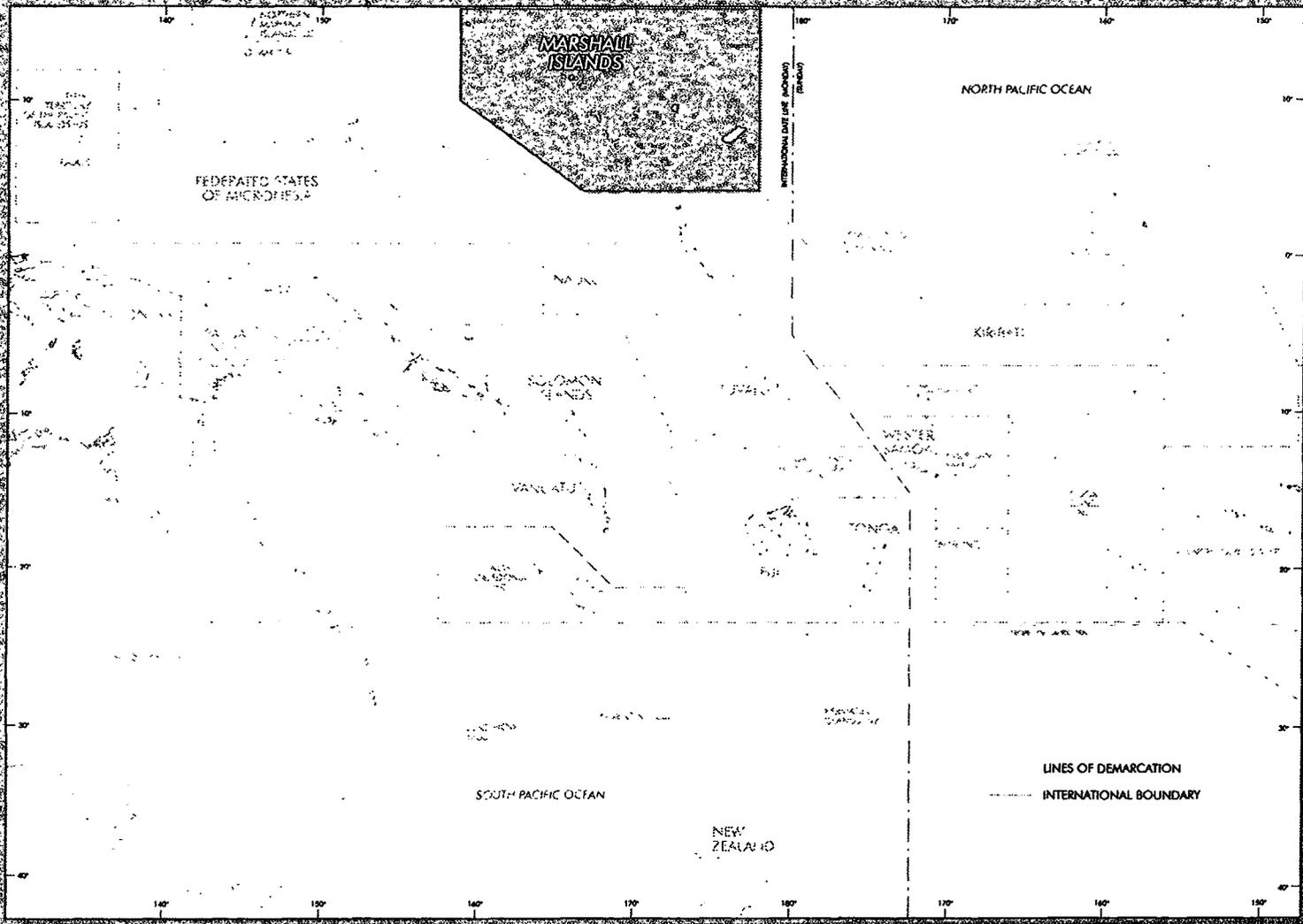


PREA

Pacific Regional Energy Assessment

Volume 6. Marshall Islands: Issues and Options in the Energy Sector



The World Bank
 in cooperation with
 The UNDP/ESCAP Pacific Energy Development Programme
 The Asian Development Bank
 and

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Abbreviations

ADB	Asian Development Bank
AIDAB	Australian International Development Assistance Bureau
AMI	Air Marshall Islands
D.U.D.	Delap-Uliga-Darrit (urban portion of Majuro Atoll)
EPA	Environmental Protection Agency (of the Marshall Islands)
ESMAP	Energy Sector Management Assistance Program (Joint World Bank, UNDP & Bilateral donors)
FDI	Foreign Direct Investment
FSED	Forum Secretariat Energy Division
GMI	Government of the Republic of the Marshall Islands
IBC	International Bridge (and Construction) Company
IPSECO	International Power Systems and Engineering Company, Ltd
KADA	Kwajalein Atoll Development Authority
KAJUR	Kwajalein Atoll Joint Utility Resource
KALGOV	Kwajalein Atoll Local Government
MEC	Marshalls Energy Company
MIDA	Marshall Islands Development Authority
OMIP	Operation and Maintenance Improvement Program (USDOJ)
OPS	Office of Planning and Statistics
PEDP	Pacific Energy Development Programme (UNDP)
PREA	Pacific Regional Energy Assessment
RMI	Republic of the Marshall Islands
USDOE	United States Department of Energy
USDOI	United States Department of the Interior

Currency

The official currency of the Republic of the Marshall Islands is the U.S. dollar.

This report is based on the findings of a mission which visited the Republic of the Marshall Islands from 30 January through 5 February and from 28 February through 7 March 1991 as part of the joint World Bank, PEDP, ADB and Forum Secretariat *Pacific Regional Energy Assessment*. The mission comprised Mr. Peter Johnston (Team Leader, PEDP), Mr. Vilhelm Mørup-Petersen (Power Engineer, World Bank consultant), Mr. George Tavanavanua (Petroleum Specialist, World Bank/AIDAB consultant), Mr. Christopher Cheatham (Energy Economist, PEDP) and Mr. Robert Lucas (Macro Economist, FSED).

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MARSHALL ISLANDS

ISSUES AND OPTIONS IN THE ENERGY SECTOR

August 31, 1992

Abstract

The consumption of commercial energy is high in Marshall Islands, spurred by government subsidies. In order to sustain a growth strategy based on energy-intensive development, the Government should ensure that energy is used efficiently, based on economic costs. A specific government department should have the overall responsibility for the energy sector, with a senior officer in charge of energy matters. In order to reduce the subsidy burden on the Government, MEC should be restructured along commercial lines, with its electricity and petroleum operations separated. The electricity tariffs should be raised to cover the full costs of supply, and all customers should be required to pay for electricity. The Government should renegotiate the outdated and poorly-written petroleum supply agreement and appoint a short-term petroleum advisor. In order to avoid the potential problems, such as water pollution and fire, due to deficiencies in fuel storage and handling, safety and quality standards be introduced soon and be strictly enforced. There is an urgent need to improve the fuel storage facilities on Ebeye. The Government should stop subsidizing automotive distillate, and begin monitoring wholesale and retail prices of petroleum products. The report recommends that the Government establish an independent company to handle all solar PV matters, and this company should charge the recipients a fee that is sufficient to cover at least maintenance costs.

Industry and Energy Operations Division
Country Department III
East Asia & Pacific Region

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ENERGY CONVERSIONS AND MEASUREMENTS

	Unit	Typical Density kg/litre	Typical Density l/tonne	Gross Energy MJ/kg	Gross Energy MJ/litre	Oil Equiv toe/unit (net)
Biomass Fuels						
Fuelwood (5% mcwb)	tonne			18.0		0.42
Coconut Residues (air dry) ¹						
Shell (15% mcwb) _{harvested}	tonne			14.6		0.34
Husk (30% mcwb) _{harvested}	tonne			12.0		0.28
Average (air dry) _{husk and shell} ²	tonne			14.0		0.33
Coconut Palm Wood (air dry)	tonne			11.5		0.27
Charcoal				30.0		0.70
Vegetable and Mineral Fuels						
Crude Oil	tonne			42.6		1.00
Coconut Oil	tonne	0.910	1100	38.4		0.90
LPG (propane)	tonne	0.510	1960	50.0	25.5	1.17
Ethanol	tonne			27.0		0.63
Gasoline (Super)	tonne	0.730	1370	46.5	34.0	1.09
Gasoline (Unleaded)	tonne	0.735	1360	46.5	34.2	1.09
Aviation Gasoline (Avgas)	tonne	0.695	1440	47.5	33.0	1.12
Lighting Kerosene	tonne	0.790	1270	46.4	36.7	1.09
Power Kerosene (Avtur, DPK)	tonne	0.795	1260	46.4	36.9	1.09
Automotive Diesel (ADO)	tonne	0.840	1190	46.0	38.6	1.08
High Sulphur Fuel Oil (IFO)	tonne	0.980	1020	42.9	42.0	1.01
Low Sulphur Fuel Oil (IFO)	tonne	0.900	1110	44.5	40.1	1.04
Electricity (MWh)						
Fuelwood ³	MWh					0.93

Fuel Conversion Efficiency

Diesel: Text uses actual where known, otherwise:

Average efficiency for small (< 100 kW output) diesel engine 0.46 l/kWh (22%).

Average efficiency of large (> 100 kW output) modern diesel 0.284 l/kWh (36%).

Average efficiency of low speed, base load diesel (Pacific region) 0.30 – 0.33 l/kWh (28% – 32% eff).

Energy Measurements

Area: 1.0 km² = 100 hectares = 0.386 mi²

1.0 acre = 0.41 hectares

Mass: 1.0 long tons = 1.016 tonnes

Energy: 1 kWh = 3.6 MJ = 860 kcal = 3412 Btu = 0.086 kgoe

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

Notes:

(1) Average yield of 2.93 air dry tonnes residues/tonne copra produced (Average NCV 14.0 MJ/kg)

mcwb = moisture content wet basis. NCV = net calorific value.

(2) Proportion: kernel 33%, shell 23%, husk 44% by dry weight.

(3) Assumes conversion efficiency of 9% (biomass-fuelled boiler).

Sources:

Petroleum from Australian Institute of Petroleum, January 1991

Renewable Energy Assessment – An Energy Planners Manual. (Gowan 1985)

Woody & Biomass Use in Agro-Industries. (PEDP, Gilmour, 1987)

Energy Data and Conversion Factors (New Zealand Energy Research & Development Committee 1984)

SUMMARY OF MAIN FINDINGS AND RECOMMENDATIONS

ENERGY SITUATION AND PRIORITIES

1. The Republic of the Marshall Islands has a rapidly-growing population of 46,000 people widely scattered over 24 populated atolls with poor soils and few exploitable resources. Although the economy was buoyant during the 1980s because of U.S. Compact funding, the GDP ^{1/} of \$1,600 per capita is based largely on public sector expenditure and is highly dependent on U.S. grants which are expected to decrease in real terms over the next decade. Future economic growth depends largely on the private sector, particularly planned joint ventures involving tuna processing and transshipment.

2. Per capita energy consumption ^{2/} of both petroleum products and electricity, is quite high by Pacific Island standards. These levels may be difficult to sustain financially. Government subsidized fuel storage and highly subsidized electricity have led to excessive energy use. Consequently a disproportionately large portion of the country's financial resources has been directed to the energy sector, possibly to the detriment of development in other sectors of the economy. With a growth strategy based on energy-intensive development, the Government of the Marshall Islands ^{3/} needs to ensure that energy is acquired and sold at prices that accurately reflect real economic cost, and that energy is used much more efficiently than at present. These conclusions reiterate similar findings reached by earlier studies.

3. **Petroleum.** Imported petroleum products dominate the national energy economy, accounting for 78% of primary energy use and 100% of commercial energy. The 1990 consumption of 511 kg of oil per capita ^{4/} was approximately 23% by value of total imports and 400% of export earnings. Until 1984, Mobil was the only marketer due to its efficient supply logistics and ownership of bulk storage on the main islands. By 1990, Mobil's market share had dropped to 56%, the rest provided by the government-owned Marshalls Energy Company (MEC), established in part to develop international bunkering.

4. The main petroleum sector issues are the desirability of MEC competing in fuel trade, improved use or disposal of excess MEC storage, the lack of on-shore competition, the absence of price monitoring, non administration of the national supply contract, declining physical standards of storage facilities, the absence of fuel storage and handling standards and the inadequacy of data collection, the final item resulting in reliance on the oil companies for volume and pricing information. Other key issues include concerns over product quality, the proliferation of service stations, and GMI concerns over security of supply. The most critical

^{1/} Provisional 1988 Government estimate at current market prices.

^{2/} Energy supply and consumption data in this report excludes the U.S. military enclave on Kwajalein Atoll.

^{3/} Abbreviated in this report as GMI or Government.

^{4/} 700 kg per capita including bunkering.

problems are on Ebeye with deteriorated 'on-shore' storage, hazardous off-shore barge storage and insecure supply arrangements.

5. Electric power. There is no national power company. Four utilities provide diesel-generated electricity to Majuro, Ebeye, Jaluit and Kili. Ninety-eight percent of generation is on Majuro and Ebeye (68% and 30% respectively) which constitute urban RMI and account for two thirds of the country's population. Over half of all households and 80% of those on the above atolls have electricity. Although the MEC generating facilities are well run technically, power cuts, low voltage levels and voltage fluctuations are frequent due to a heavily loaded distribution system with inadequate maintenance. Ebeye's utility, the Kwajalein Atoll Joint Utility Resource (KAJUR), is newer, covers a smaller geographical area, has few outages, and is well run although there is no maintenance program for the distribution network. Heavily subsidized tariffs, inadequate metering, poor revenue collection and inefficient end-use contribute to an electricity consumption per household consumer which exceeds 700 kWh per month, nearly the highest in the Pacific Islands region. With better revenue collection, planning and a utilities-based energy conservation program, a considerable reduction in fuel use can be achieved in the short term. In the longer term, investments in new generation capacity can be delayed.

6. Key power sector issues include the structure of the MEC and KAJUR, particularly the desirability and degree of privatization, localization of key staff positions within the Ebeye power station, poor power sector planning resulting in the purchase of unnecessary generation plant, inadequate attention to the quality of transmission and distribution, wasteful use of electricity, and the reluctance of the government to raise tariffs. Although tariffs are only about half of costs, GMI and atoll officials are reluctant to raise charges. A proposed seawave power project in Kwajalein Atoll, even if technically successful, will cost twice as much as expected benefits. Immediate sectoral priorities are completion of metering for all customers, improved maintenance of distribution systems and introduction of a clear policy to steadily increase the electricity price with a goal of eventually meeting full costs.

7. Household and rural energy. Limited use of biomass for direct heat and photovoltaics for small electric loads are the only significant uses of local renewable energy resources. Although coconut wastes are currently used to meet some rural and low-income urban cooking needs, they might not be adequate if electricity is priced closer to its true cost which would induce a shift to biomass. The GMI has quite reasonably identified solar photovoltaic electrification as a priority for remote communities since electricity though PV systems cost less overall than the alternative of diesel power. About 140 small PV systems have been installed on 19 atolls but many have reportedly failed or deteriorated due to poor planning and maintenance despite an ongoing Photovoltaic Preventive Maintenance Program jointly funded by USDOE, USDOJ and the GMI since late 1988. Key issues are a lack of clear responsibility, insufficient and poorly trained staff, and likely failure of the program overall if maintenance does not improve.

8. Environmental issues. The main power stations are adequately distant from residential areas, lube oil is recycled and reportedly no transformers use hazardous (PCB) fluids. Some concern was expressed regarding excessive production of CFC "greenhouse" gases from worn-

out compressors in cooling systems. However, the most serious issue is the danger of water pollution and fire due to deficiencies in fuel storage and handling. Standards should be introduced soon and be strictly enforced. Old corroded electricity generation facilities and equipment litter Majuro and form a hazard and an eyesore.

9. **Institutional issues.** Within the GMI, there is no overall responsibility for coordinating or overseeing national energy matters or the key subsectors of electricity and petroleum. As a result there are no clear policies, planning is negligible, and the basic data required for informed decision-making are not collected. The MEC is both a power company and petroleum importer/distributor with both operations subsidized; to reduce the budgetary burden on the GMI and free resources for other priorities, it should be restructured along commercial lines with electricity and petroleum operations separated. Key planning and operational staff of both MEC and KAJUR are expatriates on short-term contracts; continued training for local staff and localization efforts are important.

PRINCIPAL RECOMMENDATIONS

10. **Power Subsector.** The following measures are recommended:

For the short term,

- a) improve metering, disconnection and collection procedures; install meters for all customers, including government; and require all government and quasi-government agencies, national and local, to pay for electricity (MEC and KAJUR) 5/;
- b) increase the average MEC and KAJUR tariffs in annual steps to their full costs (including capital costs) over a five year period with extensive prior publicity explaining the new policy; and
- c) as overall tariffs are increased, introduce subsidized 'lifeline tariffs' for the first 100 kWh per month of household consumption (set at about \$0.10/kWh or half of the household tariff, whichever is higher).

For the medium term,

- d) establish standard utility budgeting and accounting systems (KAJUR), systematize collection and analysis of statistical data, prepare system maps of the distribution system, and investigate the causes of poor voltage and outages in the system (MEC and KAJUR);

5/ By mid-1992, MEC had installed meters on all government and quasi-government accounts, and only about 120 other customers remained without meters.

- e) establish formal training programs for MEC and KAJUR, including on-the-job training, off-island studies, and apprenticeships;
- f) establish realistic short-term demand and energy forecasts based on higher tariffs (MEC and KAJUR); and
- g) continue on a more systematic basis the upgrading of MEC's distribution system in Uliga 6/, using expensive underground cable systems only in the most congested areas, move the step-down transformer(s) to Darrit, and rehabilitate the 4.16 kV Darrit system.

11. Petroleum Subsector. The following recommendations are for Majuro and Ebeye:

For the short term,

- a) The Government of the Marshall Islands and the Kwajalein Atoll Local Government should act urgently to improve the fuel storage facilities on Ebeye and cease using the 'temporary' barge;
- b) Customs Department procedures should be amended to ensure that the volumes of oil products imported are physically verified, and that invoices and bills of lading accompany each shipment with accurate information provided by the oil companies on products, volumes, FOB value, shipping cost, ocean losses, and insurance;
- c) GMI should renegotiate the outdated and poorly-written 1982 Mobil supply agreement and routinely administer any new agreement;
- d) GMI should begin monitoring wholesale and retail prices of gasoline, distillate and kerosene and establish guidelines for fair prices; and
- e) GMI should cease subsidizing sales of automotive distillate;

The following medium term recommendations are closely linked to those above and no less urgent but may take longer:

- f) regulations on the storage and handling of fuels should be adopted and enforced;
- g) MEC tanks should be reconditioned to an internationally-accepted standard;

6/ By mid-1992, the problems in the Uliga switch-station that led to low voltages had been resolved.

- h) if GMI wishes to improve utilization of the MEC storage facilities, establish conditions where new suppliers might consider entering the market, and improve security of supply, it should arrange an independent evaluation by disinterested parties of its overall supply and pricing arrangements and options 7/; and
- i) appoint a short-term petroleum advisor to assist with negotiations of the proposed new supply agreement, improvement of storage, and assessment of the overall supply and pricing arrangements.

12. Household and Rural Energy The following measures are recommended:

- a) standardize stand-alone PV systems for supplying small electric loads on the outer islands;
- b) charge a monthly bill to all recipients of GMI-provided PV systems which is sufficient to cover at least maintenance costs;
- c) establish an independent solar company to handle all PV matters;
- d) carry out rural energy surveys to determine the real costs of electricity and fuel and to design measures to improve supplies and/or reduce costs;
- e) carry out household energy end-use surveys in Majuro and Ebeye to establish information on energy use patterns and to enable realistic targets to be introduced for energy savings to help reduce the impact of higher electricity prices.

13. Energy and the Environment. The following measures are recommended:

- a) dismantle, and properly dispose of, the corroded and unused electricity facilities and equipment which litter Majuro; and
- b) improve fuel storage and handling procedures.

14. Institutional Development. The following measures are recommended:

- a) reorganize the MEC into a fully commercialized company including the transfer of all assets and liabilities from government to the MEC;
- b) separate MEC's power and petroleum activities into distinct entities;

7/ This could include evaluating a Joint Users Storage Company and an export refinery although a refinery is impractical for the RMI.

- c) replace the management contract at KAJUR's power station with direct hire of expatriate engineers;**
- d) allocate responsibility for overall energy sector coordination to a specific government department (either Office of Planning and Statistics or Office of Chief Secretary) and appoint a senior-level officer to develop a national energy strategy, supervise the photovoltaics program, oversee power management contracts, oversee petroleum contract negotiation and administration, and collect and analyze energy data; and**
- e) increase the Energy Office responsibilities to include overseeing the PV programs, household energy surveys, and rural energy matters in general.**

I. ECONOMIC AND INSTITUTIONAL CONTEXT

ENERGY AND THE ECONOMY 1/

1.1 Provisional estimates indicate that real growth in GDP between 1983 and 1988 averaged nearly 8% per year, slightly over 3% per capita, largely due to the Compact of Free Association with the United States and other grant assistance. Employment growth between 1980 and 1988 exceeded 5% annually with public sector growth double that of the private sector due to increased Government of the Marshall Islands (GMI) involvement in energy, airlines, fishing, and manufacturing. The private sector is relatively undeveloped, consisting primarily of retail and wholesale trade and service activities. The primary sectors, agriculture and fishing, are predominantly subsistence, except for copra which has declined as world prices have been generally depressed during the 1980s. The weakness of the private sector is underscored by a very small volume of commodity exports, less than \$2.5 million per annum from 1986 through 1989, resulting in a large trade deficit of \$42 million in 1989. Some major indicators are shown in the Statistical Annex, Table 1.

1.2 Future growth depends critically on the GMI's ability to stimulate private sector growth and development. The government plans commercial ventures with foreign partners with the goal of privatization of public commercial operations as these become commercially viable. The main priority is to exploit the large tuna resource believed to exist in nearby waters, with many long-liners and purse seiners based at or using Majuro transshipment facilities. A transshipment base being developed at Majuro now receives fish from long-liners and prepares sashimi-grade tuna for air freight to Honolulu and Japan. Present activity is four to five long-liners per month with expected growth up to 40 per month within three to four years. A critical element is the availability of air freight capacity on Air Marshall Islands (AMI).

1.3 Visitor arrivals, mainly on government and private business, have fluctuated between about 3,000 and 4,000 in the 1983 - 1988 period with modest increases expected. GMI policy is controlled growth emphasizing small scale tourism in the outer atolls. Several agricultural ventures have also been initiated or are under study including hydroponics for vegetables in Kwajalein, commercial papaya in Laura, poultry for the domestic market, and a pilot project to stimulate growth of artisanal fisheries in the outer atolls.

1.4 The GMI capital budget has been about \$11 million during both fiscal 1988 and 1989. Financial capacity to maintain the current momentum in fisheries development, and to fund other GMI-supported initiatives and joint ventures to boost and maintain growth in the private sector, is likely to depend on the level of U.S. grant assistance and private foreign direct investment

1/ This is a brief summary of the Marshall Islands section of *Macroeconomic Overview Report, Assessment of Performance and Growth Prospects: Republic of the Marshall Islands, Federated States of Micronesia, and the Republic of Palau* (Pacific Islands Development Program, East West Center, May 1991). The ADB's first *Economic Report on the Republic of the Marshall Islands* (January 1991) was also a valuable source. All GDP projections are mission estimates: neither the Government nor ADB have estimated future GDP growth.

(FDI). Provisions under the Compact indicate that U.S. grant funding will remain at about the 1989 level of \$44 million (in 1990 dollars) through the year 2000. Other U.S. assistance, about \$10 million in 1989, has been declining and other foreign assistance has been modest, just over \$2 million in 1989. Therefore continued commercial development is likely to depend on increasing levels of FDI. Besides bringing in needed management and technical skills, increased FDI generates greater domestic revenues to GMI, and enhances the ability to attract foreign assistance.

1.5 Even modest success in developing the Majuro tuna transshipment base and other segments of national fisheries industry would boost exports substantially and generate income and employment. Linkage effects and service activities to support the fishing fleet could also be expected to generate additional private sector employment and income. Additions to hotel room inventory, together with the expansion of AMI service to Honolulu, can be expected to increase visitor arrivals. While most of the increased activity is likely to occur in Majuro, opportunities will exist for the operation of additional guest houses and perhaps small resort facilities in some of the outer atolls.

1.6 In evaluating the prospects for growth in the economy, the future trend in external assistance from the U.S. and other sources is important. Although Compact funding is assured, it will remain about the same in current dollar terms, and thus will decline in real terms. If other U.S. grant assistance is maintained at current levels in real terms, and if private sector development materializes with associated FDI, GMI revenues from domestic sources should grow sufficiently to enable slow growth or at least the same overall budgetary resources in real terms through the 1990s. Given the maintenance of overall GMI revenues, real growth in GDP at an average annual rate of 2 to 5 percent may be expected through the year 2000. With population increasing at 4% annually, even 5% economic growth will barely maintain real per capita GDP at current levels and will be well below the growth rates of the 1980s.

INSTITUTIONAL FRAMEWORK

1.7 There is no government office with overall responsibility for the energy sector. The Office of Planning and Statistics (OPS) collects limited data in order to identify issues and constraints and is attempting to develop policies and strategies. However, the data are insufficient for policy analysis, the office has only a small professional staff, and there is no energy expertise. The OPS apparently relies on others for energy sector analysis and policy initiatives and primarily edits submissions into the development plan framework. The OPS recognizes this situation and was preparing a national development plan in early 1991; the draft energy chapter includes a number of good initiatives including a proposal to establish a national energy planning and coordination capability within GMI.

1.8 Within the Office of the Chief Secretary, there is an Energy Office with one officer responsible for photovoltaic systems in remote areas and an untrained assistant to install and maintain them. There is little budgetary support for design, planning, travel or maintenance.

1.9 Petroleum. Petroleum products are imported by Mobil Oil (Guam) with bulk storage facilities on Majuro, Ebeye and Jaluit and the MEC through Shell (Guam) with storage only on Majuro. There are nine privately owned service stations on Majuro, and one each on Ebeye and Jaluit. There is no wholesale or retail price control and no legal requirements for product quality, storage, or handling. The Customs Department calculates tax revenues based on oil company submissions but does not confirm the volumes of fuel imported or their value. A supply contract negotiated with Mobil in 1982 is still in effect on Majuro but it has never been effectively administered by GMI.

1.10 Power. Electricity is generated and distributed by the MEC on Majuro, KAJUR on Ebeye, the Kili Atoll Local Government on Kili and the Ministry of Public Works on Jaluit Atoll, as discussed below.

1.11 MEC. The Marshalls Energy Company was established in 1984 as a wholly government-owned entity to generate and distribute electricity and buy and sell petroleum products. The MEC Board is appointed by the government. The Minister of Finance is chairman, and members include two other ministers, civil servants and commercial consumers. The MEC is managed by an expatriate General Manager assisted at the power plant by two expatriate engineers. The plant superintendent and distribution superintendent are both Marshallese. A program of on-the-job training for local staff has made acceptable progress. The power plant, transmission system and fuel storage facility on Majuro are the property of the GMI, which has leased the facilities to MEC until 1993. All fees and other costs to MEC for using the facilities during this period were waived by a 1988 Cabinet decision. To maintain low electricity prices, the GMI also provides MEC with an annual operating grant to balance operating deficits.

1.12 Although management of MEC is formally separate from the government, the company is financially dependent on GMI support. There is no clear policy on the magnitude of the operating subsidy and the MEC Board has no budget or tariff objectives: it is not required to cover costs. It is generally accepted that substantial tariff increases are required if MEC is to become financially viable and eliminate the need for government subsidies. However, strong political, social and commercial interests support cheap power.

1.13 KAJUR. The Kwajalein Atoll Joint Utility Resource was established in December 1990 by the Kwajalein Atoll Development Authority (KADA) and the local atoll government (KALGOV) to manage Ebeye's power facilities and a desalination unit utilizing power station waste heat. The KAJUR Board of three members is chaired by KADA's chairman. KAJUR is owned by KADA (75%) and KALGOV (25%) although the latter would like to sell its shares to the public. KAJUR receives an annual operating subsidy from GMI through KALGOV and receives large advances periodically from KADA to cover operating deficits. The facilities were constructed in 1987 and are managed under an "evergreen" contract by International Bridge and Construction Company (IBC) of Guam which employs an expatriate plant manager and an engineer. Contract terms are agreed each year. The Ebeye/Gugeegue distribution system which was built by IBC is the responsibility of KALGOV but is not routinely maintained.

1.14 *Jaluit and Kili.* Only limited information is available on the power systems of Jaluit and Kili. Jaluit is owned and operated by Public Works but management may shift to MEC under a GMI contract in 1992. Operating deficits and capital costs are financed by the Ministry of Public Works. Kili is run by International Bridge and Construction Company (IBC) under a contract with the local government.

II. ENERGY CONSUMPTION

THE STRUCTURE OF ENERGY CONSUMPTION

2.1 No information is available about household energy use surveys, industrial censuses, or household income and expenditure surveys carried out in the Republic of the Marshall Islands (RMI) from which energy use could be derived nor any studies of energy end-use in government or commerce. The 1988 Census of Population and Housing indicated the types of energy used for cooking and lighting but not quantities. Accordingly, the national energy balances (Statistical Annex, Tables 3 and 4) rely on estimates. About 90% of all energy use in the RMI is petroleum and 10% is coconut and wood waste. Almost half of all imported petroleum is used for electricity generation, nearly as much for transportation, and small amounts for other purposes.

THE CONSUMPTION OF PETROLEUM PRODUCTS

2.2 During the past five years, petroleum product imports have been relatively static ranging between 7.7 - 8.9 million U.S. gallons (MG) excluding ocean bunkers, or 9.1 - 10.9 MG including bunkers. The 1990 totals were 8.8 MG (inland) and 9.5 MG (with bunkers). Of the inland demand, low sulphur automotive diesel oil (ADO) accounted for 5.5 MG or 62%, jet fuel 2/ for 1.7 MG or 18%, gasoline for 1.2 MG (14%), residual industrial fuel oil (IFO) 0.2 MG (2%) and kerosene 0.1 MG (1%). The balance was made up of minor products such as LPG, aviation gasoline, lubricating oil and solvents. International ships' bunkers of ADO added an additional 0.8 MG.

2.3 The estimated fuel consumption by economic sector is summarized in Table 2.1 below.

2.4 **Electric Power Generation.** Electricity production which accounts for 48% of overall fuel consumption, is from petroleum fuels except for a few photovoltaic installations. Urban electrification, defined as all electricity produced in the two main centers of Majuro and Ebeye, consumed about 4.4 MG in 1990, entirely ADO except for 0.18 MG of IFO on Majuro. Rural electrification, primarily on Jaluit and Kili, consumed about 0.14 MG of ADO.

2.5 **Transportation.** The transport sector accounted for nearly 47% of RMI's 1990 petroleum consumption as follows: road transport 18%, air including international 18%, and sea including bunkers 11%.

2.6 **Road transport.** Registration records, which reportedly underestimate the true number of vehicles, indicated 1230 motor vehicles in 1988 of which 60% were automobiles. The growth rate in registrations from 1984 - 1988 was nearly 7% per year. Despite limited road mileage,

2/ The entire volume of jet fuel is treated as re-exports, that is, fuel used for international flights, although a small unknown amount is used for domestic travel.

road vehicles used 1.16 MG of gasoline and 0.56 MG of ADO. This is expected to increase in the 1990s at a lower rate than population or economic growth.

Table 2.1 Petroleum Consumption by Sector (1990)

Sector	Volume (10 ³ gallons)	Shares (%)
Electricity generation:		
urban	4,399	46.4
rural	<u>140</u>	<u>1.5</u>
Subtotal	4,539	47.9
Transportation:		
road	1,719	18.1
air	1,697	17.9
sea	228	2.4
sea bunkers	<u>773</u>	<u>8.2</u>
Subtotal	4,417	46.6
Government & commercial Use	324	3.4
Household and Other	200	2.1
Total	9,480	100

Note: Excludes lubricating oils (69,000 gallons) and fuel use at the U.S. military base on Kwajalein.

Source: Mission estimates.

2.7 Air transport. Fuel used for air transportation is mostly dual purpose kerosene (also called aviation turbine fuel, avtur or Jet A1) with minor volumes of aviation gasoline used within domestic air services. The total volume of 1.7 MG is shared between the government-owned Air Marshall Islands (AMI) and Continental/Air Micronesia, which are the only carriers that provide commercial air services to the RMI. AMI operates a leased DC-8 jet aircraft between the RMI and Hawaii three times weekly which is expected to increase to four during 1991, a Hawker Siddley 748 flying three times weekly Majuro-Kiribati-Tuvalu-Nadi-Majuro, and smaller aircraft for local inter-island flights. AMI hopes to obtain landing rights in 1991 for a weekly cargo flight to Japan. The promotion of Majuro as a fishing base for Taiwanese long liners is linked to improving the payload on the Majuro-Honolulu flight. AMI is expected to be financially weak unless additional traffic is generated and fuel prices drop.

2.8 Air Micronesia is a long-established carrier which operates a Boeing 727 aircraft four to five times a week on regularly scheduled flights stopping at most islands between Honolulu and Guam. When traffic warrants, a DC-10 is used. Like AMI, Air Micronesia prefers to use

Kwajalein as a refueling stop, uplifting only 0.1 MG of fuel per month at Majuro due to high costs.

2.9 Sea Transport. Sea transportation consumes 11% of fuel demand or 1 MG, mainly distillate except for a small volume of gasoline used for fishing, local transportation and pleasure craft. The bulk (0.77 MG) was bunker fuel for international vessels including fishing, cargo and cruise ships.

2.10 Government and commercial Use. Direct government and commercial fuel consumption of 0.3 MG (3.4% of total RMI demand) includes construction, road maintenance, direct heating and other uses. This is mainly ADO plus 12,000 gallons of LPG.

2.11 Household and Other. Household consumption includes lighting and cooking mostly in locations without electricity and consists of kerosene ^{3/} (126,000 gallons) and liquid petroleum gas (4,000 gallons). According to the 1988 Census, 36% of households use kerosene for lighting and 48% use it for cooking. Other miscellaneous consumption is 70,000 gallons of gasoline and ADO, household and other, adding up to 2% of total RMI fuel use.

THE CONSUMPTION OF ELECTRICITY ^{4/}

2.12 Because of poor metering in the past, only limited data exist on trends for consumption of electricity. Sales data for 1990 are available from the MEC and KAJUR billing systems but the growth estimates of this report are based on generation data. The reported monthly variations are extreme and unreliable so only annual estimates have been prepared. Energy growth on Majuro has averaged about 5.5% per year since 1987 with a peak demand of 7.1 MW in late 1990. In Ebeye, annual energy growth has been nearly 7% since 1987, with a peak of 2.7 MW in 1990.

2.13 As shown in Table 2.2, consumption is evenly split between residential and commercial/government with a high percentage of unmetered use. By geographical area, Majuro consumption is largely commercial/government whereas Ebeye is dominated by residential use.

^{3/} This consumption level is consistent with household energy end-use surveys carried out in other Pacific Island countries during the 1980's which indicate that RMI households would consume about 114 - 206 thousand gallons of kerosene, probably closer to the low estimate.

^{4/} There were numerous inconsistencies in the data provided by MEC and KAJUR. For example, reported consumption exceeded reported generation on Ebeye. It has not been possible to eliminate some of the inconsistencies from the data.

Table 2.2 Summary of Electricity Generation and Consumption, 1990

	Gross Generation	Technical losses (incl station use)	Electricity Consumption			Total
			Residential	Commercial ³	Unmetered	
			-----GWh-----			
MEC	42.9	7.7	9.9 (28%)	18.7 (53%)	6.6 (19%)	35.2 (100%)
KAJUR	19.2	3.6 ¹	10.1 (65%)	4.2 (27%)	1.3 ² (8%)	15.6 (100%)
Elsewhere ⁴	1.4	0.2	0.6 (50%)	0.2 (17%)	0.4 (33%)	1.2 (100%)
Total	63.5	11.5	20.6 (40%)	23.1 (44%)	8.3 (16%)	52.0 (100%)

- Notes:* 1) For KAJUR, "station use" includes energy used to operate the desalination plant.
 2) Data for KAJUR's output and sales are inconsistent; unmetered consumption is probably higher than indicated.
 3) Commercial includes government.
 4) Jaluit and Kili are approximate.

Source: Mission estimates

2.14 In Table 2.2, "technical losses including station use" are estimates, since station use is not metered and technical losses have not been evaluated. Station use is assumed to be 4.5% of gross generation (typical of large diesel stations elsewhere). Transmission plus distribution losses are assumed to 14% and 10% of energy sent out, respectively, for Majuro and Ebeye, taking into account the size and technical condition of each system.

2.15 The average consumption of electricity per residential consumer is unusually high in the Marshall Islands: approximately 600 kWh per month in Ebeye and over 1000 kWh per month in Majuro, compared to 100 - 200 kWh per month typical of other countries in the Pacific region. However, residential consumers could not afford their present high levels of consumption without the large subsidies provided by Government.

2.16 There is substantial waste in electricity consumption. For example, air-conditioners are widely used in an uncontrolled manner in spaces that are not insulated or well enclosed. The use of electricity for cooking is very high (65% of residential consumers in Ebeye and 49% in Majuro) whereas electricity is hardly used for cooking in most other Pacific Island countries.

Most commercial cooking is probably done with electricity since only about 12,000 gallons of LPG were used outside of households. If tariffs increase as a result of reduced Government subsidies to electricity, it is expected that such uses will be sharply curtailed and average consumption will fall. It is recommended that measures be undertaken to assist residential consumers to reduce consumption and reduce the impact of tariff increases. Such measures include encouraging more efficient use of air-conditioners, installing efficient lighting and switching to other forms of energy for cooking.

2.17 There are about 3,100 consumers (Table 2.3), of which about 85% are residential and 15% commercial or government.

Table 2.3 Number of Electricity Consumers by Category, October 1990

	Residential			Metered ²	Commercial		Total
	Metered	Unmetered	Exempt ¹		Unmetered ²	Estimated ³	
MEC	1,337	189	0	268	19	80	1,893
KAJUR	726	55	55	100	1	0	937
Elsewhere ⁴	47	86	100	35	10	0	278
Total	2,110	330	155	403	30	80	3,108
Percent	68	11	5	13	1	2	100

- Notes:*
- 1) Residential consumers who are landowners and who, although metered, are exempt from paying for electricity.
 - 2) Includes government.
 - 3) Indicates metered consumers whose meters are temporarily malfunctioning.
 - 4) Kili, Jaluit, and other are estimated from 1988 census data.

Source: Mission estimates

2.18 With high residential loads and heavy use of electricity for cooking, the peak load occurs in the evening (8:00 pm - 9:00 pm) in both Ebeye and Majuro. Load factors are fairly high in both systems (about 0.70 in Majuro and 0.80 in Ebeye), but will probably decline if tariffs increase and average consumption falls. Load factors have varied little since 1987 as peak load has been increasing at roughly the same high rate (6 - 7% per year) as energy consumption.

2.19 New diesel engine/generators of about 3 MW capacity that are scheduled to be installed in Ebeye and Majuro during 1991 will result in very large capacity reserve margins in both power systems, over 60% and 90%, respectively in 1992. The higher of the two estimated

growth rates shown in Figures 2.1 and 2.2 corresponds to recent historical trends; the lower corresponds to estimates of the effect of progressive tariff increases.

THE CONSUMPTION OF BIOMASS

2.20 According to the 1988 Census, 14% of households cook primarily with firewood. Based on household energy end-use surveys ^{5/} carried out in other islands of the region with similar environments and population densities, it is estimated that these families consume 1.6 kg/capita/day of biomass and that households which rely mainly on electricity or LPG for cooking also consume 0.25 kg/capita of biomass per day for occasional cooking and other uses. This adds up to a total of 7,400 tonnes for all households in 1990. Copra drying consumes an estimated 12,200 tonnes of coconut wastes based on the average 1981 - 1988 copra production ^{6/} of 5,100 tonnes and 2.4 tonnes of biomass to dry a tonne of copra. Ninety percent of the total consumption of approximately 20,000 tonnes of biomass is assumed to be coconut wastes. Overall, biomass accounts for slightly under 10% of primary energy, compared to 30 - 60% for most South Pacific island countries.

DEMAND PROJECTIONS

2.21 *Inland trade and aviation.* Real GDP growth ^{7/} in the 1990s is expected to range between 2% and 5% per year. For the high growth case, inland fuel consumption is estimated to grow at 6% for ADO and 4% for other products with power generation growing at nearly the 1986 - 1990 rate of 6%. The low growth case is associated with an average annual increase of 3% for ADO used in power generation, road transport fuel growing at 1%, ADO and jet fuel increasing slightly more than 2% and other products growing at 2%.

2.22 *Ships' bunkers.* Both projections could change significantly if major projects such as a fish cannery are constructed. The GMI's expectations for tuna fishing are very optimistic and tuna fishing is fuel-intensive so it is difficult to estimate accurately future bunker fuel requirements for fishing fleets. Typical fuel consumption for tuna vessels is shown in Table 2.4 based on a recent study of ships operating in Pacific Island waters.

2.23 With a modest increase in bunkering for fisheries, and the mid-range GDP growth of 3.5%, it is estimated that roughly 1.5 million gallons of ADO will be used for international bunkering in 1995 and 2 million gallons in 2000. An important issue for GMI is whether growth in bunkering is likely to be large enough to require additional investment in on-shore

^{5/} See "Energy Statistics Relevant to Household and Rural Energy Issues in the Pacific Islands" (PEDP Report REG 90-5, October 1990).

^{6/} 1989 - 1990 data were unavailable.

^{7/} Source is East West Center, op. cit. (footnote 1 of chapter 1).

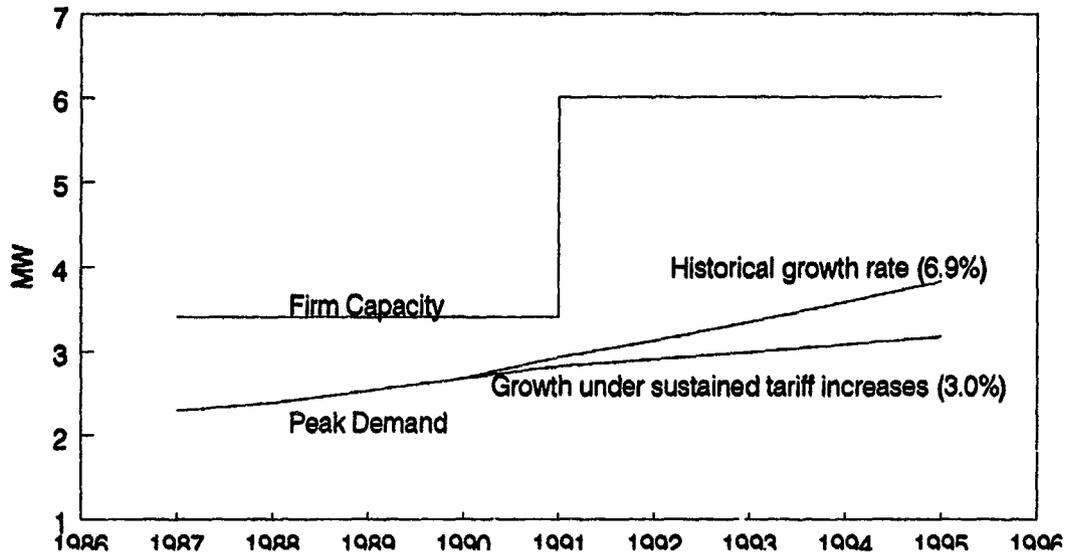


Figure 2.1 Ebeye Power System: Firm Capacity and Peak Demand

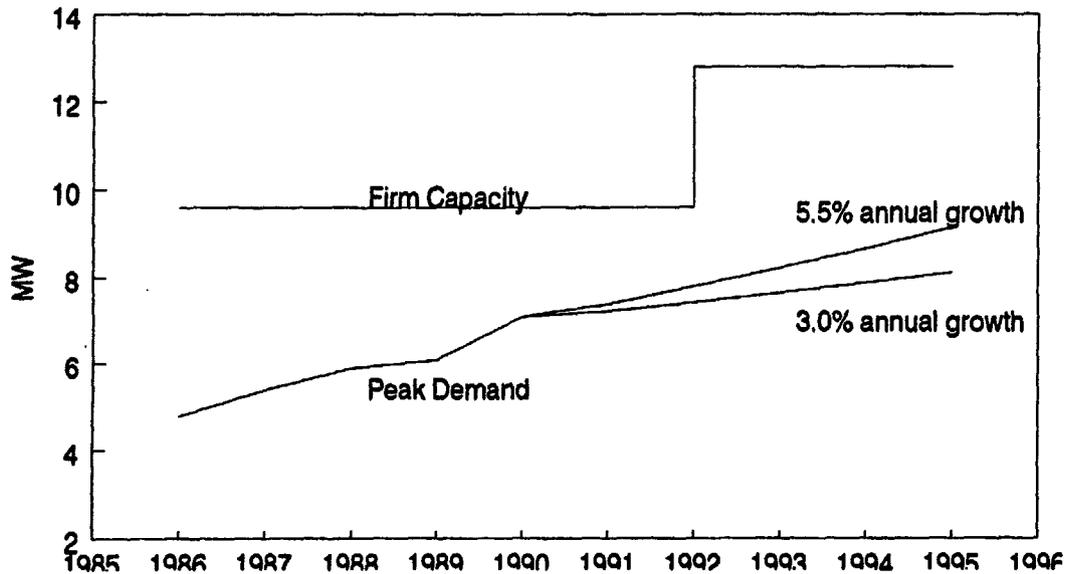


Figure 2.2 Marshalls Energy Company: Firm Capacity and Peak Demand

storage facilities. Indications are that this is unlikely to occur. If the GMI's optimistic projection of 40 long-liners by 1993 eventuates, if all fuel were purchased from Majuro, which is also unlikely, and if the above table is accurate, the demand would be about 8 million gallons per year or ten times the 1990 level. The MEC storage facilities ^{g/} are large enough to accommodate even this exceptional rate of growth in bunkering.

Table 2.4 Fuel Consumption Per Tuna Vessel

Vessel	Size	Fuel use (10 ³ USG/yr)
seiners	1,100 ton	515 - 660
long liners	100 ton	180 - 210
pole & line	n.a.	about 130

Source: *Fuel use in Tuna Fishing* prepared by W S Pintz (Forum Fisheries Agency, PEDP, FSED, 1989).

2.24 Electricity. For estimating the requirements for investment in electricity generating plant, the future maximum demand must be forecast. Recent peak demand growth rates of 5.5% (MEC) and 6.9% (KAJUR) are not likely to continue because recent high growth is due partly to supply restraints in the early 1980s. However, as Figures 2.1 and 2.2 indicate, even with rapid growth, new capacity will not be required for some years. Assuming a progressive increase in tariffs up to real costs over a five year period, the growth rate in generation, and in ADO use, is expected to be about 3% per year.

^{g/} As discussed elsewhere, however, MEC storage requires considerable maintenance and the separation distances between tanks are inadequate for ADO.

III. ENERGY SUPPLY

OVERVIEW

3.1 The RMI has an abundance of sun, wind and waves and possibly an attractive ocean thermal resource, although no temperature gradient profiles are known to have been measured. Nearly half of the land area is under biomass cover in the form of mixed coconut and scrubland. These and various other resources were assessed by the U.S. Department of Energy (USDOE) for the RMI in 1982 ^{9/}. The conclusions of this report are broadly the same as those of the USDOE nearly a decade ago: considering the status of the various alternative energy technologies, relative economics, the environment of the RMI, and the existing and planned energy infrastructure, Majuro will remain dependent on petroleum for transport and power for the medium to long term. In remote atolls, photovoltaic systems appear to be the most feasible option for small electrical needs. The USDOE also stressed energy conservation as an important energy source.

ELECTRICITY

3.2 Growth in electrical energy has averaged 5.5% per year since 1987 in Majuro and nearly 7% in Ebeye. These trends could continue if electricity prices remain well below the cost of production. Both MEC and KAJUR have well-maintained generation plant and capacity, including newly ordered equipment, which is adequate to meet load for a number of years. Installed capacity, which consists of diesel generators burning ADO, in the four public systems is 19.9 MW increasing to 26.5 MW by the end of 1991. Due to frequent power outages and, to some extent low supply voltage, most of the major commercial consumers have stand-by diesel generators.

The Marshalls Energy Company

3.3 MEC's power station, which accounts for nearly 70% of the national electricity output, was commissioned in 1986 with 12.8 MW capacity consisting of four 3.2 MW Pielstick slow speed British Crossley engines (450 rpm). The plant was erected on a turn-key contract by the International Power Systems and Engineering Company (IPSECO) ^{10/} of the U.K.. Fuel economy (14.5 kWh/U.S. gallon) is comparable to other diesel engines of similar size. The plant is well maintained in accordance with the manufacturer's recommendations. Funds for spare parts, tools and equipment are available, and adequate stocks and workshop facilities allow

^{9/} Territorial Energy Assessment (Report DOE/CP-0005/1, December 1982) which covered the RMI and other islands.

^{10/} IPSECO (International Petroleum Supply and Electricity Company), which went bankrupt in 1986, built the MEC power plant and 6 million gallon fuel storage facilities at a cost of about \$25 million excluding interest.

for effective preventive maintenance and repair of components. Good station records are maintained with simple but effective computer spreadsheets.

3.4 The plant is operated by a local plant superintendent assisted by an electrician and a mechanic, both of whom are expatriates on contract. Earlier two expatriate mechanics were employed but these positions have been localized in line with the MEC policy to train local staff to take over operations. All shift operations are handled by local staff plus an increasing percentage of maintenance and repair, both under expatriate supervision. Nevertheless, basic skills in mathematics and writing are lacking. Further training including overseas apprenticeships are necessary before local staff can take over operations completely.

3.5 Good preventive maintenance has held unplanned downtime of the engines to a minimum. Power outages caused by the plant's failure to meet demand are rare. Consequently, it is appropriate to consider the capacity of three out of the four engine-generators (9.6 MW) to be "firm capacity". In 1990, the peak load was 7.1 MW leaving a margin of 35% which is adequate for several years of load growth without considering new capacity which is already on order.

3.6 Because of anticipated savings in operating costs, the plant was designed to operate on IFO. However, several years of experience have indicated that the lower IFO price is offset by the higher costs of transporting and handling two types of fuel, electricity consumption for the preheaters and increased maintenance. In addition, increased sulphur and ash content are expected in the future from Singapore's fuel oil. Consequently environmental issues and maintenance costs related to IFO are expected to increase. The MEC's decision to use ADO in place of IFO is appropriate considering both the current relative costs and the expectations of declining IFO quality.

3.7 Power is transmitted at 13.8 kV through overhead lines along two feeders. Feeder 1 to the airport and Laura carries about 1 MW while feeder 2 to the old power station at Uliga is heavily loaded at approximately 5 MW, which is close to its maximum thermal rating. The distribution system covers the urban area from Darrit to the airport, from which a 20 mile feeder to Laura was commissioned in 1988/89. The Laura feeder was installed as a 33 kV cable with a step-up transformer from 13.8 kV at the airport and a stepdown transformer to 4.16 kV at Laura. The transformers have never been in service as the feeder is operated at 13.8 kV, enabling distribution transformers to be connected to the feeder to serve the rural consumers between the airport and Laura. At Laura, a 4.18 kV cable ring is nearly completed, and connection of consumers is in progress. The step-up to 33 kV was unnecessary given the prospective demand in the Laura area. The 33 kV transformers are not being maintained and the 33 kV cable supplies several 13.8 kV distribution transformers. Consequently introduction of 33 kV operation in the future will be complicated and is not expected to occur. A short 4.16 kV submarine cable to a small island northwest of Darrit was installed in late 1991.

3.8 The quality of the system varies according to age. Unplanned outages occur when dry periods (which result in salt contamination of the distribution lines) are followed by rain.

Typhoons do not occur on Majuro but strong winds and heavy rain cause short circuits due to restricted access to trees requiring trimming and insufficient maintenance of the power lines. Salt-impregnated poles on the main feeders are being replaced but otherwise no systematic preventive maintenance is carried out. This is clearly seen in Darrit and Uliga where the original heavily-loaded 4.16 kV system is still in service. There are insufficient distances between conductors, and the conductors are often too slack due to frequent emergency repairs and improper jointing work. It is recommended that the many heavily-loaded angle poles be guyed or reinforced. As a consequence, outages and voltage drops are more frequent in Darrit and Uliga than in the area from Dalap to Laura supplied by 13.8 kV.

3.9 The pole-mounted distribution transformers are not systematically maintained. Due to the tropical conditions with high humidity and salt contamination, corrosion is progressing rapidly and flash-overs are potential future problems. The purchase of replacement transformers and the number of outages could be reduced by introducing proper maintenance procedures.

3.10 The findings on quality of service were confirmed by large consumers who report frequent power outages with durations exceeding one hour. Standby diesel generators up to 500 kW are installed in most major commercial premises such as office buildings, banks, hotels, department stores, warehouses and workshops 11/.

3.11 The distribution voltage is at 120 volts single phase or 207 volts three phase. In practice, voltage levels under 100 volts are frequent, dropping in some cases to 92 volts on Uliga and 80 volts on Darrit 12/. While computers are often protected by separate uninterruptible power supplies and line conditioners against voltage surges, voltages which fall far below the standard cause frequent breakdowns of air-conditioners, freezers, refrigerators, electric motors and other electric appliances. The resources spent on excessive repair and replacement of electric appliances and the investments in stand-by generators could be diverted more effectively to improving the distribution system. Further, low voltage implies excessive losses in the distribution system.

3.12 The management of MEC is aware of the poor service quality experienced by consumers, but more emphasis has been placed on reliable power generation. The 4.16 kV overhead line in the downtown area of Uliga is being converted to a 13.8 kV underground cable system. The reliability and voltage quality of the distribution system could also be improved substantially by implementing fairly simple and inexpensive monitoring and maintenance procedures. It is recommended that the high maintenance standard in the power plant should also be applied to

11/ The RMI Government feels that larger companies have installed emergency generators because of erratic power supply, but as a source of back-up supply in the event that there are outages caused by uncontrollable events such as typhoons or hurricanes.

12/ By mid-1992, the low voltage problem had been corrected.

the distribution system, as this would benefit customers more than investing in new power generation capacity.

3.13 No maps of the distribution system exist. The most recent diagram and analysis available is a comprehensive 1984 IPSECO study. Consequently adequate assessment, planning and monitoring of the system cannot be carried out, and fault location and repair are complicated and time consuming. Drawings of the cable routes are only available at the Capital Improvement Program 13/ Office, not within MEC. No systematic monitoring of the load, voltages and losses in the system or distribution planning are carried out. The upgrading of transformers is based on complaints from customers about voltage levels, not MEC calculations. No facilities exist for transformer maintenance and meter adjustment. Stocks of spare parts are available but are not as well organized as those for the power plant.

3.14 The metering of MEC's customers has improved substantially since 1988 when roughly one-third of residential consumers and one-fifth of commercial/government consumers were unmetered. In January 1991, only 12% of residential consumers and little more than 6% of commercial/government consumers remained without meters 14/. However, consumption by unmetered customers is unknown and may be significant, particularly among commercial and government consumers. Unmetered consumption (which also includes inaccurate readings from faulty meters) is still almost 20% of the total electricity consumed by end-users in Majuro. It is recommended that a control program be established for existing meters. This would require portable meter control equipment costing about \$7,000.

3.15 Data on revenue collections as a percentage of the total billed per year appear to suggest a collection rate of better than 95% during FY1988 - FY1990. This high collection rate is inconsistent with outstanding electricity accounts which amount to about \$80,000 at 60 days and a further \$679,000 at 90 days in arrears. The discrepancy is unresolved but outstanding debt is due partly to non-payments accumulated during the eight-month development of the billing system, refusal of some landowners to pay bills, and expatriates who left with unpaid bills. Cabinet and court decisions are expected to resolve some of the issues. It is recommended that collection procedures be tightened and that disconnection policy be more rigorously enforced for all accounts. Apparently, accounts receivable of more than \$1.4 million dating back to FY 1987 are still carried on the books. It is recommended that these be written off as bad debts.

3.16 *MEC Expansion.* MEC's installed capacity is 12.8 MW, peak demand is 7.1 MW and firm capacity is 9.6 MW. Because of the uncertainties of load projections and the statistical nature of the peak load, it is advisable to add new generation capacity when the peak load

13/ The CIP is a long term multi-million dollar American program begun in 1976 to construct and improve infrastructure within Micronesia.

14/ By mid-1992, MEC had installed meters on all government and quasi-government accounts, and only about 120 other customers remained without meters.

exceeds 90% of firm capacity, especially as the seasonal variation of the Majuro daily peak is comparatively small. With a continuation of recent growth averaging 5.5% per year, existing capacity would be sufficient until 1994. With a lower growth rate of 3% (assuming a steady increase in tariff levels and modest conservation efforts), no new capacity would be needed before 1997. The Board of MEC has nevertheless ordered a 3.35 MW medium speed Caterpillar for delivery in 1991 as a peaking and stand-by unit. MEC expects a substantial increase in demand due to the new capital complex (0.5 MW) and the completion of a new hotel (0.5 MW). MEC also wants to prepare for prospective new fishery projects, including a possible cannery with a demand estimated by MEC as 1.5 MW. Details of demand patterns for these projects are unavailable.

3.17 A sudden acceleration of demand growth is unlikely to occur. The lead time for purchasing and installing a new engine-generator is less than two years. Even if a major fisheries project could be established in less than two years, the increased power demand will depend on the rate of development of the fishing activity, and full capacity at the cannery would not be reached for several years. If the load growth foreseen by MEC does not occur, the investment in spare capacity will not contribute to revenue or benefit consumers for some years. The interest and depreciation on the new plant must therefore be paid by an increased subsidy from the GMI or by higher tariffs. MEC has arranged a \$2.2 million five-year loan from the Bank of Hawaii guaranteed by GMI. The yearly installments of \$540,000 will aggravate the cash flow of MEC. These budgetary consequences of the loan may not have been considered by the Board or the Government.

3.18 With the new engine-generator, MEC will soon have a firm capacity of 12.8 MW provided that the power station is operated at the same technical standard as in the past. Even with a continuous load growth of 5.5%, new generation capacity should not be required before 2000. This could change, if a) major industrial projects, such as a large cannery were constructed; b) the reliability or performance of the existing engine-generators decrease substantially, or c) realistic, economical alternatives to diesel generation occur.

3.19 It is recommended that MEC monitor the load growth and the power demand by customer category and establish realistic short and medium term forecasts. Prospective development projects requiring substantial power demand should be known well in advance through regular dialogue with the Marshall Islands Development Authority (MIDA) and the national planning office (OPS), and new generating capacity should only be ordered based on approved, confirmed projects. It should be noted that some large projects would probably include private power generation.

3.20 Several options exist if additional MEC generation is required to meet demand from major developments in the near future:

- a) A 3 MW peak load engine-generator similar to engine No. 5 just ordered. This may be the least-cost option if there is a short lead time and is attractive if sudden demand growth occurs. Issues to consider are the increasing specific fuel consumption of the power plant

(with peak load engines constituting one-third of plant capacity) and the considerable age of the four base load engines seven to ten years from now.

- b) A 5 - 6 MW base load low-speed engine-generator running on residual fuel oil with exhaust boilers for preheaters and with low specific fuel cost. This would require reintroduction of IFO and maintaining MEC's good maintenance standards; an alternative is base load plant of the same size using diesel fuel.
- c) Power generation combined with a desalination plant producing about 400,000 gallons of water per day. This approach seems to have been successful in Ebeye with perhaps a 5 - 10% decrease in the thermal efficiency of power production due to desalination.

3.21 Other options for power generation in the longer term are discussed under new and renewable sources of energy.

3.22 *Rehabilitation of the distribution system.* The distribution system on Majuro is extensive, covering almost the entire atoll. At Laura, electrification is being completed and an island near Darrit will be connected with a short submarine cable. In Uliga conversion of the 4.16 kV overhead lines to 13.8 kV is underway. The 13.8/4.16 kV substation at the old power station is to be removed and the step down transformers shifted to Darrit. This rehabilitation program will improve the quality of service by reducing voltage drops, overload problems and the frequency of outages. Although underground cable systems are generally more reliable, it is recommended that they be used only in the most congested areas, as the investment cost in cables and transformers is much higher than on overhead systems. Moreover, expansion and repairs are simpler and faster with overhead line systems. MEC has no separate investment budget; funds for expanding and rehabilitating the distribution system are included in the operation and maintenance budget. The total cost, the schedule and the priorities of rehabilitating Uliga and Darrit are not clear, as activities are rescheduled by MEC management as funds permit. It is recommended that the rehabilitation be based on a consistent project including an updated system map, load flow and voltage calculations, a protection scheme, a time schedule and an investment plan. As in the past, rehabilitation should be carried out by MEC's local staff and as far as possible financed within existing budgetary constraints.

3.23 MEC is facing three well-known problems associated with a heavily loaded distribution system: frequent outages, voltage drops and excessive losses. As discussed above, MEC's focus is the downtown area, but the whole system served by the 13.8 kV Feeder No. 2 should be analyzed. The feeder has a daily peak load of about 5 MW and a rating of about 6.5 MVA corresponding to 5.5 MW. The voltage drop is about 5% and losses are considerable. A second feeder could reduce both voltage drop and losses and improve the reliability of downtown distribution substantially. Moreover, establishing a ring main could effectively reduce outage time for many consumers.

3.24 Further recommendations on distribution system investments to improve service quality require a more detailed analysis based on data which are not available from MEC. It is

recommended that a study be carried out of distribution transformer sizes, drop lines and the old installations at larger commercial consumers.

3.25 Part of the customers' trouble with poor power quality and voltage drops originates in the installation, i.e., loose connections and overloaded wiring. MEC should consider introducing customer services to help customers with measurements, trouble-shooting and energy conservation. This could also improve the monitoring of the distribution system.

The Kwajalein Atoll Joint Utility Resource

3.26 KAJUR accounts for 30% of power generation in the RMI. Installed capacity is 6 MW (9.3 MW in August 1991), firm capacity is 3.4 MW (6 MW in August 1991) and peak demand 2.7 MW. The distribution system covers all of Ebeye and extends about 7 miles to Gugeegue with distribution at 13.8 KV. Distribution problems will occur in the future, particularly as load grows in Gugeegue, unless the lack of maintenance is addressed. It is recommended that a regular maintenance program be established. It is also recommended that unmetered customers (about 5% of total) should be metered as soon possible to raise revenues and improve the accuracy of billing.

3.27 Power generation facilities are operated under a management contract with International Bridge and Construction, Inc. (IBC) which constructed the power station. The 1988 agreement, initially for one-year with an open-ended option to extend, is for overall management of the power plant and desalination facility by IBC including generation, maintenance and training of local staff. Fuel costs, accounting and spare parts (other than filters and routine maintenance parts) are extra. The contractor appears to have maintained the facilities very well. However, the station records maintained by the contractor (as required by the contract) are poor, inconsistent, and unsuitable for power planning or administration. Provisions for on-the-job training also specify a goal of 100% Marshallese staff but training has been poor, possibly because of inadequate recruitment due in part to the wage differential between Ebeye and the nearby U.S. military base.

3.28 The IBC service contract is expensive and has increased from 3.4 ¢/kWh generated in 1988 to 3.9 ¢/kWh in 1990. The contract does not specify a schedule for specific results; it is recommended that the contract be reviewed. If the relationship with IBC continues, it is recommended that a fixed three- year contract be negotiated with clearly-specified results and provisions for non-compliance. A better alternative may be direct hiring of management staff similar to the current arrangements for MEC.

3.29 The formation of KAJUR in late 1990 should improve the efficiency of operations by combining management responsibility, previously split between KALGOV and KADA, under one authority. Over time, it is recommended that KAJUR assume all functions now carried out by IBC. A \$0.5 million debt to Mobil for fuel is being settled by KADA, which will probably have to be repaid to KADA from KAJUR revenues. KADA supplies fuel and lube oil to the contractor so there is no mechanism or incentive for IBC to negotiate competitive fuel prices.

Rural Electrification

3.30 Diesel. According to the 1988 Census, 13.5% of all households away from Majuro and Kwajalein Atolls have electricity supplied from diesel systems. The bulk (63%) of these rural households are on Jaluit and Kili; elsewhere the electrification rate is under 6%. Limited records indicate that Jaluit and Kili households use a great deal of electricity - about 700 kWh per consumer per month. At least a third of rural consumers are metered but information on costs, revenues, tariff rates, etc., is not available.

3.31 Fuel costs for electricity production in Jaluit were reported to be \$73,000 in 1990 with output and end-use consumption estimated as 550,000 kWh and 460,000 kWh respectively based on reported fuel consumption and assumed losses. Total billing for Jaluit power consumption was reportedly \$48,000, or about 10¢ per kWh sold, although actual collections were much less. Costs including capital costs are estimated to exceed 35¢ per kWh. There are plans to transfer operation of the Jaluit power station, now run by Public Works, to the local government for operation by MEC under contract; the proposed terms are unknown. No records are available of power station output, expenditure, peak load, station use or customers.

3.32 The power system in Kili was upgraded at a cost of about \$1 million by the GMI in mid 1990 with 2 new 550 kW engine/generators to serve the displaced inhabitants of Bikini Atoll. The Kili power plant is operated under contract with IBC. Although all consumers (about 100, mainly residential) are metered, none are billed for electricity. Present peak demand is reported to be 120 kW; annual output is estimated at 790,000 kWh to supply end-use consumption of 630,000 kWh. Production costs including capital charges are estimated to be close to 40¢ per kWh sold. Costs are covered through Bikini atoll reparation payments from the U.S. but no records appear to be kept.

3.33 Photovoltaics. An additional 4% of rural households have photovoltaic (PV) lighting, typically two or three fluorescent lights provided by the Energy Office. There is no consistent policy on payments for the service, no regular visits to assure that the systems are working well, and no maintenance or spare parts program. Expansion of photovoltaic power to remote areas is said to be a government priority. The GMI's draft 1991 national development plan establishes a target of 1,480 household PV systems and 50 solar pumping systems to be installed during the next five years, at least a ten-fold increase over present installations. A PV Revolving Fund and a PV Preventative Maintenance Program have been proposed by the Energy Office but no detailed plans exist. Although these are essential for the success of the PV program, they are not sufficient. Photovoltaic technologies are reliable but, like diesel, they require careful planning and regular maintenance. A great deal more planning and financial support than currently planned will be required for successful rural electrification through PVs.

3.34 In Utirik, a centralized photovoltaic system was provided some years ago by the USDOE to demonstrate reticulated electricity through PVs. This is being converted with USDOE assistance during 1991 to 60 stand-alone systems to improve reliability. The local community is providing \$50,000 or about half of the conversion costs but there are no plans by the GMI to

provide regular maintenance. In addition about twenty stand-alone PV systems are planned for Jabwot Island by 1992 financed through the Pacific Forum Secretariat.

PETROLEUM PROCUREMENT AND DISTRIBUTION

3.35 Mobil Oil has been the traditional supplier of petroleum products into Micronesia with coastal bulk storage on all the main islands supplied by company owned and operated local coastal tankers (LCTs) using Guam as the transshipment center. In the RMI there are bulk facilities in Majuro, Ebeye and Jaluit. The nature of the market (very small volumes dispersed over a wide area of ocean) and the efficient supply logistics employed by Mobil have made it extremely difficult for competitors to establish themselves on any of the Micronesian islands.

3.36 However, Mobil's monopoly in Majuro, was broken in 1984 when the government commissioned the MEC power station complex with its own huge fuel depot. The fuel facilities were designed to handle heavy fuel oil both for the power plant and for bunkering which was optimistically expected to grow substantially. As shown in Table 3.1 below, the facilities are oversized, capable of handling nearly a year's consumption. The tanks are now used mainly to store ADO which is more flammable than IFO and which has much more stringent safety requirements. In view of the safety risk, it is recommended that the facilities be modified ^{15/} including an increase in spacing between tanks used for ADO. This can be done in part by removing unnecessary tanks.

Table 3.1 Petroleum Storage (1990)

Product	Capacity (^{'000} gal)	Monthly Use (^{'000} gal)	Coverage (months)
ADO	7,166	521	13.8
Lubes	10	0	-
Gasoline:			
regular	336	101	4.2
super unleaded	84		
Jet fuel	<u>517</u>	<u>152</u>	<u>3.4</u>
Total	8,133	774	10.5

Notes: 1) Includes Mobil & MEC facilities on Majuro, Ebeye and Jaluit.

2) MEC accounts for three-fourths of total; MEC lube tank is unused.

Source: Mission estimates.

^{15/} MEC management disagree with this statement and feel that the tanks meet acceptable specifications for ADO.

3.37 The MEC storage capacity and fuel discharge facilities allowed suppliers to use larger medium range (MR) tankers for ADO and IFO, eliminating LCT transshipment through Guam and reducing freight costs to Majuro by nearly 10 cents per gallon. To use the larger vessels efficiently, MEC must receive its total annual requirements in at most 2 voyages. Even this requires less than half of the available tankage. If MEC costs were calculated on a full cost basis, the lower landed cost advantage might be more than offset by the high capital costs of storage. However, the RMI government absorbs all capital costs permitting false savings to be passed on to the consumer in the form of lower prices. MEC's fuel costs to the power house and to its customers are subsidised since MEC bears no responsibility for any capital costs of its fuel storage facilities. This subsidy makes Mobil's operations uncompetitive with MEC's.

3.38 Competition and Market Share. MEC tenders for the supply of its ADO (and earlier IFO) requirements and is currently supplied through Shell. MEC also sells ADO in competition with Mobil which in 1990 had 56% of the national market by volume compared to MEC's 44%. MEC's market share has been achieved through control of fuel supply to its main power house, government business and international bunkers which totalled 4.1 million gallons or 65% of the ADO market in 1990. Mobil's share has been drastically reduced, restricted to onshore diesel business mostly through service stations and other islands' requirements. A small portion of the international ADO bunker business has also been retained by Mobil.

3.39 In addition to ADO, MEC has 84% of the lube market. However, other products are still handled exclusively by Mobil because the MEC facilities cannot store and handle products such as gasoline and kerosene. Expansion of MEC's product range would require major capital investment which appears to be uneconomical.

3.40 Terms of supply. A supply contract was signed between Mobil and the GMI in 1982 and is typical of the Micronesian agreements of that time, with FOB prices based on Mobil Singapore posted price, Worldscale/AFRA freight rates, a varying transshipment freight rate from Guam and a fixed on-shore margin which does not appear to be cost-related. The agreement is extremely difficult for the GMI to administer, since it requires a considerable knowledge of the petroleum market and daily information on price components. Apparently Mobil has never provided the base price build-up and GMI has never tried to monitor the contract, relying totally on the supplier for accurate pricing. In view of these shortcomings, it is recommended that GMI renegotiate the contract to provide better terms but, equally important, use formulas which are easily verifiable by the GMI.

3.41 Ebeye is the second largest market in the RMI. Products continue to be supplied by Mobil although a separate contract was apparently negotiated several years ago with Shell for power station supply, dependent upon construction of storage facilities which have not been built. Without the security of a contract, Mobil has continued operations in Ebeye deferring any investments until the company's future in the market is clarified. The Ebeye market is probably not big enough for two onshore marketers; until this issue is resolved, neither the community nor the suppliers will have any security and substandard facilities will continue to be used.

3.42 Security of supply and the refinery option. The GMI has expressed concern about security of petroleum supply because of Mobil's dominant position and has approached at least one company about constructing a refinery in Majuro primarily for exports to Asia and to meet local demand. The RMI demand of 600 barrels per day could not justify a refinery, typical sizes being well over 100,000 barrels per day. With Majuro's limited land area, scant supplies of fresh water, and large distances from sources of crude oil and markets, there is no justification for a refinery for export or meeting local demand. If Micronesia were a suitable location to serve the Asian market, a more logical location would be Guam with an existing (moth-balled) refinery, better infrastructure, better water supplies, and a better-trained workforce. Even if it were built, a refinery would not necessarily increase the security of supply. Further, even very low levels of pollution could damage fisheries activities for some distance from the site. It is recommended that GMI not pursue the possibility of building a refinery in Majuro.

NEW AND RENEWABLE SOURCES OF ENERGY

3.43 The primary requirements for commercial energy in the RMI are for transport fuel and electricity. The RMI cannot produce liquid transport fuels such as ethanol locally, and hydrogen fuels from ocean thermal technologies are in the experimental stage. Possible options for electric power are discussed below.

3.44 Biomass. Biomass, mainly combustion of coconut shells and husks, is expected to continue to account for under 10% of primary energy, primarily for copra drying and cooking. There is little likelihood of a significant expansion of biomass as an energy resource in the RMI due to limited land availability and the relatively poor fertility of atoll soils. Tree farming for power is not a viable option.

3.45 Power from fuels other than oil. Electricity from non-petroleum fuels is not a viable option in the short or medium term. Transport costs for imported fuels such as coal are high, the economic scale is larger than local demands warrant, and steam-based generation is complicated. Tire burning has been proposed with generating costs reportedly \$0.16 per kWh but environmental problems could be considerable, the "fuel" may not be readily available, costs are uncertain, and impacts on tourism and fish exports could be serious.

3.46 Wind energy. The 1982 USDOE report judged winds in the RMI to be attractive based on measurements from five islands and the open sea. In the northern atolls, winds were reported to average 9.3 meters/second (21 miles per hour) during the December to March season with steady northeast trade winds, dropping to 5 m/s (11 mph) from July through November. In the southern islands, winds averaged 5 and 2.7 m/s (11 and 6 mph) respectively during the same periods. The northern sites appear to have an excellent wind energy regime but data in general are suspect. At the Majuro weather station, for example, the anemometer is below the tree line. A program of monitoring and confirming the RMI wind conditions would be worthwhile if funded externally under an assistance program.

3.47 Experience elsewhere in the region with small commercial wind technology has been poor; although the technologies improved considerably during the 1980s, small wind systems are not suitable for the RMI at present. Winds are irregular necessitating diesel back-up so the main savings are fuel costs, maintenance is problematic on remote islands with a corrosive environment, and spare parts are expensive. Wind is not recommended as an option for consideration until the wind regime is verified, suitable technology for RMI conditions is identified, and there are funds for regular inspections and maintenance.

3.48 *Seawave*. Recently a contract was signed between KADA and a U.S. company to construct a 200 - 300 kW seawave power plant on Gugeegue island of Kwajalein Atoll about 5 miles from Ebeye. The contract reportedly requires KAJUR to purchase all energy produced at 17 ¢/kWh initially, adjusted upward by the U.S. consumer price index with the maximum set at the actual cost of diesel supply from the KAJUR power station. The value of the seawave plant to KAJUR is the fuel saved, about 8 ¢/kWh in 1990. KADA agreed to the high price because the Board feels that future installations of this type might eventually meet the power demands of a number of other islands. It is recommended that the RMI determine its seawave potential, through SOPAC ^{16/} assistance if available, and KADA should reconsider the seawave project carefully before making any commitments. The system is untried and other pilot seawave projects have not proved to be robust. It is further recommended that KADA should not invest any of its own money in the venture. Even if the system is constructed and works well for a few months, it is recommended that the purchase option not be exercised because the lifetime is likely to be short and a small company may be unable to provide a guarantee of any real value.

3.49 *Ocean thermal energy*. A recent study ^{17/} of Ocean Thermal Energy Conversion (OTEC) economics suggests that one of the best opportunities for commercial systems in the near future is 1 - 10 MW open-cycle designs which produce electricity and desalinated water for islands with high power costs and scarce water, exactly the situation on Majuro. A 1 MW land-based open-cycle system would produce 500 thousand gallons of fresh water per day. Unfortunately, the technology does not yet exist and the capital investment would be high: over \$18 million for the prototype. The author of the study feels that a working 1 MW demonstration facility could be built under realistic developing country conditions by 1995. OTEC systems are

^{16/} The Suva-based South Pacific Applied Geoscience Commission has an active seawave energy monitoring program in about five Pacific Island countries with Norwegian government support.

^{17/} *Economics of Ocean Thermal Energy Conversion* by Luis Vega, Pacific International Center for High Technology Research, Honolulu (chapter 8 of "Ocean Energy Recovery: The State of the Art", American Society of Civil Engineers, 1991).

not expected to be commercially available this century but they could be an option for the RMI later.

IV. POLICY ISSUES AND PRIORITIES

PRICING ISSUES

Petroleum Product Pricing

4.1 The CIF cost of petroleum products delivered to the RMI is not available. This information is not collected by Government and is not available from the petroleum suppliers. A rough estimate of the 1990 CIF cost - based on discussions with Customs officials, MEC, Mobil Oil and others - is \$10 million. It will not be possible to judge whether the RMI receives reasonable prices for petroleum products unless Customs procedures are amended so that better information is collected. Even then, the old 1982 Mobil supply agreement cannot be monitored effectively to assure that CIF prices are consistent with the agreement, because of the lack of baseline data, because GMI lacks the skills to do so and because the GMI does not have regular access to independent price information 18/.

4.2 Table 4.1 indicates wholesale and retail prices of fuels at the main consuming locations, Majuro and Ebeye.

Table 4.1 Petroleum Product Prices in March 1991

Product	Majuro		Ebeye			
	Government	wholesale retail	Government	wholesale	retail	
----- U.S. dollars per gallon -----						
Gasoline:						
regular	1.163	1.734	2.130	1.163	1.770	2.530
super unleaded		1.850	2.250			
ADO						
Shell	1.092	1.391	1.950	1.092	1.491	2.240
MEC	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Kerosene	1.266	1.620	2.100	1.266	1.680	2.450

Notes: 1) Majuro prices include following import taxes: gasoline 25¢/gallon, kerosene 5¢, jet fuel & avgas 15¢, and ADO none. Majuro Atoll Local Government tax is additional 3¢ for jet fuel.

2) Ebeye taxes as above plus additional 6¢ KALGOV local government tax on all fuels.

3) n.a. = not available.

Source: Mission estimates

18/ This information is regularly available through the Forum Secretariat Energy Division's Petroleum Section (formerly the RPU).

4.3 The CIF prices on Majuro compare well with other Pacific Island countries. However, pump prices are much higher, mainly because of high retail margins; for gasoline, for example, these are about 40¢/gallon on Majuro and 76 ¢/gallon on Ebeye. For ADO, the margins are 56¢/gallon and 75¢/gallon respectively. In Fiji retail margins on both gasoline and ADO are on the order of 11¢/ gallon. The higher retail margins on Majuro are due in part to the proliferation of low-volume retail distributors, with nine service stations operating, alleged price fixing, and a complete lack of price monitoring by the government.

4.4 In order to protect the consumer, it is recommended that government establish price guidelines. Following discussions with the oil companies and consumers, an agreed formula would be established for calculating maximum wholesale and retail prices. Through legislation or regulation, there should be punitive provisions for non-compliance by oil companies or service station dealers and retailers. It is recommended that GMI monitor prices to ensure that all parties conform to the agreement.

4.5 An analysis of the profitability of three or four representative service station retail sites is required to establish a reasonable retail margin. These margins, differing for each product, would provide an adequate return on sites with a minimum throughput of 200,000 gallons per year to ensure that prices are not too high and to discourage further proliferation of small volume sites. Similarly, it is recommended that Mobil's profitability be evaluated to establish a fair and reasonable formula for calculating wholesale prices.

4.6 Broadening MEC's product marketing. The very small size of the RMI market limits opportunities for effective competition which could lower consumer prices. Because MEC already sells ADO at a lower price than Mobil, it has been suggested that the company should also market gasoline and other products and, accordingly, funds have been allocated to upgrade storage facilities. The expectation is that MEC has excessive tankage which could be simply reallocated to other products which are supplied to MEC on tender. However, the tanks are poorly maintained and separation distances are unsafe for flammable products. The heavy capital investment required to bring the tanks to an acceptable standard would necessitate a sizeable increase in demand if costs were to be recovered. However, the local market is too small to allow this. Mobil's facilities are more than adequate for the total market.

4.7 Jet fuel prices. AMI's 1990 fuel uplift at each location is shown in Table 4.2 with the average prices paid for the fuel at these locations. The low Kwajalein price, better than that of Honolulu, is due to the U.S. military supply contract. Although this is partly off-set by high landing fees, it is recommended that AMI continue to take full advantage of the low fuel cost in its future schedules.

Table 4.2 Air Marshall Islands Jet Fuel Prices (1990)

Location	Uplift (U.S. gallons)	Average Price (¢/gallon)
Honolulu	911,318	68.83
Nadi	225,225	92.18
Kwajalein	498,956	64.00
Majuro	477,216	106.49
Tarawa	49,903	126.43
Funafuti	65,409	148.84

Note: Differences are due both to varying CIF prices and the taxes levied.

Source: Air Marshall Islands, 1991.

Power Tariffs and Utility Finance

4.8 The "affordability" of power tariffs. To what extent can the general public and the business community in the Marshall Islands absorb higher electricity costs without a significant rise in the cost of living or a threat to new investment? Although data required to estimate this are poor, some experience elsewhere indicates that consumers are more concerned about the reliability of power than its cost, will reduce their consumption by reducing waste as the cost increases and with few exceptions do not make the cost of electricity a key criterion in investment decisions. There is evidence that this experience also applies to Majuro and Ebeye ^{19/}.

4.9 Residential consumers. As shown in Figure 3.1, 31% of residential consumers use 74% of the total residential electricity consumed in Majuro. The 495 consumers in this group use at least 500 kWh and in a few cases more than 2,000 kWh per month, averaging about 1,250 kWh per month; therefore their average monthly bills are high - \$125 - even at the low tariffs now in effect. These consumers are clearly among the higher-income households in Majuro, who could afford to pay higher tariffs. However, if the tariff were to increase, consumers in this group are likely also to reduce consumption considerably. Usage at the average level of this group by a household implies that much of the consumption is wasted in inefficient or non-essential uses which could be reduced at little or no cost to the user, given appropriate financial incentives in the form of higher tariffs. For example, users could at no cost switch off non-essential lighting and air-conditioning, could close windows and doors in air-conditioned spaces,

^{19/} The following section presents data for Majuro, but the pattern in Ebeye is similar.

and (at some cost) insulate spaces, install timers on air-conditioners and water heaters, switch to more efficient forms of lighting and to non-electric fuels for cooking, etc., all at substantial reductions in electricity use. These changes would limit the financial impact of the tariff increase to each consumer. Such a response to higher tariffs by high-income consumers would also reduce energy requirements in the power sector and hence the need for operating subsidies and would reduce peak demand allowing capacity additions to be deferred.

4.10 Experience in both developed and developing countries shows that electricity consumption is highly dependent on income, as is evident in Majuro. Consumers at the lower end of the income scale form the majority of residential consumers but consume a small fraction of total residential electricity. For example, just over 50% of all residential consumers (804 consumers) use only 13% of residential electricity, with household consumption ranging from 50 kWh/month or less to 300 kWh/month. Of these, 519 consumers (33% of the total) use at least 100 kWh/month and account for 11.6% of total residential consumption (1990). The average monthly consumption for consumers in this group is about 188 kWh; their average monthly bill is \$19. The balance, 285 residential consumers (18% of the total) use less than 100 kWh/month and account for less than 2% of residential electricity. Some of these consumers and some of those in the higher consumption bands are unmetered, and data on their consumption are lacking. The assumed average monthly consumption of the lowest group is 50 kWh per month and their average monthly bill is \$10 for metered customers (the minimum) and \$15 for unmetered customers (the flat rate).

4.11 The results of a Ministry of Finance analysis of 1990 tax records for 3,776 private and public sector employees carried out in February 1991 ^{20/} indicates the range within which the majority (about 70%) of annual wages lies: \$3,000 - \$10,000 per year, weighted toward the lower end of that range, perhaps an average \$4,500-\$5,000 per year. Annual wages of \$3,000 (\$250 per month) or less are found in about 10% of the individuals surveyed. Based on average monthly electricity bills that range between \$10 (for consumption less than 100 kWh/month, assumed to include mainly the poorest residential consumers) and \$19 (for consumption of 100-300 kWh/month, assumed to include mainly consumers with incomes close to the average of \$400 per month), the average expenditure on electricity consumption up to 300 kWh per month (and possibly more) appears to be about 5% of household income in the Marshalls, a figure quite close to experience in other Pacific Island countries, even those countries which have higher electricity tariffs.

4.12 The effect of a tariff increase on residential consumers who use 100-300 kWh per month or more will undoubtedly be a mixture of increased expenditure (especially in the short term) and conservation. The adjustment to higher tariffs will include reductions in waste and improved efficiency. In the long term, adjustment to higher tariffs should reduce electricity consumption by enough to return expenditure on electricity to approximately the same percentage of income

^{20/} This was prepared in March 1991 for this report.

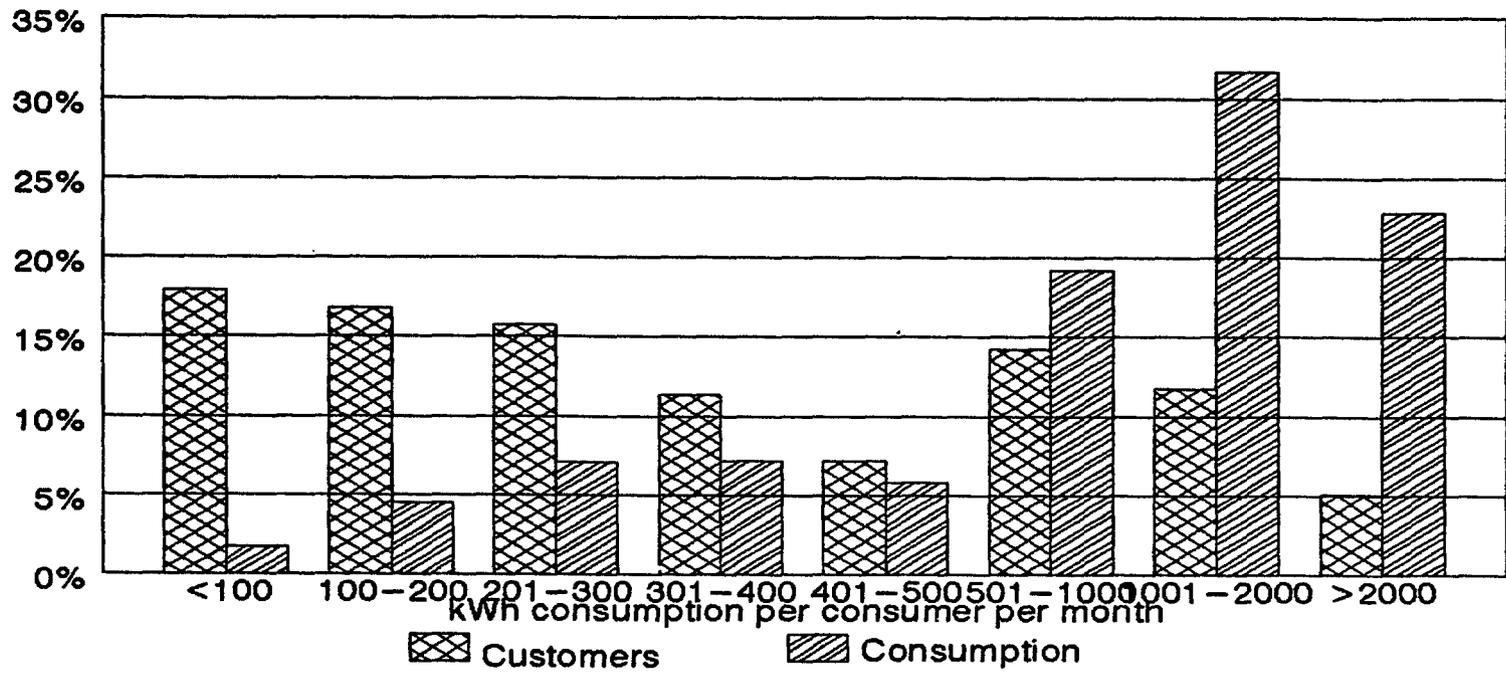


Figure 4.1 Residential Billing Distribution (Marshalls Energy Company)

that prevailed before the tariff increase.

4.13 However, adjustment will be more difficult for consumers at the bottom of the income scale, since their already low consumption (less than 100 kWh/month) is concentrated in "essential uses" (i.e., minimal lighting and refrigeration, no electric water heating or air-conditioning) with few opportunities to conserve. One hundred kWh/month provides for such "essential uses" as follows: a small refrigerator (60 kWh/month) plus 3 x 40w incandescent light bulbs (not energy efficient but common even in low-income households due to their low initial cost) used for 6 hours per night (22 kWh/month) plus 2 x 20w fluorescent lights (7 kWh/month) plus radio, fan, etc. (11 kWh/month). In order to protect low-income consumers, it is recommended that consumers using 100 kWh per month or less be offered a "lifeline" tariff.

4.14 A lifeline tariff, in fairly common use in developing countries ^{21/}, is a subsidised tariff applied to a small initial "block" of electricity consumption defined as essential use, for which only residential consumers are eligible. Thus the rate per kWh for the first 100 kWh consumed per month by a household would be less than the rate charged for electricity in excess of 100 kWh per month. The tariff for consumption greater than 100 kWh/month would be set to recover the utility's full cost of production plus a slight margin to recover the cost of the subsidy. (Though the subsidised tariff is designed to benefit only low income consumers, for ease of administration it would in fact apply to all residential consumers. However, only consumers who use 100 kWh/month or less would benefit significantly from the subsidy; higher charges to other consumers would eliminate the subsidy to them.) A lifeline tariff has the advantages of being fairly easy to administer and not very costly to the utility's other customers, since low-income domestic consumption is usually a very minor portion of total sales.

4.15 *Commercial consumers.* Electricity in most of the commercial and industrial enterprises found in the Marshall Islands is usually a small proportion of total costs, rarely exceeding 5%. Much more important to total costs in the retailing, construction, and service industries in the Marshalls are such factors as labor, real estate, availability of raw materials and the cost of goods sold. Increases in the cost of electricity in these commercial activities can be passed on to consumers without a significant increase in the price of the final product. In any case, there is evidence that the private sector in the Marshall Islands (as in other countries) puts more importance on reliable electric service than on cheap electric service: many commercial enterprises have invested in their own standby generating equipment to use when MEC's system fails. The two largest retailers in Majuro (Gibsons and Robert Reimers Enterprises) indicate that the monthly electricity costs of each company contribute slightly more than 3% to their retail product prices. One company stated that the cost of electricity in Majuro was of much less concern to them than the quality of service: staff had complaints about the frequency of supply interruptions and voltage fluctuations, and felt that if service did not improve, they might

^{21/} Countries in the Pacific region with "lifeline" rate structures for residential consumers are: the Cook Islands (initial block 120 kWh/month), Papua New Guinea (100 kWh), Tuvalu (100 kWh), and Vanuatu (60 kWh).

recommend that management undertake the considerable investment necessary to provide for their own electrical needs independently.

4.16 The commercial sector can be expected to respond to higher electricity tariffs in a variety of ways, including investment in means to improve the efficiency of electricity consumption and perhaps raising the price of what they produce or sell, although final product prices should not be affected significantly. Substantially lowered production or employment or much higher prices for consumer goods is an unlikely result of higher electricity tariffs.

4.17 **Utility finance.** The revenues of MEC and KAJUR are insufficient to cover operating costs and are only equivalent to half of total costs including depreciation of assets ^{22/} for MEC and one-third for KAJUR. The mid 1990 MEC tariff increase of about 30% (from 8 to 10¢/kWh residential and 9 to 12¢/kWh commercial) reduced the deficits but there is no evidence of further measures to lower the total subsidy. In 1990, MEC received \$1 million or 25% of operating expenses from GMI, while KAJUR received \$0.2 million from GMI plus advances from KADA of \$1.6 million to pay for fuel and the IBC contract, amounting to 72% of operating expenses. In 1990 GMI also wrote off more than \$200,000 in taxes owed by MEC. Due largely to investment in new generators for each power system, the 1991 grants will increase substantially.

4.18 The GMI has asserted that reduction or elimination of the financial burden of the subsidies to the power sector is a high priority. The elimination of subsidies by raising the tariff to an appropriate level, while allowing the utilities to exercise control over their own finances is necessary to improve management and reliability and bring the consumption of electricity more closely in line with what the country can afford. It is recommended that tariffs be gradually increased to the full cost of supply with corresponding reductions in the subsidy. In order to mitigate the short term disruptive effects of raising the tariff, it is further recommended that tariff increases be combined with assistance to consumers to help them conserve energy.

REGULATORY AND OTHER POLICY ISSUES

Overview

4.19 The draft energy chapter of the 1991 - 1995 RMI development plan identifies as key sectoral issues the RMI's complete dependence on fossil fuels for power generation, pricing electricity below cost, wasteful use of electricity by government and the absence of a central government agency with responsibility for energy. The objectives during the planning period are to establish a government agency which will coordinate energy and develop energy plans, establish and maintain a comprehensive data base, reduce the growth rate of the petroleum import bill, use solar energy to provide reliable power to all outer island population centers and

^{22/} This excludes MEC assets (owned or leased) which should be allocated to fuel storage and KAJUR assets which are used for seawater desalination. See Annex 1 for an analysis of costing.

to improve electric power management and revenue collection. Among the specific measures to meet these objectives are gradually increased electricity tariffs, reduced air conditioning use in government buildings, and improved maintenance for PV systems.

4.20 It is recommended that the GMI decisively pursue these measures which are similar to those of the previous development plan. It is also recommended that the GMI appoint a senior-level energy officer, either within the Office of the Chief Secretary or the OPS who would be a member of the MEC Board, oversee contracts for other large power stations (Ebeye, Jaluit and Kili), supervise the rural photovoltaics program and supervise any short-term experts brought in to advise GMI on petroleum, power, or other energy matters.

Petroleum Subsector

4.21 **Engineering and Safety.** With the rapid increase in population and urbanization on Majuro and Ebeye and the increasing concern with environmental issues, it is necessary to develop petroleum industry guidelines. It is recommended that the RMI's Environmental Protection Agency (EPA) regulations be updated to ensure adequate pollution provisions. However, these do not address the adequacy and appropriateness of the engineering design of the facilities nor do they cover operations to safeguard lives, to minimize the risks of fire and provisions for fighting fires. Attempts to remedy this situation, if any, are unknown. It is recommended that the GMI adopt suitable standards ^{23/} for storage, handling and transport of fuels and enforce them rigorously.

4.22 Petroleum storage in Ebeye is hazardous. Ebeye's oil depot is in poor condition with unsafe and badly-rusted tanks, leaky bunds, and drums stored in public areas outside the depot fence. Only gasoline is handled in the on-shore depot; ADO is stored in a rusty barge of 250,000 gallon capacity at the main dock reportedly delivering poor quality fuel containing rust and seawater to the power station.

4.23 **Service stations.** It is recommended that the number of service station outlets on each of the islands be limited for safety, environmental and economic reasons. On Majuro, the nine existing stations should be the maximum allowed. If other companies want retail outlets to compete against Mobil, these sites can be obtained through negotiations with owners and, if necessary, the introduction of franchise legislation.

4.24 **Products and Quality Control.** Six grades of fuel are marketed on Majuro and four in the rest of the RMI. The four common grades are Regular Gasoline, Dual Purpose Kerosene

^{23/} The FSED Petroleum Section plans to complete work begun by PEDP on a "*Pacific Islands Standard for Combustible and Flammable Liquids*" for South Pacific Forum island countries modifying Australian, New Zealand, U.K. and U.S. codes to suit the regional environment. It is expected that the document will be completed by late 1992. It can be further modified by the government to suit local requirements.

(Jet A-1/Lighting Kerosene), Low Sulphur Automotive Distillate Oil (ADO) and Avgas 100/130. Residual fuel oil (RFO, IFO) has been discontinued from April 1990. On Majuro unleaded 95 octane 24/ gasoline is marketed in addition to regular 91 octane leaded gasoline.

4.25 The availability of two grades of gasoline provides a choice for motorists but at high cost penalties imposed by supply logistics (small shipments, high freight costs per gallon) and a requirement for duplication of storage and handling onshore. It is recommended that GMI determine from Mobil the justification for providing two grades of gasoline and the associated cost penalties. It may be advantageous for GMI to specify a single grade of gasoline that would satisfy most of the automobile fleet, probably an unleaded 93 octane grade.

4.26 In recent years there have been allegations in Majuro of substitution by marketers of inferior fuel sold as a premium grade at the higher price. There appears to be some substance to these accusations. To ensure that such fraudulent practices end, it is recommended that government request refinery certificates for fuel shipments. If there are any questions regarding fuel quality, samples should be tested through an independent laboratory such as Lockheed (Honolulu) or SGS Far East Limited (Guam).

4.27 **Data Collection and Analysis.** Analysis of the petroleum subsector is hampered by the lack of reliable information available from government offices. Most data on fuel came from Mobil and Shell and is incomplete. Without independent government data, it is impossible to eliminate inconsistencies. However, with minor procedural changes, the Customs and Revenue Department should be able to document import volumes, duty paid, CIF values and re-exports. The following changes, which will improve administration of petroleum supply contracts, are recommended:

- a) A customs official should supervise the dipping of the individual bulk tanks for each supplier before and after each tanker discharges fuel. All volumes should be calculated at ambient temperature. All tank valves should be locked and sealed by the customs officer after the "before discharge" dip, to be broken by the customs officer after the completion of the "after discharge" dip on each tank. The customs officer should be the only one authorized to break the seal.
- b) The importer should complete the Customs Import Entry (instead of government as is present practice) and submit the entries within one week of the completion of each tanker discharge and pay the total duty once the document has been verified by Customs and before any new stock from the tank is drawn.

24/ All references to octane are RON or Research Octane Number.

- c) All Customs Import Entries should have verified supporting shipping documents 25/ including Shipping Invoices and Bills of Lading. These should contain the following information: product quantities loaded at 60°F, the unit FOB cost of each type of fuel, the freight cost per gallon, the total cost of the total cargo, ocean losses, and the insurance paid.
- d) When processing the Customs Import Entry, Customs should verify volumes imported (from the "before" and "after" bulk tank dips), the value and other details.
- e) In addition to the above, Customs should arrange to dip all company-owned bulk fuel tanks on June 1st and January 1st each year to ascertain the quantities of fuel in stock on those dates. These will enable Government to establish the six-monthly demand volume through each installation 26/.

Power Subsector

4.28 The main policy issue for the GMI is the "commercialization" of MEC, implying:

- a) transferring the assets from GMI to MEC balanced with a GMI loan or turning it into government-owned equity. No new legislation is needed;
- b) giving responsibility for tariffs and investment budgets to the MEC Board; and
- c) defining a long range policy for government subsidies to the power sector.

4.29 Of all Micronesian countries, the Marshall Islands has made the most progress in organizing its power utilities to operate as autonomous corporations, notwithstanding the large subsidies. Of particular importance, an institutional structure for the power sector exists on both Majuro and, more recently, Ebeye which consolidates all power sector responsibilities under one management.

4.30 Officials in both Ebeye and Majuro are contemplating carrying the corporatization process a step further by inviting participation in (and in Majuro, management of) the power utilities by the private sector. A Privatization Committee was formed in Majuro under the Chairmanship of the Minister of Finance in early 1990 to examine the issue of privatizing a large number of Government and semi-Government entities. Although the Committee's report (submitted in August 1990) was inconclusive regarding the prospects of privatizing any specific entity, it did

25/ If Guam Custom officials supervise loading of the tanker, they should stamp the documents; otherwise officials at the loading port should be required to verify the documents.

26/ Volume Demand = OS + VI - CS where OS = Opening Stocks, VI = Volume Imported at ambient temperature during the period, and CS = Closing Stocks in the tanks.

include the MEC in the list of organizations that should be privatized eventually. In Ebeye, where the power utility is presently owned 75% by KADA and 25% by KALGOV, KALGOV intends to eventually sell its shares to private interests.

4.31 In Majuro, GMI appears to have three objectives in seeking to privatize the MEC:

- a) to reduce the costs of the supply and distribution of both power and petroleum through efficiency improvements, thereby limiting the need for future price increases;
- b) to improve the reliability of the power supply; and
- c) to reduce and ultimately eliminate the financial burden on Government of subsidies to MEC.

4.32 While the privatization or commercialization (the distinction is discussed below) of MEC might relieve the Government of the burden of subsidies, privatization is unlikely to reduce the cost of energy production. The MEC is a well-run, efficient utility. Improvements in recent years have included extensive and effective use of computers in record keeping, billing, accounting, and inventory, and reductions in expatriate staff while promoting qualified local personnel ^{27/}. Where maintenance has been inadequate (for example, the tank farm), the cause is mainly the severe budget constraint stemming from the low tariffs charged for energy. Though large, the annual Government cash subsidy to MEC is not adequate for necessary maintenance. It should be noted that MEC's management has no discretion in setting the tariff high enough to meet costs; when revenues and cash subsidies are insufficient, needed expenditures have to be deferred. Present management have performed well in making budget compromises when necessary to keep MEC running, but the condition of the equipment has inevitably deteriorated.

4.33 Improving the generating plant's reliability significantly would be extremely expensive. Reliability is presently as good as could be expected given MEC's budget limitations. Improvements in maintenance and in the system's reliability can only come about through raising the tariff assuming that the subsidy to MEC is not increased.

4.34 The third of the Government's objectives, reducing the burden of the subsidy, can be achieved by taking two parallel steps: 1) commercializing the MEC, that is making MEC accountable for all costs of energy production including capital costs, and giving it some discretion to set the tariff to meet those costs; and 2) finding a way to market the excess storage capacity in the tank farm, probably to an overseas petroleum marketer.

^{27/} By mi-1992, an outcome of this effort was that MEC's accounting, inventory and billing systems had been fully computerized, and were in compliance with the U.S. Auditor General's guidelines.

4.35 Until these changes take place, there is a direct trade-off between the Government's subsidy to MEC and MEC's energy prices to consumers: as one is reduced, the other increases. Privatization or commercialization of MEC will do very little to affect the terms of the trade-off. In the long run, the Marshall Islands must adjust to substantially higher energy prices. By comparison, the efficiently-run Vanuatu power system has been in private hands for more than 40 years and also uses diesel plant for all generation. This utility's average electricity revenue is about 26¢ per kWh compared to 10¢ in Majuro and 7.5¢ in Ebeye.

New and Renewable Sources of Energy

4.36 The GMI has ambitious plans to expand the use of photovoltaic systems for remote islands. The key policy issue is how to establish a mechanism for financing, designing, installing and maintaining them so that the recipients have an affordable and reliable source of electricity for small loads. There has been considerable experience in the Pacific Islands with managing photovoltaic electrification, the most relevant example being the Tuvalu Solar Energy Cooperative Society (TSEC). Tuvalu, with only 9000 people and a per capita GDP one fourth that of RMI's, has established a relatively successful independent, commercially-based utility devoted entirely to providing and servicing PV systems for households on remote atolls. It does so at a cost equivalent to, or lower than, the same services provided from diesel power, and at higher rates of reliability. The TSEC began with aid finance but now relies primarily on users' fees. Its success is due to dedicated management, competent outside advice, decentralized technical and administrative resources, and fundamental emphasis on high quality maintenance and the ready availability of spare parts. If the RMI proceeds with its plans to expand use of PVs for small remote loads, it is recommended that a similar approach be considered 28/.

ENERGY CONSERVATION

4.37 Average electricity consumption per household consumer exceeds 700 kWh per month which is very high for the Pacific Islands 29/. A large amount of electricity is wasted due to inefficient appliances (cooling, freezing, water heating and lighting) and excessive air-conditioning. A considerable potential for energy conservation exists through proper maintenance and operation of existing equipment and by phasing out inefficient appliances. Cooking with diesel-generated electricity is extremely inefficient; conversion to LPG or kerosene would reduce energy conversion losses and could be cheaper for the consumer if electricity were

28/ *"Rural Utilities and the Role of Photovoltaics"* by Herbert Wade (S.P.I.R.E., Tahiti, 1990) explains the success of the Tuvalu cooperative and has suggestions which would be useful for the RMI program.

29/ The high per capita consumption of electricity is, in part, a legacy of the times when the U.S. administered the Marshall Islands. At that time, electricity was virtually free, which led to high consumption levels.

sold at cost. However, the consumer has no incentive to save electricity due to heavily subsidized prices. In 1984 the RMI published guidelines 30/ on energy efficiency but these appear to have been ignored.

4.38 Even simple conservation measures could be introduced, such as cleaning air conditioning filters, de-icing refrigerators and freezers, time controls on air conditioning, solar heating of water, etc. Lighting is generally outdated: inefficient incandescent lights still dominate residential use, both indoor and outdoor. A campaign is recommended to introduce the new electronic mini-fluorescent lamps which fit into existing fixtures and reduce energy consumption by as much as 80%. These lamps are not presently marketed in the Marshall Islands. In commercial and government buildings slim-type fluorescent tubes with high frequency coupling can reduce consumption by 30%. In some places automatic daylight dimming or simple photo sensor switches could be introduced.

4.39 If electricity tariffs are substantially increased as recommended, there will be a strong inducement for the general public to reduce electricity use. A government energy conservation and management program could ameliorate the initial impact of higher tariffs by working ahead of time with importers to assure that efficient lights, time switches and appliances are available, that import duties and taxes discourage wasteful appliances (standard electric burners and ovens) and encourage efficient ones (modern kerosene pressure stoves, LPG stoves, microwave ovens, fluorescent lights, etc). Such a program is encouraged in concert with the increase in electricity tariffs.

4.40 According to the USDOE Territorial Energy Study, these types of programs had already been identified for implementation by the GMI in 1982 but there has been no discernible progress. If such a program had been implemented in the early 1980s, the RMI would have saved many millions of dollars in oil imports and electricity investments with no reduction in living standards.

4.41 Within MEC, investments in energy conservation will often be more economic than investments in new generation capacity. As long as electricity is considered to be a nearly free commodity, a conservation programme will not be successful. In the long term, conservation of electricity benefits the utility by lengthening the period of time between new capacity additions, which has significant financial benefits for the power utility. For example, if a reduction in the growth rate of peak demand from 5% per year to 3% makes possible a deferment for five years of a new engine/generator costing \$1 million, the present value of the investment will be only \$620,000 31/ rather than \$1 million. Deferring investment allows available funds to be used for other purposes until they are needed for the investment, purposes

30/ *"Thermal and Lighting Efficiency Standard"* (RMI with USDOE).

31/ At a 10% annual discount rate. The present value of a \$1 million investment five years from now is $\$1 \text{ million} / (1 + 10\%)^5 = \$620,921$.

which could not be met if the investment were required now. As Figures 2.1 and 2.2 show, the new 3 MW capacity additions in Majuro and Ebeye scheduled for 1991 delay the need for additional capacity in either system well into the next century. Neither investment is necessary at present; a deferment of several years might have been possible in both cases. Nevertheless, in the short term, the benefits of energy conservation will be felt in fuel savings and possibly a reduction in peak losses, and the financial savings of deferred capacity will in time become significant.

ENVIRONMENTAL ISSUES

4.42 Petroleum Supply. The main threats to the environment in the oil industry are the risks of spillage and pollution of ground water supply and the lagoon area during tanker discharges and loadings, ships' bunkering operations and transfers from bulk fuel tanks to the powerhouse tanks. To ensure that the industry can respond to emergencies, it is recommended that the industry should have the following minimum equipment: oil booms of 100 meters coverage, a small boat with an outboard engine, dispersants, ropes, sponges and tools and accessories for clean up operations. These, together with fire fighting emergency equipment, should be contained in a lock-up trailer kept on stand-by at the location of every such operation. Only Mobil has some such provisions on Majuro.

4.43 It is recommended that the RMI petroleum industry also comply with normal international operating requirements which specify pre-tanker discharge tests (on pipelines, hoses, tanks, communication equipment, etc.), minimum manning levels to ensure that all such equipment and assets are sound, and specific training for these operations. It is also recommended that periodic tests on these assets be carried out. These standards are apparently not observed in the RMI although the oil industry is increasingly enforcing such provisions in other parts of the Pacific.

4.44 Service stations, back-yard garages and ships' bilges are typically the main sources of pollution in urban waters apart from bulk fuel depots that are not equipped with drainage controls. It is recommended that the RMI EPA regulations be revised to adequately cover these and that the local authorities should also be made aware of legal requirements.

4.45 Electricity Supply. The power station is sufficiently distant from residential areas so there are no particular problems concerning noise and pollution from the exhaust. All lube oil is recycled. MEC has completed a program of refitting transformers containing PCB; the chemicals have been returned to the U.S.. Voltage fluctuations, in combination with poor maintenance, however, leads to break down of compressors in air-conditioners, refrigerators and freezers. This leads to excessive release of CFC gases from worn out compressors which contributes to the "greenhouse effect" and ozone depletion.

V. INVESTMENTS AND TECHNICAL ASSISTANCE PRIORITIES

ENERGY PLANNING AND COORDINATION

5.1 Given its size, the RMI does not require a fully-fledged Ministry of Energy. However, it should have a competent senior official who oversees the energy sector. He/she should have sufficient Government backing to enable implementation of accepted recommendations. The past wastage of energy - and more importantly the excessive funds already spent and the opportunities to improve the situation - justify the recruitment of an expert adviser for 12 - 24 months. This is recommended.

POWER SUBSECTOR

5.2 During 1990, a USDOJ/Army Corps of Engineers consultancy team visited Majuro and Ebeye to assess general needs for rehabilitating infrastructure including the power sector. As a result, an "Operations & Maintenance Improvement Program" (OMIP 32/) has been proposed for the power sector in the RMI focusing on tools for maintenance and technical monitoring financed partly by USDOJ. It is expected that many of the recommendations of both reports, which differ in emphasis but complement each other, could be partly financed by the U.S. government.

5.3 *Distribution.* The most serious technical weakness in the two major power systems in the RMI is in the distribution networks. It is recommended that distribution in both power systems, especially in parts of the Majuro system, be rehabilitated to reduce losses, reduce the frequency of outages, and improve voltage regulation. Prior to rehabilitation, it is recommended that the distribution in each power system be systematically analyzed and essential records be created or brought up to date.

5.4 Technical assistance in MEC and Ebeye distribution is needed for:

- a) preparing an updated line diagram as the first step toward a 'system map';
- b) analyzing the load, losses and voltages in all feeders;
- c) developing a revised protection scheme with sectionalizers, fault indicators, etc;
- d) designing a rehabilitation and maintenance programme for the most congested portions of the distribution systems including the need for capacitor banks; and

32/ The most recent report is the "*Second Year Review: OMIP Team's Field Report for the Republic of the Marshall Islands*" (Louis Berger International and Barrett Consulting Group, June 1991).

e) analyzing the need for additional feeders for system reinforcement.

5.5 It is recommended that a system map be established, preferably on a standard desktop computer. This need not be complicated considering the relative simplicity of the distribution system. The emphasis should be on collection of system inventory data, not exact geographic information, which can be extremely costly. It is recommended that MEC and KAJUR personnel be actively involved in the implementation and they should later take over complete responsibility for maintenance of records and maps. The initial cost of developing the map would be at least \$75,000 for MEC and somewhat less for KAJUR.

5.6 Training. An education and training program with time away from Majuro is necessary if local staff are to take over responsibility for MEC within the next five years. Minimum permanent staff should include a General Manager, an Administrative Manager, a Senior Distribution Engineer (superintendent), a Senior Power Station Engineer (station manager or superintendent) assisted by an Electrical Engineer and two Mechanical Engineers. It is recommended that an organization chart be approved by the Board of each utility. The senior engineers should have extensive training locally and overseas. Apprenticeships should be established immediately. The linesmen should be trained in preventive maintenance. Disciplines which need to be strengthened by MEC are transformer maintenance, relay setting and meter adjustment. Outside assistance could sponsor appropriate staff members or recruits for overseas technical courses of up to one year; longer courses would be handled by RMI or U.S. scholarship programs. There are technical courses for linesmen, power station operators, mechanics, electricians, etc., of one to two months duration available through other power utilities in the region including those in Papua New Guinea and Fiji; outside assistance could provide funds for travel and subsistence for such training at comparatively little cost. Although training has been carried out reasonably well in Majuro (less true of Ebeye), it remains an urgent priority for the development and complete localization of the RMI's power utilities in the long term. The level of assistance for both technical and professional power sector training in the RMI is likely to exceed \$50,000 per year.

5.7 Accounting and record keeping. Technical assistance is needed to support the utilities in creating and maintaining adequate financial accounts and operating records of the type and standard suited to commercial corporations. Record keeping in Majuro and Ebeye is not systematic, and in some respects (especially in Ebeye) is simply lacking. Accounting procedures often do not follow commercial practices. Accounting and record keeping procedures and formats should be standardized in all RMI power systems to simplify oversight of power operations by national authorities. The assistance required to support these efforts, involving design of procedures, collection of initial data, and training of staff is estimated at \$45,000 including software costs.

5.8 Cost study, asset valuation, and tariff review. In conjunction with the establishment of an improved accounting system for the utilities, it is recommended that a detailed study be carried out of power production costs, the value of assets, and the tariff required to recover costs. This would assist the utilities in defining their financial objectives and advising GMI on subsidy

policy. The work would combine well with assistance to create standard accounting and record keeping systems. The estimated cost is \$50,000 - \$100,000.

PETROLEUM SUBSECTOR

5.9 *Ebeye storage.* Ebeye needs new storage facilities; it is recommended that the existing hazardous barge no longer be used. It is further recommended that new storage be negotiated with the oil companies as part of a new supply agreement.

5.10 *MEC storage.* It is recommended that tank surfaces be stripped to bare metal, refurbished and repainted and that trees be planted on the ocean side of the bulk tanks to provide additional protection. Some stairs and railings are already dangerously rusted and the roof cladding and truss to the pumphouse need replacement. The cost of the urgently required maintenance is approximately \$250,000. This maintenance is distinct from the need to shift tanks to assure adequate separation for flammable products (ADO) and additional safety measures which could cost an additional \$1 million. While these measures would add to fuel costs, they are justified on security and safety grounds.

5.11 *Advisory services.* It is recommended that an expatriate petroleum specialist be recruited to work with a local counterpart to be trained to take over afterwards. The specialist would advise government in negotiations with oil companies on storage and supply contracts, establish a new system within Customs to verify costs and volumes, and train local staff to administer the contracts. This could require 6 man-months (\$50,000) over a two year period.

NEW AND RENEWABLE SOURCES OF ENERGY

5.12 *Photovoltaics.* Technical assistance is recommended to help establish a long-term photovoltaic programme including assessment of staffing needs, suitable equipment and appliances, establishment of a permanent organization, etc. The estimated cost is \$30,000 excluding any expenditure on measuring the solar resource.

5.13 *Wind.* Further monitoring and analysis is recommended of the wind regime in the RMI possibly through the services of the Forum Secretariat. The estimated cost is \$30,000 for a two-year study at one site, less if part of a wider regional assessment program.

Annex 1

ESTIMATED POWER COSTS FOR MEC AND KAJUR

Overall. The cost of power in Majuro and Ebeye for FY 1990, from mission estimates, is about 19.7¢ and 22.2¢ per kWh sold ^{1/} respectively, compared with estimated revenues of 9.9¢ and 7.6¢ per kWh sold, as shown in the following tables. In each case, these costs include operating costs (fuel, lubricants, personnel costs, administration, materials (Majuro), the IBC management contract (Ebeye), insurance, bad debts, travel, professional fees and taxes where applicable) and annual capital charges (interest and depreciation) for the utilities' productive assets. Much of the data in the tables had to be estimated, since detailed operating and financial records either do not exist (especially in Ebeye) or are hard to interpret. For example, information about an FY1989 cost item was sometimes applied to FY1990 also, since FY1990 data are commonly missing. Other "data" are arbitrary: for example, the bulk of bad debts that have been steadily building up in Ebeye since 1987 were applied to FY1989, significantly increasing the cost of power for that year. The value of total assets, which has a very significant effect on the cost of power in any power utility, was roughly estimated by the mission for each power system; it is recommended that a professional asset valuation be carried out in Majuro and Ebeye to improve the capital cost estimates.

Though the sizes of the two power systems differ (Majuro has twice the installed capacity and a much larger distribution system than Ebeye, and produces about twice the annual output), the total cost of production per kWh sold in each power system in FY1990 is fairly close, since per-unit fuel and capital charges are similar. Two cost items, however, are significantly higher in Ebeye than in Majuro, and mainly account for the somewhat higher overall per-unit cost of power in Ebeye: (1) bad debts (uncollected bills) are much higher in Ebeye and (2) the cost of the IBC contract for managing the power station is much higher than the combined expatriate and local personnel costs for operating the much larger Majuro power system.

MEC. Operating costs in FY1990 were just under 13¢ per kWh sold, decreased somewhat from 14.5¢ in the previous year, reflecting a sharp reduction in taxes (\$223,300 in MEC's tax liability was forgiven by GOMI in FY1990) and improved metering (which increased the quantity of energy "sold"). Capital charges were estimated to account for an additional 6.8¢ per kWh sold.

KAJUR. Operating costs in FY1990 slightly exceeded 16¢ per kWh sold, sharply down from 23¢ the previous year; the decrease is mainly artificial since costs in FY1989 have been calculated to reflect a sizable one-time write off of bad debts. This was done mainly to illustrate the negative impact of bad debts on total costs. Capital charges are about 6.1¢ per kWh sold. As noted above, KAJUR is paying a high cost for its management contract with IBC; substantial savings could result if KAJUR hired overseas professional labor on direct contract, as MEC does.

^{1/} "kWh sold" includes metered sales, estimated sales, and "exempt" sales - i.e., all energy which the utility recognizes as part of the total consumption of its customers. Thus it excludes technical losses, which are treated as part of the cost of operation.

TABLE 1
MARSHALLS ENERGY COMPANY
 PRO FORMA OPERATING INCOME AND EXPENDITURE ACCOUNT
 FOR ELECTRIC UTILITY OPERATIONS
 YEAR ENDED SEPTEMBER 30

			FY 1990 40,978 29,877		FY 1989 38,911 25,653	
REVENUE						
Electricity sales			\$2,916,541		\$2,342,709	
Other utility income			\$49,006	\$2,965,547	\$76,898	\$2,419,607
Contracting revenue	1		\$180,655		\$88,593	
Less contract expenses			\$203,788	(\$43,111)	\$11,853	\$76,740
Total revenue				\$2,922,436		\$2,496,347
Sales revenue per kWh sold, cents			9.83		8.10	
EXPENDITURE						
1. Operating Costs						
<i>Generation</i>						
Fuel and Lubricants			\$2,009,792		\$1,730,814	
Salaries & personnel costs			\$424,118		\$388,894	
Materials & repairs			\$277,477		\$90,103	
Insurance			\$51,975		\$43,782	
Professional fees			--		--	
Travel			\$19,364		\$19,172	
Other expenses incl part administration	2		\$97,231	\$2,878,967	\$77,345	\$2,359,750
<i>Distribution</i>						
Salaries & personnel costs			\$221,544		\$198,053	
Materials & repairs			\$438,868		\$505,222	
Insurance			\$18,688		\$15,483	
Bad Debts			\$1,072		\$357,194	
Taxes	3		--		\$81,778	
Professional fees			--		--	
Travel			--		\$2,842	
Other expenses incl part administration	2		\$284,867	\$976,037	\$240,618	\$1,371,251
Total annual operating costs				\$3,858,994		\$3,731,001
Total operating cost per kWh sold, cents			12.61		14.54	
2. Capital Costs, amortized at 6%						
<i>Generation</i>						
Asset		Value	Life (yrs)			
Power plant		\$11,000,000	15	\$1,132,560	\$1,132,560	
Power station buildings		\$3,000,000	25	\$234,660	\$234,660	
Residential buildings		\$575,000	30	\$41,773	\$41,773	\$1,409,044
<i>Distribution</i>						
Asset		Value	Life (yrs)			
Distribution system		\$8,000,000	25	\$489,360	\$489,360	
Plant machinery etc		\$668,400	5	\$158,201	\$121,789	\$581,150
	In 1989:	\$513,021	5			
	In 1990:					
Total annual capital costs				\$2,038,905		\$2,000,163
Total capital cost per kWh sold, cents			6.82		7.80	
Total Costs (operating plus capital costs, generation plus distribution)				\$5,897,899		\$5,731,164
SURPLUS of EXPENDITURE over REVENUE:						
Total cost per kWh sold, cents			19.72	\$2,970,163	22.34	\$3,234,847

Notes: (1) Revenues earned by MEC from government for operation of minor power facilities outside of Majuro (e.g., Jaluit).
 (2) 90% of total annual MEC Administration expenses allocated to power.
 (3) Gross receipts taxes of \$223,300 forgiven by RMI Government in 1990.

STATISTICAL ANNEX

TABLE 1
SELECTED DEVELOPMENT INDICATORS FOR THE MARSHALL ISLANDS

		1985	1986	1987	1988	1989	1990
GDP ¹ (US\$ m)		\$45.2	\$56.5	\$64.8	\$68.7	na	na
Per capita (US\$)		\$1,232	\$1,470	\$1,611	\$1,630	na	na
Total Imports ² (US\$ m)		\$29.2	\$30.6	\$32.2	\$33.8	\$44.4	na
Total Exports ³ (US\$ m)		\$2.7	\$1.2	\$1.9	\$2.1	\$2.3	na
Inflation Rate ⁴		-0.2%	4.6%	-0.7%	2.9%	na	na
Sea Area (km ²)	750,000						
Land Area (km ²)	180						
Wage & Salary Employment ⁵		5,142	6,791	7,139	10,056	na	na
Ave Wage/Salary ⁶ (US\$/hour)		\$2.50	\$2.27	\$2.79	\$3.19	na	\$3.73
Economically Active		na	na	na	11,488	na	na
Total Population ⁷		36,702	38,429	40,237	42,130	44,112	46,188
Urban ⁸ (%)		51%	52%	52%	53%	54%	55%

Overseas Development Assistance

Annual ODA ⁹ (US\$ m)	\$23.7	\$44.7	\$44.7	\$44.7	\$44.7	\$44.7	\$44.7
ODA (% GDP)	53%	79%	69%	65%	na	na	na
ODA ¹⁰ (% Recurrent Government Expenditure)	55%	129%	53%	80%	72%	na	na
% Bilateral ¹¹	100%	100%	100%	100%	95%	> 90%	> 90%
ODA per Capita (US\$)	\$647	\$1,163	\$1,111	\$1,061	\$1,013	\$968	\$968

Sources: 1) Economic Report on the Republic of Marshall Islands (ADB, January 1991).

2) Marshall Islands Statistical Abstracts (1988, 1989).

3) Feb 1991 survey of wages, RMI Government.

4) Mission estimates.

Notes: ¹ Current Market Prices (provisional data). US currency is official RMI currency.

² CIF, except 1988 & 1989 are FOB. Until 1989 imports excluded Govt imports & tax exempt goods.

³ FOB; 1986 and 1987 data provisional.

⁴ Based on Majuro Consumer Price Index only.

⁵ From source 2); income tax returns except 1988 from Census.

⁶ Mission estimates for Majuro. Source 2 except 1990 is source 3, actually covering early 1991.

⁷ Based on 1973 and 1988 Census data adjusted to mid-year.

⁸ Only D.U.D. (Majuro) & Ebeye (Kwajalein) considered urban. Non Census years estimated.

⁹ Exact figures unavailable; average of US Compact funds (annual plus non-recurring) for 5 years from 1986/87 - 1990/91 excluding Nuclear Claims Trust Fund. Total will drop slightly from 1991/92.

¹⁰ Based on annual Compact funds & other US and foreign grants to national government only as percentage of national recurrent government expenditure excluding "Expendible Trust Funds".

¹¹ Based on ODA as explained in note 10 above.

SELECTED PROJECTIONS FOR MARSHALL ISLANDS (1990 – 2000)

	1990	1995	2000
Population¹:			
urban	25,173	33,052	43,397
rural	21,015	23,164	25,018
total	46,188	56,216	68,415
GDP (\$ millions; 1988 prices)²:			
high growth (5% real)	72.9	93.0	118.7
medium growth (3.5% real)	72.9	86.6	102.8
low growth (2% real)	72.9	80.5	88.8
GDP/Capita³ (1988 prices):	\$1,578	\$1,540	\$1,503
Electricity Generation⁴ (GWh):			
1987 – 1990 growth rate	63.5	84.4	112.3
reduced growth rate	63.5	73.5	85.1
Fuel Consumption⁵ (thousand US gallons)			
Gasoline	1,212	1,374	1,566
Jet A1	1,695	1,981	2,318
Kerosene	126	148	173
ADO	5,474	7,060	8,862
IDO	0	0	0
IFO	180	0	0
Lubes	69	81	95
Avgas	2	2	3
LPG	16	22	27
Others	2	3	4
Total Inland	8,776	10,671	13,048
Bunkers (ocean)	773	1,500	2,000
Total RMI trade	9,549	12,171	15,048

- Sources:**
- 1) Total population from Marshall Islands Statistical Abstract (1988, 1989).
 - 2) Govt. & supplier fuel data are both inconsistent; mission estimates based on both.
 - 3) Fuel projections based on middle of high and low projections.

- Notes:**
- ¹ Midyear medium growth scenario. Assumes urban growth remains 5.6% per year.
 - ² GDP in 1988 dollars at market prices. Assumes 3% annual real growth 1988 – 1990.
 - ³ In 1988 dollars. Assumes medium GDP growth.
 - ⁴ Mission estimates for Majuro, Ebeye, Jaluit & Kili. MEC accounts for about 2/3 of total. Jaluit and Kili total of 1.4 GWh in 1990, 1.5 GWh (1995) & 1.6 GWh (2000). "Reduced growth" of 3% per year assumes tariffs increase to true cost by 1995.
 - ⁵ Mission estimates assuming median real GDP growth of 3.5% per year.

ENERGY BALANCE ESTIMATES FOR THE REPUBLIC OF THE MARSHALL ISLANDS (1990)
(*000 TOE)

	Fuelwood	Coconut Residues	Total Biomass	Electricity ⁴	Gasoline	Jet A1	Kerosene	ADO	IFO	Avgas	LPG	Others	Petroleum	Total Energy
Primary Supplies														
Production	0.6	6.0	6.6											6.6
Imports					3.7	5.5	0.4	21.3	0.6	0.01	0.05	0.01	31.7	31.7
Bunkering/exports						(5.5)		(2.6)					(8.2)	(8.2)
GROSS AVAILABLE	0.6	6.0	6.6	0.0	3.7	0.0	0.4	18.7	0.6	0.01	0.05	0.01	23.5	30.1
Conversions														
Public Power Generation				15.5				(14.9)	(0.6)				(15.5)	0.0
Transformation losses				(10.2)										(10.2)
Station Use				(0.3)										(0.3)
Transmission/Distribution Losses				(1.2)										(1.2)
NET SUPPLIED	0.6	6.0	6.6	3.8	3.7	0.0	0.4	3.8	0.0	0.01	0.05	0.01	8.0	18.4
Final Consumption														
Households ^{1,2}	0.6	1.9	2.6	1.7			0.4				0.01		0.4	4.7
Transport														
Air ⁶						0.0				0.01			0.0	0.0
Sea ⁵								0.8					0.8	0.8
Land					3.5			1.9					5.5	5.5
Government/Commercial				2.0				1.1			0.04		1.1	3.1
Industrial/Construction				0.1										0.1
Agroindustries ³		4.0	4.0											4.0
Other					0.2			0.1				0.01	0.2	0.2
TOTAL	0.6	6.0	6.6	3.8	3.7	0.0	0.4	3.8	0.0	0.01	0.05	0.01	8.0	18.4

Source: Mission Estimates

Notes:

- (1) Cooking and lighting. Only real data is 1988 household census (4923 hh & 8,672 people/hh). Population growth = 4%/yr. Assume hh growth = 3%/yr.
- (2) Biomass cooking: Assume Abaiang/Tamana/Vaitupu/Tongatapu rural cooking patterns. Large hh size therefore 5,000 kg/hh/year (1.6 kgs/cap/day).
For those 680 households (5916 people) cooking entirely/mainly with biomass assume:
5916 people x 1.04² x 1.6 kgs/cap/day x 365 days/year/1000 kgs/tonne = 3,737 tonnes
For (4923-680) households (36,914 people) cooking who sometimes cook with biomass assume average of 0.25 kgs/cap/day:
36,914 kg/cap/day x 1.04² x 0.25 kgs/cap/day x 365 days/year/1000kgs/tonne = 3,643 tonnes
Total cooking (assumed to be 80% coconut waste, 20% other biomass) 7,380 tonnes
- (3) Agroindustries: 1990 copra production not known. 1981-1988 average of 5100 tonnes assumed
Fuel consumption for drying assumed at 2.4 tonnes coconut residues/tonne copra produced (open fire drying). 12,240 tonnes
- (4) Includes Majuro, Ebeye and rural (mostly Jaluit, Kili).
- (5) Bunkers for international fishing fleets, cargo and cruise ships 773,000 US gals/year (MEC records).
Assumes Government surveillance vessels consume 750 KI/year. In addition (860,000-773,000 USgals) in local sea transportation (PEDP Report REG 89-12).
- (6) Estimated 1 million US gal uplifted by Air Micronesia and remainder by AML. Small portion (0.1 MG?) for local flights but all treated as international.

ENERGY BALANCE ESTIMATES FOR THE REPUBLIC OF THE MARSHALL ISLANDS (1990)
(Original Units)

	Fuelwood (tonnes)	Coconut Residues (tonnes)	Total Biomass (tonnes)	Electricity ⁴ (GWh)	Gasoline (kUSgal)	Jet A1 ⁵ (kUSgal)	Kerosene (kUSgal)	ADO (kUSgal)	IFO (kUSgal)	Avgas (kUSgal)	LPG (kUSgal)	Others (kUSgal)	Petroleum (kUSgal)
Primary Supplies													
Production	1,476	18,144	19,620										
Imports					1,212	1,695	126	6,247	180	2	16	2	9,480
Bunkering/exports						(1,695)		(773)					(2,468)
GROSS AVAILABLE	1,476	18,144	19,620	0	1,212	0	126	5,474	180	2	16	2	7,012
Conversions													
Public Power Generation				64				(4,359)	(180)				(4,539)
Transformation losses													
Station Use				(4)									
Transmission/Distribution Losses				(14)									
NET SUPPLIED	1,476	18,144	19,620	45	1,212	0	126	1,115	0	2	16	2	2,473
Final Consumption													
Households ^{1,2}	1,476	5,904	7,380	20			126				4		130
Transport													
Air ⁴						0				2			2
Sea ⁵								228					228
Land					1,160			559					1,719
Government/Commercial				24				312			12		324
Industrial/Construction				1									
Agroindustries ³		12,240	12,240										
Other					52			16				2	70
TOTAL	1,476	18,144	19,620	45	1,212	0	126	1,115	0	2	16	2	2,473

Source: Mission Estimates 1990

Notes:

- (1) Cooking and lighting. Only real data is 1988 household census (4,923 hh & 8,672 people/hh). Population growth = 4%/yr. Assume hh growth = 3%/yr.
- (2) Biomass cooking: Assume Abaiang/Tamara/Vaitupu/Tongatapu rural cooking patterns. Large hh size therefore 5,000 kg/hh/year (1.6 kgs/cap/day).
For those 680 households (5916 people) cooking entirely/mainly with biomass assume:
5916 people x 1.04 ^ 2 x 1.6 kgs/cap/day x 365 days/year/1000 kgs/tonne = 3,737 tonnes
For (4923-680) households (36,914 people) cooking who sometimes cook with biomass assume average of 0.25 kgs/cap/day:
36,914 kg/cap/day x 1.04 ^ 2 x 0.25 kgs/cap/day x 365 days/year/1000kgs/tonne = 3,643 tonnes
Total cooking (assumed to be 80% coconut waste, 20% other biomass) 7,380 tonnes
- (3) Agroindustries: 1990 copra production not known. 1981-1988 average of 5100 tonnes assumed
Fuel consumption for drying assumed at 2.4 tonnes coconut residues/tonne copra produced (open fire drying) 12,240 tonnes
- (4) Includes Majuro, Ebeye and rural (Jaluit, Kili)
- (5) Bunkers for international fishing fleets, cargo and cruise ships were 773,000 US gal/year (MEC records).
Assumes Government surveillance vessels consume 750 KI/year. In addition (860,000-773,000 USgal) in local sea transportation
- (6) Of 1.695 MG avtur, about 1 MG uplifted by Air Micronesia for international flights. 0.315 MG used by AMI for all flights. Total treated as bunkers.

Table 3a

ENERGY BALANCE ESTIMATES FOR THE REPUBLIC OF THE MARSHALL ISLANDS (2000)
(**'000 TOE**)

	Fuelwood	Coconut Residues	Total Biomass	Electricity ^a	Gasoline	DPK	Kerosene	ADO	IFO	Avgas	LPG	Others	Petroleum	Total Energy
Primary Supplies														
Production ^c	0.9	6.8	7.7											7.7
Imports					4.8	7.6	0.6	30.2	0.0	0.01	0.1	0.0	43.2	43.2
Bunkering/exports						(7.6)		(6.8)					(14.4)	(14.4)
GROSS AVAILABLE	0.9	6.8	7.7	0.0	4.8	0.0	0.6	23.4	0.0	0.01	0.1	0.0	28.8	36.5
Conversions														
Public Power Generation				20.9				(20.9)					(20.9)	0.0
Transformation losses				(13.8)										(13.8)
Station Use				(0.4)										(0.4)
Transmission/Distribution Losses				(1.5)										(1.5)
NET SUPPLIED	0.9	6.8	7.7	5.2	4.8	0.0	0.6	2.5	0.0	0.01	0.1	0.0	8.0	20.9
Final Consumption														
Households ^{1,2}	0.9	2.8	3.7	2.3			0.6				0.1		0.6	6.6
Transport					4.8	0.0		1.8		0.01			6.6	6.6
Government/Commercial				2.7				0.7					0.7	3.4
Industrial/Construction				0.2										0.2
Agroindustries ³		4.0	4.0											4.0
Others												0.0	0.0	0.0
TOTAL	0.9	6.8	7.7	5.2	4.8	0.0	0.6	2.5	0.0	0.01	0.1	0.0	8.0	20.9

Source: Mission Estimates 1990

Notes:

- (1) Cooking and lighting. Population projections based on 1988 household census. Population growth = 4%/yr.
- (2) Biomass cooking: Assume 1990 estimates for rural cooking patterns
Assume 1000 households (8,672 people) cooking entirely/mainly with biomass and consuming 1.6 kgs/cap/day
8,672 people x 1.6 kgs/cap/day x 365 days/year / 1000 kgs/tonne = 5,064 tonnes
For 59,743 people cooking who sometimes cook with biomass assume average of 0.25 kgs/cap/day
59,743 people x 0.25 kgs/cap/day x 365 days/year / 1000kgs/tonne = 5,452 tonnes
Total cooking (assumed to be 80% coconut waste, 20% other biomass) 10,516 tonnes
- (3) Agroindustries (assume 5,100 tonnes copra at 2.4 kgs coconut residues/tonne copra produced) 12,240 tonnes

5,064 tonnes

5,452 tonnes

10,516 tonnes

12,240 tonnes

ENERGY BALANCE ESTIMATES FOR THE REPUBLIC OF THE MARSHALL ISLANDS (2000)
(Original Units)

	Fuelwood	Coconut Residues (tonnes)	Total Biomass (tonnes)	Electricity ¹ (GWh)	Gasoline (kUSgal)	DPK (kUSgal)	Kerosene (kUSgal)	ADO (kUSgal)	IFO (kUSgal)	Avgas (kUSgal)	LPG (kUSgal)	Others (kUSgal)	Petroleum (kUSgal)
Primary Supplies													
Production	2,103	20,653	22,756										
Imports					1,566	2,318	173	8,862	0	3	27	0	12,949
Bunkering/exports						(2,318)		(2,000)					(4,318)
GROSS AVAILABLE	2,103	20,653	22,756		1,566	0	173	6,862	0	3	27	0	8,631
Conversions													
Public Power Generation				83.5				(5,687)					(5,687)
Transformation losses													
Station Use				(1.7)									
Transmission/Distribution Losses				(23.7)									
NET SUPPLIED	2,103	20,653	22,756	61.5	1,566		173	1,175		3	27		2,944
Final Consumption													
Households ^{1,2}	2,103	20,649	22,752	27.7			173				27		200
Transport					1,566			846		3			2,415
Government/Commercial				32.0				329					329
Industrial/Construction				1.8									
Agroindustries ³		4	4										
Others													
TOTAL	2,103	20,653	22,756	61.5	1,566		173	1,175		3	27		2,944

Source: Mission Estimates 1990

Notes:

- (1) Cooking and lighting. Population projections based on 1988 household census. Population growth = 4%/yr.
- (2) Biomass cooking: Assume 1990 estimates for rural cooking patterns
 Assume 1000 households (8,672 people) cooking entirely/mainly with biomass and consuming 1.6 kgs/cap/day
 $8,672 \text{ people} \times 1.6 \text{ kgs/cap/day} \times 365 \text{ days/year} / 1000 \text{ kgs/tonne} =$ 5,064 tonnes
 For 59,743 people cooking who sometimes cook with biomass assume average of 0.25 kgs/cap/day
 $59,743 \text{ people} \times 0.25 \text{ kgs/cap/day} \times 365 \text{ days/year} / 1000 \text{ kgs/tonne} =$ 5,452 tonnes
 Total cooking (assumed to be 80% coconut waste, 20% other biomass) 10,516 tonnes
 (3) Agroindustries (assume 5,100 tonnes copra at 2.4 kgs coconut residues/tonne copra produced) 12,240 tonnes

**MARSHALL ISLANDS PETROLEUM MARKET
1985 – 1990 IMPORT VOLUMES (thousand US Gallons)**

Product	1985	1986	1987	1988	1989	1990
Gasoline	899	1,219	1,387	1,386	1,470	1,212
Jet A1	1,059	919	1,986	1,385	1,554	1,695
Kerosene	126	122	126	127	127	126
ADO	735	2,279	1,869	3,849	4,180	5,474
IDO	1,697	1,420	1,487	1,247	558	0
IFO	1,638	1,764	2,037	584	0	180
Lubes	na	na	na	55	58	69
Avgas	na	na	na	na	na	2
Solvents	na	na	na	na	na	0
LPG	na	10	12	14	16	18
Total Inland Trade	6,154	7,733	8,904	8,647	7,963	8,776
Bunkers:						
ADO		1,328	1,958	2,210	1,487	773
IDO						
IFO						
Total Bunkers	na	1,328	1,958	2,210	1,487	773
Total Trade	6,154	9,061	10,862	10,857	9,450	9,549
Percent change			19.9%	0.0%	-13.0%	1.0%

Sources: Mission estimates based on information supplied by Mobil Oil Company and Marshalls Energy Company.

Note: No reliable data available from government or oil companies on C.I.F. (or F.O.B.) values of fuel imports except MEC's ADO.

TABLE 6
MARSHALL ISLANDS NATIONAL PUBLIC ELECTRIFICATION

1) Majuro Power System

	1985	1986	1987	1988	1989	1990
Consumers (number)						
Residential metered	na	na	na	na	na	1362
Residential flat rate	na	na	na	na	na	187
Gov/commercial metered	na	na	na	na	na	273
Commercial flat rate	na	na	na	na	na	19
Estimated	na	na	na	na	na	84
Total¹	na	1438	1518	1730	1798	1925

Capacity (MW):

Installed Diesel	12.8	12.8	12.8	12.8	12.8	12.8
Firm Diesel	9.6	9.6	9.6	9.6	9.6	9.6
Max Demand	4.2	4.8	5.4	5.9	6.1	7.1

Output (MWh):

Generation Diesel	na	32,834	35,717	37,956	38,911	42,907
Station usage	na	1,478	1,607	1,708	1,751	1,931
Total sent out	na	31,356	34,110	36,248	37,160	40,976
Technical losses ²	na	4,390	4,775	5,075	5,202	5,737
Non-technical losses ³	na	9,041	10,423	9,148	6,304	5,363
Net Consumption⁴	na	17,925	18,912	22,025	25,654	29,876

2) Ebeye Power System

Consumers (number)

Residential metered	na	na	na	na	na	726
Residential flat rate/est.	na	na	na	na	na	55
Govt/commercial metered	na	na	na	na	na	100
Commercial flat rate/est.	na	na	na	na	na	1
Exempt	na	na	na	na	na	55
Total	na	na	na	na	870	937

Capacity (MW):

Installed Diesel	na	na	6.01	6.01	6.01	6.01
Firm Diesel	na	na	3.40	3.40	3.40	3.40
Max Demand	na	na	2.30	2.39	2.53	2.68

Output (MWh):

Generation Diesel	na	na	15,715	16,330	17,386	19,200
Station usage	na	na	1,556	1,617	2,074	1,901
Total sent out	na	na	14,160	14,714	15,312	17,299
Technical losses	na	na	1,416	1,471	1,531	1,730
Non-technical losses	na	na	na	na	na	1,247
Net Consumption	na	na	na	na	na	14,922

3) Majuro plus Ebeye Power Systems

Consumers⁵ (number)

Residential	na	na	na	na	na	2385
Commercial/Government	na	na	na	na	na	393
Estimated	na	na	na	na	na	84
Total	na	na	na	na	2668	2862

Sources: 1) Mission estimates; Both MEC and KAJUR data are extremely limited and inconsistent.

Notes: ¹ 1990 actual; 1986-1989 from first month of following year.

² Estimated as 14.5% of energy sent out.

³ Unmetered consumption including street lights.

⁴ Sales of electricity.

⁵ Residential includes Ebeye exempt; Estimated includes both residential and commercial.

TABLE 7
REPUBLIC OF THE MARSHALL ISLANDS
URBAN ELECTRIFICATION PERFORMANCE INDICATORS (1990)

	MEC ¹	KAJUR ¹
Fixed Assets (millions US\$) ²	15.0	7.9
Average Revenue (USc/kWh)	9.9	7.6
Average Cost (USc/kWh)	19.7	22.3
Capital	6.8	6.1
Fuel	6.7	8.4
Other operating	6.2	7.8
Estimated ROI ³ (%)	- 20%	- 29%
Fuel Consumption ⁴ (litres/kWh)	0.261	0.291
Households Electrified ⁵ (%)	78%	83%
KWh/year/consumer ⁶	6,792	12,361
KWh/year/employee ⁷	745,000	738,000
Employees/MW installed ⁸	4.3	4.3
Outages		
Number	50 - 100	few
Average duration (hours)	1 - 3	na
Customers affected (%)	10 - 25%	na
Voltage drop/increase	5 - 30%	< 10%

Source: Mission estimates.

Notes:

- ¹ MEC = Marshalls Energy Co; KAJUR = Kwajalein Atoll Joint Utility Resource.
- ² Fixed Assets as of 30 December, 1990.
- ³ Rate of Return on estimated fixed assets.
- ⁴ Automotive diesel oil use: MEC = 14.5 kWh/US gallon; KAJUR = 13.0 kWh/USG.
- ⁵ % of atoll households (1988 Census). 1990 utility records indicate 64% (MEC) and 75% (KAJUR). For entire country, 56% of households are electrified excluding 3% with photovoltaic lighting.
- ⁶ Consumption per household consumer.
- ⁷ Generation.
- ⁸ KAJUR includes Kalgov maintenance staff.

TABLE 8
REPUBLIC OF THE MARSHALL ISLANDS
ELECTRICITY TARIFF STRUCTURE (1990)

	MEC ¹	KAJUR ²
Commercial metered (\$/kWh)	0.12	0.10
minimum (\$/month)	10	
Government metered (\$/kWh)	0.12	0.10
minimum (\$/month)	10	
Residential metered (\$/kWh)	0.10	0.08
Commercial flat rate (\$/month)	100	100
Residential flat rate (\$/month)	15	10

Source: Marshall's Energy Company

Notes:

- ¹ MEC = Marshalls Energy Company.
- ² KAJUR = Kwajalein Atoll Joint Utilities Resource.
- ³ MEC residential & commercial rates before Feb '90 were \$0.08 & \$0.10/kWh. From Feb '90 – 1 Oct '90 they were \$0.09 & \$0.11/kWh respectively.
- ⁴ KAJUR commercial metered apparently \$0.12/kWh from '91. KAJUR "flat rates" are estimated consumption but effectively flat rates.

TABLE 9

RURAL ELECTRIFICATION IN THE MARSHALL ISLANDS (1990)

	Diesel	PV
Households supplied by grid ¹	147	42
Isolated rural consumers ²		
number of atolls	20	14
number of households	86	27
Total rural households with electricity	233	69
Percentage of all rural households	13.4%	4.0%
Rural kWh generated ³		
total in 1990 ⁴	1,400,000	na
per consumer ⁵	5,000	na
% rural consumers metered	> 34%	none

Sources: 1) Census of Population & Housing 1988 (RMI Office of Planning & Statistics).
2) Mission estimates.

Notes: ¹ Rural consumers refer to all those away from Majuro and Kwajalein atolls.
Diesel grid refers to Kili and Jaluit systems only.
PV grid on Utirik being converted to stand-alone systems.
² PV excludes about 73 Majuro & Kwajalein atoll household solar systems.
Percentage of PV systems actually functioning not known.
³ Mission estimates; approximate only.
⁴ of which about 95% accounted for by Jaluit and Kili atolls.
⁵ Including estimated 45 other consumers (school, government, etc).

TABLE 10
NON-CONVENTIONAL ENERGY RESOURCES
AND USE IN THE MARSHALL ISLANDS

Systems Installed	1985	1990
Photovoltaics¹:		
number	< 60	142
kW_{peak}	< 6	11 - 12
Microhydro:		
number	not applicable	not applicable
kW		
Biomass:		
number	na	na
kW	na	na

Resources		
OTEC²	Temperature differential (°C)	22 - 24
	Distance offshore (km)	na
Tides	Mean range (metres)	na
Solar	Insolation (kWh/m² per day)	4.8 - 5.5
	Average daily hours	na

Sources: 1) Census of Population and Households (RMI, 1988) for PV systems.
 2) Ocean Energy Guide (ESCAP, Bangkok, 1990) for ocean resources.
 3) Territorial Energy Assessment (USDOE, Dec 1982)
 for solar data for Majuro, Enewetok, Utirik.

Notes: ¹ Apparently household systems only (1988).
² Sea level to 1000 metre depth.
³ na = not available.

TABLE 11
ESTIMATED BIOMASS RESOURCE:
THE MARSHALL ISLANDS (km²)

Forest Cover:	1985	1990
Primary	na	na
Plantation	na	na
Secondary	na	na
Total	na	na
Agricultural	na	na
Mangroves	na	na
Agricultural Plantations:		
Coconut¹	90	na
Oil Palm	0	na
Total	90	na
Total Resource		
Total Land Area	181	181

Sources: 1) First Five Year Development Plan (RMI, 1987)

Notes: ¹ 22,000 acres (8910 ha). Of 6500 ha productive, 69% is senile.

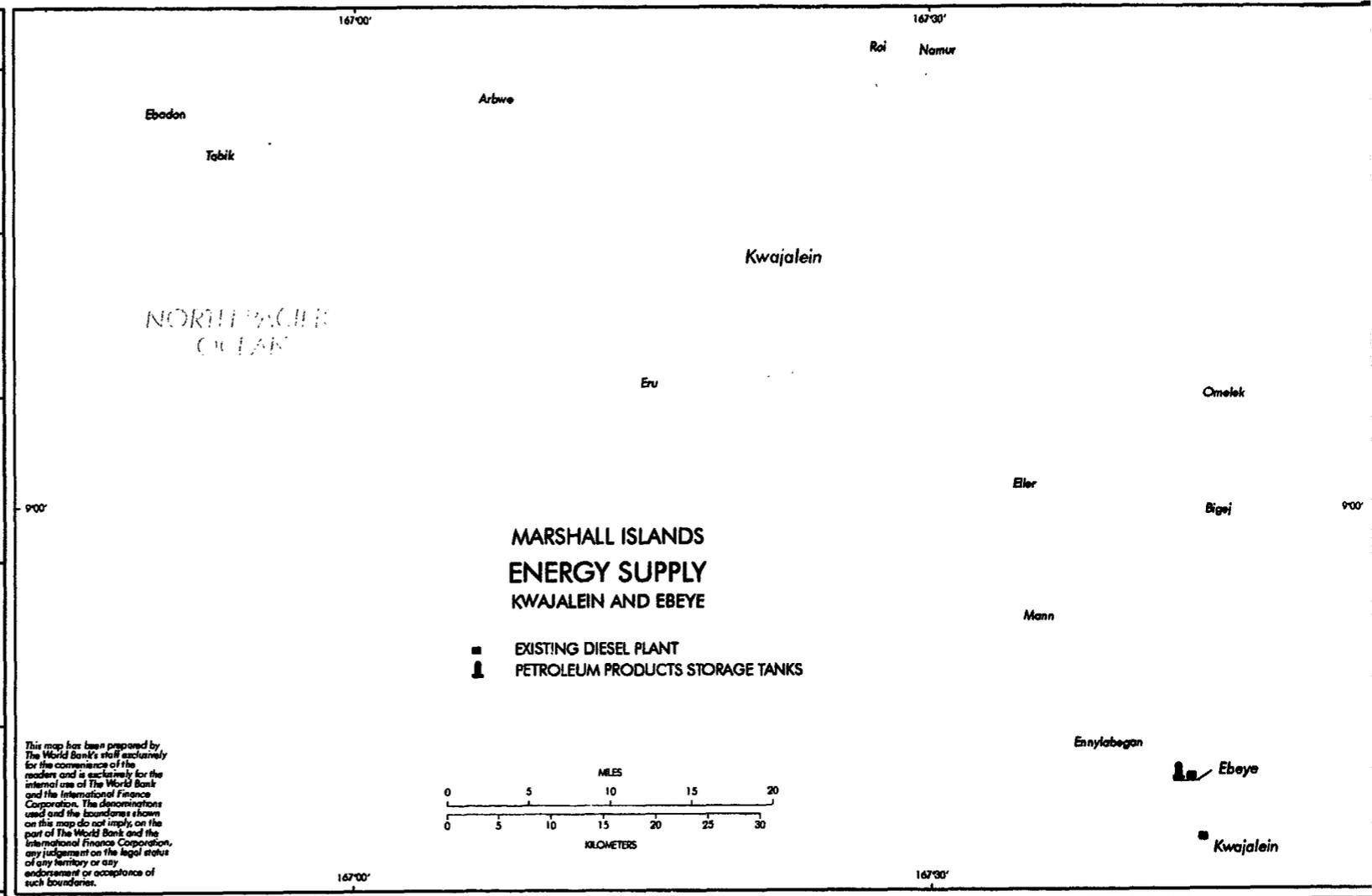
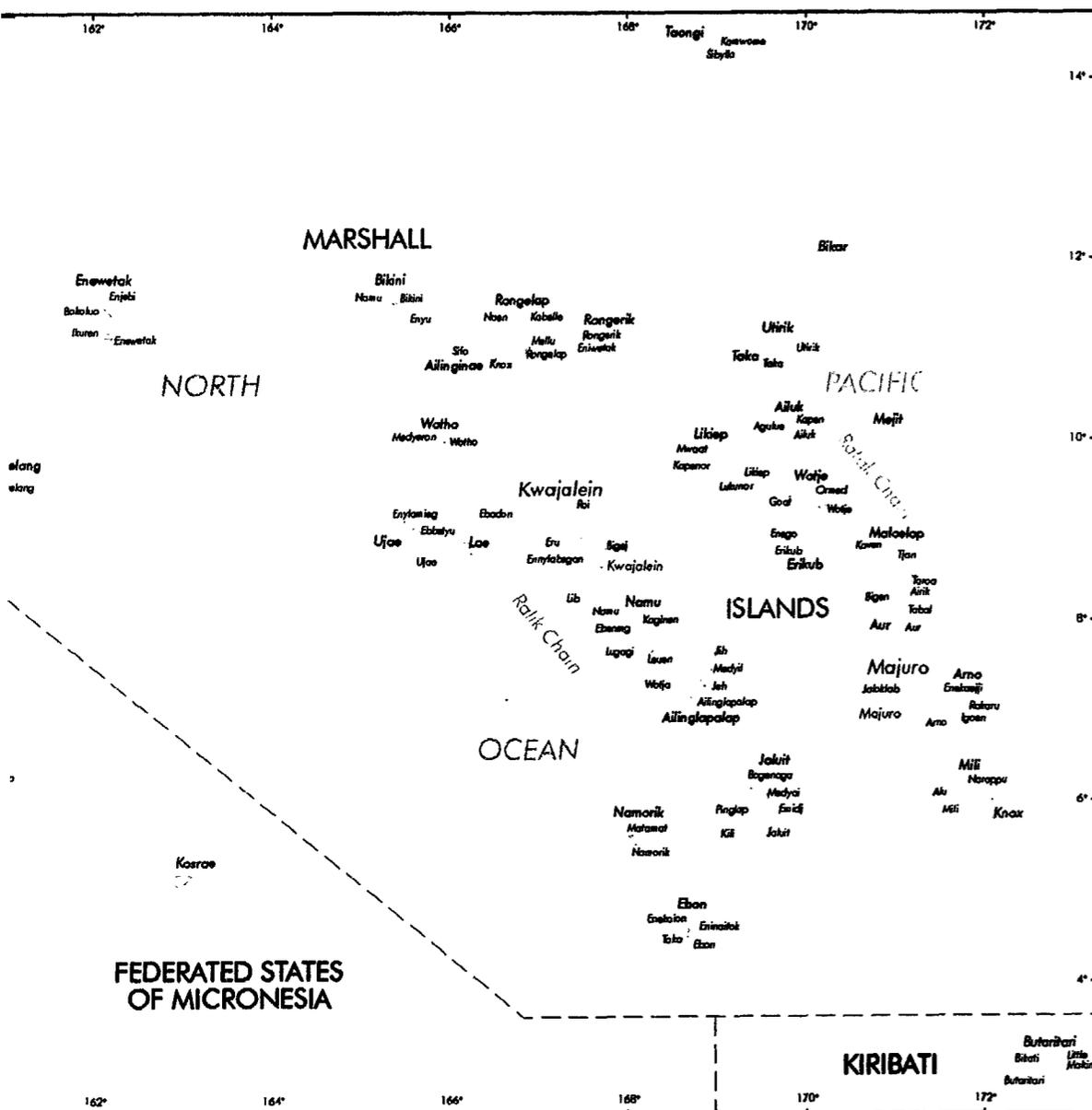
MARSHALL ISLANDS ENERGY SECTOR CAPITAL INVESTMENT AND PLANS: 1990 – 1991
 Externally Financed Technical Co-operation Projects and Activities (thousands of US dollars)

Activity	Source of Finance	Assistance Committed	Year	Project Duration	Begin-End Dates	Description and Location of Project
Power meters	MEC	80	1990	ongoing	not known	Install new consumer meters.
Switching station	TTPI, Saipan	50	?	1991	"	Majuro installation.
Power distribution	MEC	164	1991	ongoing	"	Phase II, Laura, Majuro. Upgrading downtown D.U.D. to 13.8 kV. Upgrading distribution system.
	MEC	150	?			
	MEC	400/yr	1990			
Substations	GMI	200	?		"	Majuro.
New power plant	KADA	2000	1991	1991	"	New 3 MW diesel-generator for KAJUR
Tank Farm refurbishment ¹	GMI	75	1991	?	"	Upgrade MEC storage to handle gasoline, etc.
Rural electrification	Australia	60?	1991	ongoing	"	Install new PV systems in remote areas.

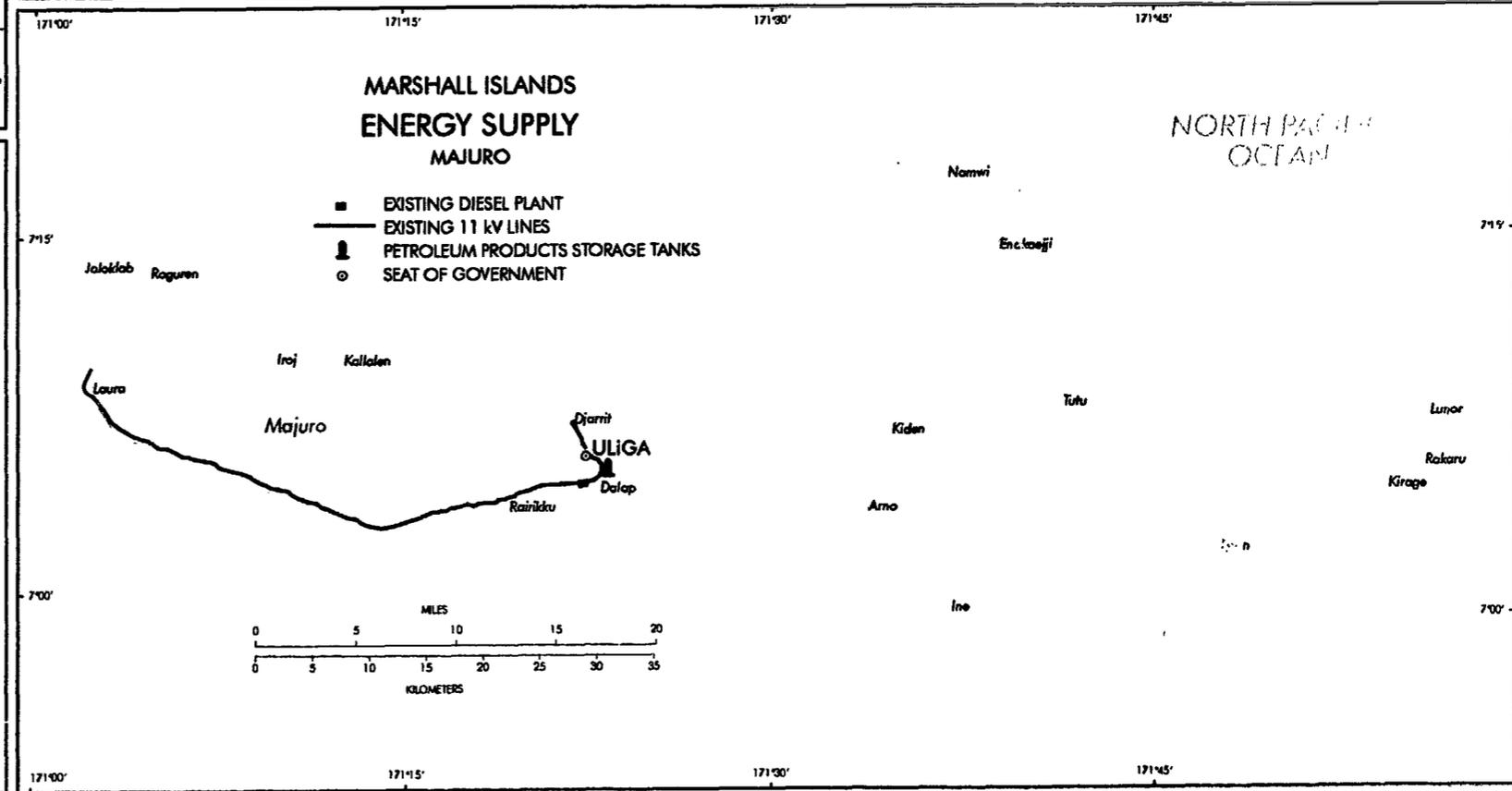
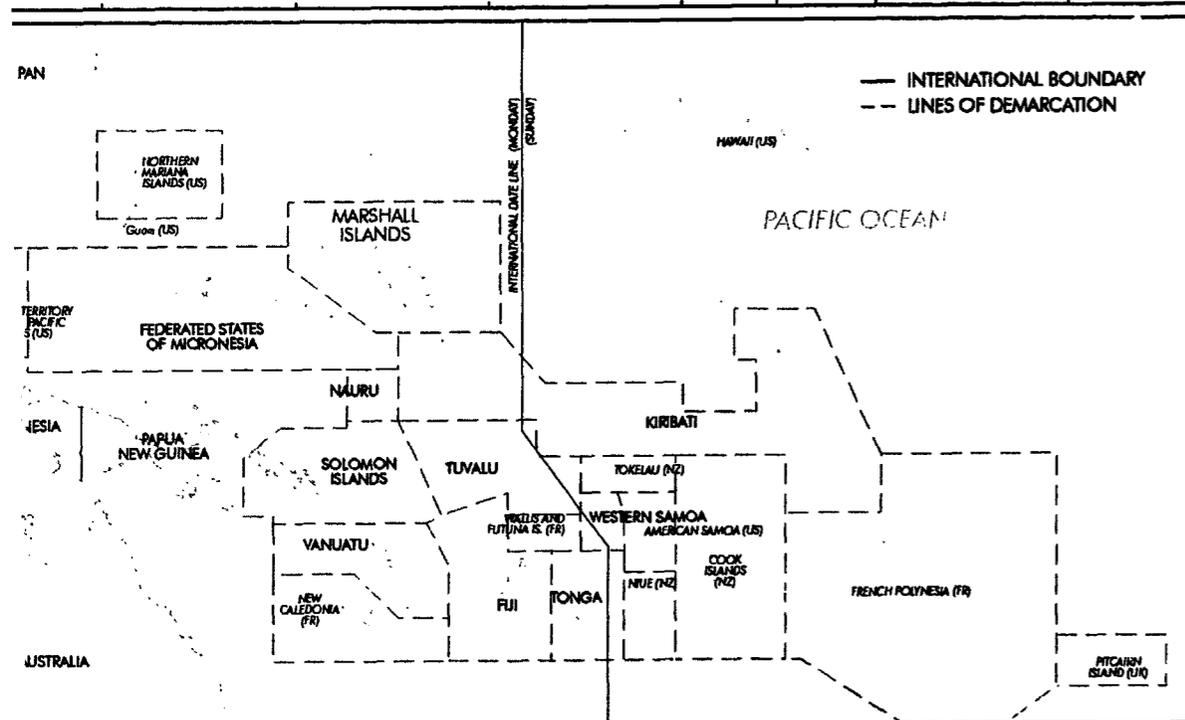
Source: Mission discussions with RMI officials; draft 1991 – 1995 development plan.

Notes: 1) Mission estimates are \$ 1 million to upgrade to safe, international standard.

2) Essentially all of the RMI's capital budget is "externally" financed as the source of funds is US Government.



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