was used as a well casing, as well as many other additional small items. Every nut, bolt, piece of electrical tape, etc. that the system required was included in the package. Chuuk State contracted WERI to deliver these kits to Chuuk and provide workshops for personnel in the Rural Sanitation Program (RSP) office concerning their installation, operation, and maintenance.

The intent of the systems was that they be extremely simple to install, operate, and maintain. They pumped water at the will of the sun. No switch was included and it was simply recommended that, if a storage tank overflowed, a rag be thrown over the modules to turn off the pump. The diaphragm pumps were inexpensive but also would only last a few years at most so the RSP office had hundreds of spare pumps on hand to replace pumps as they failed.

Many of the pumps that were installed at public facilities (dispensaries, schools, etc.) were

vandalized. As anticipated, the Rule pumps eventually failed but only some owners came to the RSP office for free replacements. As the years went by, more and more of the systems fell into disuse. However, even in 2000 some pumps were being replaced. This implies that at least some of the wells survived and/or that other people recognized that the Rule pump was a cheap and disposable solution to low volume groundwater pumping.

This project was the first significant solar project in Chuuk and besides providing the ground water for sanitary uses, the project was important in introducing solar energy to almost every island in the state.

4.1.2 Mwoakilloa Atoll, Pohnpei State

Mwoakilloa atoll was the site of the first village electrification trials in Pohnpei State. In the late 1980s, 46 solar lighting units were installed in homes and a larger PV system was installed at the Mwoakilloa Municipal Office that operated lights and a freezer. Technical support was provided by the Pohnpei Energy Office though local persons received training in basic maintenance of the systems. By the mid -1990s, most of the systems had failed.

4.2 Operational Renewable Energy Systems

4.2.1 Micro-Hydro

In 1988 the Nanpil run-of river hydropower system was commissioned near Kolonia on Pohnpei. The generating capacity is 2.06 MW (one 725 kW and one 1,335 kW unit) with a maximum output reduced to 1.8 MW at maximum flow because of intake limitations. The design output was 4,000 MWh for a typical hydrological year but actual production has been considerably less. Because of dry periods and lack of water storage, Nanpil has not contributed to Pohnpei's firm generating capacity. The penstocks were damaged several years ago so Nanpil is not currently functional and the costs of renovation are understood to be high. In the early 1990s (PREA, 1992) there was a proposal to increase Nanpils catchment area at a cost of $6 million but the additional output was uncertain as hydrological data were limited. A 1.0 MW Japanese-funded hydro scheme was proposed at Lehn Masi and a 0.2 MW system at Senipehn but neither eventuated, presumably due to high costs.

The only other state with hydropower potential is Kosrae. A microhydro system of 35 kW was designed and constructed by the US Army Corps of Engineers in the Malem River in the late 1980s but never operated due to land tenure issues that were not resolved. The output was also reportedly too low to contribute significantly to the demand of a nearby community (Steve Lindsey, February 2004).

4.2.2 Biogas

Beginning in about 2000, small biogas systems have been constructed by the College of Micronesia and the Agricultural Extension Service for demonstration. One has been placed in each of six municipalities with five pigs as the manure source for each but only the system at the Agricultural Experiment Station remains in operation. The gas is bled off and not used for energy as people find the concept of using biogas from manure for cooking offensive.

4.2.3 Biomass

There is no biomass energy production known to the team other than traditional uses of wood.

4.2.4 Biofuel

Coconut oil is produced in small quantities at a trial factory on Pohnpei but it is not intended for energy use and there is no known use of biofuels in FSM to date.

4.2.5 Solar Water Heating

Solar water heaters are commercially available on all islands of FSM and are used mainly on commercial buildings, particularly tourist facilities. Due to the limited demand for piped hot water in homes, there are few domestic installations of any form of piped hot water.

4.2.6 Photovoltaics

Pingelap, Pohnpei

In 1996-97, 129 SHS were installed on Pingelap. The systems were funded by the local government and installed and operated by the Pohnpei Utility Corporation (PUC). Description of System. The system utilized a 75-watt Siemens module to operate two ThinLite fluorescent lights. To avoid using a wall switch, pull chain switches were used. Sealed 200Ah 12V batteries were controlled by an SCI charge controller. The batteries were greatly oversized and sulfated early in their life since they were rarely at full charge. There were problems with the pull chain switches (also the case with the later Fiji Vunivau project). Many of the controllers have had to be replaced.

This project was an experiment by PUC with outer island electrification. There was a flat monthly charge of $5 dollars for the use of the systems. The intent was that the charge would generate enough funds to replace the batteries five years or so later as well as cover the cost of a maintenance person and the bill collector. Maintenance has not been good and collections have been poor since no disconnects for non-payment are made. The systems are not working up to design standards and the project is not considered a success by the PUC. Overuse has been a problem and timers were installed to turn off power after midnight since lights were being left on all night.

In 2001 local funds purchased two Amana 22 ft^3 freezers powered by 660Wp of panel, a Trace C50 battery controller, a 24V battery bank using Concorde PVX122255 sealed units feeding a Prosine 1800W inverter that powers both freezers). The system cost $16,200. Users are charged by the pound of fish frozen. Maintenance is by the Pohnpei Energy office. The inverter has failed and been replaced, otherwise the system has performed adequately.

Mwoakilloa, Pohnpei

In 1998, about 42 homes and public buildings on the island of Mwoakilloa received solar photovoltaic installations using French funding. Systems included 135Wp of panels, Trojan batteries with a 4-5year life, a controller, 3-12W and 1-8W fluorescent tube lights. The state government owns the systems and has maintenance responsibility through a local solar committee. But it has not been able to keep the systems operating well with only about half currently working well. Numerous problems of collection of the $5 monthly fee and poor maintenance have plagued the project.

Sapwuhafik, Pohnpei

In 1999, 105 SHS were installed on Sapwuhafik by the PUC on behalf of the Pohnpei Energy Office. The systems consisted of 75Wp of panel, 2-15W ThinLite fluorescent lights, a Trojan 27TM battery and a Trace C-12 controller. Systems are under the maintenance control of the

Energy Office. Users paid $15 to receive the systems and agreed to a $5 per month charge. Most systems remain operational though over use is common.

Pakin, Pohnpei

In 2002, 21 SHS were installed by the Energy Office on Pakin using the same technical and institutional design as for Sapwuhafik. All systems were working at the time of the team visit.

Also on Pakin, a Danhoff centrifugal pump with 400Wp of panel capacity was installed in 1987. The system was designed to provide about 11,360 liters/day (3000 US Gallons/day) over a 6 meter (20 foot) head. The pump was directly connected and has functioned well, meeting its design requirements and over a long term. In 2002 the pump was refurbished and continues to provide water to the community.

Paren and Lenger Islands

In 2000, two small islands in the Pohnpei lagoon received SHS from the Energy Office. Lenger (17) and Paren (47) received 100Wp panels, 2-15W ThinLite fluorescent lights, a Trojan 27TM battery and a Trace C-12 controller. Funding was from the Italian government. The systems have not survived well, with only about 25% operational. No fees are being paid and many of the systems have been badly abused with batteries often disconnected and taken for fishing.

Namonweito, Chuuk

In 1995, about 56 household lighting systems funded by the State of Chuuk were installed on Unanu, Makur, and Onou Islands, Namonweito Atoll, Chuuk State, FSM

The systems were designed to be exceptionally high in quality and conveniently expandable. Each system initially consisted of two 75-watt Siemens solar modules and three sealed gel cell batteries of around 100 amp-hours each. An SCI ASC charge controller was used and charger, fuses, metering, and all connections were located in a Carlon water-tight enclosure with transparent cover. The array rack had space for an additional module. The system only powered two 15 watt (Thin Lite) lights, so it had excess capacity, the logic being that the system would function even in situations where there would be limited hours of sunlight per day due to shading of the modules.

The systems were given to the recipient households and no fees were charged nor were any arrangements made for maintenance, the individual households were fully responsible.

The success of the project has been variable. Some households have been able to keep the systems operational, others have abandoned them. Many of them limp along as the original batteries are long overdue for replacement. Some families have replaced the batteries, usually with automotive batteries as that is the only type of battery conveniently available on Chuuk. A few families have added a small inverter to the system and use it primarily for watching an occasional video. A few families use the system to power an SSB or other type of radio. Some of the systems have been damaged in typhoons where the original mounts became insecure or a tree fell on the roof of the house. In general, in spite of little or no maintenance, some ill advised modifications etc. the systems continue to function to provide basic lights.

Satawal, Yap

In 1996, Yap approached the French government for funding to install 341 PV systems for households on outer islands. Although the full funding was not provided, France did agree to electrify the island of Satawal, Yap, using photovoltaics. The project, completed in 2001, included systems for 50 households:

1-50Wp solar panel
1-10A Total Energie regulator
1-12V sealed 85Ah battery Oldham 12RGTS85
2- 8W tube type fluorescent lights

And a community system that consists of:

12-50Wp solar panels
1-30A RMP regulator
1-sealed 24V 545Ah battery bank, Oldham 2EGS545 (2V)
1-24V-12V DC converter for lights
6-8W fluorescent tube type lights
2-200 liter refrigerator/freezer Total Energie TCS-200

The system is under the operational control of a local solar committee and local maintenance personnel were trained by the contractor. The use of sealed batteries has the positive effect of reducing the possibility of error in maintenance but they cost more and have a shorter life than open cell batteries of the same quality and capacity. The systems are operational but power outages are frequent in households due to the relatively small panel capacity available.

4.3 Future Renewable Energy Project Plans

The European Union (EU, 2002) has allocated 4.08 million euros (US$4.94 million at 23 June 2004 exchange rates) to the FSM for renewable energy or energy efficiency development for rural areas or remote islands of the four states. In 2002, a French-supported team (PPA, 2002) proposed that the funds should be spend on ten small electrification projects for communities in remote locations using coconut oil biofuel or hybrid coconut oil / solar systems. At the time of writing, the proposals were under consideration by the GoFSM and the four states. The 4 m € EU grant is the only confirmed source of new grant finance for RETs and energy efficiency in the FSM.

There is a proposal for a coalition of Pacific-based universities and colleges, including the College of Micronesia and led by the University of Hawaii, to research and develop bioenergy resources for the FSM and other American-affiliated islands (UH, 2004) with support through a USDOE Sun Grant Initiative but no details are available.

The Energy Office on Pohnpei is seeking funding for another 350 SHS for electrification of the remaining outer island communities. These could be included in the upcoming EU project if application is made this year for their inclusion.

5 Barriers to Development and Commercialization of Renewable Energy Technologies

In the previous chapters, barriers to the development, use and commercialization of RETs in the FSM have been raised implicitly. This chapter more explicitly considers such barriers, which have been identified through interviews, observation and reading earlier studies. In most PICs, a workshop was held on strengths, weaknesses, opportunities and threats (SWOT) related to RE and RETs. This was not possible in the FSM due to the lack of a national consultant and no timely access by the GoFSM to workshop finance.

For convenience, the barriers are categorized as follows: 1) fiscal and financial; 2) legislative, regulatory and policy; 3) institutional barriers; 4) technical; 5) market; 6) knowledge and public awareness; and 7) environmental and social. There are numerous overlaps among categories so classifications are to some extent arbitrary. The barriers have not been prioritized.

In brief, the energy sector has had a very low priority in the FSM for some time. There is no clear overall responsibility for energy matters, no staff allocated specifically to energy and a long history, now apparently ending, of heavy subsidies for energy provision, particularly for electricity. The low priority and the history of subsidies constitute serious barriers to the rational development and use of RETs.

5.1 Fiscal and Financial Barriers

Subsidized electrification. Most capital costs for power development were met by US government grants before Independence and by Compact grants since then. The tariff structure has been set at a level which covers only operational and maintenance (O&M) costs. Even these have been heavily subsidized in at least two states (Kosrae and Chuuk) through the $3m dollar annual Compact energy grant which recently ended. In general, FSM consumers have not been charged the full cost of electricity. If RET alternatives are priced at the full cost of equipment and O&M, this would be a large barrier to their introduction and use even if their real life-cycle costs are lower than diesel-generated electric power.

Direct subsidy of state government energy costs. In at least two states (Pohnpei and Yap), the Compact energy allocation was used to reduce the electricity and fuel costs of the state governments, effectively removing any incentives for improved energy efficiency.

Poor collection of electricity utility charges. A decade ago, no state utility collected from consumers more than 20% of the actual cost of electricity supply. In several states electricity bills were often unpaid and even today, there are large arrears in at least one state. This is effect an additional subsidy for diesel-generated electricity.

No incentives for RETs. There are no specific incentives in terms of tax breaks or 'green' loans for RE development.

Subsidized petroleum fuels. In Kosrae, the state-owned Micronesia Petroleum Company has received state subsidies. The amount and purpose are unknown and it is not possible to state whether this reduces prices sufficiently to be a genuine barrier to RETs.

5.2 Legislative, Regulatory and Policy Barriers

Lack of policies and appropriate legal tools. As in most PICs, there have been drafts over the years of energy policies, but there is no national energy policy which has been formally endorsed by the government and thus no guidelines for government agencies, states or

utilities regarding RETs. The lack of appropriate legislation, approved energy strategies and policies, guidelines and regulations form a barrier to the rational development of energy overall as well as RE.

5.3 Institutional Barriers

Lack of institutional structure for energy. Almost every PIC has an energy unit within a government ministry and several have government departments responsible for energy policies and often implementation of energy activities. Many energy sector issues require fiscal, financial, investment and regulatory decisions. In FSM, the DoEA is an appropriate department to coordinate energy but it cannot do so without a clear mandate and staff allocated to energy matters. The apparent reluctance of the states to allow a central government energy role is a barrier to rational energy use in general, including RE.

Lack of clear responsibility for energy matters at the state level. Responsibility for energy varies at state level but no states currently have a state energy planner. State governments have supported RE projects but there is no regular budget allocation specifically for RE. There are no staff in any state who work full-time on RE.

No coordination of energy activities. There is no interministerial mechanism for coordinating energy matters, but rather temporary *ad hoc* country teams or coordinating groups tied to a specific donor-funded initiative. No one seems to be really in charge of energy.

Lack of institutional arrangements for sustainable RE operations. All states of the FSM lack institutional arrangements (such as RE cooperatives) which are required if RE systems are to operate and be financially viable over long periods.

5.4 Technical Barriers

Poor understanding of opportunities and obstacles to RET. In general, discussions suggest that except for solar photovoltaics, there is relatively poor knowledge of which RETs are appropriate to the needs of the FSM, costs and constraints to their use.

Limited knowledge of renewable energy resources. There has little, if any, measurement or analysis of the FSM's RE potential, with much available data dating from the 1980s. As far as the team has been able to determine, there has been no assessment of biomass, wind, solar, geothermal or ocean energy resources. There is general data on wind conditions but no monitoring of wind conditions at potential sites specifically for wind energy.. In general, there is very limited technical information about FSM's RE potential.

Individual states are too small to be able to concentrate the needed skills for large scale project design and implementation. With the small size of each state, it is not reasonable to expect competency in renewable energy project design to be developed in many agencies. Competency in renewable energy project technical and institutional design should reside in a single organization at the national level and all renewable energy projects should be required to at least be vetted by that organization before submission for funding.

5.5 Market Barriers

Small dispersed population. With a population of only 100,000 widely spread over four states, the local market is too small for local manufacture or cost-effective inter-state transport of most RETs and is probably too small to attract suppliers who are willing or able to provide effective back-up or technical services.

5.6 Knowledge and Public Awareness Barriers

Lack of reliable energy data. There is little reliable data within FSM on energy use patterns or trends, no systematic data collection and limited capacity to assess energy sector needs. There have been no studies of the practical potential for energy savings through demand-side management programs.

Low level of public awareness regarding energy issues and options. No public information programs to raise the general public awareness of renewable energy options and general energy issues have been carried out.

Lack of RET and EET training capacity. Although Micronesia has a tertiary college, there is little or no consultancy, training or research activities on RE issues and a limited number of FSM nationals with training in RE and energy issues in general.

5.7 Environmental and Social Barriers

Land tenure issues. The small hydroelectric project on Kosrae was stymied by land tenure issues. It is not known whether access to land for RE projects is a serious issue in any states but it is a common issue in nearly all other PICs and a real barrier to RE development.

Vulnerability to cyclone damage. The FSM has been subject to a number of serious cyclones in recent years. Any RE project must be designed for cyclone conditions and in some cases, the potential damage even to well-designed systems, forms a barrier to RE development.

6 Capacity Development Needs for Removing the Barriers

This chapter examines the capacity development needs of the FSM. Addressing these may help to remove or reduce key barriers identified in Chapter 5.[11] These are not prioritized. Many of the suggestions below do not fit exclusively, or even primarily, into one category. There is also some repetition with similar issues covered under more than one heading. Finally, it is easier to identify barriers than practical means to remove them (or most would have been removed long ago).

Each of the four states and the national government have different needs for capacity development. The different size and physical conditions that characterizes the four states also affects the requirements for capacity development. Therefore the following capacity development recommendations include the level of priority seen for each of the states and the national government.

6.1 Electricity

Data collection and analysis capacity building. At the national level, there needs to be developed an improved capacity to collect, analyze and distribute electricity system data from the four states. Without up to date, complete and accurate data regarding electricity production and use, the national government's ability to make energy policy and carry out existing energy policies is weakened. SOPAC and SPC have had programs for upgrading national data collection and data management. These clearly need to be continued.

Utility planning and forecasting capacity development. At the state level, the utilities generally lack capacity in forecasting and long range planning, capital decision making using marginal cost information, the rational use of IPPs or cogeneration opportunities and in particular an understanding of renewable energy technology to rationally fit renewable energy into their planning process. This is a program that PPA has worked on in the past and may be able to continue to support.

6.2 Renewables

General RET training development. Staff in infrastructure development agencies in each state that may have responsibility for renewable energy projects need training in the basics of renewable energy technology, renewable energy project design as required by the Pacific Island environment, training in the design of sustainable institutions for operating and maintaining those projects and training in making sustainable financial arrangements for the long term success of the projects. This problem is common to many PICs and justifies a regional program.

Project design capacity development. The limited experience with renewable energy projects has resulted in there being a lack of capacity with regards to renewable energy project design, evaluation and operation. As a result, donor created projects have tended to be almost completely developed by the donors and have historically resulted in both technical and institutional designs that are not optimized for the social and physical conditions that exist. At all levels of government, there needs to be an improved understanding of the technical and institutional requirements for successful integration of renewable technologies

[11] Some of the same or similar recommendations are made in other PIREP reports. In some cases, it may be appropriate to carry out similar studies concurrently in several countries, or through a regional effort. This is discussed in volume 1 of the PIREP assessments, the regional overview.

into the national energy delivery system and a continuing dialogue with donors to attempt to design both technical and institutional systems to best fit the site requirements. This problem is common to many PICs and justifies a regional program.

Technical capacity building. Technical capacity for the installation, operation and maintenance of renewable energy systems is very limited and there needs to be capacity development at all levels for understanding, installing and maintaining both stand alone and grid connected installations of biomass, biofuel, small hydro (Chuuk and Pohnpei), and solar PV systems for electricity generation. Assistance is needed to develop technical training programs at T3 and the College of Micronesia to support renewable energy and energy efficiency programs. Most PICs have a similar requirement and a regional project for the needed training development is justified.

Decision maker information provision. The upcoming EU renewable energy project will have as the local implementers the utilities in each state. Most are ill prepared for this responsibility and in particular do not understand the advantages and disadvantages of stand-alone and grid connected renewable energy systems as applied to the new rural customer groups of each state. Before the final project structures are prepared for each state, there needs to be training for decision makers in each of the utilities regarding the options for renewable use for rural electrification and the relative economic, financial and social aspects of each of those options. As this is a common requirement throughout the Pacific, a regional decision maker training program appears appropriate.

6.3 Policy and Regulation

At present there are no obvious needs for energy legislation or regulation. It is too early to consider standards or certification for renewable energy systems since it is not yet clear what forms are appropriate to FSM and it is not good practice to impose restrictions on technical development without a clear objective for improved public safety or operational efficiency.

State energy policy development. In Kosrae, Chuuk and Yap, responsibility for energy development, particularly rural energy and renewable energy, became unfocused with the elimination of their energy planner positions. In those states, there needs to be a clear designation of responsibilities and coordination of energy activities to help ensure that development is in line with policy, that donor organizations are able to have a consistent and knowledgeable contact point for energy projects and to help ensure that energy projects are appropriate to the needs of the State. Although the needs for capacity development at the State level involve some different issues than at the national level, the PIEPSAP should be considered for providing assistance to each of the four states.

7 Implications of Large Scale use of Renewable Energy

7.1 Solar PV

Since the large scale use of solar PV in FSM will be for rural electrification, the primary environmental effect will be the need to dispose of worn out lead-acid batteries. Though the sulfuric acid in the batteries is easily neutralized and rendered environmentally harmless, the lead components have the potential to cause heavy metal poisoning through leaching into ground water if disposed of on land or through the reef food chain if disposed of at sea. Therefore it will be important that a system for the collection, safe storage and shipment to a battery recycling centre be included with the institutional arrangements for solar PV implementation in rural areas. Lead-acid batteries are probably the most recycled manufactured good in the world, with some estimates as high as 85% of all batteries sold ending up being recycled and there are recycling centers in Hawaii, Guam, Australia and New Zealand.

Quality of life improvement will be the primary benefit of PV based rural electrification. Improved lighting can be expected to benefit educational efforts, homemaker tasks and such productive activities as repairing fishing nets, handicrafts and shifting work activities such as copra cutting from the heat of the day. Electronic entertainment and communications also can be expected to be improved.

7.2 Biofuels

Large scale use of biofuels has the potential for significant economic benefit both to the nation as a whole – through the reduction in import expenditures – and to rural areas where the raw materials will be produced. Biofuels are one of the very few technologies that directly benefits both urban and rural populations. Urban populations benefit from stable fuel prices and lower pollution while rural populations benefit from markedly increased economic activity. The nation as a whole has reduced risk of economic trauma due to large price swings for energy and reduced risk of supply interruption or delivery delays.

For FSM there are no significant social or environmental disadvantages to large scale biofuel production if the production system is optimized. It must be noted that the production structure sued for the supply of biofuels can be established a number of different ways (e.g. collection and expelling on outer islands, collection on outer islands and expelling on the capital island, etc.) and several approaches to biofuel production should be analyzed carefully for cost and large scale practicality prior to implementation to determine the least cost solution and therefore the maximum benefit to all parties.

7.3 Existing opportunities

The EU project for FSM will almost certainly include capacity building efforts both through formal training and on-the-job activities. This is the only renewable energy project that is committed and can be committed for co-funding.

7.4 Future opportunities

The EU project will provide capacity building only at the time of project implementation and no long range capacity building is likely to be included. If the renewable energy systems that are installed under this project are to continue to operate, there will need to be access to a continuing means of training new operators and maintenance personnel. This long term training capacity will need to be developed under an existing technical training program such as the T3 program or the College of Micronesia. Since each state will have different requirements, it is anticipated that the capacity development process will have to be duplicated at the training facilities of each state.

Assistance is needed to the national government in the development of a National Energy Policy that will be specific for the conditions in FSM. Where the national government does not have authority in energy matters, policy development assistance to the individual states will be needed. Though the end result may be similar to that of the policies implemented in the other PICs, the structure and division of policy responsibility will most likely be quite different and cannot be designed from a generic regional energy policy.

Project development capacity building focused on small hydro (Chuuk and Pohnpei), biomass combustion, biofuels and solar energy can be provided under a regional capacity development program. The training should include persons from each state who have responsibility for renewable energy development and persons from each utility who are expected to integrate renewable energy into utility operations.

Utility upper management capacity for forecasting, marginal cost decision making and renewable energy integration could be carried out on a regional basis since these issues are common to most PIC utilities.

8 ANNEXES

Annex A – Persons Interviewed by the Local and International Consultants for PIREP

1) NATIONAL GOVERNMENT

John Mooteb	Acting Secretary., Department of Economic Affairs (DEA), and Head of Environment and Sustainable Development, P.O. Box PS 12, Palikir, FSM 96941; Ph: (691) 320 2646; e-mail: climate@mail.fm (and PIREP National Coordinator)
Ceaser Hadley	Meteorological Officer-in-Charge, FSM National Weather Service; P.O. Box 69 Pohnpei FSM 96941; e-mail: ceasar.hadley@noaa.gov
Cindy Ehmes	Sustainable Development Officer, DEA
Maderson Ramon	Deputy Assistant Secretary, Tourism Unit, DEA; e-mail: mkramon@mail.fm
Patrick McKenzie	Chair, EU National Authorizing Committee and consultant for 2004 Economic Summit, DEA
Mark Sturton	ADB Economic Adviser, DEA
Eneriko Suldan	Assistant Secretary and Head of Statistics, DEA
Prihmer Johnson	Statistician, DEA
Glenn McKinley	Statistics Adviser, DEA
Robert Hadley	DEA
Jane Chigiyal	Deputy Assistant Secretary, American Affairs, Ministry of Foreign Affairs (MFA)
Kohler Carl	Head of Customs, Department of Finance and Administration
Stephen Muller	FSM Customs Adviser e-mail: stepmul0309@yahoo.com
Ishmael Lebehn	Deputy Assistant. Secretary. Agriculture Unit, DEA, FSM National Government, Ph: (691) 320-2646; e-mail: smagri@mail.fm

2) CHUUK

Dr. Steve Winter	Solar Expert, email: stephenwinter@mail.fm
Joseph Konno	EPA, Weno, e-mail: cpiccap@mail.fm
Clark Graham	Pacific Resources for Education and Learning, graham@prel.org
Jin Ha Don	Managing Director, Yoolim Corp., Ph: (691) 330-3300; e-mail: selkk@hitel.net
Christina "Kiki" Stinnett	Chuuk Women's Council, e-mail: finnchuuk@mail.fm
Minoru "Mino"Mori	CEO CPUC, Ph: (691) 330 2400, e-mail: mino@mail;fm
Larry Goulard	Operations Manager. CPUC

Julita Albert	EPA, Weno, e-mail: chuukbio@mail.fm
Edward Sos	Customs Division, Chuuk

3) KOSRAE

Simpson Abraham	Executive Director of the Kosrae State Development Review Commission (DRC); ph (691) 370-2076; e-mail: simpson@mail.fm
Larsen Livaie	Administrative Officer; DRC
Andon Jonah	Officer-in-Charge, Micronesian Petroleum Corporation (MPC), PO Box 400, Tofol, Kosrae, 96944, FSM; Ph: (691) 370-2386; fax: 370-2388, e-mail of GM (Weston Luckymis): Weston@mail.fm
Lisa Llavore	Accountant, MPC
Fred Skilling	General Manager, Kosrae Utilities Authority (KUA); P.O. Box KUA, Tofol, Kosrae, FSM 96944; FSM; Ph:370-3799; e-mail: kua@mail.fm
Likiak Wesley	Administrator, Division of Planning and Statistics (DPS), P.O. Box 878, Tofol, Kosrae, FSM, 96944; Ph:(691) 370-3163, Fax: (691) 370-2004; e-mail: kosplan@mail.fm
Gerry Protacio	Electrical Engineer; KUA; e-mail: kuaengr@mail.fm
Nena Nena	Administration (KUA); e-mail: kua@mail.fm
Nena Benjamin	Chairman, Utwe-Walung Marine Park
Hostino Livaie	Utwe-Walung Marine Park; Ph: (691) 370-5193 or 390-2321; e-mail:hlivaie@mail.fm
Wright Abraham	Administrator for Rural Development, Public Works Department
Timothy Timothy	Former Administrative Officer, KUA

4) POHNPEI

Marcelino Actouka	General Manager/Chief Executive Officer, Pohnpei Utilities Corporation, P.O. Box C, Kolonia, Pohnpei; Ph: (691) 32-2374; e-mail: puc@mail.fm
Tony Actouka	Acting Director, Office of Transport and Infrastructure, Pohnpei State Government. (former Chief, Energy Management); e-mail: tonya@mail.fm
Alfonso Ada	Pohnpei Economic Development Authority (EDA); e-mail: eda@mail.fm
Jesse Sidley	T3 program, PICS Secondary School, Ph:(691) 320-3928

Marites Delosreyes	Accountant, EDA
Mike Abraham	EDA
Wolfgang Mueller Glück	Pacific International, email: wmueller-glueck@bass-pro-tec.de
Eldon Hellan	Executive Director, Pohnpei Environmental Protection Agency (EPA); Ph: (691) 320-2927; E-mail: pniepa@mail.fm
Donna Scheuring	Environmental Adviser, Pohnpei EPA
Keller Eliam	Coconut Development Authority (CDA)
Puvaneswaran	Consultant, CDA
William Hawley, Sr.	Owner, Pohnpei LP Gas Distributing Company
Cataleno Sam	Pohnpei Coconut Products

5) YAP

Faustino Yangmog	General Manager, YPUC, Ph: (691) 350-4427, e-mail: fyangmog@mail.fm
Bill Acker	Businessman, Ph: (690) 350-2300; e-mail: billacker@mantaray.com
Thomas Tun	Chief of Planning
John Tiefmai	T3 program (Trade, Training Testing), Walter HS
Don Evans	Businessman

6) OTHERS

Stevenson Joseph	Senior vice-president; FSM Development Bank; P.O Box M, Pohnpei, FSM, Ph: (691) 320 5300; e-mail:stevej@mail.fm
Dr Steve Lindsay	National PIREP Consultant (resigned before completion) Director, Micronesian Aquaculture and Marine Consultant Services, P.O Box 2178, Kolonia, Pohnpei, 96941, FSM; Ph: (691) 320 7257; e-mail: slindsay@mail.fm
Dr. Kwang-soo Lee,	Coastal and Harbor Engineering Laboratory; Korea Ocean Research and Development Institute (KORDI).

Annex B - References

ADB, 2002 *Federated States of Micronesia Country Strategy and Program Update: 2003 – 2005* (Manila; July)

ADB, 2003 *FSM Section, Millennium Development Goals in the Pacific: Relevance and Progress* (downloaded from www.adb.org; Manila; March)

ADB, 2003 *Key Indicators of Asian & Pacific Countries: FSM 1983-2000* (Manila)

ADB, 2004 *FSM Participatory Assessment on Poverty and Hardship* (Presentation by Lulu Zuniga, ADB consultant; Palikir; 19 January)

ADB, 2004 *The Federated States of Micronesia Hardship and Poverty Status Discussion Paper* (A: Assessment of Hardship & Poverty; B: Strategies for Equitable Growth & Hardship Alleviation; as presented to national workshop; 30 January)

ADB, undated *FSM Country Data* (downloaded from www.adb.org; January 2004)

BFSM, 2003 *Bank of the Federated States of Micronesia Annual Report for 2002*

CIA, 2003 *World Factbook: Marshal Islands chapter* (updated August)

EU, 2002 *Federated States of Micronesia - European Community Country Strategy Paper and National Indicative Programme for the Period 2002 – 2007* (24 June)

EU, 2003 *Financing Proposal for the 5 New ACP Countries, Federated States of Micronesia, Nauru, Niue, Palau, & Republic of Marshall Islands: Energy* (Final Draft; August)

Forsec, 2001 *Foreign Investment Environment in Individual Forum Island Countries: Federated Sates of Micronesia* (updated July)

Forsec, 2004 *Pacific Fuel Price Monitor* (Edition 6; 25 February)

FSMDB, 2003 *FSM Development Bank Annual Report for 2002*

GoC, undated *Chuuk State Environmental Protection Act* (Title 22; CAP 1 of the Chuuk State Code)

GoC, undated *Public Service System* (Title 9; CAP 1 of the Chuuk State Code)

GoFSM, 1997 *Foreign Investment Act of 1997* (Title 32; Chapter 2; Laws of the FSM)

GoFSM, 1997 *National Climate Change Action Plan – 1997* (FSM Climate Change Program; Palikir)

GoFSM, 1999 *FSM: National Communication Prepared Under the United Nations Framework Convention on Climate Change* (Pohnpei)

GoFSM, 1999 *Proceedings of the Second FSM Economic Summit* (Pohnpei; September)

GoFSM, 2000 *FSM National Energy Policy* (Draft; prepared with help of Forsec))

GoFSM, 2002 *Chuuk State Census Report: 2000 Federated States of Micronesia Census of Population and Housing* (Chuuk Branch Statistics Office; Weno; December)

GoFSM, 2002 *Federated States of Micronesia National Assessment Report: Synopsis of Issues, Activities, Needs and Constraints: Sustainable Development 1992 to 2002 and Beyond* (report to World Summit on Sustainable Development; Kolonia; August)

GoFSM, 2002 *Federated States of Micronesia National Biodiversity Strategy and Action Plan* (Palinkir)

GoFSM, 2002 *FSM Infrastructure Development Plan: FY2003-FY2017* (Vol. I: Executive Summary; Vol II: Program Evaluation; Vol. III: Plan Implementation; Final Report; May)

GoFSM, 2002 *Kosrae State Census Report: 2000 Federated States of Micronesia Census of Population and Housing* (Kosrae Branch Statistics Office; Tofol; December)

GoFSM, 2002 *National Census Report: 2000 Federated States of Micronesia Census of Population and Housing* (Division of Statistics, Department of Economic Affairs; Palikir; May)

GoFSM, 2002 *Pohnpei State Census Report: 2000 Federated States of Micronesia Census of Population and Housing* (Pohnpei Branch Statistics Office; Kolonia; December)

GoFSM, 2002 *Yap State Census Report: 2000 Federated States of Micronesia Census of Population and Housing* (Yap Branch Statistics Office; Colonia; December)

GoFSM, 2003 *Economic Developments: 1987-2003* (Draft Chapter 1 of Federated States of Micronesia Strategic Development Plan; Department of Economic Affairs; 12 December)

GoFSM, 2003 *Consumer Price Index* (Vol. 5; Third Quarter 2003; Division of Statistics; National Government; Palikir; December

GoFSM, undated *The Federated States of Micronesia Environmental Protection Act* (Title 25; CAP 5; Laws of the FSM)

GoFSM/USA, 2003 *Compact OF Free Association, as Amended, Between the Government of the United States of America and the Government of the Federated StatesofF Micronesia* (Palikir, Pohnpei, 13 May 13)

GoFSM/USA, 2003 *Joint Communiqué on the Signing of Documents Amending Certain Provisions of the Compact of Free Association Between the Federated States of Micronesia and The United States of America* (Kolonia, Pohnpei, 13 May 13)

GoFSM/USA, 1986 *Compact of Free Association* (Title Two: Economic Relations; Article I: Grant Assistance)

GoK, 1998 *Micronesia Petroleum Corporation* (State Law 6-98 ; Chapter 13 of the Kosrae State Code)

GoK, 2002 *Kosrae State Action Plan 2003-2007* (Tofol)

GoK, 2004 *Kosrae State Economic Situation Report* (Tofol; prepared for Third FSM Economic Summit; 8-10 March)

GoK, undated *The Utility Authority* (State law 5-38; Chapter 12 of the Kosrae State Code)

GoK, undated *Protection of Environment* (Title 11; CAP 13 of the Laws of the Kosrae State Code)

GoP *Public Utilities Corporation Act* (Pohnpei; State law 2L-179-91)

GoY, undated *Environmental Quality Protection Act* (CAP 15 of the Laws of Yap State)

GoY, undated *Yap State Public Service Corporation* (Title 14; CAP 1 of the Yap State Code)

HIES, 1997 *Spill Response Plan – Micronesia Petroleum Company Kosrae POL Storage Facility* (Honolulu; 1 May)

KUA, 2004 *Kosrae Power Sector Statistics and Tariff Schedule* (Tofol; 25 February)

MPC, 2004 *Kosrae Petroleum Statistics* (Tofol; 25 February)

Pacific Magazine, 2004 *Kosrae Utility Authority Budget Subsidy* (in FSM Business; February issue)

PPA, 2002 *Potential Sustainable Energy Projects in the Federated States of Micronesia and Nauru* (prepared by Dr Gilles Vaitilingam and Patrice Courty; Suva; October)

TNC, undated *A Blueprint for Conserving the Biodiversity of the Federated States of Micronesia* (with UNDP, GEF and US Forest Service; possibly 2003)

WB, 2002 *Micronesia, Federated States, at a Glance* (20 September)

WB, et. al. 1992 *Federated States of Micronesia: Issues and Options in the Energy Sector* (Volume 3 of *Pacific Regional Energy Assessment* or PREA; prepared jointly by World Bank with UNDP/ESCAP PEDP plus ADB and Forum Secretariat)