SPREP

Pacific Islands Renewable Energy Project

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

GEF

UNDP

The Secretariat of the Pacific Regional Environment Programme

Pacific Regional Energy Assessment 2004

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

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PIREP

our islands, our lives...

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

Ms Yumie Crisostomo, National PIREP Coordinator

Mr Herbert Wade, International PIREP Consultant/Team Leader

Mr Peter Johnston, International PIREP Consultant

with additional inputs from

Mr Ben Chutaro, short-term consultant

The international consultants visited the Marshall Islands from 14-19 February (Wade), 21-24 February (Johnston) and 8-11 March 2004 (Wade and Johnston), with the scheduled time in-country shortened by several days because of airline flight disruptions.

Following the reassignment of the previous National PIREP Coordinator, Ms Yumie Crisostomo graciously agreed to assume the coordination role, despite having no formal energy responsibility, and was very supportive. Due to an accident, the National Consultant was unfortunately unable to undertake the task. Mr. Ben Chutaro was engaged during the mission and ably supported the mission with data collection. However, due in part to the absence of a local consultant for an extended period, there are numerous data gaps, particularly for the islands away from Majuro atoll. All discussions were held on Majuro. The report reviews the status of energy sector activities in the Marshall Islands in March 2004.

A May draft of this report was provided for review by the RMI National PIREP Coordinating Committee, Secretariat of the Pacific Regional Environment Programme, United Nations Development Programme and others but only a very minor comments were received. The contents are the responsibility of the undersigned and do not necessarily represent the views of the Government of the Republic of the Marshall islands, the national PIREP committee, SPREP, UNDP, the Global Environment Facility or the various individuals who kindly provided the information on which this assessment is based.

Herbert Wade and Peter Johnston

October 2004

ACRONYMS

AAGR	Average Annual Growth Rate
AC	Alternating Current
ACP	African, Caribbean, Pacific countries
ADB	Asian Development Bank
ADMIRE	Acting for the Development of Marshall Islands Renewable Energies
ADO	Automotive Diesel Oil
ASPA	American Samoa Power Authority
BMI	Bank of the Marshall Islands
CCA	Common Country Assessment (of the UN)
CFD	Caisse Francaise de Development (French development bank)
CIA	Central Intelligence Agency (USA)
CIF	Cost+insurance+freight
COFA	Compact of Free Association
CPI	Consumer Price Index
CROP	Council of Regional Organisations of the Pacific
DC	Direct Current
DPK	Dual Purpose Kerosene (Jet fuel and Domestic kerosene)
DSM	Demand Side Management for efficient electricity use
EC	European Community
EDF	European Development Fund
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ENSO	El Niño/El Niña oceanic climate cycle
EPD	Energy Planning Division (formerly Energy Planning Unit)
EPPSO	Economic Policy, Planning and Statistics office
EPU	Energy Planning Unit (now Energy Planning Division)
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
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
GoRMI	Government of the Republic of the Marshall Islands
HF	High Frequency
Hp	Horsepower
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
KADA	Kwajalein Atoll Development Agency
KAJUR	Kwajalein Atoll Joint Utility Resource
KALGOV	Kwajalein Atoll Local Government
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
MAEC	Marshalls Alternate Energy Company

MDG	Millennium Development Goals
MEC	Marshalls Energy Corporation
MIDA	Marshall Islands Development Authority
MIDB	Marshall Islands Development Bank
MIMA	Marshall Islands Mayor's Association
MIMRA	Marshall Islands Marine Resources Authority
MINEP	Marshall Islands National Energy Policy
MOU	Memorandum of Understanding
MRD	Ministry of Resources and Development
R&D	Resources and Development
NASA	US National Aeronautics and Space Administration
NEPA	National Environmental Protection Authority
NOAA	National Oceanographic & Atmospheric Administration (USA)
NTA	National Telecommunications Authority (RMI)
OEPPC	Office of Environmental Planning and Policy Coordination
OIEP	Outer Islands Energy Policy
OPS	Office of Planning and Statistics
OTEC	Ocean Thermal Energy Conversion
PACER	Pacific Agreement on Close 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)
PREFACE	Pacific Rural/Renewable Energy France-Australia Common Endeavour
PSA	Private Sector Assessment
PV	Photovoltaic
RECD	Rural Economic Community Development
RET	Renewable Energy Technology
RMI	Republic of the Marshall Islands
SHS	Solar Home Systems
SOE	State Owned Enterprise
SOPAC	South Pacific Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SWOT	Strengths, Weaknesses, Opportunities and Threats
TCPA	Tobolar Copra Processing Authority
TTPI	Trust Territories of the Pacific Islands
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States
USDA	United States Department of Agriculture
USDOI	United States Department of the Interior
USP	University of the South Pacific
V	Volts
WB	World Bank
Wh	Watt hours of energy

Energy Conversions, CO_2 Emissions and Measurements

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

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

Diesel Conversion Efficiency:

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

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

Volume 1 US gallon = 0.833 Imperial (UK) gallons = 3.785 liters — 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 gigagram) = 1000 million grams (10^9 grams) = 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%, husks 44% (by dry weight).
c) Assumes conversion efficiency of 30% (i.e., equivalent of diesel at 30%).
d) Assumes conversion efficiency of 9% (biomass - fuelled boiler).
e) Point source emissions

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

TABLE OF CONTENTS

1. Country Context

Physical. The Republic of the Marshall Islands consists of two groups of atolls and islands: Ralik in the west and Ratak to the east, within a rectangle extending 1150 km north-south and 1300 km east-west, about 3200 kilometers from Honolulu and Tokyo. Twenty-two of 29 atolls, and four of the five small raised coral islands are inhabited. The islands are typically several km long and rarely over 200 meters in width.

Social. At the last census in 1999, there were 50,840 people in the RMI, with 68% on two atolls: 47% on Majuro and 21% on Ebeye in Kwajalein From 1988-1999, the population grew 1.45% per year (1.6% for urban Majuro/Kwajalein), a dramatic decrease from the 1980-1988 growth rate of 4.3% (5.8% for urban islands). The rapid drop in growth is due largely to free access to the United States for RMI citizens. Assuming a continuation of 1988-1999 trends, the 2010 population will be 59,600.

Environmental. The climate is moist and tropical with a wet season from May to November. The annual average temperature is 27°C, typically 30° maximum and 25° at night, with relative humidity ranging from 76% at midday to 83% at night. Rainfall is 1000-1750 millimeters in the north and 3000-4300 mm in the south. Tropical cyclones and droughts are not frequent but do occur.

Biodiversity in atolls is among the lowest in the world but there is a great diversity of life on the reefs. The government has signed various treaties and conventions related to environmental protection, including several with energy implications: the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. An initial communication to the UNFCCC, indicating greenhouse gas (GHG) emissions, was submitted in 2000. Environmental issues, related to rapid population growth and high population densities in Majuro and Ebeye, include inadequate potable water and lagoon pollution from household wastes.

Historical and Political. The Marshall Islands have been under Spanish control (until 1885 with several atolls added in 1898), German (until 1914), Japanese (until 1944) and American, under military control and then a UN trusteeship, with self government in 1979 and independence in 1986. The Republic of the Marshall Islands joined the UN in 1991. Under a Compact of Free Association, which went into effect in 1986, the US has maintained military defense, operated a missile testing site at Kwajalein Atoll, and provided substantial assistance. Over 17-years (1987-2003) from the start of the original Compact through a two-year extension, the U.S provided approximately $750 million.

The Parliament (Nitijela) has 33 members elected to a four-year term by popular vote. The Nitijela elects a president from its members for a four-year term. National elections were held in November 2003 and will next be held in 2007. Traditionally, there are no formal political parties, but rather factions or interest groups. There is also twelve-member advisory Council of Chiefs.

Economic. The RMI is heavily dependent on external assistance, grants averaging 60% of Gross Domestic Product (GDP) since independence, mostly through the Compact. As grant flows declined in the 1990s, real per-capita income fell below pre-independence levels. From 1990-2000, real GDP declined 1.6% annually. From 1995-2001, per-capita GDP dropped by nearly 35 percent. Unemployment is high, human development indicators lag behind other middle-income countries, and income distribution is uneven, with considerable poverty on the outer atolls.

A new 20-year Compact provides an opportunity to shift toward economic self-reliance and is expected to contribute about $66 million per year (before inflation adjustments), about 60% of current GDP. The ADB notes an improvement in the economy since 2001 with 3% growth in 2002 and 2003, and about the same level expected in 2004 - 2005. A private sector study in 2003 concludes that doing business in the Marshall Islands is difficult due to problems with property rights, a poor legal framework, underdeveloped financial institutions, the huge role of the state, and an atmosphere of tension and mistrust between government and the private sector.

Much of the income on the outer islands comes from copra sales but low copra prices have led to an interest in coconut oil as a 'biofuel.' Remittances from relatives on Majuro and pensions are also common sources of outer island cash.

Institutional Context for Energy. Responsibilities for energy within government and government-owned enterprises are as follows: i) the *Energy Planning Division* of the Ministry of Resources and Development (MRD) is responsible for energy policy, coordination and implementation, but there is only one energy planner position and the EPD tends to deal mainly with solar photovoltaic (PV) energy for outer islands; ii) the *Marshalls Energy Company* is responsible for electric power on Majuro, operates the power systems of Jaluit and Wotje under a government contract, imports and distributes petroleum fuel products, and installs, operates and maintains renewable energy systems in remote areas on contractual basis; iii) the *Kwajalein Atoll Joint Utility Resource* generates and distributes electricity on Ebeye; iv) the *Economic Policy, Planning and Statistics Office* is the key national development planning agency and is closely involved in rural electrification policy; and v) the *Office of Environmental Planning and Policy Coordination* handles all Global Environment Facility (GEF) activities, all programs under the UNFCCC and has coordinated the RMI PIREP study.

Renewable energy development has been ad hoc with various ministries responsible for projects and independently establishing standards and operational and maintenance (O&M) procedures. A Marshalls Alternative Energy Company was established for a time in the mid 1990s but was never fully established and no longer exists. There are still separate renewable energy activities within the EPD and the telecommunications, fisheries, health and education ministries. Fortunately MAEC responsibilities have now shifted to MEC.

Energy Policies and Legislation. There have been numerous donor-assisted studies over the past fifteen years resulting in various draft energy policy documents. Apparently only two were endorsed by Cabinet, a 1994 *Outer Islands Energy Policy* (OIEP) and a 2003 *Marshall Islands National Energy Policy* (MINEP). An ADB outer islands electricity study in 1995, although not a policy document, has become the RMI 'bible' for rural electrification. The agreed policies emphasize local energy sources, the use of commercially proven technologies, and recovery of operating costs from consumers.

The 2003 policy has had little impact, as the energy planner position is vacant, there is no EPD structure or assessment of needs, no specific activities, no work plan, no sense of priorities, no timing for implementation, and no budget to implement the policy or monitor projects. Nonetheless, prospects for renewable energy are reasonable due to the broad acceptance of the ADB framework of rural electrification through PV over the past decade; the willingness and ability of MEC to manage renewable energy initiatives, and the agreement between MEC and the government specifying respective responsibilities. MEC plays a *de facto* lead role in energy sector implementation and coordination.

The following laws or regulations directly or indirectly relate to energy sector matters: i) the *MEC Regulations* designate Majuro as MEC's sole supply area but there is no Electric Power Act to regulate either MEC or KAJUR and no formal policy framework for national electrification; ii) the *Retail Price Monitoring Act* provides powers to monitor and regulate retail prices but regulations have never been promulgated and there is no price control over petroleum fuels; iii) the *Unfair Business Act* could in principle be used to monitor electricity and fuel prices but has not been used for this purpose; iv) the *Consumer Protection Act* protects against unfair or deceptive business practices and could be used to regulate some aspects of renewable energy; v) the *Bulletin Boards and Price List Act* could be used to control fuel prices in outer islands but it is not enforced; vi) the *Alternative Energy Fund Act* established a revolving fund for development, marketing and operation of alternative energy, but this may no longer exist; vii) the *Import Duties Act* specifies tax rates on all commodity imports; and viii) the *Environmental Protection Act* provides powers regarding land use, pollution control and emissions.

2. Energy Supply and Demand

Energy Supply. The RMI is overwhelmingly dependent on imported petroleum fuels, which accounted for 78% of gross energy supply in 1990, 22% being biomass. Although there are no recent data on biomass consumption, the mission estimates that about 90% of energy use in 2003 is from petroleum, biomass remaining significant but declining to about 10 percent. The main petroleum imports are gasoline, diesel fuel, dual-purpose kerosene (used as aviation turbine fuel and household kerosene), and liquid petroleum gas (LPG). Mobil and MEC provide products in Majuro, Mobil supplies most outer islands except for distillate where MEC has a price advantage (due to large storage capacity), and Shell provides aviation fuel. Despite the lack of price control, fuel prices (excluding duties and taxes) are about average for Pacific Island Countries (PICs).

Despite numerous attempts, the PIREP mission was unable to obtain petroleum fuel imports or sales over the past decade. The 2003 data are suspect but, in the absence of other information, form the basis for estimating current demand, likely growth in demand and GHG emissions.

MEC supplies electricity on Majuro, Jaluit and Wotje and expects to eventually provide power to 28 other atolls. On Majuro, MEC had 24.4 MW (derated) of diesel capacity and about 12 MW of maximum demand in 2003. The current consumption per residential consumer is estimated to be 720 kWh per month, among the highest of all PICs. Generation has grown 6.6% per year from 1999-2003, the number of customers 3.8% annually and peak demand eight percent. MEC customers on other islands account for only 5% of demand.

The second largest power system is KAJUR on Ebeye. The mission was unable to obtain recent data but the 1999 census shows that at least 1,089 households (90%) had access to electricity. In 2002 KAJUR generation was 16.2 GWh, only 84% of the 1990 figure. In early 2004, MEC charged 12¢/kWh for domestic customers and 16¢ for commercial and industrial users. KAJUR's charges are about 3 ¢/kWh higher.

Energy Demand. In 2003, the RMI imported about 94 million liters of petroleum fuel. Mobil was unwilling to provide data and the import data contain inconsistencies. Based on limited and questionable information, about 68% of imports are used for transport, 30% for electricity generation and only 2% for direct commercial or household use. If the data are reasonably correct, in 2003 emissions of GHGs were 246 Gg. (This is an order of magnitude above the government estimate for 1994 – under 10 Gg – which should probably have been about 100 Gg and was presumably miscalculated.)

In 1999, 63% of households used electricity for lighting, 31% used kerosene and 5% relied on solar systems. Nearly 90% of urban households had electric lighting compared to 13% in outer islands, 71% of whom used kerosene. Households which reported using wood as their main cooking fuel increased from 14% in 1988 to 30% in 1999 nationally, with rural wood use increasing dramatically from 36% to 79% of all households. If accurate, this may have been due to low copra prices, a key source of income, in the late 1990s.

Energy Growth and Potential GHG Reductions. Because of the paucity of reliable data on current energy use patterns, projects of future use must be considered tentative. It seems likely that RMI's population will continue to grow at 1% per year or less, economic growth is unlikely to exceed 3%, and both electricity generation and inland fuel use may continue to grow at 5% per year. In this case, assuming no significant investment in renewable energy or energy efficiency, GHG emissions would increase from roughly 246 Gg in 2003 to about 400 Gg in 2013.

There are few indigenous energy sources that commercial technologies can tap, mainly wind and biomass. It is estimated that the upper limit of probable opportunities for reductions in GHG emissions is about 22 Gg in 2013 (6% of 'base case' 2013 projected emissions without renewable energy and efficiency investments), of which 64% would be from energy efficiency improvements and 34% from renewable energy. These estimates exclude practical social, financial, environmental or economic constraints.

3. Technical Potential for Renewable Energy Technologies

Resources. The RMI's indigenous renewable energy resources are summarized below.

- *Solar*. NASA satellite data for oceanic solar radiation are adequate for developing solar PV designs in the RMI. The resource appears to be greatest in the northern islands and least in the middle islands. However, throughout the country there is an adequate solar resource for cost effective rural electrification through PV.
- *Wind*. There is a moderate seasonal wind resource, with perhaps sufficient wind for energy development in the northernmost islands. However, there is very little data and none specifically designed for assessing energy potential. It would be reasonable to assess the wind energy potential for Majuro and Ebeye, where power demands are high.
- *Hydro*. There is no hydro resource in the Marshall Islands.
- *OTEC.* Although there is clearly a good ocean thermal resource, OTEC is an unproven technology and the economic size of a commercial facility -when eventually built- would exceed the demand for all islands except possibly Majuro.
- *Geothermal*. There is no known geothermal resource. .
- *Wave.* At the RMI's low latitudes, wave energy is moderate. There are no commercially available wave energy systems operating, all designs in development or prototype stage. Wave energy is unlikely to be significant for the RMI for the foreseeable future.
- *Biomass.* Because of poor atoll soils and small land area, large-scale energy production from biomass appears to be impractical in the RMI. A possible exception is biofuel from coconut oil to replace distillate. Copra production has been declining, reaching about 4000 tonnes in 2003. If all were converted to oil, this would be equivalent to 2.8 million liters of distillate, roughly 10% of consumption in 2003. There is also some potential for biogas production for cooking or small-scale power production from piggeries, if pigs were contained in a community holding area.

Appropriate Technologies for Development. Solar PV is the most appropriate technology for electricity production from renewable energy in the RMI. Biomass, other than for cooking and copra drying, is not practical as a long-term energy source but senile coconut trees could provide significant biomass for energy in the short term. Biofuels have considerable potential, since copra production is still the mainstay for outer islands and oil can be produced at small scales. Wind is an unknown energy resource in the RMI and resource measurements should commence soon. Wave energy and OTEC have long-term potential but both are the prototype stage. There is no hydro potential, and no practical geothermal or tidal energy development potential.

4. Renewable Energy Experience

Renewable Energy Experience. The RMI's experience with renewable energy is summarized below, by far the most experience being with solar photovoltaics.

- *Wind and biogas*. There were brief small-scale demonstrations of wind and biogas during the TTPI days but apparently nothing since then.
- *Biomass*. Biomass remains important for cooking and copra drying but there has been no commercial use of biomass energy.
- *Wave*. About 1990 KAJA considered a 200-300 kW sea wave energy system on Giugeegue Island, near Ebeye. KAJUR was to purchase electricity at 17¢/kWh, about double the value of the electricity produced based on fuel costs at the time. The project never eventuated.
- *Solar*. During the TTPI period, around two hundred solar lighting systems were installed on various atolls. Most rural dispensaries received a solar vaccine refrigerator and most atolls

received one or more solar powered high frequency radios along with solar powered lighting for public buildings and a few homes.

- Fifty household lighting systems were purchased from BP Australia and were installed on Lae, Aur, Ailuk and Majuro. Twenty-nine household lighting systems were purchased from Hawaii and installed on Arno and Ebon. About 1993, the Forum Secretariat installed 20 solar home systems (SHS) on Jabat. There were numerous technical problems but some systems continue to provide light and the project may be refurbished and operated by MEC. In 1993, the Japan International Cooperation Agency (JICA) installed solar freezers for ice making and fish storage on Ailinglaplap, Likiep and Namu atolls with an expansion in 1997. The systems functioned until 2002, when there were failures due to corrosion. JICA is expected to repair the facility.
- *Institutional experience for solar*. The TTPI systems were essentially gifts to households, which were expected maintain them. A 'rent to own' approach was tried in Maloelap (1995) and Aur and Ailuk (1992), where households were to pay $8-10 per month until installations were paid for. Basic O&M was by a local technician with irregular visits from an MRD technician, with no disconnections for non payment of fees. In 1996, the French government funded a SHS project, based on a solar utility concept, on Namdrik providing 134 home systems, six larger refrigerators and street lighting. MAEC owned and maintained the systems, which used pre-payment metering, and users were to pay a monthly fee for the service. There were various technical, operational and social problems, the last including clashes with the island leadership leading to several lessons: i) involve the recipient community, particularly the leaders, in planning; ii) pre-payment meters do not resolve earlier non-payment problems; and iii) complicated payment, institutional and technical systems are inappropriate for remote sites with poor communications and limited access.

Current Projects. Current renewable projects in the RMI are summarized below.

- *Biofuels*. Tobolar Copra Processing has reportedly had three diesel vehicles fuelled by a coconut oil/diesel biofuel blend for various periods in the past five years. They are considering an expanded program but lack finance to develop the biofuel market.
- *Solar PV*. Rehabilitation of the failed Namdrik PV project began in 2000 with funding from the SPC's 'Pacific Rural Renewable Energy France-Australia Common Endeavour' (PREFACE). Only the solar panels could be salvaged. About 115 installations had been completed by the end of 2003. Community leaders were integrated into the project but payment of fees was under 50% during the first year, due in part to thefts or faulty accounting. MEC has taken over management, and plans to enforce disconnections for non-payment. Quality of service is expected to improve and there are clear indications that households have sufficient funds to pay for the service.

In 2002-2003, eleven health centers received solar systems from a UN trust fund. Unfortunately, lighting is AC (introducing significant losses and encouraging use of additional appliances which can overload the system), inappropriate batteries were used, there was little interaction with EPD, there was minimal capacity building, and no mechanism was established for maintenance. The systems are likely to fail after a few years.

80 PV systems are planned for Mejit, similar to the Namdrik PREFACE installation. MEC will handle operation and maintenance.

Future Projects. An annual government budget of about US$500,000 is expected for further outer island solar electrification. The RMI has also requested Global Environment Facility (GEF) support to develop a comprehensive program for GEF funding for renewable energy capacity building and barrier reduction relating to solar PV, biofuel and wind. Under the Cotonou agreement, the RMI is to receive a grant of about $2 million from the EU for renewable energy and energy efficiency measures. The funds are expected to be for PV installations as part of the outer island electrification program, with installations unlikely before 2007.

Proposed Projects. The PIREP team proposes the following: i) a feasibility study and concentrated planning effort for coconut oil production on outer islands to supplement diesel fuel for electricity generation; ii) a feasibility study on the economic use of senile coconut trees removed for replanting with higher yield varieties; iii) small scale trials of outer island biofuel production; iv) feasibility study of community piggeries with associated biogas production; v) development of renewable energy training capacity at the College of the Marshall Islands; vi) trials of roof top PV for integration into the Majuro grid; and vii) a wind resource survey for Majuro and Ebeye.

5. Barriers to Renewable Energy and Energy Efficiency Development

The key barriers to renewable energy and energy efficiency in the RMI are: i) inadequate capacity within the government to regulate, develop, implement and monitor renewable energy and energy efficiency projects; ii) fragmented implementation of projects with little sharing of resources, information and experience; iii) a lack of standards or certification for components and training; iv) irregular incomes on outer islands, making difficult for households to make regular cash payments; v) the RMI's small size and its wide geographical distribution; vi) poor access to outer island villages; vii) the loss of skilled people through emigration; viii) low level of public awareness of the benefits of energy efficiency; and ix) the lack of wind energy resource data.

6. Capacity Development Needs

Key capacity development needs are: i) improved capacity of the Energy Planning Division of MRD to deal with energy policy issues, legislation, project development, and monitoring and analyzing energy activities; ii) improved capacity of MEC for its new role in renewable energy for rural electrification including training capacity for maintenance, creation of standards and certification measures for PV-based rural electrification, and development of monitoring and analysis methodology for SHS installations; iii) the EPD, MEC and KAJUR all require capacity building to develop DSM measures, particularly for transport, government and large electricity customers; iv) private businesses currently selling renewable energy equipment require assistance in locating suppliers for equipment satisfactory for use in the RMI; and v) MRD and the private sector require assistance for the rational development of biofuels as a rural island alternative to diesel fuel.

7. Implications of Large Scale Renewable Energy Use

Solar. Individual solar home systems are not problematic at a large scale, except for capital investment costs and the collection and recycling of batteries. Benefits include better quality of life through improved communications, education, health and improved lighting. There would be modest employment on outer islands.

Biofuel. Large-scale use of biofuel could substantially increase rural incomes. Biofuel use should be environmentally benign as spills readily biodegrade and pollutants are minor. Economic viability of locally produced biofuels (compared to central production in Majuro) may be a serious issue and needs to be carefully assessed. If poorly planned and implemented, large-scale biofuel production can create social frictions and undermine traditional values. For the biofuel to be produced at the lowest possible cost at the location of its use, careful system design for the whole process from tree to end-use is necessary, particularly for the atoll type islands where there transport within the atoll is expensive.

Biogas. Social and environmental benefits of large-scale biogas include reduced cash outlay for cooking fuels and possibly genset operation, and more hygienic control of animal wastes. Difficulties include the need for concentrated housing of the community's pigs and chickens and developing mechanism for the fair distribution of the costs and benefits of gas production.

8. Energy Efficiency

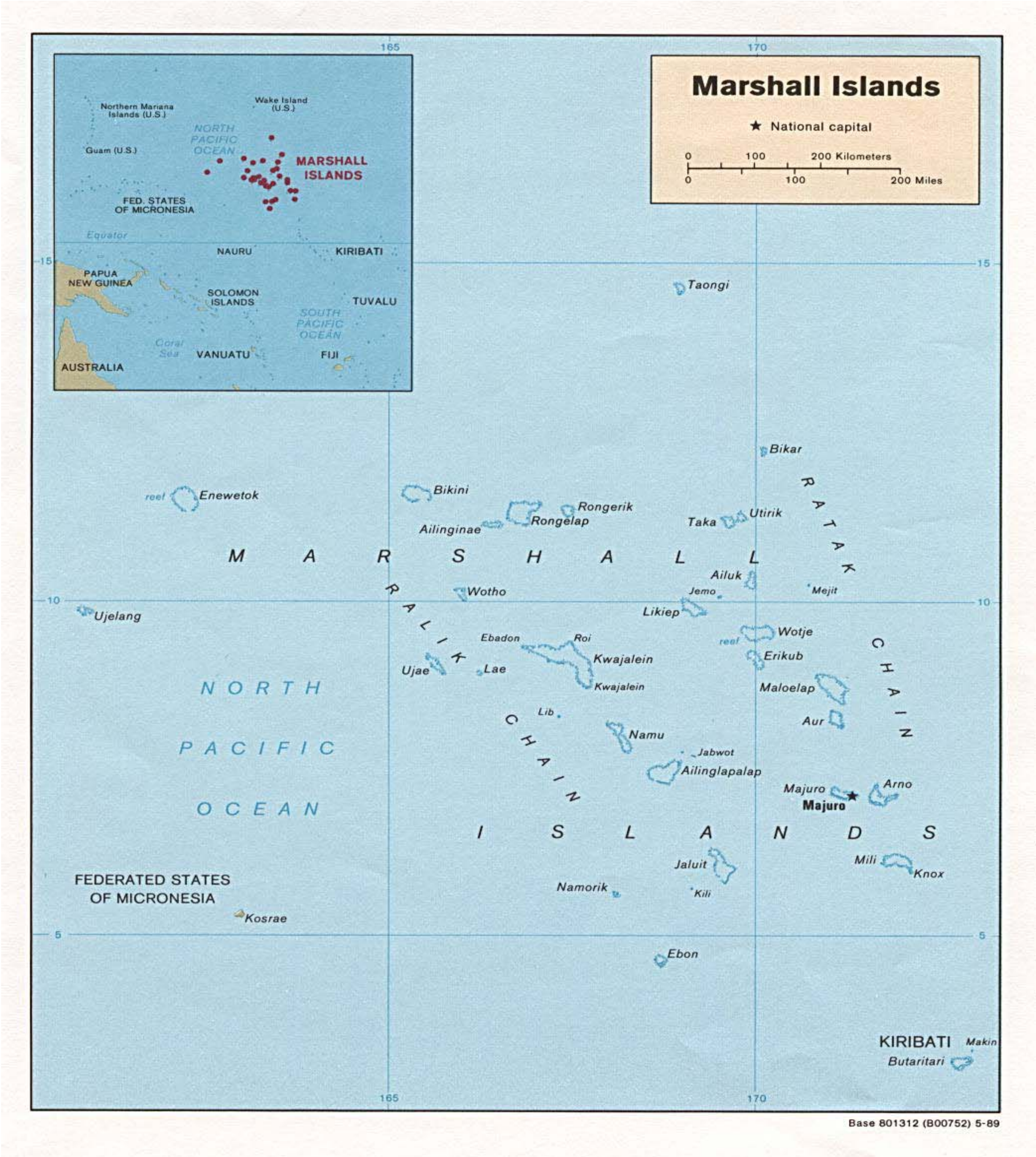
For Majuro and Eybye, renewable energy is much more expensive than petroleum-based energy. The use of petroleum for transport or electricity production should be as efficient as practical so the high cost of renewable energy is not wasted on inefficient users. Transport accounts for about two-thirds of the RMI's fuel use providing scope for significant improvement in transport fuel efficiency. Electricity production accounts for about 30% of national petroleum consumption. The efficiency of electricity use by heavy industrial and commercial users can be considerably improved at relatively low cost, generally far cheaper than generation expansion.

9. Co-Financing and Implementing Capacity Development Needs

EU outer island PV electrification is the only firm donor project providing an opportunity for co-financing with PIREP. Should other opportunities arise, the following would be useful for co-financing:

- capacity development within MEC for system design, installation, operation and maintenance, both at project implementation and for the indefinite future;
- capacity building for the College of the Marshall Islands for PV installation and maintenance within its electrical trades program;
- capacity building for EPD on project development and management, and energy data management;
- technical assistance and training for development and management of biofuel production for transport;
- training for marine personnel to improve the efficiency of marine transport; and
- development of mechanisms and approaches to reduce the inefficient use of private cars on Majuro.

Map showing the location and islands of the Republic of the Marshall Islands



10. Country Context

1.1 Physical

The Republic of the Marshall Islands (RMI); consists of atolls and islands divided into two groups, the western or Ralik (sunset) group and the eastern or Ratak (sunrise) group. These are contained within a rectangle extending north and south some 1150 km and east to west about 1300 km located between about 4° to 15º north latitude and 160º to 172º east longitude. The RMI is more than 3200 km from the nearest sizeable trading centers of Honolulu and Tokyo. Twenty-two of the 29 atolls are inhabited as are four of the five small raised coral islands. Although some islands are several kilometers long they rarely exceed a few hundred meters in width and are often considerably narrower. Kiribati lies to the immediate south and the Federated States of Micronesia (FSM) to the west. The total land area of the RMI is about 181 km^2 there is an exclusive economic zone (EEZ) of 1.2 million km^2. The entire country is low lying with almost no land more than five meters above mean sea level (Figure 10-1). Kwajalein vies with Kiritimati Island in Kiribati as the largest atoll in the world with Kwajalein having the bigger lagoon and Kiritimati the larger land area.

Figure 10-1 - A RMI atoll approached from the sea

Source - GoRMI, 2000

1.2 Social

Tables 1-1 and 1-2 show population and it's distribution. In 1999, there were 50,840 people (6478 households) living on 25 atolls. Sixty eight percent of the national population lived on two atolls with 46.6% on Majuro and 21.4% on Kwajalein, mostly on the tiny island of Ebeye.

As Table 10-1 shows, the RMI's population grew at a modest average annual growth rate (AAGR) of 1.45% from

Table 10-1 - RMI Population, Ralik and Ratak Chains, 1920-1999

Year	Total Population	Ralik Chain		Ratak Chain	
		Population	*% total*	*Population*	*% total*
1920	9,693	4,919	50.7	4,774	49.3
1925	9,538	4,778	50.1	4,760	49.9
1930	10,130	5,308	52.4	4,822	47.6
1935	10,126	5,292	52.3	4,834	47.7
1958	14,163	6,644	46.9	7,519	53.1
1967	18,578	8,732	47.0	9,758	52.5
1970	22,888	12,159	53.1	10,729	46.9
1973	25,045	10,692	42.7	14,334	57.2
1980	30,873	13,684	44.3	17,189	55.7
1988	43,380	17,502	40.3	25,878	59.7
1999	50,840	19,915	39.2	30,925	60.8

Source: GoRMI website www.rmiembassyus.org/statistics (Feb. 2004)

1988-1999, a dramatic decrease from the extremely high 1980-1988 AAGR of more than 4.3%, with most growth in the Ratak chain. From 1980-1988, the urban – peri-urban population (i.e. Majuro/Kwajalein) grew at 5.8% annually compared to 1.8% for the rest of the country, slowing to 1.6% and 1.1% respectively for 1988-1999. Table 10-2 shows the land area of the atolls and islands of the RMI and the population by island at the time of the 1999 census.

The rate of natural increase of the RMI population has not been decreasing (Figure 10-2). This rapid drop in the rate of increase of population is due largely to free access to the United States for RMI citizens. That makes it difficult to accurately project future population levels for the RMI. In 2000, before the 1999 census results had been analyzed, the Office of Planning and Statistics (OPS) estimated the population as 55,000, projected to reach 95,000 by 2010. However, assuming 1988-1999 trends, the 2010 population will be about 59,600 and the current population in 2004 is 54,600 of which Majuro/Kwajalein would account for 37,400 or 68.5 percent.

Table 10-2 - RMI Land Area and Population (1999)

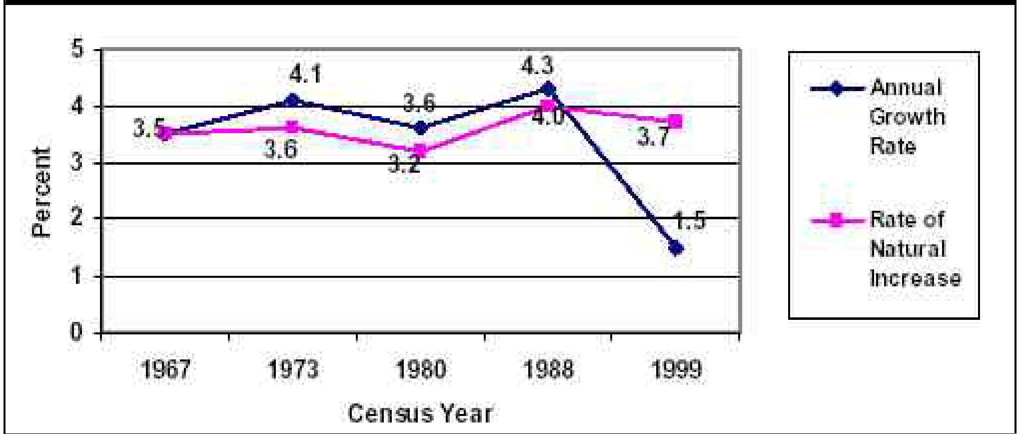
Atoll or Island	Land (km^2)	Lagoon (km^2)	Pop.	HH	Density (people / km^2)	HH size
Ailinglaplap	14.69	750.3	1,959	236	133	8.3
Ailuk	5.36	177.3	513	88	96	5.8
Arno	12.95	338.7	2,069	244	160	8.5
Aur	5.62	239.8	537	86	96	6.2
Bikini	6.01	594.1	13		2	
Ebon	5.75	103.8	902	122	157	7.4
Enewetak	5.85	1,004.9	853	109	146	7.8
Jabat Is.	0.57	0.0	95	15	167	6.3
Jaluit	11.34	689.7	1,669	229	147	7.3
Kili Is.	0.93	0.0	774	90	830	8.6
Kwajalein	16.39	2,173.8	10,902	1,213	665	9.0
Lae	1.45	17.7	322	32	222	10.1
Lib Is.	0.93	0.0	147	15	158	9.8
Likiep	10.28	424.0	527	82	51	6.4
Majuro	9.71	295.1	23,676	3,080	2,438	7.7
Maloelap	9.82	972.7	856	138	87	6.2
Mejit	1.86	0.0	416	60	223	6.9
Mili	15.93	646.7	1,032	136	65	7.6
Namdrik	2.77	8.4	722	118	261	6.1
Namu	6.27	397.6	903	127	144	7.1
Rongelap	7.95	1,004.3	19		2	
Ujae	1.86	185.9	440	67	236	6.6
Ujelang	1.74	66.0	0		0	
Utrik	2.43	57.7	433	65	178	6.7
Wotho	4.33	94.9	145	18	34	8.1
Wotje	8.18	624.3	866	108	106	8.0
Totals	*181.48*	*10,867.9*	*50,840*	*6,478*	*280*	*7.8*

Source – 1999 Census; Note: urban/urbanised atolls are in bold print

1.3 Environmental

The climate of the Marshall Islands is moist and tropical with a wet season from May to November, with the wettest months being September-November. The RMI has a trade wind influenced climate with north-easterly winds blowing throughout the year. The trade winds are frequently interrupted locally during the summer months by the movement of the zone of inter-tropical convergence across the area. The annual average temperature is 27°C, typically around 30° maximum with a drop to around 25° at night, and relative humidity ranges from 83% at night to 76% at midday. Surface ocean currents tend to drift westward with the prevailing winds.

Figure 10-2 - RMI Natural Increase and Population Growth Rates, 1967-1999



Source: RMI Statistical Yearbook 2002 (GoRMI, 2003)

The RMI experiences considerable climatic differences from north to south along the atoll chains as well as from east to west across the breadth of the nation. Conditions are drier in the north, with annual rainfall averaging between 1000-1750 millimeters compared to the south with 3000-4300 mm. Extreme weather events, such as tropical cyclones and droughts, are not frequent but there have been cyclones resulting in loss of life. Observations show that these hazards are experienced more often during El Niño events (GoRMI, 2000).[1]

The northern atolls typically experience about half the rainfall of the south, although the pattern shifts with the El Niño oscillation. Rainfall is typically heavy, with the wettest months being September, October and November. Precipitation is typically through intense showers although continuous rain is also common. Heavy rains, storm surges and high seas occur as side effects of storms passing to the north in the May to November North Pacific typhoon season. Typhoon Zelda in 1971 hit hard. Gay and Axel, both in 1992, were the most recent major storms to hit the Marshall's. In 1994 storm surges and high surf caused coastal damage on Majuro and other atolls in the group.

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

[1] GoRMI is the Government of the Republic of the Marshall Islands. See Annex 2 for a list of materials referenced such as (GoRMI, 2000).

The GoRMI has signed 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, Law of the Sea, and the Convention on Biological Diversity. The initial national communication to the UNFCCC, indicating greenhouse gas (GHG) emissions, and vulnerability and adaptation to climate change, was submitted in September 2000. Table 10-3 summarizes the status and date of signing of key environmental conventions.

Table 10-3 - Ratification of Environmental Treaties and Conventions by the RMI

Status in RMI	**Protection of natural resources** (SPREP Convention)	**Conservation of nature** (Apia Convention)	**Hazardous wastes** (Waigani Convention)	**Nuclear free Pacific** (Rarotonga Treaty)	**GHG reductions** (Kyoto Protocol)	**Ozone depleting substances** (Montreal Protocol, et al.)
Signed	25 Nov 86	-	16 Sep 95	06 Aug 85	16 Mar 98	–
Ratified	23 Jul 90	20 Jul 90	23 May 01	20 Oct 86	15 Nov 00	21 Dec 92
Entered into force	22 Aug 90	26 Jun 90	21 Oct 01	11 Dec 86	n/a *	17 June 93

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, PIFS and SPREP (Jan. – March 2004) and GoRMI 2002; (There are minor inconsistencies among sources)

The RMI has participated in international assemblies on climate change and has expressed concern about sea level rise, calling for countries to work together to reduce GHG emissions lest the RMI become uninhabitable. A program of using solar energy for most outer island electrification is in part an effort to demonstrate an effort to control green house gases.

Environmental issues in the Marshall Islands, related to rapid past population growth and the high density of settlement in Majuro and Ebeye, include inadequate supplies of potable water, and the pollution of lagoons from household waste and discharges from fishing vessels. Growing problems of waste disposal have also emerged (GoRMI, 2000). Atolls have very limited space for landfill sites and the fragile environment, particularly ground water lenses and coral reef ecosystems, are easily degraded. These problems are particularly acute for Majuro and Ebeye, and are contributing factors to the stresses placed on the coral reef.

1.4 Historical and Political

1.4.1 History

The first Micronesian navigators appear to have arrived in the Marshall Islands as early as 2000 BC but it was not until 1529 that the Spaniard Alvaro Saavedra brought Europeans to the Marshall Islands. Although the Treaty of Tordesillas (1494) 'gave' the Marshall Islands to Spain, little interest was shown in taking possession. It was British Captain William Marshall of the *H.M.S. Scarborough* who gave the country its western name as he sailed through the group in 1788 while transporting convicts to Australia. Fortunately, the mid-1880s predations of the 'Blackbirder' slavers did not reach the

Marshalls and the serious depopulation that took place in Tuvalu, Tokelau and some of Kiribati did not occur. In general, contact with Western countries was based on trade and missionaries with few incidents of violence. By the mid-1800s, both Americans and Germans had established a commercial and religious presence in the Marshall Islands and in 1878, Captain von Werner of the German Navy entered into a treaty with the Ralik group for trade. In 1885, under mediation of Pope Leo XIII, the German government annexed the Marshall's after paying Spain the sum of $4.5 million for its claim dating from the Papal grant of 1494. In 1886 Germany formed a formal protectorate and in 1887 the Jaluit Company was created and entrusted with the Marshall's governance.

Spain's loss of the Spanish-American war in 1898 also cost Spain all of its Pacific claims and resulted in Germany receiving the disputed atolls of Ujelang and Enewetak, thereby putting all of present-day RMI under German control. At the beginning of the First World War in 1914, Japan forcibly removed Germany from the Marshall's and took control. After the war, the League of Nations granted Japan a mandate to continue to administer the islands. By the late 1930s, Japan was preparing for war in the Pacific and Mili, Jaluit, Maloelap, Wotje and Kwajalein were developed into a south-north line of defense, with the construction of supply depots, airfields and fortifications.

In late 1941 the Pacific War began and in 1943 the American invasion of the Marshall's commenced. By 1944, America was in military control of the Marshall's and remained so until 1951 when the United States Department of the Interior assumed responsibility following the establishment of the Trust Territories of the Pacific Islands (TTPI) by the United Nations in 1947. The TTPI included present day Palau, the Northern Marianas, Federated States of Micronesia and the Marshall's.

1.4.2 Post WWII

After the allied victory in the Pacific, the U.S began a program of nuclear weapons testing in the Marshall Islands, which would strongly affect the future of Marshallese–US relations. Bikini was first used as a test site with the evacuation of the Bikini population followed by a 1946 surface blast in Bikini lagoon. American nuclear testing then expanded to include Enewetak atoll in 1948.

In 1952 the first hydrogen bomb was exploded on Enewetak, followed in 1954 by "Bravo" on Bikini exploding the most powerful hydrogen bomb thus far. Unanticipated radiation fallout caused the death of Japanese fishermen in nearby waters and forced the evacuation of Rongelap, Rongerik, Utirik and Ailinginae, although not until exposure had reached serious levels for both U.S military and local people living on those islands. Although the Rongelapese were eventually allowed to return to their island, they worried about lingering radiation and left after a few years so Rongelap remains nearly uninhabited. After the 1954 test and resulting public outcry in the U.S, no further nuclear testing was carried out in the Marshall's, although Christmas Island (Kiritimati in Kiribati) was the site of further high-altitude British hydrogen bombs tests.

As a step towards independence for the TTPI, a Congress of Micronesia was created by the U.S in 1965, with representatives from all of the TTPI islands. Twelve years later, the

Marshall Island's Constitutional Convention adopted a constitution blending traditional governance with a national model based on the U.S system of government. In 1979 the Marshall Islands officially became self-governing. In 1982 the name "Republic of the Marshall Islands" became official and in 1983 the voters approved a Compact of Free Association (COFA or Compact) with the United States. The Compact granted the RMI sovereignty while providing $336.5 million in aid grants,[2] U.S military defense and funds for renting a missile testing range at Kwajalein Atoll. With the approval of the US Congress in 1986, the COFA went into effect; in 1990 the U.N ended the RMI's Trusteeship status, and in 1991 the RMI became a member of the United Nations. Over the full 17 years (FY 1987–FY 2003) from the start of the original Compact through the end of a two-year extension, the US provided approximately $750 million to the RMI (ADB, 2004).

1.4.3 The political system

The RMI's Parliament, or Nitijela, has 33 members, elected by popular vote of all citizens aged 18 years or older to a four year term. The President and Head of State is Kessai Hesa Note, since 3 January 2000. The President is elected by the Nitijela from its members for a four-year term. Cabinet is selected by the President from the members of the Nitijela. The last national elections were held in November 2003, returning the previous government to power. The next elections will be in November 2007. Traditionally there have been no formally organized political parties, but rather factions or interest groups with no formal platforms or party structures. There is also a twelve-member Council of Chiefs, which is advisory.

1.5 Economic[3]

RMI remains heavily dependent on external assistance, with grants averaging almost 60% of Gross Domestic Product (GDP) since independence in 1986. The United States provided most of the assistance through funding under the economic provisions of the original Compact (FY 1986-2001; extended through FY2003). As grant flows declined in real terms in the 1990s, the RMI's economic growth weakened, and real per-capita income fell below Pre-independence levels. Fiscal expenditure and economic growth were also constrained by the need to retire external public debt incurred on commercial terms in the early 1990s against future Compact revenues. From 1990-2000 (ADB, 2003b), real GDP declined by 1.6% annually. From 1995-2001 (the latest official data at the time this report was prepared), real GDP and real per-capita GDP contracted by nearly 25% and 35% respectively. Formal employment has not increased since the late 1980s (Figure 10-3).

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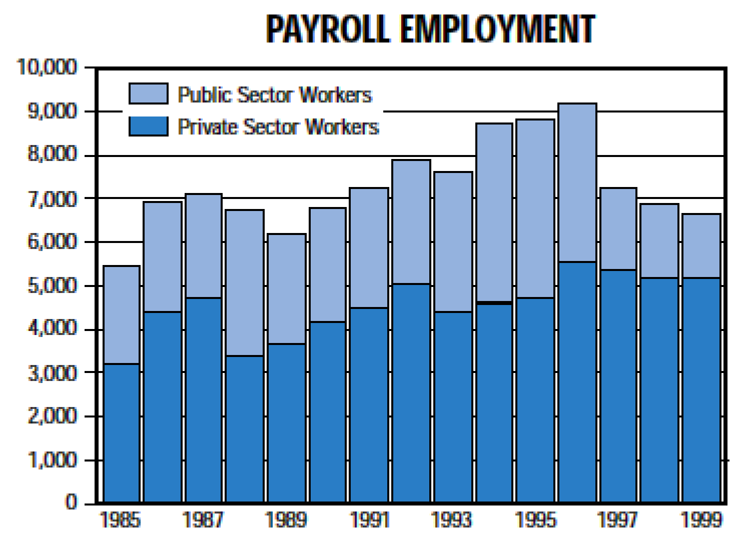
[2] Section 211 of the COFA specified, *"to the Government of the Marshall Islands, $26.1 million annually for five years commencing on the effective date of this Compact, $22.1 million annually for five years commencing on the fifth anniversary of the effective date of this Compact, and $19.1 million annually for five years commencing on the tenth anniversary of this Compact. Over this fifteen-year period, the Government of the Marshall Islands shall dedicate an average of no less than 40 percent of these amounts to the capital account."* The actual amount received by the RMI was higher as funding was partly linked to inflation and the agreement was extended for two additional years.

[3] The first two paragraphs borrow heavily from the International Monetary Fund's most recent RMI report (RMI, 2003).

Between 1988 and 1999, the unemployment rate jumped from 12% to over 30% and is probably essentially unchanged since then. Human development indicators have lagged behind those of other middle-income countries, and the income distribution is uneven with a high incidence of poverty on the outer atolls.

Figure 10-3 - Paid Employment in the RMI from 1985 - 1999



Source: Bank of Hawaii Economic Report, April 2001

1.5.1 The Compact

A new twenty year Compact agreement includes a revised package of economic assistance with another opportunity to shift toward economic self-reliance. The economic provisions include a temporary increase in total grants — largely to support a Compact Trust Fund, which is meant to replace grant funding after FY 2023. American budgetary support from grants will decline steadily in real terms throughout the period covered by the agreement. The renewed Compact also includes a number of accountability measures meant to improve the efficiency of grant use.

According to the Asian Development Bank (ADB, *Asian Development Outlook*, 2004), *"the critical policy development in 2003 was the passage into US law in late November of the Compact of Free Association Amendments Act 2003, which sets out the nature and terms of US financial assistance for the period FY2004–FY2023). The overall annual financial support potentially receivable in this period, prior to inflation and other adjustments, is in the order of $66 million, or about 60% of the current nominal GDP level."*

1.5.2 Recent growth and prospects

The GoRMI is signatory to the three Pacific regional trade and economic trade agreements, the most important of which are the Pacific Island Countries Trade

Agreement (PICTA) and the Pacific Agreement on Closer Economic Relations (PACER; between PICTA signatories and Australia and New Zealand). The GoRMI has also signed the Cotonou Agreement, providing membership in the African, Caribbean and Pacific (ACP) group of countries, and thus access to development assistance from the European Union. Key economic treaties, other than the Compact, are shown in Table 10-4.

Table 10-4 - RMI and Regional Economic Treaties

Status	SPARTECA	PACER	PICTA
Signed	14 July 1980	18 Aug 2001	18 Aug 2001
Ratified	24 Feb 1981	10 Oct 2001	10 Oct 2001
Entered into force	26 Mar 1981	03 Oct 2002	13 April 2003

Source: Note from Pacific Islands Forum Secretariat (PIFS, January 2004)

Table 10-5 summarizes recent economic data for the RMI.

Table 10-5 - Marshall Islands, Selected Economic Indicators

Indicator	1999	2000	2001	2002 (Est.)	2003 (Est.)	2004 (Proj.)
Real GDP (% change)	0.6	0.9	-1.3	4.0	2.0	1.5
Consumer prices (%change)	1.9	0.9	1.8	1.7	-1.9	1.5
Central government finances (% of GDP)						
Revenue and grants:	67.6	75.2	82.5	76.0	75.4	75.1
Of which: Grants	40.1	50.4	58.7	49.8	50.0	50.6
Expenditure	57.1	66.0	72.8	79.5	66.6	78.2
Overall balance	10.6	9.2	9.7	-3.5	8.7	-3.1
Usable government financial assets:						
(US$ million.; end of period)	4.8	9.4	4.2	2.1	3.4	0.8
Trust Funds (US$ mn.; end of period)	...	...	...	16.3	32.6	41.6
Commercial banks (US$ mn.; end-Dec.):						
Foreign assets	25.0	30.6	31.7	40.1	48.4	...
Private sector claims	23.5	26.6	30.3	35.6	37.4	...
Total deposits	54.3	58.5	60.2	69.4	72.2	...
One-year time deposit rate (%)	5.0	6.2	4.1	4.0	3.9	...
Average consumer loan rate (%)	20.5	19.2	16.5	16.5	16.1	...
Balance of payments (US$ million):						
Trade balance	-52.4	-41.9	-39.7	-41.1	-47.1	-51.1
Net services	-8.7	-2.2	-2.4	-3.3	-4.3	-4.1
Net income	22.6	26.3	19.7	25.1	33.2	26.6
Private and official transfers	32.6	43.5	51.9	40.1	40.3	42.9
Current account including official transfers	-5.9	25.7	29.5	20.8	22.2	14.4
Current account excluding official transfers	-44.6	-24.0	-28.6	-31.4	-30.3	-40.2
Overall balance	-7.6	4.6	-5.2	14.2	17.7	-27.3
External debt (US$ mn.; end of period)	98.5	91.9	76.8	85.4	90.7	90.1
(%of GDP)	101.8	93.3	77.5	81.5	86.5	83.3
External debt service (US$ millions)	36.2	20.6	26.3	3.2	4.1	4.1
(% of exports of goods and services)	327.1	130.4	150.6	16.8	20.0	18.1

Sources*:* IMF, 2003 with data provided by RMI authorities and IMF staff estimates.

The economy appears to have improved since 2001, mainly reflecting increased government expenditure made possible by higher external assistance. Based on available data,[4] annual GDP growth is estimated to have averaged about 3% in FY2002 and FY2003 following weak or negative growth in previous years. The ADB (2004) estimates that real GDP will increase by 2-4% in 2004 and three percent in 2005.

In recent years, the inflation rate (i.e. the consumer price index for Majuro) remained under 2% partly due to modest growth in import prices and an increasingly competitive retail environment. Outside of construction, the private commercial sector generally remains stagnant. In recent years, bank loans to the private sector declined sharply and a number of major retailers struggled, partly owing to the increased competition. GoRMI purchases of contracted services decreased, particularly hurting private companies involved in transportation and facilities maintenance. Copra production plummeted due to irregular shipping and the lagged effect of weak export prices. On the positive side, a tuna processing plant expanded its operations.

1.5.3 Millennium Development Goals

In September 2000, 147 countries including the RMI adopted the Millennium Development Goals (MDGs), a set of targets with quantifiable indicators, now widely used to assess development progress. The ADB (2003b) has reported on the progress of its Pacific Developing member Countries (PDMCs) toward meeting the MDGs. For the RMI, the ADB concluded:

> *"Progress towards the MDGs in the Marshall Islands is slow. In 1999, an estimated 20% of the population was living below the US$1 per day poverty line. Primary enrolment rate was 84% in 1999 (no clear time series available). Retention rates, secondary enrolment and educational achievement need to be improved particularly in the outer islands. Efforts need to be strengthened and further attention directed to ensuring that all parts of the population have access to essential and quality education and health care services. The target of eliminating gender disparities in primary and secondary education has almost been achieved. Child mortality rates (both under-five and infant mortality rates) have fallen significantly. There is a dual disease pattern with both communicable and non-communicable diseases emerging. Life-style diseases are increasingly becoming a major cause of morbidity and mortality. Malnutrition associated with excessive consumption of junk food is also increasing. Access to potable water and improved sanitation facilities is very low with significant differences between rural/outer islands and urban areas."*

[4] The IMF notes that data is very limited. *"In particular, core economic data need to be compiled and reported on a timely basis, and the quality of the data needs to be enhanced." (IMF, 2003)*

1.5.4 Investment and banking

A recent private sector assessment analyzed the business environment in the RMI (ADB, 2003d):

> *"The conclusion ... is that doing business in the Marshall Islands is difficult. Problems with property rights and the laws related to business transactions make arms length contracting almost impossible and finance very difficult to obtain. The prominent role of the state in the economy raises costs for business and crowds out employment and entrepreneurship. The impact of state intervention augments the negative effects of isolation, size, and vulnerability of the country, which are further compounded by a trade regime that is characterized by variable tariff rates and taxes on imports on which there are many exemptions. This situation has resulted in an atmosphere of tension and mistrust between government and the formal private sector. At the same time, the institutions and incentives inherent in the current system put native-born Marshallese at substantial disadvantage in doing business. The problem is not the result of discrimination or exclusion, but rather because the interaction between property rights on the one hand and the financial system on the other disbars most of the local population from even the possibility of mobilizing their wealth to finance business ventures. Furthermore, the incentives faced by Marshallese in the outer atolls, especially the government-sponsored copra purchasing scheme, do not encourage entrepreneurial activity.*

The same study characterized the institutional foundation of financial markets in RMI as very underdeveloped: *"Property rights in land are uncertain because of communal ownership and movable property rights, the basis for pledging assets as collateral against lending, are very weak. The result is that lending for business support occurs only to those who have substantial assets. Other important financial market issues include possible regulatory concerns with the largest commercial bank on the island and the poor state of the development bank."* The Usury Act of 1989 (Title 20, Chapter 8) sets a cap on annual interest rate of 24 percent. There are three banks operating in the RMI:

- *The Bank of the Marshall Islands (BMI)*, by far the largest bank with about $60 million in total assets. It has 50% private sector ownership, the remainder being owned by the social security system (35%) and the Marshall Islands Development Bank (15%);
- *The Bank of Guam*, with assets of about $20 million is foreign owned, does very little lending and is not really a force in the RMI financial system; and
- *The Marshall Islands Development Bank (MIDB)* was established to promote development lending but in practice undertakes substantial consumer lending to Marshallese.

The BMI dominates the financial sector both in terms of deposits and lending, accounting for over 60% of private sector credit. It has branches in Majuro and Ebeye and operates monthly mobile banking services to the outer islands on government vessels. The mobile banking service revolves around purchase of copra: the BMI provides the funds to buy the copra and accepts deposits from the sellers. Conceptually, this could be an interesting approach for other Pacific Island Countries (PICs).

Most loans are consumer loans, with repayments deducted from borrowers' paychecks. BMI has only some $5 million in lending to companies. Lending rates are in the region of 18% (consumer loans) and 13.5% (commercial). Time deposit rates are 4-5% for 12-month deposits. The bank is reluctant to lend for business purposes and generally only does so to the large companies on the island with which it has been dealing for an extended period. The BMI normally requires 75% cash security against loans. They have reportedly (Chutaro, 2004) never given loans for start-ups, unless the borrower has substantial cash reserves with the bank.

The MIDA has a high proportion of non-performing loans, resulting in severe liquidity problems. There have been unconfirmed reports of past political pressures to lend to well-connected people regardless of creditworthiness and ability to repay. Even after an unconditional loan of $5 million from Taiwan, MIDA was not liquid in mid 2003 because of the severe portfolio problems, and as a result was not then lending.

None of the banks have made loans specifically for renewable energy, energy efficiency or related energy services. As banks are reluctant to provide loans to businesses, unless the business is well established and has substantial reserves with the bank, this is unlikely to change. There is reportedly an interest within the RMI of establishing micro-credit facilities for small business development but the PIREP mission has no details.

The United States Department of Agriculture (USDA) Rural Economic Community Development (RECD) program has lending programs which can be used in principle for renewable energy technologies (RETs) such as solar home lighting. Currently RECD is providing self-help loans and grants for disadvantaged, low-income families to build homes. Although RETs could be included as within house construction, the PIREP mission does not know if this has occurred.

1.5.5 Outer Island Economy

Copra

Much of the income on the outer islands comes from copra sales handled through a national cooperative. It is common for shops on the outer islands to extend credit to residents with payment arrangements made through purchasers signing over income from cooperative sales. A similar longer-term finance arrangement could be developed for the payment for renewable energy services or systems.

The Tobolar Copra Processing Authority in Majuro receives copra from the outer islands and produces coconut oil for export. Production varies from year to year but recently has been around 5000 tons (US short tons; 1.0 ton = 0.907 metric tonnes) per year of copra.

The mill has a capacity to process about 10,000 tons of copra a year.[5] The relatively low export price of coconut oil has led Tobolar to look for other markets, including biofuel as a diesel fuel replacement. Tobolar has operated three diesel pickup trucks on biofuel and is interested in converting its own plant and transport diesel engines to coconut oil.

External Payments

Remittances from relatives on Majuro are a common source of cash. It is common for arrangements to be made for payments for outer island services to be made to a Majuro agent by family members. Pension payments for retired persons and the elderly also represent a significant cash income source for many households on the outer islands.

1.6 Institutional Context for Energy

Energy responsibilities within the GoRMI and its state owned enterprises are summarized in Figure 10-4. As in all PICs, the Finance Ministry, through its control of funding, financial incentives and taxation, has important energy responsibilities as well.

Figure 10-4 - GoRMI Energy Sector Responsibilities

Ministry of Resources and Development (MRD)	**Marshalls Energy Company** (MEC)	**Office of the President**	
Energy Planning Division (EPD) • Energy planning and coordination • Energy policy review and implementation • Public-private energy program partnership promotion • Investigation of energy service funding opportunities • Ensure standards, especially for solar equipment • Establish national energy database	• Electricity generation and distribution • Petroleum fuel purchase, storage and sales • RE installation, operation and maintenance	**Economic Policy, Planning and Statistics Office** (EPPSO) • Overall development policy • Energy sector finance • Donor liaison	**Office of Environmental Planning and Policy Coordination** (OEPPC) • Environmental aspects of energy • Focal point for Kyoto protocol (GHGs) and GEF

Note: A separate power utility (KAJUR) serves the second main urban centre of Ebeye
The telecommunications, education and health ministries are also involved in solar PV.

Responsibilities are explained below.

- *Energy Planning Division*. The EPD was established within the Ministry of Resources and Development (MRD) by cabinet on April 17, 2003.The EPD has overall responsibility for energy policy, coordination and implementation. However, there is only one professional energy planner position and one support staff position, the second effectively part-time.[6] Although the EPD deals with overall national planning and the promotion of energy efficiency and conservation, its main focus is on renewable energy (RE) in remote areas, particularly solar photovoltaic (PV). MRD

[5] Annexes to *the Namdrik Project Report Final Review*, Jean-Michel Durand, October. 2003

[6] In mid May 2004, the Energy Planner position, which had been vacant since October 2003, was filled.

and the Marshall's Energy Company (below) jointly recommend rural electrification priorities, based mainly on solar energy, to cabinet, which establishes priorities and financing.

- *Marshall's Energy Company*. The MEC was established in 1984 as a state-owned enterprise (SOE). It is responsible for electric power generation and distribution on Majuro and operates the power systems of Jaluit and Wotje under contract from the GoRMI, with the government guaranteeing any revenue shortfalls. MEC also imports, stores, distributes and re-exports petroleum fuel products. Under a Memorandum of Understanding (MOU) with the GoRMI (MEC/GoRMI, 2003) agreed in November 2003, MEC installs, operates and maintains RE installations in remote areas on a project-by-project contractual basis, with funding from the government, donor agencies or others. MEC is one of the few SOEs that is profitable and no longer receives government subsidies (ADB, 2003d). The Board of Directors consists mostly of government officials but also two private sector representatives.
- *Other energy utilities*. There is no national electric power utility in the RMI. The Kwajalein Atoll Joint Utility Resource (KAJUR) was established in 1990 by the Kwajalein Atoll Development Authority and the local government to manage power generation and distribution on the island of Ebeye and a water desalination system using waste heat from the power plant. A Marshall's Alternative Energy Company (MAEC) was established through the Marshall Islands Development Authority (MIDA) as a corporation in 1994 to develop renewable energy systems in outer islands. It was dissolved in 2003 with assets transferred to the MEC.
- *Economic Policy, Planning and Statistics Office*. The EPPSO, within the Office of the President, is the key national development planning agency and is involved in any Compact-related activities and major infrastructure projects. It has been closely involved in rural electrification policy. As the name suggests, it also has the main GoRMI responsibility for developing and maintaining statistical databases.
- *Office of Environmental Planning and Policy Coordination*. The OEPPC, also in the Office of the President, is the GoRMI's environmental focal point, which includes all Global Environment Facility (GEF) activities and programs under the UNFCCC (i.e. the Kyoto Protocol) and is, as such, a key agency regarding financial support for RE and EE (energy efficiency) including carbon credits. OEPPC has coordinated PIREP activities within the RMI.

1.6.1 Institutional arrangements for Renewable Energy

Renewable energy development in the 1980s and early 1990s was *ad hoc*. The telecommunications, health and education departments all developed schemes independently for their own facilities and the U.S Department of Interior (USDOI) developed demonstration projects for wind and photovoltaics, implemented by a small team of GoRMI energy officers. In 1994, the ADB provided a technical assistance grant for the development of electrification for the outer islands. In their report (ADB, 1995), it was recommended that most outer islands be considered for electrification through solar

PV and that an institutional structure be developed for their design, implementation and continuing maintenance. Although the MEC was the preferred institutional location, it was fully occupied in developing the Majuro electricity system and refused to add outer island solar PV to its responsibilities. This led to the establishment of a separate rural electrification institution, the MAEC within the MRD. A manager was hired and an office established. Although MAEC took part in the establishment of the French funded 1996 Namdrik PV project, it was never fully staffed and the EPD carried out most of its functions, effectively reverting to the pre-MAEC institutional arrangements.

Although the intent of the MAEC was to place outer islands renewable energy development within one structure, it was never fully developed as an institution and failed in its stated purpose. Today, there are still separate renewable energy activities within the MRD's EPD, and the telecommunications, fisheries, health and education ministries. As discussed in Chapter 3, this has resulted in installations that range from those of high quality well suited to the Marshalls' situation, to off-the-shelf systems which are unlikely to survive for long on an outer island. Fortunately, by the late 1990s, the MEC had achieved its goal of raising the Majuro and Jabwor (Jaluit) electricity systems to a high technical standard and have now agreed to manage PV-based rural electrification, which is planned to include most of the outer islands.

1.7 Energy Policies and Legislation

1.7.1 Energy policy

There have been several advisory missions to the RMI on energy policy issues over the past fifteen years or so by the ADB, the Pacific Islands Forum Secretariat (PIFS), the UN Development Programme (UNDP), the South Pacific Applied Geoscience Commission (SOPAC), and U.S agencies separately or in partnership. Draft energy policies were developed by the GoRMI with support from these organizations. As far as the PIREP mission is aware, only two received formal cabinet endorsement, the 1994 *Outer Islands Energy Policy* (OIEP)[7] and the 2003 *Marshall Islands National Energy Policy* (MINEP). Another study, although not formally policy related took place as the OIEP was being developed and, in effect established a national rural electrification policy which remains, according to the national planning office (EPPSO), the "bible" for rural electrification a decade later: the *Outer Islands Electrification Feasibility Study for the Republic of the Marshall Islands* (ADB, 1995).[8]

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[7] The OIEP was more formally the 'Outer Islands Energy Program' which included an 'Outer Islands Energy Policy' and 'Outer Islands Energy Plan' (PIFS, 1998).

[8] The ADB carried out detailed analysis of four technical options: i) photovoltaics; ii) automatic internal combustion engine powered generators; iii) automatic internal combustion engine with battery reserve; and iv) a hybrid of photovoltaic array, internal combustion engine and battery reserve. For all atolls except one, the least cost was individual photovoltaic installations.

In July 1994, the RMI Cabinet approved the following objectives of the OIEP:[9]

- contribute to the social and economic development of the Outer Islands through the provision of reliable energy services;
- encourage the use of low emission technologies and native energy resources for the production of energy on the Outer Islands of the RMI;
- ensure that the provision of energy services is based on both a least cost development strategy and on technically and commercially proven technologies that utilize decentralized alternative energy options without ruling out grid connections when such connections are the economically viable option; and
- guarantee full cost recovery from consumers for the provision of energy services while making explicit budgetary provisions for government and non-government assistance when such assistance is socially justified.

Policy guidelines for the OIEP included tariffs and fees, subsidized funding, operations and expansion, energy conservation and efficiency programs, and safety and the environment. Tariff and fees were to reflect the full cost of the energy services provided and protect the long-term financial viability of the program. Subsidization of the program was to be clearly recognized and made explicit in the GoRMI budget.

As discussed in Section 1.6, the MAEC was established to implement the OIEP in accordance with the ADB's study. Although the MAEC has since been dissolved, the OIEP policies have, by and large, been retained in the current *Marshall Islands National Energy Policy* (MINEP).

Unlike most PICs, the RMI Cabinet has formally considered and approved its energy policy (GoRMI, 2003). The MINEP, approved in April 2003, is meant to *"provide clear guidance and direction to the EPD as it plans, implements, and monitors energy initiatives, programs and projects throughout the Republic."* The MINEP has six core areas, each with corresponding policies and strategies, as summarized in Table 10-6.

The 2003 policy has had little impact thus far. There is no formal structure for the EPD, and there has been no assessment of an appropriate staffing structure or numbers. There is no distinction between policies and the strategies needed to put them into effect. The core areas and policies appear to be broadly appropriate but there are no specific activities, no sense of priorities, no timing for implementation, no budget to implement the policy (except for specific renewable energy projects), little or no funding for monitoring projects, and for some core areas the lead agency is not clear. It is understood, however, that a work plan is currently being developed.

[9] This description is paraphrased from a review of the OIEC and MAEC by Solomone Fifita (PIFS, 1998).

Table 10-6 - The National Energy Policy of 2003	
Core areas	**Key Policies and strategies**
National coordination and planning	• Coordinate energy planning and programs • Review and implement the policy as appropriate • Promote public/private partnerships • Investigate regional and international funding • Update and standardize renewable energy equipment and ensure compliance • Establish national energy supply and demand database
Renewable energy / rural electrification	• Assess RMI's RE potential • Promote use of proven RETs in rural areas, especially PV • Promote solar water heating in Majuro, Ebeye and hotels in cooperation with MEC • Establish financial, legal and institutional framework for rural electrification and RE
Electric power	• Promote more efficient end-use of electricity • Influence MEC through MRD's board membership • Ensure power development is based on least-cost development incorporating DSM and full cost recovery from consumers
Petroleum	• Secure reliable supply through competitive tendering • Assure appropriate standards for products, storage and handling and disposal • Encourage fuel conservation and efficient use • Ensure reliable, affordable petroleum fuels supply in rural areas • Establish and enforce guidelines for fuel pricing in outer islands
Energy Efficiency and conservation	• Develop energy efficiency programs for government and private sector • Promote energy star rating for white goods (e.g. refrigerators) • Develop and disseminate information on benefits of EE and conservation
Transport	• Develop emission control regulations and procedures • Promote and enforce vehicle efficiency standards • Develop framework for energy efficient ground and sea transport
Cross-cutting issues	• Develop national capacity including strengthening EPD with adequate staff and skills • Incorporate environmental considerations into energy planning (including safe disposal of waste and PV batteries

Source: *Marshall Islands National Energy Policy* (GoRMI, 2003), with text edited and summarized
Notes: RE = renewable energy; RET = RE technology; DSM = demand side management; EE = energy efficiency

The existence of an energy policy that is vague, and the establishment of an EPD with little funding and only one professional position, is a cause for some concern, particularly considering the fragmented situation regarding energy project implementation. Despite this, the prospects for a successful rural electrification program through renewable energy are reasonable due to:

- the acceptance of the ADB framework for rural electrification through renewable energy as *de facto* policy;
- the continuity of this broad ADB/OIEP approach for a decade;
- the willingness of MEC to manage the renewable energy initiatives; and
- the existence of a formal MOU between MEC and the GoRMI regarding respective renewable energy responsibilities.

Nonetheless it is in the interests of the GoRMI and the MEC to establish clear policies and mechanisms to assure that the operating and maintenance costs of the RE program are financed by users, rather than rely on government subsidies. Similarly, for energy policy areas other than renewable energy – for example petroleum, urban electric power and efficiency – the intentions of the GoRMI should be developed into appropriate actions and supported where required by legislation.

1.7.2 Energy-related legislation

There are various laws and legal tools in the RMI directly or indirectly related to energy sector matters:

- *Electric Power Act*. None. There is no national power sector legislation to regulate either MEC or KAJUR. In the absence of such legislation, the objectives of the utilities, and measuring technical, economic and financial performance can easily change with new management or board membership or under donor pressure. Similarly, the obligations and responsibilities of MEC may be unclear.
- *MEC Regulations*. There are MEC Regulations, which the mission has not seen, which reportedly designate Majuro as the supply area in which MEC has the sole right to provide electricity. According to MEC advertisements which regularly appear in the local newspaper, the RMI *"Revised code, Section 60, makes it a crime for anyone to hook up to any electrical line or receive electricity by any means other than through an MEC authorized connection"*.
- *The Retail Price Monitoring Act* of 1992 (Title 10, Chapter 11 RMI Revised Code of 1998) establishes the Marshall Islands Price Monitoring Board to monitor retail prices and authorizes cabinet to promulgate regulations to enforce and implement this act. However, the cabinet has neither promulgated regulations nor appointed a board. There is no formal price control over petroleum fuel products.
- *The Unfair Business Act* of 1998 (Title 20, Chapter 3 RMI Revised Code) authorizes the Attorney General to monitor uncompetitive practices in the RMI and ensure that there are no restrictions to trade. It could in principle be used to monitor electricity and fuel prices.
- *The Consumer Protection Act* of 1998 (Title 20, Chapter 4 RMI Revised Code) authorizes the Attorney General to investigate businesses engaging in any act or practice, which is unfair or deceptive to the consumer, the fine for which is $10,000 dollars.
- *The Bulletin Boards and Price List Act* of 1976 (Title 20, Chapter 6 RMI Revised Code) is a carry over from the TTPI administration and applies mainly to outer island trade, especially fuel prices to the outer islands. In effect, it provides the same powers in remote areas as the Retail Price Monitoring Act of 1992, which can be applied to urban centers and outer islands. It is not enforced and it is not known why the Act was not repealed.

- *The Alternative Energy Fund Act* (Title 35 chapter 3) establishes a revolving fund for the development, marketing and operation of alternative energy systems in the RMI, presumably under the MAEC. The mission has not seen the legislation. It is not clear whether a fund was actually established and, if so, whether it remains active or who manages it. MEC reportedly (Chutaro, 2004) knows little about it.
- *The Import Duties Act of 1989* (Title 48, Chapter 1 RMI Revised Code), as amended in 2001 (Bill No. 75 P.L 2001-43) specifies a uniform tax on all imports at the rate of eight percent of the cost, insurance and freight (CIF) value except for specific *ad valorem* rates or unit taxes for specified imports (listed in Table 10-7). Import duties are the same for efficient or inefficient energy-using appliances. Under earlier legislation, there were duty exemptions for all equipment, materials, etc. imported for the operation and maintenance of manufacturing, tourism, and fishing operations. This could have been used for renewable energy technologies but was repealed due to widespread abuse. GoRMI imports are exempt from import duty.

Table 10-7 - RMI Import Duties

Product	Rate ($ or % of CIF value)
Gasoline	20 %
Distillate; Kerosene	5 %
Motor vehicles	$2,500, new $1,500, used
Public vehicles	5 %

Source: Chutaro, 2004. Excl. drinks, tobacco, etc (Vehicle duty based on 'Kelly's Blue Book' rates but no less than specified above.)

- *The Environmental Protection Act* (Title 35) is meant to foster the sustainable use of the RMI's natural resources. It establishes a National Environmental Protection Authority (NEPA) with powers regarding land use, pollution control and emissions. The mission is not aware of whether NEPA has been set up or whether it is involved in any energy use matters.

1.7.3 Energy sector coordination

In part because the EPD is understaffed but largely because MEC is active in electric power, petroleum fuels and renewable energy technologies as well as working in a number of islands on a contractual or advisory basis, MEC plays the *de facto* lead role in energy sector implementation and coordination. There is apparently no formal energy coordination or an active coordinating committee for PIREP or other donor-supported energy initiatives.

2 ENERGY SUPPLY AND DEMAND

2.1 Energy Supply

As a country with a very small land area made up of low lying atolls, the RMI has limited indigenous energy resources and, like other atoll states, is overwhelmingly dependent on imported petroleum fuels in the energy sector. The *Pacific Regional Energy Assessment* (PREA; WB, et. al, 1992) estimated that 78% of gross energy supply in 1990 was from petroleum, the remaining 22% being biomass, placing the RMI among the PICs with the highest petroleum dependency. A rural energy study was carried out in the RMI in 1994 (ADB, 1995) but it did not consider biomass use. As far as the PIREP team is aware, there have been no biomass energy surveys in RMI; it is thus not possible to accurately estimate changes in biomass supply or consumption. However, petroleum clearly continues to dominate, with biomass use probably accounting for a considerably lower percentage of total energy supply in 2003 than it did in 1990, possibly less than 10% of gross energy use.

2.1.1 Petroleum supply

The main petroleum products imported to the RMI are petrol (gasoline), diesel fuel (also called distillate, automotive diesel oil or ADO), liquid petroleum gas (LPG), and dual-purpose kerosene (DPK) used as aviation turbine fuel (Jet-A1) and household kerosene.

As noted in the previous chapter, the MEC imports, stores, distributes and re-exports petroleum products, primarily ADO plus some LPG. MEC is considering importing and petrol, kerosene and aviation fuel, which would require new storage facilities. The other main importer is Mobil Oil Micronesia, Inc., which has bunkering tanks on Ebeye and Jaluit atolls and sells to an American military enclave on Kwajalein atoll.[10]

Mobil sells a full range of fuel products except LPG and has a broad customer base, which includes selling gasoline, kerosene and ADO to distributors (gas stations), diesel to fishing vessels and transiting yachts, and aviation fuel to international and domestic airlines. Until recently, Mobil dominated the Micronesian aviation fuel market, losing the contract to supply Continental Airlines, by far the dominant international air carrier in Micronesia, to Shell.

Most of the RMI's outer island fuel supply is from Mobil, except ADO, where MEC has a considerable price advantage. Mobil does not deliver to outer atolls, but provides fuel from its main depots in 200 liter drums (nominally 50 US gallons; minimum of 6 drums) to outer island suppliers and local governments, some of which is delivered by a small government-owned fuel tanker.[11] Consumers cannot buy directly from Mobil.

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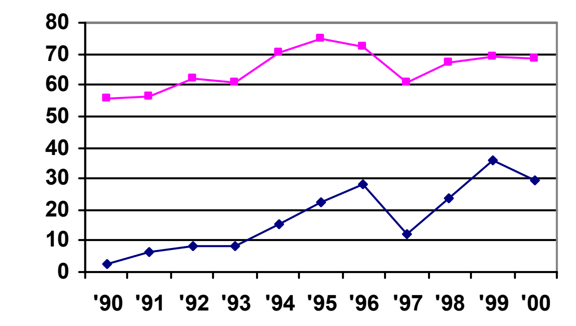
[10] The United States Army Kwajalein Atoll (USAKA) base on Kwajalein, near Ebeye, is mainly used as a missile testing range. Energy supply, consumption and policy issues in his report exclude coverage of the Kwajalein military enclave.

[11] The tanker, the *MV Jobake*, reportedly (Chutaro, 2004) spends much of its time in port. It is not known how much fuel it actually delivers to outer atolls. It is owned and operated by the GoRMI Ministry of Transportation and Communications, displaces 150 tons, and has the capacity for about 50-52 KL (13,400 - 13,800 US gal) each of petrol, kerosene and diesel.

Mobil reportedly owns the fuel pumps and storage tanks at the independently owned petrol stations on Majuro and station owners cannot sell fuel that they bought from other suppliers. Owners must enter into an exclusive agreement with Mobil, under which Mobil can remove its equipment if owners breach the agreement. Mobil will only sell fuel if the stations use Mobil-certified equipment.

Despite numerous attempts over several months, the PIREP mission was unable to obtain petroleum fuel imports or sales over the past decade, or even consistent data for the past several years, necessary to establish trends to allow reasonable projections of future fuel imports. Figure 2-1 shows how fuel imports (in value) vary considerably from year to year. From 1998-2000, petroleum fuels have accounted for an exceptionally high 35-44% of total imports[12] and have been 3-4 times the value of all domestic exports.

Figure 2-1 - Petroleum Fuel and Total Imports ($m)



Fuel bottom line; total top line; Source: ADB, 2003

Table 2-1 provides the imports of fuel – including re-exports/bunkering of ADO and jet fuel – in 2003 as provided by MEC.[13] Without data for the past 5-10 years, the mission is unable to say whether these are typical levels of recent fuel imports.

Table 2-1 – Petroleum Imports in 2003 (millions)

Product	USG	Liters
Petrol	1.55	5.87
Kerosene / Jet A	14.97	56.70
Diesel	16.52	63.20
Other Oils	0.10	0.38
LPG	0.20	0.74
Total	*33.34*	*126.89*

Source: Chutaro, 2004; USG = U.S gallons

Table 2-2-Petroleum Storage, Majuro (ML)

Product	ADO	DPK	Gasoline
MEC	22.7	–	–
Mobil	2.5	2.9	1.0
Total	*24.2*	*2.9*	*1.0*

Source: Chutaro, 2004 from MEC

2.1.2 Storage

MEC and Mobil have about 28 million liters (ML) of storage capacity in Majuro (Table 2-2) of which 86% is for distillate. MEC has space to expand but Mobil, located next to a school and a growing community, does not. Due in part to limited storage capacity, Mobil has reportedly run out of both petrol and aviation fuel awaiting the arrival of the

12 This is no doubt due in part to the high volume of re-exports of distillate, about 8 million liters in 2003, or 25% of total fuel imports. However, even taking this into account, RMI fuel imports are among the highest in the region as a percentage of total imports.

13 There are serious inconsistencies in the fuel data for 2003. Depending on the source, for example, Mobil ADO data vary by a factor of ten! However, Mobil was unwilling to provide any data. Although attempts were made to resolve the differences, no further data were provided.

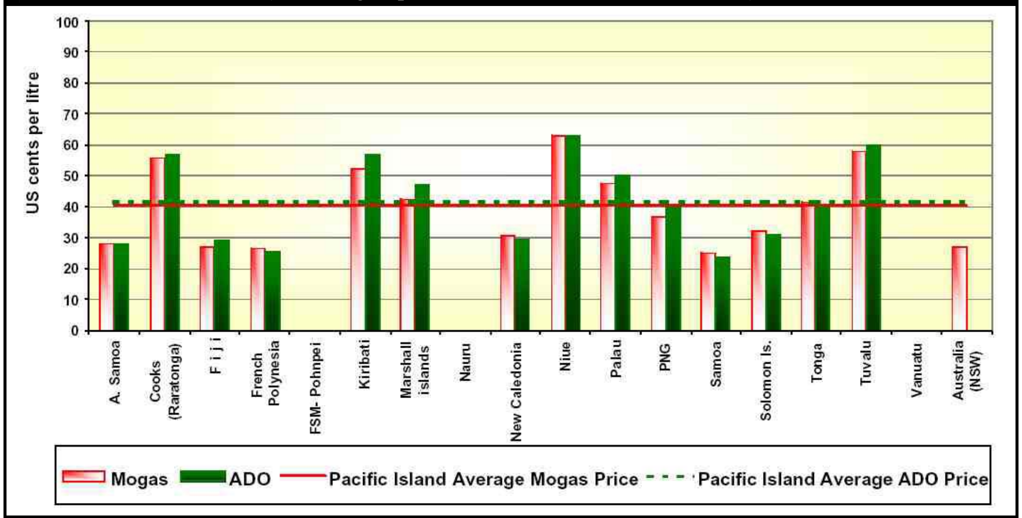
supply tanker from Guam. The domestic airline, Air Marshall Islands, has reportedly (Chutaro, 2004) cancelled flights due to lack of fuel.

2.1.3 Petroleum pricing

As noted in the previous chapter, the GoRMI has the legal power to impose price control on petroleum products, but it has chosen not to do so. Mobil and MEC establish their own prices. There is a 5% import duty on ADO. Fuel sales are generally also subject to Gross Revenue Tax and Sales Tax.[14] However, MEC pays no duty or taxes on fuel used for electricity generation. There is no duty or tax on bunker sales of any fuel products to foreign fishing, as this is considered a re-export. MEC is able to charge lower ADO prices than Mobil due to the large storage capacity of the MEC tank farm and the large volume of diesel sales to foreign vessels.

Recent wholesale prices of petrol and ADO (excluding all taxes and import duties) are shown in Figure 2-2, provided by the PIFS. In December 2003, prices of ADO in Majuro were about the same as the PIC average, with ADO somewhat higher. However prices were lower than those of many of the smaller PICs. Although not shown in the figure, the retail price (excluding duties and taxes) of petrol in Majuro was about the same as Pohnpei and Palau, suggesting that RMI may have high retail mark-ups

Figure 2-2- Pacific Island Country Wholesale Petrol & ADO Prices
(excluding import duties and taxes; Nov/Dec 2003)

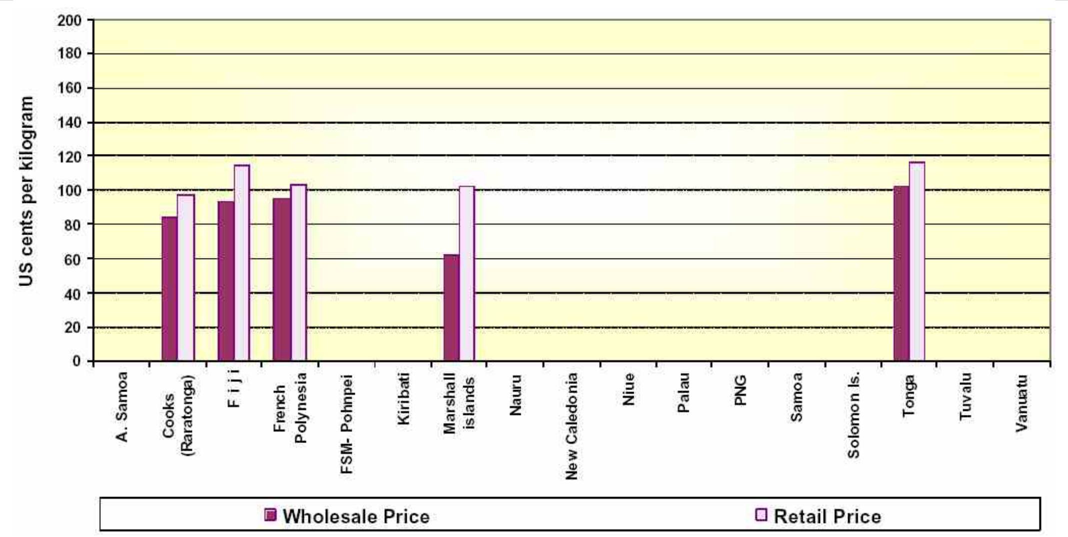


Source: Pacific Fuel Price Monitor, Edition 7 version 2 (PIFS; 12 May 2004)

[14] Requests to the GoMI to provide the amount of these taxes were unanswered.

Figure 2-3 shows LPG prices for a small sample of PICs. If the data are correct, the RMI's wholesale price is far below the PIC average but its mark-up to retail pricing is very high. RMI does not provide kerosene prices to the PIFS so similar comparisons cannot be made for that fuel.

Figure 2-3 Pacific Island Country LPG Prices
(excluding import duties and taxes; Nov/Dec 2003)



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

It was not possible for the mission to obtain information on the volume of fuel sales to Ebeye or the outer islands, or the differences in prices between Majuro and outer islands.

2.1.4 Biomass energy supply

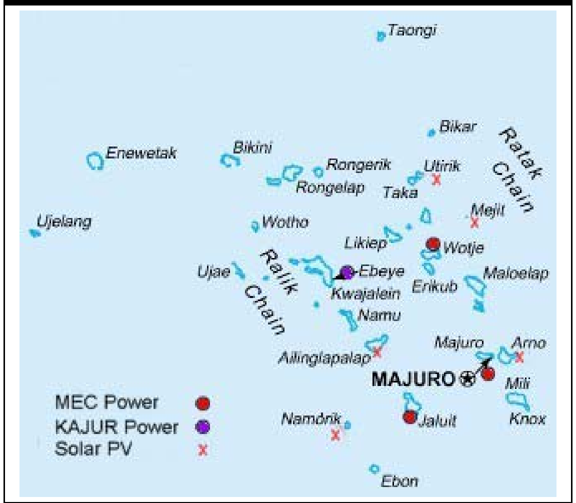
The demand estimates of section 2.2.2 suggest that total biomass supply in 1999 (the latest year with reasonable estimates of biomass use for cooking) was about 19,500 tonnes, of which 62% was for household cooking and 38% for copra drying. This is equivalent to about 6,650 tonnes of oil equivalent (toe).[15] In 2003, with higher copra production and assuming that biomass energy for cooking has increased at the rate of population growth, total biomass energy supply would be about 7,570 toe.

[15] This assumes 88% of total is coconut residues and 12% fuelwood. Conversions to TOE are from Annex 2.

2.1.5 Electricity supply

MEC

Figure 2-4 - RMI Electricity Supply



Note: Solar PV = Atolls with 20 or more homes with PV

MEC currently supplies electricity on Majuro, Jaluit and Wotje (Figure 2-4) and "is committed to providing power to the 28 atolls that currently do not have any power …" (MEC, 2003). On Majuro, MEC has 29 MW of installed nameplate diesel capacity, 24.4 MW (derated), and about 12 MW of maximum demand in 2003.[16] Table 2-3 summarizes MEC's Majuro operations. MEC has not provided sales data. In 1990 (PREA; WB, 1992) Majuro's residential customers used over 1,000 kWh per month on average, among the highest consumption levels of any PIC and on a par with Nauru although less than Niue. The current consumption per residential consumer is not known but is estimated to be 720 kWh per month (Chutaro, 2004).

Table 2-3 - MEC Generation and Customers on Majuro

Year	Generation (GWh)	Number of Customers					
		Commercial	Govt	Metered	Lifeline	Other	Total
1990	42.91	–	–	–	–	–	2,261
1995	61.67	–	–	–	–	–	2,327
1996	62.62	193	80	955	1,481	25	2,734
1997	62.12	203	87	905	1,604	39	2,838
1998	64.11	222	73	961	1,554	36	2,846
1999	62.93	258	70	1,621	1,067	18	3,034
2000	69.24	272	82	1,174	1,585	35	3,148
2001	73.52	389	124	1,125	1,525	39	3,202
2002	79.76	322	97	1,411	1,479	24	3,333
2003	81.30	–	–	–	–	–	3,528

Source: *RMI Statistical Yearbook 2002* & MEC, 2004 – = not available

Since 1990, generation has grown at an AAGR of 5.0% (6.6% from 1999-2003) and the number of customers has grown by 3.4% annually (3.8% from 1999-2003). Peak demand

[16] MEC has stated its 2003 peak as 11.8 MW (MEC, 2004) and 12.5 MW (MEC, 2003).

has reportedly grown at an AAGR of eight percent for the past decade (MEC, 2003) and is expected by MEC to continue at the same rate.

2.1.6 Small atoll systems

On Jaluit (Figure 2-5) in 2003, MEC had two 275 kW twelve-year old generators (250 kW each operational), a maximum demand of 190 kW and about 112 customers, a slight increase over 1994 when the peak demand was 110 kW with 79 metered consumers (ADB, 1995). On Wotje, there are two 275 kW one-year old generators (275 kW each operational), a maximum demand of 65 kW and about 75 customers. MEC also operates a small plant on Rong-Rong Island in Majuro with about 32 customers. Majuro clearly dominates MEC operations with about 95% of its customers.[17]

Figure 2-5 - Jabwor, Jaluit Atoll

Source: GoRMI

There are small diesel systems operated by local government authorities on Kili atoll (reportedly three 550 kW gensets, 200 MWh/month generation and roughly 90 customers. Bikini atoll reportedly has 585 kW of diesel capacity (two 205 kW gensets; one 175 kW) generators and 10 MWh per month of generation.[18]

2.1.7 KAJUR

The second largest power system in the RMI is KAJUR on Ebeye, the county's second urbanized island, in Kwajalein atoll. In 1990 (PREA, 1992), the KAJUR system had about 3.5 MW of firm capacity, 2.5 MW of peak demand, 19.2 GWh of generation, 15.6 GWh of consumption. There were 937 customers of whom 726 were metered residential customers, each using about 600 kWh/month. The PIREP mission was unable to visit Ebeye and has very limited information on the current operations. For several years, the KAJUR system was operated by the American Samoan Power Authority (ASPA) under a

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[17] The capacities, maximum demand and customer numbers are approximate as there were several data sheets (MEC 2003 & 2004) which differed. There are no reliable data on generation for these small systems.

[18] The source is Chutaro, 2004 based on telephone interviews.

contract. For the past two years or so, several ASPA staff members have reportedly managed the system under individual contracts. The 1999 census shows that at least 1089 households out of 1213 had access to electricity but there was no information on the total number of consumers. In 2000, 2001 and 2002 respectively, total KAJUR generation was 15.00, 14.01 and 16.18 GWh. In 2003, there were apparently about 16% more residential customers than in 1990 but generation was only 84% of the 1990 figure.

2.1.8 Electricity charges

For some years, MEC had a range of consumer types and charges: a commercial metered rate per kWh, a monthly commercial flat rate, a government metered rate, a residential metered rate per kWh, a residential monthly flat rate per month, and a residential lifeline rate for those consuming less than 500 kWh per month. Currently there is a much simpler tariff structure for both MEC and KAJUR, as shown in Table 2-4.

Table 2-4 - Power Tariffs, 2003

Utility	Residential	Commercial & government
MEC	12.0	16.0
KAJUR	15.5	18.5

Source: Chutaro, 2004

Under the 1987–2003 Compact there was a specific allocation (Section 214) meant *"as a contribution to efforts aimed at achieving increased self-sufficiency in energy production"* which provided $2 million annually to the GoRMI. The money was apparently used in part for a bond issue in the early 1990's and as security for construction of MEC's newest power plant. After the bond was cleared in 2001, the funds, or at least a portion of them, were used to subsidize electricity tariffs on Majuro. The new Compact has no similar provision, suggesting that MEC may soon seek an increase its charges. MEC must receive cabinet approval before charges can be raised.

KAJUR has installed a number of pre-payment meters as the utility has a large number of delinquent accounts, apparently mostly from the Kwajalein Atoll Development Agency (KADA) and the island government, KALGOV. The rate per kWh is the same for metered customers and those who use a pre-payment card.

2.2 Energy Demand

2.1.9 Petroleum

Mobil Oil was unwilling to provide any information on its sales. MEC, provided a breakdown of ADO use for power generation, re-exports (largely for foreign fishing boats) and other. Dual-purpose kerosene imports do not distinguish between fuel used for aviation fuel and for household cooking and lighting. Some limited data on LPG sales suggest that most is probably used mainly for commercial purposes in hotels and restaurants. A large amount of ADO is re-exported – it is the RMI's largest export in value – and this is not included as domestic consumption. Finally, demand estimates are based on the data of Table 2-1 which introduces two sources of error: i) the data themselves are of unknown but dubious accuracy as various sources are inconsistent; and

ii) the table provides imports during the calendar year which could differ by consumption during the year of 5% or more.

The following assumptions are made for petroleum use in 2003:

- *electricity generation*. MEC reportedly (Chutaro, 2004) used 22.0 ML of ADO to generate 81.3 GWh. This is 3.7 kWh/liter, which is reasonable. Assuming that KAJUR generated 16 GWh (about the same as 2002) and used 3.3 kWh/liter, it would have used about 4.8 ML. Other use is minor. The total is about 27 ML;
- *ground and sea transport*. It is assumed that all of Mobil's ADO imports and the remainder of MEC's inland ADO imports, is for ground and sea transport. There are no data available to distinguish between sea and ground transport use. All petrol is for transport.
- *air transport*. There are no data indicating the extent to which DPK used for airlines is divided between internal and international travel. The PIREP mission cannot make a meaningful estimate.
- *household kerosene use*. At the time of the 1999 census, 31% of all households, and 71% of rural households (i.e. all households outside of Majuro and Ebeye) reported that their main lighting energy source was kerosene (Table 2-6). About 41% of all households and 56% of urban households reported that their main cooking fuel was kerosene (Table 2-7). Unfortunately, there are no data on sales to households and no recent household energy use studies to provide information on typical consumption levels for lighting and cooking. At best, old energy use surveys can provide rough estimates of RMI household kerosene use, about 1 ML in 2003.[19]
- *LPG use*. Only 1.7% of households cooked primarily with LPG in 1999. This is unlikely to exceed 2% in 2003. Old surveys suggest that those households which use LPG for cooking typically consume about 12 kg per household per month, suggesting household use in the RMI of 20 tonnes per year, about half of LPG imports. The rest is probably used by hotels, restaurants and other commercial users.

2.2 Petroleum Energy Balance and GHG Emissions

Table 2-5 summarizes the approximate petroleum use in RMI in an energy balance based on the above assumptions. However, the results are of limited use useful: i) it is unlikely that less than 10% of inland ADO is used in ground and sea transport, suggesting that the ADO import data are in error; and ii) a very large percentage of the reported kerosene imports may be for international air travel. The estimated 2003 emissions of GHGs of 246 Gg in the table is thus overestimated to the extent that kerosene is used for international air transport and underestimated to the extent that the stated ADO imports

[19] The surveys cover different years and societies, a range of household sizes, different technologies for lighting and cooking (pressurized and wick-type) and a range of disposable cash incomes. Very roughly, those who used kerosene for lighting but not cooking used between 4 and 8 l/hh/m. Those who cooked mainly with kerosene used between 11 and 22 l/hh/m. Those who used kerosene for both cooking and lighting reported about 18-22 l/hh/m. The RMI has larger family sizes and higher real incomes than those surveyed 20 years ago. Assume crudely that 40% of all RMI households use on average 20 l/hh/m. With 6,880 households in 2003, this is only 0.7 ML.

are too low. The actual GHG emissions attributable to energy use within the RMI during 2003 are probably somewhat less than the Table 2–5 indication of 246 Gg.

In its initial communication to the UNFCCC (GoRMI, 2000), the GoRMI calculated 1994 GHG emissions. Because the report contains no information on the volume of petroleum fuel imports (or sales) or the percentage of total emissions attributed to petroleum (rather than agriculture or land use), the 1994 estimates are not directly comparable to those estimated in this report. However, petroleum fuels accounted for most national emissions so the magnitude of CO_2 releases should be similar. The GoRMI report indicates total emissions in 1994 of 0.0025 million tonnes of carbon, which is equivalent to 0.0092 million tonnes of CO_2 or 9.2 Gg, which appears to be an order of magnitude too low. Even if actual 2003 emissions were on the order of 200 Gg, it is likely that 1994 emissions were roughly 130 Gg.[20] The PIREP team does not know the reason for such a huge discrepancy.

Table 2-5 - Estimated Consumption of Commercial Energy in RMI by Sector (ToE; 2003)

Source	Imports		— Consumption in Thousand Tonnes of Oil Equivalent —					
	ML	'000 tonnes	Transport	Electricity	House-holds	Commercial & industry	'000 TOE	GHGs (Gg)
Motor spirit	5.87	4,300	4,670	0	0	0	4,670	14.68
Kerosene/Jet fuel	56.70	45,000	48,185	0	865	0	49,050	147.42
Distillate (ADO)*	30.5	25,600	3,180	24,500	0	0	27,680	82.35
LPG	0.74	400	0	0	220	220	440	1.18
Total	93.8	75,300	56,035	24,500	1085	220	81,840	245.63
% of total ToE	–	–	*68.5%*	*29.9%*	*1.3%*	*0.3%*	*100%*	–

Sources: Table 2-1 and the assumptions indicated in the text.

Notes: Tonnes, toe and GHG from conversions table; Excludes losses/transformations 1 Gg = 1,000 tonnes of CO_2 equivalent
* ADO excludes 32.7 ML of re-exports. Excludes 0.38 ML of lube oils and other products

2.2.1 Household energy demand

Table 2-6 shows the most frequently used energy forms for household lighting. In 1999, 63% of households reported that they used electricity for lighting, up from 56% a decade earlier. Kerosene dropped from 36% of all households to 31%, and solar PV increased from 3% to 5%. Urbanized households in Majuro and Kwajalein (Ebeye) make up two thirds of all households. In 1999, nearly 90% of urban households had electric lighting

Table 2-6 - Household Lighting, 1988 & 1999

Location	No of HH	— % of households using —			
		Elec	Kero	Solar	Other
1999:					
Majuro	3080	88.3	11.0	0.3	0.4
Kwajalein	1213	89.8	9.6	0.0	0.6
Rural	2185	13.4	70.8	15.0	0.7
Total RMI	6478	63.3	30.9	5.2	0.5
1988:					
Majuro	2228	78.1	20.4	0.7	0.8
Kwajalein	960	81.9	1.1	5.9	10.0
Rural	1735	12.9	7.6	4.0	8.3
Total RMI	*4923*	*56.0*	*36.1*	*2.9*	*5.0*

Sources: Census of Households and Housing, 1988 & 1999
Notes: Totals may not add to exactly 100%

[20] This assumes that petroleum fuel use, and GHG emissions, have grown by about 5% annually since 1994.

compared to only 13% of the outer rural islands, 71% who used kerosene.

The most common energy sources used for household cooking is shown in Table 2-7. Surprisingly, households which reported using wood (including minor use of charcoal) as their main cooking fuel increased from 14% in 1988 to 30% in 1999, rural usage increasing from 36% to 79% of all households.

Table 2-7 - Household Cooking, 1988 & 1999

Location	No of hh	% of households using				
		Elec	Kero	LPG	Char	Wood
1999:						
Majuro	3080	35.9	54.1	2.8	< 0.1	6.7
Kwajalein	1213	38.4	59.4	0.3	< 0.1	1.1
Rural	2185	6.0	10.8	0.7	3.2	78.5
Total RMI	6478	26.3	40.5	1.7	1.1	29.9
1988:						
Majuro	2228	49.4	46.8	1.1	–	2.4
Kwajalein	960	64.1	33.1	1.3	–	0.4
Rural	1735	6.5	57.2	1.0	–	35.9
Total RMI	4923	37.1	47.8	1.1	–	13.8

Sources: Census of Households and Housing, 1988 & 1999
Note: Totals may not add to exactly 100% Char = charcoal

During the same period, kerosene for cooking dropped from 48% to 41% of all households and from 57% to only 11% of rural households. However, it cannot be concluded from a sample of two years[21] that there has been in fact a major shift from kerosene to wood use for rural cooking. Such a change in the short term could be reasonably assumed if copra prices had fallen sharply in 1998/1999, reducing rural cash incomes. An ADB report (*Meto2000*; ADB, 2001), does show copra producer prices in the RMI of $433, $420 and $357 per short ton in 1995, 1996 and 1997 respectively, dropping sharply to $180 in 1998. A recent study (*Hardship in the Marshall Islands*; ADB, 2003a) also notes that the RMI slipped from fifth to eighth place among twelve PICs in UNDP's human development rankings between 1994 and 1999. In 1999, the ADB estimated that two-thirds of outer island households fell below the poverty line of $1 per day. The continuing low copra prices of recent years suggest that fuelwood use in rural RMI could thus still be considerably higher than in 1990 but this is speculation.

2.2.2 Biomass energy demand

The PREA (WB et. al.; 1992) estimated that 19,620 tonnes of biomass was used for copra drying and household cooking in 1990. Of the total, 62% (coconut residues) was for drying 5,100 tonnes of copra, with the other 38% (about 20% fuelwood and 80% coconut residue) for household cooking. In 1999 the RMI produced about 3,040 tonnes of copra (3,355 short tons; ADB, 2001). Assuming the same methods of drying as in 1990, this suggests that 7,300 tonnes of biomass was used for copra drying. The 1999 census report is the most recent data on biomass use for cooking (Table 2–7). Assuming that those who cooked primarily with biomass in 1999 used the same amount per household as in 1990,

[21] A *Household and Income Expenditure Survey* in 2002 (GoRMI, 2002a) included expenditures during the survey period on household energy use but 86% of those surveyed were in Majuro or Ebeye, the remainder in Jabor and Likiep. The total sample size was about 10% of all households. The rural sample was probably not typical of RMI and fuelwood was not covered so the HIES cannot be used as a third sample year for household energy use.

the total cooking demand in 1999 was 12,200 tonnes. Total biomass consumption would have been 19,500 tonnes, almost exactly the same as in 1990, except that copra drying accounted for 38% and cooking 62%, a reversal of the earlier percentages.

For 2003, with copra production of 3875 tonnes, the same assumptions suggest 9300 tonnes of biomass for copra drying. Assuming that biomass for cooking has grown at the 1988-1999 rate of population growth, cooking would have consumed 12,900 tonnes, for a 2003 total of 22,200 tonnes, about 7570 toe.

2.3 Energy Growth and Opportunities for GHG Reductions

2.3.1 Growth in energy use

The PREA included a projection of energy growth (i.e. petroleum use), for the RMI from 1990–2000. Based on trends of the 1980s, PREA projected the following AAGRs: population 4.0%, real GDP 3.5%, electricity generation 3-6% depending on electricity prices;[22] inland fuel consumption 4.0% and ocean bunkers 4.7 percent.

These estimates were quite inaccurate. The actual population growth rate (Section 1.2) over the past decade has been less than 1.5%. From 1990-2000 real GDP *declined* by 1.6% annually, dropping by 25% from 1995-2001 (Section 1.5.2). During the same period, electricity generation by MEC (Section 2.1.5) grew by 5% per year, inland fuel use by perhaps 3.7% and ocean bunkers declined slightly.[23] The only PREA projection which may be close to being correct was inland fuel use, assuming that the (dubious) 2003 data are accurate.

As noted in other PIREP national assessments, energy use in small countries can change quickly, often linked to a single investment in a new hotel, cannery, road network, etc. Energy use is not necessarily closely tied to economic growth and population as it often is in larger countries – and as PREA assumed for the RMI. Clearly growth in RMI's energy use over the past decade has not correlated with population and economic growth and may not do so in the coming decade.

Nonetheless, in the absence of other information on likely patterns of development that would influence energy use, it is assumed that there will be some correlation between future growth in population, the economy and energy. It seems likely that, as RMI's citizens continue to have free access to the USA, population growth will be modest, perhaps 1% per year or less. The ADB expects the new Compact funds to account for about 60% of GDP (as during the original Compact period) and expects real economic growth over the next three years to average three percent. It is not unreasonable to expect both electricity generation and inland fuel use to continue to grow at 5% per year. In this

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[22] The higher growth rate assumed subsidized electricity prices on Majuro; the lower rate assumed that consumers pay the actual price by 1995.

[23] As noted earlier, these estimates are based on questionable data. The growth in fuel use should recalculated if and when improved data becomes available. The inland consumption for 1990 is based on the PREA Statistical Annex Table 2, excluding Jet A1. AAGR is calculated from 2003 data of Table 2-1 excluding all DPK except household use. Ocean bunkering is based on PREA for 1990 and MEC for 2003.

case, assuming no significant investment in renewable energy or energy efficiency, fuel use and GHG emissions over the next ten years would be as shown in Table 2-8.

Table 2-8 – Crude Estimates of Growth in Commercial Energy in RMI, 2003-2013 (ToE; 2003)				
Source	2003		2013	
	KL	GHGs (Gg)	KL	GHGs (Gg)
Motor spirit	5,870	14.7	9,562	23.9
Kerosene/Jet fuel	56,700	147.5	92,364	240.1
Distillate (ADO)*	30,500	82.2	49,685	134.1
LPG	740	1.2	1,205	1.9
Total	93,810	245.6	152,816	400

Sources: Table 2-5 and assumed 5% growth in fuel use; Notes: Excludes marine bunkering and lube oils

2.3.2 Opportunities for GHG reduction

Table 2-9 summarizes possible options for GHG reduction that are optimistic but technically viable. Of the total GHG emission reductions of 22 Gg in 2013, 64% acrue from energy efficiency measures and 36% from renewable energy.

Table 2-9 - Indicative Energy Savings & GHG Savings from Renewable Energy, 2013				
Technology	Potential fuel savings	GHG_2 savings (Gg)	% of savings	Comments & assumptions
Biodiesel	2,800 KL ADO	7.6	34	All copra used for coconut oil fuel production
Solar PV *	130 KL ADO	0.4	2	Assume that nearly all unelectrified rural atoll homes receive solar PV instead of gensets
Efficiency (electricity) [24]	4,420 KL ADO	11.9	53	10% of ADO used for power generation
Efficiency (transport)	956 KL of gas	2.4	11	10% of 2013 gasoline use
Hydro; geothermal	Zero	0		No hydro potential; no known geothermal resource
Ocean	Zero	0		No commercial OTEC or sea wave systems yet available
Other biomass	Zero	0		No likely viable biomass candidates
Solar thermal **	Very small	0		Hotels have solar water heating; limited scope for more
Wind	Zero	0		Unlikely to be viable near any appreciable load
Total		*22.3*	*100*	*Under 6% reduction of 2013 projected total*

Source: PIREP mission estimates Assumptions:
* In 1999, there were 6478 households of which about 31.5% or 2040 were unelectrified. Assume that all new Majuro and Ebeye households (and those of other islands now served by MEC or KAJUR) continue to be grid connected. If other rural households grow by 1% annually, there could be about 2,322 candidate households for solar PV by 2013. Assume that 2,300 are provided with 150 Wp solar home systems producing 0.37 kWh/day each for 300 days per year, a total of 255,000 kWh per year. If this is used in place of small gensets which use 0.5 l/kWh, the savings are 128,000 liters of ADO, equivalent to reductions of 346,000 kg of CO_2 emissions. This is 0.35 Gg.
** Even if new hotels and businesses install SWH, GHG reductions would be minimal.

The reductions are based on analyses of renewable energy and energy efficiency but do not take all social, financial, economic or environmental constraints into account and therefore represent the reasonable upper limit of potential savings. The next chapter provides the basis for the renewable energy estimates.

[24] From Table 2.5, 95% of ADO (0.95 x 49,685 KL = 47,000 KL) is for electricity generation. 10% of this is = 4,700 KL. Renewable energy displaces about 6% of this (3,000/47000) so 94% of fuel savings (4420 KL) have a GHG-reducing effect.

The mission endorses the RMI's plans for the electrification of outer islands through solar PV as a means of reducing GHG emissions and also supporting their sustainable development efforts by providing electricity to outer islands. The main opportunities for near term GHG reductions in RMI are likely to be through improved efficiency of energy use, particularly in electricity supply and use. There also is some opportunity for improvement of transport fuel efficiency, particularly vehicular transport on Majuro. Although encouraging import of fuel-efficient vehicles would have long-term benefits and is a recommended action, energy savings would be modest for some years as vehicles are durable goods with a long lifetime.

3 Technical Potential for Renewable Energy Technologies

3.1 Resources

3.1.1 Solar Resource

Since atoll island climates do not significantly differ from those of the surrounding ocean, the NASA satellite data for solar radiation is considered by the PIREP mission to be adequate for the development of solar designs in the Marshall Islands.

Table 3-1 – Solar Radiation, horizontal and tilted receiver values

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Southern boundary of the Marshall Islands, 5°N 170°E (near Ebon)													
Horizontal	4.8	5.37	5.46	5.54	5.12	5.01	5.08	5.53	5.53	5.6	4.94	4.82	5.23
Tilted	5.45	5.8	5.49	5.51	5.3	5.3	5.31	5.61	5.38	5.91	5.54	5.59	5.52
Central area of the Marshall Islands, 7°N 168°E, near Ailinglaplap													
Horizontal	5.09	5.7	5.83	5.92	5.53	5.27	5.26	5.59	5.31	5.33	4.79	5.37	
Tilted	5.58	5.95	5.7	5.65	5.48	5.3	5.25	5.42	5.06	5.43	5.14	5.46	5.45
Northern boundary of the Marshall Islands, 12°N 167° E, near Rongerik													
Horizontal	5.5	6.08	6.59	6.84	6.64	6.48	6.31	6.08	5.73	5.57	5.11	5.21	6.01
Tilted	7.01	7.09	6.86	6.25	6.62	6.67	6.39	5.84	5.67	6.21	6.26	6.78	6.47

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

The solar resource appears greatest in the northern islands with the middle islands receiving less than either the northern or southern extremes. However throughout the Marshall Islands there is sufficient solar resource for cost effective rural electrification.

3.1.2 Wind Resource

Wind data collected by the Meteorological Service indicates a seasonal and moderate energy content for most of the RMI although there are indications that the northernmost islands may have sufficient wind resource for energy development. The measurements are not at optimal heights nor were the instruments located with an open reach for wind on all sides. As a result, the wind energy resource is likely to be greater than the measurements indicate but it is unlikely to be economically useful at the low latitudes the RMI occupy, at least in the south where the majority of the population resides. To ensure that a possible renewable energy resource is not overlooked, however, it is reasonable to assess the wind energy levels on Majuro and Ebeye where energy demand is high enough to allow direct connection to the grid with several megawatts of capacity. Given the land use issues that prevail and the need to have the wind machine free of turbulence from tall trees, consideration should be given to locating wind machines on the reef or in the lagoon.

3.1.3 Hydro Resource

There is no hydro resource in the Marshall Islands.

3.1.4 OTEC Resource

Although there is clearly a good ocean thermal energy conversion (OTEC) resource (i.e. the temperature differentials are high between the surface and deep ocean waters), the economic size of a commercial OTEC facility, which does not yet exist, would be well above the demand for all islands except possibly Majuro. However even for Majuro's demand, OTEC remains an untried technology and cannot be recommended until at least a demonstration facility at the required scale has been successfully built and thoroughly tested elsewhere in the world.

3.1.5 Geothermal Resource

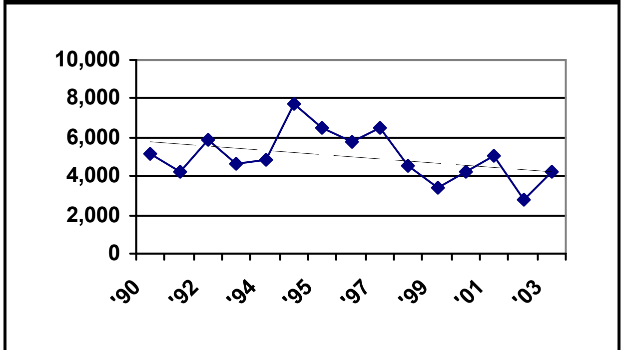
There is no known geothermal resource.

3.1.6 Wave Energy Resource

At the low latitudes of the RMI, wave energy is moderate. Since there are no commercially available wave energy machines and all designs remain in the development or prototype stage, wave energy is unlikely to be a significant power producer in the RMI for the foreseeable future.

3.1.7 Biomass Resource

Figure 3-1 - Copra Production in Tons



Source: Chutaro, 2004

The poor soils of atolls and their small land area make it impractical to consider large-scale energy generation from biomass in the RMI. The primary resource is the coconut forest and, except for replacement of trees every 30-50 years, the only biomass resource is the waste from copra production. That is used for cooking and for drying of copra.

However, the use of coconut oil as a substitute for diesel fuel, especially for outer island power generation and transport, is possible. Figure 3-1 shows copra production in short tons from 1990-2003, with the trend line shown as a dashed line. If the RMI produced 4,400 short tons (about 4,000 tonnes) of copra and all was converted to coconut oil, this would only produce about 2,700 tonnes of oil (2.97 million liters), equivalent in energy terms to about 2.8 million liters of ADO.

There are no operational biogas digesters known to be in operation in the RMI although there were demonstration units installed in the TTPI in the 1980s. If village pigs were to be contained in a community holding area that included the necessary infrastructure for biogas generation and distribution, it could provide cooking fuel or operate a small generator for community use. Such an installation would also improve hygiene and waste disposal while providing high quality fertilizer for gardens.

3.2 Appropriate Technologies for Development

There is long experience with solar photovoltaics and that continues to be the most appropriate technology for electricity production from renewable energy in the RMI. As atoll agricultural productivity is low, biomass for energy production other than for cooking and copra drying is not practical for the long term, although for the short term replacement of senile coconut trees may provide significant biomass for energy production. Biofuels have considerable potential since copra production is still the mainstay for the outer island economies and a methodology for local production and use of biofuels could be developed. Solar thermal is appropriate for water heating in those areas where there is a need such as for resorts, hospitals and some agricultural processing facilities. Domestic water heating is not considered to be an important technology since there is little demand for piped hot water in RMI homes.

Wind energy is an unknown resource in the RMI and wind resource measurements should commence as soon as possible. Due to the requirement for wind turbines to be clear of tall trees and well away from interruptions along the path of wind flow, wind systems will probably be best located on the reef or in the lagoon.

Wave energy and OTEC have future potential but neither is yet beyond the prototype stage of development.

There is no possibility for hydro, geothermal or tidal energy development under present cost conditions.

4 Renewable Energy Experience

4.1 Renewable Energy Experience

4.1.1 Wind energy

Although a demonstration of wind and biogas was carried out by the US Department of Interior in the TTPI days with a small turbine located near the hospital, it worked intermittently and soon failed. As far as the PIREP mission could determine, there has been no subsequent use of wind energy.

4.1.2 Biomass

Biomass for cooking and copra drying remains an important use of renewable energy on the outer islands but there has been no commercial use of biomass energy.

4.1.3 Wave energy

According to the PREA (WB, et. al, 1992), a contract was signed about 1990 between the Kwajalein Atoll Development Agency and a US company, which was to construct a 200-300 kW sea wave energy conversion plant on Giugeegue island, about 8 km from Ebeye. The contract reportedly required KAJUR to purchase all energy produced at 17¢/kWh initially (to be adjusted upward by the US consumer price index with the maximum increase dependent on the cost of ADO at KAJUR), although the value of the electricity at the time was only 8¢/kWh, the costs of fuel which would have been saved. The project never eventuated.

4.1.4 Solar Photovoltaics

During the Trust Territory period, around two hundred solar lighting systems were installed on various atolls. Most rural dispensaries received a solar vaccine refrigerator and most atolls received one or more solar powered high frequency radios along with solar powered lighting for public buildings and a few homes.

The PV installation on Utirik, implemented in the mid-1980s with funds from the US Department of Energy and with design and installation by Hughes Aircraft (USA), was unique in that the entire village was connected to a 120 volt DC battery charged by a 16 kW_{peak} solar photovoltaic array. The system worked poorly, was not well designed to fit the needs of the village, and never provided the desired level of service to the community. With no institutional system in place for maintenance, it soon fell into disrepair. In 1994 Sandia National Laboratory of the USA sent a team to evaluate the failed project and attempt to salvage the solar panels so they could be redistributed for individual solar home systems. Unfortunately the panels were deemed technically unsuitable for solar home system use and the rehabilitation project was not carried out.

Most solar home systems (SHS) up to the late 1990s were funded through an Alternative Energy Fund within the RMI, although a few systems were privately purchased. The money came largely from the U.S Government and the PIFS (then called the Forum Secretariat).

Table 4-1 – PV installations as of 2002 (not all operative)

Atoll	Fisheries freezers	HF Radio.	School	Comm-Hall	Dispensary	Individual System	Total
Majuro						10	10
Kwajalein		2					2
Ailinglaplap	1	2	1	1	2	2	9
Jaluit		3		1	1		5
Arno		3	2	2	1	18	26
Mili		2	2	1			5
Namorik		2		2	1	133	138
Namu	1	2		1	2	1	7
Maloelap		3	3		2	20	28
Ebon		2		3		11	16
Enewetak		1	1				2
Wotje		2	1		1		4
Ailuk		2		1	1	10	14
Ujae		1	1	1			3
Likiep	1	1	1		1		4
Mejit		2	2	1	1		6
Aur		1	2	1	1	10	15
Utirik				1		2	3
Lae		1	1		1	18	21
Lib		1	1		1		3
Jabat		1	2	1	1	30	35
Wotho		1	1	1			3
Bikini						10	10
TOTALS	3	45	21	17	17	265	366

Source – *Outer Islands Electrification Study*, ADB, April 1995 and *Annexes to the Namdrik PREFACE Project Report Final Review*, Jean-Michel Durand, 2003

Fifty lighting systems were purchased as packages from BP Australia which included one BP 'self-regulating' panel, a BP 120 Solar Bloc battery and two 15 watt fluorescent lights. They were installed on Lae, Aur, Ailuk and Majuro.

Twenty-nine systems were purchased from Inter Island Solar in Hawaii, consisting of one Arco M53 panel, a 110 Ah Johnson Gel Cell maintenance-free battery, an SCI controller and two 15 watt fluorescent lights from Thinlite. They were installed on Arno and Ebon.

About 1993, the Forum Secretariat purchased and installed 20 SHS for Jabat with two 50 Wp panels, an open cell 100 Ah battery, an SCI controller and two 15 watt Thinlite fluorescent lights. The systems were purchased from Showa Solar Far East, Singapore. There have been numerous technical problems including damage to many batteries because the local technician added acid instead of water to cells. Some systems continue to provide light and it is likely that the systems will be refurbished and brought under MEC operation and maintenance control as the rural electrification program proceeds.

In 1993, the Japan International Cooperation Agency (JICA) installed solar powered freezers for ice making and fish storage on Ailinglaplap Atoll (Airok Island), Likiep Atoll (Likiep Island) and Namu Atoll (Majikin Island). The installations included 5.4 kWp of solar panels arranged in two separate systems, each having a 96 volt, 400 Ah battery feeding an inverter. Three freezers were included, plus a radiotelephone and lighting.

In 1997 JICA added another 3 kWp of solar panels, a 48 volt 1340 Ah battery bank and more lighting. No additional freezers were included in the upgrade; the power was mainly to provide lighting for the fish processing areas.

The Marshall Islands Marine Resources Authority (MIMRA) is responsible for the JICA project 'the improvement of the fish marketing system in the outer islands in RMI' including system maintenance. The installations worked well until about 2002 when one section of the Likiep freezer failed due to connector corrosion. The freezer system on Ailinglaplap failed in 2001 due to corrosion of the inverter circuitry. In 2004, JICA fielded a team to investigate the status of the systems and to propose repairs where necessary. A follow-up repair team will carry out the repairs.

Institutional experience

A number of institutional forms have been tried in the RMI. Under the TTPI, systems were essentially provided as a gift to households, which were expected to provide for maintenance. Later, a 'rent to own' approach was tried in which users on Maloelap (1995), Aur and Ailuk (1992), received the systems from MRD and agreed to pay $10 per month to MRD until the installations were paid for. The systems on Jabat were the first to be installed under a rental arrangement with an $8 per month payment to MRD. In all cases, the operation and maintenance arrangements included basic battery maintenance by a local technician and irregular visits by a technician from MRD, with no disconnections for non payment of fees.

Figure 4-1 – Ailinglaplap Solar Fish Freezing Facility

Source: Masahiro Kaimoto, 2004

In general, communities were made responsible for basic maintenance of home systems with a technician from the MRD Energy Office on call for repair service. No fees were collected for maintenance. For dispensary, communications and education systems, local staff were required to maintain the equipment, a mechanism that has not worked well.

4.1.5 Namdrik 1996 project

In 1996, the French Government funded a solar electrification project on Namdrik through their Small Energy Projects Programme. The Caisse Francaise de Development (CFD) acted as the financier for the FF 2,612,000 (US$ 503,000) cost of the project. Transenergie of France was hired as design and implementation consultants with MAEC (within MRD) as the implementing agency. Total Energie (France) was contracted to supply the PV systems. The lighting systems operated at 24 volts and consisted of:

1 – 76 Wp solar generator (2 Photowatt PWX400 modules)
1 – Module support structure with wood or cement post
1 – Total Energie RMP microprocessor regulator
2 – Stecco 3000 lead acid solar batteries
1 – Total Energie SunCash prepayment meter
3 - fluorescent light fixtures 24V 13W
1 – LED nightlight 2 watts
1 – polypropylene battery case

Additional two panel systems were installed for street lighting and six 12-panel systems with inverters and refrigerators, intended for community refrigeration, were purchased for chiefs' houses.

A pre-feasibility study was carried out on Namdrik, second mission included a survey of homeowners, and the solar utility concept was introduced to the islanders. Two town meetings were called to answer questions that had not previously been asked during the survey. Transenergie used survey results for the design, and the solar systems were ordered from Total Energie, a subsidiary of France's Total Petroleum. The materials arrived in Majuro two months later in four containers. The equipment was then transferred to Namdrik using the MRD landing craft.

All households desiring solar electrification signed a MAEC service contract showing that MAEC owned the system, with households renting them and receiving a maintenance service from MAEC. Removal would occur after 93 days of non-payment. Fees were $8 per month for a standard lighting system (two panels) and $48 for a large system (12 panels) that included an 800 watt inverter, a 300 liter refrigerator and six lights. No deposit was required and the first month's service was free. The intention was for the six large systems (installed on the houses of the chiefs) to be used to operate community refrigerators, but they were used primarily by the chiefs themselves.

Payment was through pre-payment meters manufactured by Energy Measurements Ltd. (South Africa) with additions by Transenergie to fit the needs of solar system metering. Each "SunCash" meter required the entry of a 16 digit code, which was provided by the MRD Energy Officer and sent by radio to Namdrik every month. Payment was by cash to the agent on the island, to the local solar committee, directly to the MRD and through automatic debit of pension payments for retired persons on Namdrik.

The 134 household lighting installations plus six larger refrigerator power systems and several streetlights were completed by eight workers in five weeks. The Transenergie agent supervised the installations, installed all controllers and pre-payment meters and performed all final system checks.

The SunCash meters had frequent technical problems that could not be repaired on island and transmission by HF radio of 140 codes containing 16 numbers each, keyed to each customer, was an onerous task and prone to delays and errors. The result was frequent power outages for households even when they wanted to pay for the next month, causing widespread frustration and damage to some systems as households attempted to access the power that they were promised by wiring around the control system. Although several community meetings were held regarding the project, there was little active involvement of island leadership and they were not involved in the fee collections or the project management. Indeed, the MRD energy planner was quoted in a MAEC document[25] as saying that he *"… found the Namdrik local government to be the most difficult part of this solar project. When they saw that the utility could generate almost 1,100 US dollars each month, they wanted a piece of the action. We had to fight them for five months and they still believe they deserve some of the MAEC's money!"*

Figure 4-2 – 1996 SunCash meter and controller

Source: Marion Ferguson 2002

Figure 4-3 – 1996 Two system installation

Source: Marion Ferguson 2004

Fighting the island leadership proved to be the project's undoing. Since they were given no part in the project financial arrangements, and with the accounts unavailable for their inspection, the chiefs suspected that the money being collected was being siphoned off the island for no benefit to the islanders themselves. Also, because the systems had been provided to the government

[25] Transenergie S.A. Namdrik Final Report, T. Parker, January 1997.

free of charge, it was felt that that there should be no payment by users. Because the island leadership refused to pay, and encouraged the other islanders not to pay, the collection system collapsed, the SunCash meters were incapacitated and individual households took over responsibility for maintaining their own systems. By 1999, few of the household systems remained operative with only the large systems on the chiefs' houses still working well.

4.1.6 Lessons Learned

There are several lessons from the Namdrik experience:

- involve the recipient community at all levels, particularly community leadership;
- pre-payment meters do not cure non-payment problems for solar electrification;
- complicated payment, institutional and technical systems are likely to be serious problems for solar electrification on a remote site with poor communications and limited or expensive access.

4.2 Current Projects

4.2.1 Biofuels

The Tobolar Copra Processing Authority (TCPA) is considering the use of coconut oil as an alternative to imported ADO. TCPA has three diesel vehicles currently running on a coconut oil/diesel biofuel blend and have reportedly (Chutaro, 2004) used this fuel to some extent for the past five years. TCPA apparently has limited access to capital finance and would require either a grant or a capital subsidy from the GoRMI to develop the market for biofuel. Unlike the case in some PICs, TCPA has not been subject to special taxes on the biofuel produced, to replace the loss of import duty on the ADO displaced.

4.2.2 Solar Photovoltaics

Namdrik Rehabilitation

In 2000, the Pacific Rural Renewable Energy France-Australia Common Endeavour (PREFACE) — an Australian $3 million project funded jointly by Australia and France under the Secretariat for the Pacific Community (SPC) — designated the failed Namdrik PV project for rehabilitation. The only components that could be salvaged from the 1996 French project were the 38 Wp solar panels. The other components installed included:

2 – 13 W indoor tube type fluorescent lights LABCRAFT BL12/13
1 – 13 W outdoor tube type fluorescent light LABCRAFT BL12/8
1 – Total Energie TR10 12/24V10A controller
2 – Oldham 6RGTS181 flat plate sealed batteries 181 Ah @ C100
1 – LED night light
1 – DC/DC converter ADAP.DC12V/3-4.5 V@0.7A & 6-9 V@1A

The panels were pole mounted and the battery and charge controller were placed in a large fiberglass lockable box at the base of the pole.

Figure 4-4 – 2002 PV Installation

Source: Marion Ferguson

By the end of 2003, approximately 115 installations had been completed, including five at churches, two at schools and one at a health center. At the time, sufficient materials were still available for about 15 more systems, and efforts were being made to secure additional household commitments for systems.

Unlike the earlier Namdrik project, community leaders were integrated into the project. Nonetheless, the response of the community for payment of fees has been poor. During the first year, when collection was by the local committee, recorded collections were less than 50%. Records indicated that twenty recipients never made any monthly payments. Part of the problem appears to have been theft of payments or faulty accounting. Collections were sometimes made by the technician without providing a receipt and $2,000 was unaccounted for during the first year of operation. In a survey of about a third of recipients, many households claimed payments had been made that were not shown in the accounts. Although steps have been taken to ensure that no one makes a payment without receiving a receipt, concern remains regarding collections, since disconnects for non-payment are not being carried out. MEC management, which has taken over responsibility for the systems, has clearly stated that they will enforce disconnects for non-payment and removals for extended non-payment, making it likely that collections will improve dramatically. MEC has also provided assurance that the quality of maintenance, and thus the power reliability, will also improve.

Table 4-2– Namdrik Solar Project Summary	
Characteristics	**Detailed comments about the project characteristic**
Location of the project	Namdrik, Marshall Islands
Commissioning date	October 2002 (initial commissioning, final in 2004 after turnover to MEC)
Budget	$600,000
2004 operational status	Fully operational
Primary objectives	To meet the lighting and basic entertainment needs of the households on Namdrik
Population served	All households on Namdrik
Funding arrangements	Grant by Australia-France under the PREFACE project
Implementation arrangements	SPC contracted with Pacific Energie (New Caledonia) for the provision of components and the supervision of installations
Source of maintenance and operation funds	As of April 2004, the MEC took over operation and maintenance of the project. Households paid $200 for the initial installation and a continuing fee of $12 per month for maintenance. If there is a shortfall in cash, MRD will provide MEC with the difference between collections and cost.
What input comes from recipients	It is intended to be the case that all inputs come from recipients but until more experience is gained in the maintenance of the systems, the actual cost of operation and maintenance will not be known.
Local involvement in project implementation, operation and maintenance	PREFACE trained business agents and technicians on Namdrik to manage the project. MEC has taken over that organization and will continue to use local persons for basic technical and business services.
Capacity building components	Technical training for technicians and hands on training by PREFACE during the installation. MEC will provide continuing training as needed.
Relative success at achieving project objectives	Technical objectives appear to have been met for the short term though there are concerns that the capacity of the systems is too low for the demands of the Namdrik households. Future technical problems are expected with the complex controllers and with the use of sealed batteries in a high temperature environment. Social objectives were partially met in that good quality lighting was provided and power for small entertainment appliances was made available. However there is an unmet demand for higher power appliances such as video systems that requires more capacity than is available with the 80Wp systems.

During the first year, there has been a dramatic increase in ownership of TV/VCRs (to about 60% of households) despite the fact that the PV systems could only operate them intermittently[26]. Additionally, many households purchased radios, tape players and CD players (mostly in combination). This is a clear indicator that there is substantial cash available to even remote island households and also that the main demand appears to be for the use of entertainment appliances. Requests for larger systems have been received but no arrangement has been made to meet that demand, except to allow installation of additional 80 Wp systems under the same terms. With only a little more than one year of operation, it is too early to compile a list of lessons learned.

[26] *Annexes to the Namdrik Project Report Final Review*, Jean-Michel Durand, October. 2003

UN Health Center Project

In 2002-2003, eleven health centers received solar electricity financed by $250,000 from U.N Trust Fund grants. This included ten small clinic installations with:

14 – Shell Solar SM55 panels (770 Wp total)
2 – Solarix 12V/30A battery controllers
2 – 12V@240 Ah batteries
2 – 12V@150 Ah batteries
1 – 115VAC ceiling fan (20W)
1 – Trace Inverter (size not specified)
6 – 15W indoor 115 VAC fluorescent lights
2 – 15W outdoor 115 VAC fluorescent lights
1 – Water pump 115 VAC
1 – 12V DC 130 liter medical refrigerator for vaccine storage
1 – VHF communication unit (already installed)

Three solar distillation units for battery water production were also included to supply all 10 installations. There two separate power systems: i) one to operate the vaccine refrigerator; and ii) the second for the rest of the appliances. Unfortunately the use of AC lights and fans introduces unnecessary power losses and invites additional AC appliances that can overload the system if there is not strong user discipline. Also inverters (which convert the DC power to AC) in atoll environments have had poor reliability with the loss of the inverter resulting in no power for lights and the fan. Since 12V or 24V DC lights and ceiling fans are readily available, the use of a high-cost, low-reliability inverter seems to be a poor design choice. A 24VDC design would have lower losses and easier wiring. What is worse, for sufficient storage capacity, the two 12V batteries must be connected in parallel for each of the two systems, a configuration that results in shorter battery life than a series combination providing 24 volts.

For Likiep with its large clinic, a larger system was installed. It consists of:

40 – Shell Solar SM55 panels (2200 Wp total)
1 – Tarom 48V/45A battery controllers
1 – Solarix 12V/30A
6 – 12V@300 Ah batteries
1 – 115VAC ceiling fan (20W)
1 – Trace Inverter U2548 (48 VDC, 2500 W 120 VAC)
16 – 15W indoor 115 VAC fluorescent lights (already installed)
2 – 15W outdoor 115 VAC fluorescent lights
1 – Water pump 115 VAC
1 – 12V DC 130 liter medical refrigerator for vaccine storage
1 – Solar distillation unit for battery water production
1 – VHF communications radio (already installed)

As with the smaller systems, the vaccine refrigerator has a separate power supply (440 Wp) to ensure high reliability operation. Unfortunately, refrigerator system was also 12

VDC using paralleled 12V batteries. The designer did choose 48V for the other system (1,760 Wp) for lights, dental equipment, fan and pump.

The systems were designed, purchased and installed by an external (German) contractor selected by the UN with little interaction with EPD. Although the systems are complex, there was minimal capacity building, no institutional structure established for maintenance, and in general the project repeated most of the mistakes of previous health center PV projects that this system replaced. Unless there is immediate action taken to improve the mechanisms for maintenance, the project is unlikely to survive for more than a few years.

At the time of writing in early 2004, additional small clinic solar systems had been specified for purchase by the Health Department under their budget. The specifications were not available at the time of the country visit.

Mejit household electrification

Mejit was identified in 2000 for French funding of 80 systems, each having 150 Wp of panel capacity and the same sealed 12V batteries and lights that were used in the PREFACE installation on Namdrik. Tenders were received and are being evaluated in early 2004. The MEC will handle operation and maintenance.

Rural systems tendered but cancelled

One million dollars was allocated in the 2002 national budget for 500 rural household systems. Two hundred and fifty systems were tendered, with tender bids received in 2003, but the contract for the systems was never let. Implementation of the program has been delayed, although preparations have continued including the hiring by MEC of a solar system engineer and initial development of a training program for outer islands technicians.

4.3 Future Projects

In April 2003, the MRD proposed a coalition of MRD, MEC and the Marshall Islands Mayors' Association (MIMA) to work toward the rational and sustainable development of solar electrification for the outer islands. An annual budget of approximately US$500,000 is expected for outer island PV electrification.

On February 26, 2004, the GoRMI endorsed a request to the Global Environment Facility (GEF) for a PDF-A grant[27] of $25,000 to develop a comprehensive program for GEF funding for renewable energy capacity building and barrier reduction relating to solar photovoltaics, biofuel and wind. The project to be developed is called ADMIRE (Acting for the Development of Marshall Islands Renewable Energies) and was initially proposed during PREFACE implementation. The intent is to bring all government and donors initiatives under one technical and management strategy to avoid duplication, standardize equipment and place implementation and management under one structure. With MRD as

[27] This is a 'Project Development Fund' grant, to develop the concept for a larger GEF project.

its focus, ADMIRE plans to establish and coordinate a multi sectoral effort to promote renewables such as PV, wind, biofuel, solar water heating, bioclimatic design norms and links with energy efficiency activities such as demand side management.

4.3.1 European Union

Under the Cotonou agreement and membership of the ACP group of countries, the RMI is eligible for development assistance from the European Union (EU) through the European Development Fund (EDF). Four other PICs became eligible at the same time: FSM, Nauru, Niue and Palau. The EU has allocated slightly more than $11 million for renewable energy and energy efficiency measures in the five countries, of which the RMI will receive about $2 million in grants. The financing agreements may be signed by September 2004 with a project management unit established in Fiji thereafter. Although the grants are expected to form part of the outer island electrification program, there is no EU commitment yet regarding use of the funds. In 2005, an EU team is expected to visit the RMI to specify the actual program. On-the-ground installations are unlikely before 2007.

4.4 Proposed Projects

The PIREP team proposes the following:

1. *Feasibility study and a concentrated planning effort for coconut oil production on outer islands to supplement diesel fuel for electricity generation*. The production and use of coconut oil as a replacement for diesel fuel in the rural Marshall Islands will require development of a cost effective, efficient yet simple process for oil production, delivery and use. A study is initially needed to determine if the economics are better for production of the fuel on the rural islands or in a central location with copra shipped to the plant and oil shipped back. Practical approaches should be determined for the collection of raw materials and compensation for involved landowners. The study should also survey all manufacturers of equipment for small-scale oil extraction and biodiesel production including those in developing countries such as the Philippines, India and Indonesia.
2. *Feasibility study on the economic use of senile coconut trees removed for replanting with higher yield varieties*. If biofuel production is to occur on a scale sufficient to help offset petroleum imports for transport, increased productivity of the coconut tree inventory will be required. The replacement of senile trees with new stock will require disposal or use of the senile trees that are cut down. A study to determine the most practical economic use of those trees (biomass combustion for energy, lumber, exotic wood furniture production, etc.) should be carried out so that this large resource is not wasted.
3. *Small scale trial of outer island biofuel production.* At least three outer island sites should be selected for pilot application of biofuel production for outer islands. Different technical approaches should be tried in each pilot project to determine the most cost effective methodology for outer island biofuel production.

4. *Feasibility study of community piggeries with associated biogas production*. If outer island villages can be convinced that community piggeries are appropriate, trials for the development of village energy through biogas production at the piggeries should be undertaken. At least three pilot projects are recommended with variation in the approach used for distributing the produced gas to users to help determine the most cost effective and socially satisfactory approach (piped gas to houses, electricity generation at the piggery, compressed gas delivered in cylinders, etc.)

5. *Development of renewable energy training capacity at the College of the Marshall Islands.* The large planned expansion of PV for outer island electrification will require a permanent training capability for field technicians. The College of the Marshall Islands should be assisted and funded to develop that capability and to integrate PV training into its existing electrical trades program so that all electrician graduates have at least basic training in the special requirements of PV.

6. *Trials of "roof top" solar for integration into the Majuro grid.* Solar PV can provide useful input to the Majuro grid which has a mid-day peak demand that is well matched to the availability of solar energy. Trials of small (3-4 kWp) 'roof top' systems on government and MEC buildings should be undertaken to gain experience in the technology and performance.

7. *Wind resource survey for Majuro and Ebeye*. Majuro and Ebeye could benefit considerably from the supplementation of diesel generation with wind energy if the resource is sufficient for economic production. A well designed resource survey (with survey equipment at specific sites in Majuro and Ebeye most likely to be reasonable for wind turbine installation) is needed to determine the economics of wind energy for those locations.

5 BARRIERS TO RENEWABLE ENERGY AND ENERGY EFFICIENCY DEVELOPMENT

The barriers to renewable energy and energy efficiency development have been listed and categorized but it must be recognized that the categories are somewhat arbitrary and some barriers can fit several categories. The listing is not prioritized since there is no justifiable scheme for designating one barrier as "worse" than another.

5.1.1 Financial Barriers

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

Lack of credit finance for outer island purchases of solar home systems. Sales of solar home systems to outer island residents would increase if appropriate credit finance could be arranged.

5.1.2 Institutional Barriers

In RMI the only existing institution likely to implement renewable energy on any scale is the MEC for rural electrification using solar home systems. MRD will be primarily responsible for policy development and its implementation.

Capacity in MRD. There is inadequate capacity within the GoRMI to regulate, develop, implement and monitor renewable energy and energy efficiency projects.

Capacity in MEC. Although MEC has had more experience with solar rural electrification than any other Pacific Utility, the large programs being developed using local and EU funding will require additional personnel who will need training in renewable energy and there will be a need for advanced skills for component specification and selection to fit the specific RMI outer island conditions. MEC will also have to develop a training capacity for field technicians.

Fragmented implementation base. There is little sharing of resources, information and experience among the Fisheries, Telecoms, Agriculture, Health, Education, Environment and the Energy Unit regarding implementation of renewable energy projects. In a country as small as the RMI, it is difficult to maintain sufficient capacity for a single organization to design, install and maintain renewable energy systems. Fragmented implementation means that no implementer has adequate capacity to properly carry out a project.

5.1.3 Technical Barriers

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

No standards or certification for components or personnel. Each project from each organization has used different components and different training processes. If all projects used compatible or standard equipment, spare parts, logistics and training of technicians would be much easier.

No wind energy resource data. The wind resource is not known so wind energy development cannot proceed.

Difficult environment for electrical and mechanical equipment. The tropical marine environment in RMI is a problem for mechanical and electronic equipment. Electronic control systems and DC to AC converters are particularly vulnerable and must be designed specifically with the salt laden air, high ambient temperature and moist conditions in mind.

Emigration to the USA. With past easy access to the USA, there has been a constant outflow of experienced, well-educated personnel that has made it difficult to retain trained staff for the long term.

5.1.4 Market Barriers

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

Small size. The small size of the country, and its wide geographical distribution, makes it difficult to develop the capacity for design, implementation, operation, maintenance and monitoring of renewable energy systems.

Income on outer islands is irregular. For the outer islands, cash income is irregular as it is largely based on copra, making it difficult for some households to make cash payments on a fixed monthly schedule.

Access to outer island villages is difficult and expensive. Often reaching a project site involves both plane or ship transport to the atoll, and further travel by small boat to the project site.

5.1.5 Informational and Public Awareness Barriers

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

Lack of information about renewable energy at all levels. There needs to be more good quality information available to decision makers, the general public and businesses regarding the advantages, disadvantages and costs of renewable energy technologies.

Public awareness. There is low public awareness of the benefits of energy efficiency making acceptance of DSM programs difficult.

6 Capacity Development Needs

The Energy Planning Division of MRD has inadequate capacity to deal with energy policy issues, energy legislation, developing energy projects or monitoring and analyzing existing energy activities. The need for technical capacity development has been reduced somewhat (but is still necessary) as MEC, which has technical competence, is taking over operation and maintenance of rural electrification projects. The EPD requires assistance to develop policy, develop standards and certification measures, and to coordinate the rural energy development efforts that are currently scattered across numerous government agencies (particularly Health and Education) and the MEC.

The MEC needs capacity development relating to its new role in renewable energy for rural electrification. Development is needed in training capacity for maintenance personnel, assistance is needed in the creation of standards and certification measures for photovoltaic-based rural electrification and assistance is needed in the development of monitoring and analysis methodology specifically for SHS installations.

The EPD, MEC and KAJUR need capacity building in the development of demand side energy efficiency measures, particularly for transport, government and large electricity customers.

The private businesses currently selling renewable energy equipment have inadequate technical knowledge to properly assist customers in component selection, have little experience in the provision of follow-up services and need assistance in locating reliable suppliers for equipment known to be satisfactory for use in the RMI environment.

Assistance is needed at MRD and the private sector for the rational development of biofuels as a rural island alternative to diesel fuel.

6.1 Implementation of Capacity Development

6.1.1 Reducing Fiscal and Financial Barriers

Develop capacity for credit finance for solar home systems. There appears to be significant market for solar home systems on the outer islands that could be partially met by private businesses that can arrange for credit finance. A program that helps banks, NGOs, Cooperatives and private business to develop micro-finance for solar home system purchase is a need in at least five PICs and can be developed into a regional capacity development project.

6.1.2 Reducing Institutional Barriers

Capacity development for policy and strategy implementation in MRD. The development of PIC capacity in policy and strategy development and implementation is expected to be covered by the PIEPSAP.

Capacity development for MEC. Persons responsible for field technician training, project development, project management, equipment specification and purchasing, spare parts management, maintenance and fee collections at MEC can benefit from the experience of other PICs and that of other solar based rural electrification projects around the world. Assistance in developing this capacity is needed in several PICs and can be provided as a regional program.

6.1.3 Reducing Technical Barriers

Development of standards and certifications for renewable energy applications. Because of the difficult environmental conditions for electrical and mechanical equipment in RMI, many components that provide reliable service elsewhere may have a short life installed on an outer island. Since a number of PICs need to develop standards for component purchasing and certification systems for technicians, the needed assistance could be organized through a regional program.

Wind Resource Assessment. There can be no rational wind energy development until the resource is well understood. The capacity to perform proper wind resource assessments needs to be developed in RMI. This is a need in many PICs and can be addressed regionally.

College of the Marshall Islands capacity development To ensure wider understanding and competence in renewable energy in RMI, electrical trades curricula should include short modules on solar PV both for stand alone applications. The plumbing trades program would also benefit from a module on solar water heater installation and maintenance. These needs are common to most PICs and development of the modules and assistance for training instructors could be provided through a regional project.

6.1.4 Reducing Informational and Public Awareness Barriers

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

Public Information Programs. For acceptance of renewable energy, an understanding of its benefits and problems is necessary. RMI would benefit from the development of a public information program focused on renewable energy and energy efficiency. As this is a need for most of the PICs, the necessary public information materials can be developed regionally and delivered to countries along with short term training and advice in their proper delivery

7 IMPLICATIONS OF LARGE SCALE RENEWABLE ENERGY USE

7.1 Solar

The large-scale use of solar energy over the next decade will primarily be in the form of solar home systems for outer island electrification. Individual solar systems for households are not problematic at a large scale, other than the capital investment required and the need to collect and recycle batteries. Benefits of rural SHS are primarily quality of life improvements with improved communications, education, health and extended hours for home and work activities through greatly improved lighting.

Some added employment on outer islands will be a small boost to the rural economy. Since the cost of solar energy services is approximately the same as the cost of lighting fuel and dry batteries, rural cash flow is likely to be neutral with neither an influx nor an exit of cash from rural communities.

There are very limited opportunities for cash generation on outer islands that are increased by the availability of an electric energy supply so rural electrification, whether by solar or by diesel grid, is unlikely to significantly increase rural investment in economically productive activities.

7.2 Biofuel

The social and environmental advantages of biofuel are generally quite positive. Socially, the large-scale use of biofuel could have a major positive effect through substantially increased income to rural households. Environmentally, biofuels are much less likely to create problems by spills as they readily biodegrade, and pollutants from their combustion are less toxic than from petroleum products.

The primary problems lie in the economics of biofuel. The labor and transport costs of the RMI outer islands make it difficult for locally produced biofuels to compete with imported diesel fuel (although this could change if the crude oil price increases experienced during 2004 continue). Also the limited land area and small parcel ownership are problem for large scale production of biofuels since the output from many small holdings must be efficiently combined to provide the large volume of biofuels needed for significant impact on petroleum imports. Large-scale biofuel use implies an equitable method of developing the plantations and compensating landowners, then creating a labor-efficient process for the gathering, transport and processing of coconuts or other oil crops. If poorly planned and implemented, large-scale biofuel production can create social frictions and undermine traditional values.

For the biofuel to be the lowest possible cost at the location of its use, careful system design for the whole process, from tree to end-use, is necessary, particularly for the atoll type islands where there transport from place to place within the atoll is expensive.

The options of small-scale oil production in the outer islands and shipping copra to a central location for larger scale oil production should be assessed. Although it would not be as efficient, local oil production would eliminate the cost of shipping copra to Majuro and then shipping the oil back to the island, and would leave expeller residue in the atoll for pig and chicken feed. Although this approach would reduce the cash coming into the island, it would also reduce the cash outflow for fuel. Careful design of the oil production system will be important to maximize social, financial and environmental benefits.

7.3 Biogas

Social and environmental benefits of large scale biogas generation would include reducing the rural cash outlay for imported fuels for cooking and possibly engine operation, provide a better cooking environment than wood or even kerosene and provide improved control of animal wastes.

There are social issues that need to be faced. Biogas production at the scale needed to replace LPG and kerosene use for cooking will require concentrating the housing of the community's pigs and chickens to allow economic production of gas. The gas must either be collected and piped under pressure to the houses or compressed into cylinders and provided to houses in the same form as LPG is delivered now. As with solar PV, considerable land area space will be needed, and that may be difficult to arrange on some islands. A process considered equitable by all parties would be required for payment to landowners and animal owners, related to the amount of gas produced and used by households otherwise social problems can be expected.

8 ENERGY EFFICIENCY

For Majuro and Eybye, renewable energy will be significantly more expensive than its petroleum-based counterpart. Therefore if the cost of renewable energy input to the existing electricity and transport systems is to be minimized, the use of energy needs to be as efficient as practical so the high cost of renewable energy is not being wasted on inefficient users. Any program for renewable energy for electricity generation or providing fuels for transport on the urban islands should be closely linked with energy efficiency programs so that the high cost energy is used as efficiently as possible.

8.1 Petroleum Use

Transport is the largest user of petroleum in the RMI, accounting (Table 2–5) for about two-thirds of fuel use. Marine transport is a major user of diesel fuel along with MEC. Automobiles on Majuro, along with private boats powered by outboard motors, represent the main use of gasoline. Jet fuel is used for inter-island flights as well as for international carriers. Kerosene and LPG are the main cooking fuels on Majuro and increasing in use on the outer islands.

There is scope for significant improvement in petroleum use efficiency in the RMI but only in the transport sector. The use of private cars has increased to the point that there is serious traffic congestion in the morning and late afternoon causing traffic to move slowly and fuel efficiency to be very poor. Improvement in traffic flow through increased public transport, flex-time arrangements for employees, etc. can have a favorable impact on land transport efficiency. Providing incentives for purchasing small cars, or penalties for large cars, can also be effective. Incentives for using diesel power for passenger cars and small trucks can also significantly increase the efficiency of fuel use. The MEC has several small electric trucks, but in Majuro where electricity is generated by petroleum fuel, this does not reduce petroleum use for transport.

Marine transport efficiency improvements are possible and could be considered under the ADB's outer-island transport infrastructure project, a $10 million effort intended to improve the quality of shipping and personnel transport for the outer islands.

8.2 Electricity

Electricity production (Table 2–5) accounts for about 30% of RMI's national petroleum consumption. MEC has low generation and distribution losses so supply side efficiency cannot be significantly improved in a cost-effective manner. However, the efficiency of electricity use by consumers, i.e. demand side efficiencies, can be improved a great deal at relatively little cost. To date there have been no concentrated efforts to improve demand side management (DSM), but with demand approaching capacity, the MEC should consider establishing DSM programs especially for its largest industrial and commercial users.

9 Co-Financing and Implementing Capacity Development Needs

The upcoming outer island electrification project of the EU is the only firm donor project that provides an opportunity for co-financing by PIREP. However, the government has plans for locally funded rural electrification projects that are not yet firm but could provide an opportunity for co-financing. Should future projects provide an opportunity, the following activities would be useful under a GEF co-financing arrangement specific to the Marshall Islands though most can be more efficiently developed regionally.

1. The planned development of outer island solar electrification will require significant capacity development within MEC for system design, installation, operation and maintenance. This will be required both at the time of project implementation and repeatedly for the indefinite future, and could be implemented through co-financing in association with the finance of the hardware component.
2. Capacity building is required for the College of the Marshall Islands to include solar photovoltaic installation and maintenance in its electrical trades program.
3. Capacity building for EPD regarding project development, project management and energy data management is urgently needed if renewable energy and energy efficiency measures are to be rationally and effectively implemented, monitored and regulated. This will need to be financed largely from external sources.
4. Technical assistance and training related to the development and management of biofuel production will be needed if renewable energy is to be used for transport. This should be from external sources and directed at agricultural specialists working with coconut growers as well as energy department personnel.
5. A training program for marine diesel mechanics, ship's officers and ship owners needs to be developed to improve the efficiency of marine transport. This could be co-developed with local and external resources.
6. Majuro's long narrow landmass, with a single primary road along with the continually increasing number of private vehicles, has created a traffic problem particularly commuting to and from work. It has also resulted in relatively low transport efficiency for Majuro. Consideration should be given to the development of more efficient arrangements to reduce the inefficient use of private cars through the provision of external expertise in association with local resources.

Annexes

Annex 1 – People Interviewed by Local and International Consultants for PIREP

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Tommy Debrum	Deputy General Manager, National Telecom Authority,
Mike Slinger	General Manager, TOBOLAR Copra Oil processing Plant,
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Jerry Kramer	Chief Executive Officer, Pacific International, Inc. (PRI)

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Forum Secretariat	www.forumsec.org.fj	Economic data; investment climate
Food and Agriculture Organization (FAO)	www.fao.org/DOCREP/003/X6900E/x6900e0q.htm and www.fao.org/DOCREP/003/X1576E/X1576E05.htm	Asia and Pacific National Forestry Programme updates for RMI
IEA International Small-Hydro Atlas	www.small-hydro.com/	Hydro data
UNESCO	(portal.unesco.org/en/ev.php@URL_ID=17637&URL_DO=DO_TOPIC&URL_SECTION=201.html	Rays of Hope, covering school hybrid project
Tinytech	www.tinytechindia.com	Coconut oil expelling technology