Report No. 10441-EAP

The Federated States of Micronesia
Issues and Options in the Energy Sector
Annex B

July 31, 1992

The World Bank in Cooperation with
The UNDP/ESCAP Pacific Energy Development Programme
The Asian Developmnt Bank and the Forum Secretariat Energy Division

FOR OFFICIAL USE ONLY

Document of the World Bank

Abbreviations

ADB	Asian Development Bank
ADO	Automotive Distillate Oil
AIDAB	Australian International Development Assistance Bureau
CIF	Cost, Insurance, and Freight (included in price quoted)
DPK	Dual Purpose Kerosene
DPW	Department of Public Works
ESMAP	Energy Sector Management Assistance Program (Joint World Bank, UNDP & Bilateral donors)
FDI	Foreign Direct Investment
FOB	Free On Board
FSED	Forum Secretariat Energy Division
FSM	Federated States of Micronesia
GDP	Gross Domestic Product
MG	Millions of (U.S.) Gallons
OBP&S	Office of Budget, Planning and Statistics
OMIP	Operation and Maintenance Improvement Program (USDOI)
OTEC	Ocean Thermal Energy Conversion
PEDP	Pacific Energy Development Programme (UNDP)
PREA	Pacific Regional Energy Assessment
PU&C	Public Utilities and Contracts
PV	Photovoltaics
RON	Research Octane Number (octane "rating" for gasoline)
TOE	Tonnes of Oil Equivalent
USDOE	United States Department of Energy
USDOI	United States Department of the Interior

Currency

The official currency of the Federated States of Micronesia is the U.S. dollar.

This report is based on the findings of a mission which visited the Federated States of Micronesia from 5 through 15 February and from 23 through 28 February 1991 visiting all four states (Chuuk, Kosrae, Pohnpei, and Yap) 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).

TABLE OF CONTENTS

List of Tables, Figures, and Annexes

Page

List of Tables in main text

List of Figures

Annex 1: Statistical Tables

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	1.04
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 km^2 = 100 hectares = 0.386 mi^2
	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 converson 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. **Overall.** The Federated States of Micronesia (FSM) has a population of over 100,000 people increasing by approximately 3% per year and living on approximately 65 populated (of 600 total) volcanic islands and atolls scattered over 965,000 square miles of the Pacific Ocean, located roughly midway between Hawaii and the Philippines. The FSM comprises four states (Chuuk, Kosrae, Pohnpei (the national capital), and Yap) with widely varying endowments of natural resources and population densities. Governed under a federal structure, powers and responsibilities not specifically assigned by the Constitution to the national government reside with the states, which therefore have a high degree of autonomy. The economy is highly open, with a large volume of imports - $680 (FOB) per capita in 1988, the latest data available - largely supported by Compact[1] funds and other U.S. assistance.

2. Agriculture and fishing are primarily subsistence, although small semi-commercial segments of the primary sector supply local markets. Small volumes of fish, copra, trochus shells, handicrafts and other commodities are exported. Tuna is a major resource in FSM waters, currently exploited predominantly by foreign fishing vessels. The GDP[2] of $1,500 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, expected to be two to four percent per year during the 1990s, depends on the private sector, particularly planned joint ventures involving tuna processing and tourism.

3. Although energy use patterns vary considerably from state to state, a few generalizations can be made. Due to inefficiencies in the production and delivery of energy to consumers, particularly in the power sector, a large portion of the country's financial resources has been directed to the energy sector. In all states, there is an abundance of installed electrical generating plant in relation to load which, due to poor maintenance and other factors, is often barely sufficient to meet peak demand. Installed capacity per capita in FSM, at more than 370 kW, is high in comparison with other countries in the region, nearly triple the corresponding figure in relatively well-developed Fiji, for example. There are separate petroleum supply contracts with each state and thus cost penalties associated with low volumes. Moreover, a proliferation of retail outlets for petroleum products results in high fixed costs in the supply of fuels to consumers. With a growth strategy based on energy-intensive development (tourism and fish processing), the government of the Federated States of Micronesia[3] needs to assure that energy is acquired and sold on reasonable terms and supplied much more efficiently than at present.

4. **Petroleum.** Imported petroleum products dominate the national energy economy accounting for 88% of primary energy use and 99% of commercial energy. 1990 consumption of 500 kg of oil per capita is approximately 6% by value of total imports (FOB, 1988, higher in later years) equivalent to 76% of export earnings. Mobil is the only

---

1 "Compact of Free Association" between the FSM and U.S., providing a 15-year assistance program (1986 - 2001) and specific rights for the U.S.

2 Provisional 1988 government estimate at 1988 market prices.

3 In this report referenced as the "national government" or "FSM". State governments are referenced by name, e.g., the government of Chuuk, the government of Pohnpei, etc.

marketer[4], a situation which is unlikely to change due to Mobil's efficiency of supply logistics and ownership of bulk storage on the main islands of all four states. Mobil has a separate supply agreement with each state, some (Pohnpei and Chuuk) dating to 1982. The terms are not unreasonable but some provisions, such as FOB prices based solely on posted Singapore prices, should be reviewed in any new supply agreements.

5. The main petroleum sector issues are the lack of competition in the supply of petroleum products to FSM, the proliferation of service stations and associated high fixed costs, the security of supply and the cost implications of improving security, the absence of price monitoring, non administration of the supply contracts by the states or the national government, concern over product quality and the grades of gasoline being marketed, declining physical standards of storage facilities in several states, the absence of fuel storage and handling standards, and the inadequacy of data collection resulting in reliance on Mobil for volume and pricing information. The most critical problems are on Chuuk and Pohnpei with deteriorating on-shore storage and encroaching commercial development in the immediate vicinity of storage.

6. **Electricity.** There is no national power company. Four utilities provide diesel-generated electricity to Moen (Chuuk), Kosrae, Pohnpei, and Yap. Chuuk and Pohnpei accounted for roughly a third each of total generation in 1990, with 20% and 13% respectively in Yap and Kosrae. With the exception of the electrified outer islands of Ulithi and Woleai in Yap, generation is restricted to the main islands of the respective states, which contain 85% of the country's population. About 27% of all national households and over 40% of those on the main islands are connected. The technical condition of the power generating capacity varies considerably by state with Pohnpei and Chuuk showing the greatest signs of neglect and deterioration; maintenance standards are better in Kosrae and Yap. In all states however, power cuts, low voltage levels and voltage fluctuations are frequent due to heavily loaded generation and distribution systems with inadequate maintenance. The power plants in all states are subject to much-reduced working lives because of poor maintenance, necessitating a greater investment in capacity and higher fixed costs than would otherwise be required. Although the power systems in FSM are among the most capital-intensive of the predominantly diesel-based systems in the region, much of the capital equipment has been run down very quickly and therefore produces little output per dollar expended relative to other countries in the region.

7. Tariffs are heavily subsidised throughout FSM with no state recovering more than 20% of costs, metering is inadequate[5], and revenue collection is poor. The total 1990 subsidy to electricity consumers was about $11.2 million. Management responsibility for the power utilities of each state is fragmented across several government departments, with power system operation and maintenance generally separate from metering, billing, and revenue collection, which is further separate from responsibility for the budget. Pohnpei and Yap are taking steps to centralise management responsibility within state utilities. With better planning, more efficient institutional organisation, and especially improved maintenance, considerable improvements in power system reliability, quality of power, and returns on investment can be achieved. In addition, in all states except Kosrae, additional capacity can be deferred by using existing capacity more effectively.

---

[4] With the exception of a minor volume of lubricants supplied by Shell in Yap.

[5] Tariffs have not even been officially set in Chuuk, due to an almost total absence of metering.

8. Key electricity issues include exceptionally poor maintenance, the institutional structure of state utilities, poor power sector planning and operation 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. The immediate sectoral priorities are organising the state utilities into financially autonomous corporations, refurbishing run-down plant, metering of all customers, improving revenue collections, and introducing a clear policy of steadily increasing the electricity price with the goal of eventually meeting full costs.

9. **Household and rural energy.** Hydroelectric generation in Pohnpei, biomass for cooking and photovoltaics for small electric loads are the only significant uses of local renewable energy resources. Three state governments have identified solar photovoltaic (PV) electrification as a priority for remote communities. About fifty small PV systems have been installed in the remote parts of three states but many have reportedly failed or deteriorated due to poor planning and maintenance. Key issues are a lack of clear responsibility at the national level leading to inadequate mechanisms for the disbursement of available aid funds to support PV programs, insufficient and poorly trained staff, and likely failure of programs in Chuuk and Pohnpei if maintenance does not improve.

10. **Environmental issues.** In general, the main power stations are adequately distant from residential and office areas, with the exception of Kosrae, where the power station is adjacent to the government offices, creating a noise nuisance. Lube oil is recycled or burned and reportedly no transformers use hazardous polychlorinated biphenyl (PCB) fluids. In Pohnpei, there is risk of marine oil pollution in the event of mishap in the ill-maintained barge which houses the main power station. A further serious issue is the danger of water pollution and fire due to deficiencies in fuel storage and handling, especially in Chuuk and Pohnpei. Adequate standards should be introduced soon and be strictly enforced.

11. **Institutional issues.** Within the state and national governments, there is no structure for coordinating or overseeing energy matters or the key subsectors of electricity and petroleum. As a result there are no clear state or national policies, planning is negligible, and the basic data required for informed decision-making are not collected. Reliable records of petroleum import volumes and values are generally not available in the state or national governments, so that the country is dependent on Mobil for basic information. There is no routine administration of supply contracts in any state or the national government; it has been the experience in other countries that considerable savings can result if qualified persons are appointed in government to verify that the supplier is adhering to contract provisions.

12. The state power utilities are poorly organised and heavily subsidized. The advantages and disadvantages of eventually combining the four state utilities into a single national utility should be carefully considered; loss of state autonomy in power sector investment decisions under a national utility, for example, could be outweighed by the advantages of standardizing equipment, national fuel tendering, developing a national program for training, attracting overseas finance on better terms, allocating power sector expertise where needs are greatest, etc.

13. Restructured utilities, whether state or national, will require expertise not available locally; temporary overseas recruitments are likely to be required to assist in management. Aside from reorganization, training in virtually all aspects of power utility operations is *the* priority need. In all states, power sector operational and maintenance expertise is in critically short supply and senior management capable of taking responsibility for

autonomous utility corporations is lacking. With the assistance of qualified temporary overseas personnel, coupled with greater allocations of resources to training than in the past, FSM can develop a comprehensive power sector training programme to ensure that trained local managers will be available for FSM's corporatised power utilities within the 1990s. This is a reasonable goal, however, only if FSM begins a well-coordinated effort in all states now.

PRINCIPAL RECOMMENDATIONS

14. **Petroleum Subsector.** The following immediate measures are recommended:

a) 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 (all states);

b) further development in the vicinity of the fuel storage facilities in Pohnpei should be prohibited and measures taken to mitigate the impact of likely oil pollution to the hotel and fisheries project that are located there now;

c) the national government should attempt to persuade the states of the benefits of organising a national tender for fuel supplies (i.e., consolidating the current state contracts) and begin the coordinating work required for a national tender; if a national tender is not possible, some provisions of the outdated 1982 Mobil supply agreements in Pohnpei and Chuuk should be renegotiated;

d) the national government should appoint a short-term petroleum advisor for 12 - 24 months to assist with negotiating a national supply agreement, improving storage, and assessing the overall supply and pricing arrangements; and

e) existing and new agreements should be routinely administered.

The following short-to-medium term measures are recommended:

f) national regulations on the storage and handling of fuels should be adopted and enforced; and

g) storage facilities in Chuuk should be reconditioned to an internationally-accepted standard.

15. **Power Subsector.** The following immediate measures are recommended for all states except where specified:

a) enact legislation to centralize all power utility management functions, including operation and maintenance, planning, procurement, metering, billing, revenue collection, budgeting, etc., under one authority;

b) organize a consultancy to determine manpower requirements of the restructured state power utilities;

c) begin recruitment for senior management positions as soon as possible, both locally and where necessary, overseas;

d) establish training programs for all state power systems including on-the-job training, studies overseas, and apprenticeships for technical staff; and formal degree courses and on-the-job training by overseas professionals working with local under-studies for managerial staff;

e) immediately improve metering, disconnection and collection procedures, install meters and require payment from all customers, including government;

f) introduce a tariff of 10/kWh for all consumers in all states, followed by annual increases in gradual steps to their full costs (including capital costs) over a period of five years or less with extensive prior publicity explaining the new policy,

g) as tariffs are increased, introduce subsidized "lifeline tariffs" for the first 100 kWh per month of household consumption (set at about 10/kWh or half of the normal household tariff, whichever is lower);

h) purchase vans, tools, equipment and spare parts and rehabilitate the stores and workshops to enable the staff to undertake preventive maintenance and customer service; and

i) rehabilitate the substation at the power station in Chuuk.

The following short-to-medium term measures are recommended for all states except where specified:

j) establish standard utility budgeting and accounting systems, systematize collection and analysis of statistical data (in a consistent format in all states), prepare system maps of the distribution system, and investigate the causes of poor voltage and outages in the system;

k) adopt realistic short-term power and energy demand forecasts based on higher tariffs and likely economic developments;

l) when new capacity is needed, study the feasibility of bringing out-of-service capacity back on-line before purchasing new plant, and refurbishing operating equipment to increase efficiency and output;

m) in Kosrae, determine the feasibility of refurbishing the old Caterpillar and White Superior gensets and purchasing equipment to synchronize them with the 1.5 MW Caterpillar commissioned in 1990;

n) in Chuuk and Pohnpei, systematically upgrade the distribution systems where outages and/or low voltage are serious problems;

o) in Chuuk, conduct a feasibility study prior to rehabilitating the Dublon power system and transfer responsibility for the power facilities at Dublon to the state Bureau of Public Works; and

p) seriously consider the option of combining all state power utilities into one national power utility.

16. **Household and Rural Energy.** The following measures are recommended:

a) carry out household energy end-use surveys in all states 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;

b) 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.

c) standardize stand-alone PV systems for supplying small electric loads on outer islands;

d) charge a monthly bill to all recipients of government-provided PV systems which is sufficient to cover at least maintenance costs; and

e) strengthen the capacity of the state Energy Offices to plan, install and systematically maintain photovoltaic systems through improved training, staffing, and budgets.

17. **Energy and the Environment.** The following measures are recommended:

a) inspect and refurbish or replace (as required) the ALCO barge in Pohnpei; and

b) improve fuel storage and handling procedures.

18. **Institutional Development.** The following measures are recommended:

a) The national government should train local officials or recruit expertise to monitor fuel supply contracts, and begin monitoring wholesale and retail prices of gasoline, distillate and kerosene to establish guidelines for fair prices;

b) allocate responsibility for national energy sector coordination to a specific national government department (Office of Resources and Development) 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

c) increase the capacity of state government Energy Offices to oversee PV programs, household energy surveys, and rural energy matters in general.

I. ECONOMIC AND INSTITUTIONAL CONTEXT

ENERGY AND THE ECONOMY[1]

1.1 The Federated States of Micronesia (FSM), consisting of the states of Chuuk, Kosrae, Pohnpei, and Yap, is a mixed market-subsistence economy. The market economy is driven by a large public sector which is sustained by external assistance, largely from the U.S. Estimated GDP increased from $106.5 million in 1983 to $144.7 million[2] (about $1,500 per capita) in 1988, of which nearly 30 percent was subsistence production. There has been almost no growth in real per capita GDP since 1983. Investment in 1988 declined both absolutely and proportionately compared with 1983: whereas private fixed investment increased from $3.7 million to $13.5 million, government investment declined from $34.1 million to $21.1 million. Future growth of the economy depends on the nation's ability to utilize U.S. Compact funds - a 15-year assistance package for FSM granted by the U.S. under an agreement signed in 1986 - and other external investment to develop the private sector. Commercial fishing and tourism have the most potential for becoming market-oriented growth sectors.

1.2 Since the late 1950s, population growth has averaged 3% per annum and now totals about 101,000. In all states a growing proportion of the population lives in or near the state capital urban area[3]; the outer islands population share has declined from 30% of the total in the 1950s to about 15% currently. The population is young, with an estimated 47% below the age of 15. As the age group 20 - 29 is expected to increase at the highest rate (3.6% per annum), the economy faces a severe challenge to create sufficient jobs to absorb new entrants to the labor force. The average annual growth rate of the labor force since 1980 has been about 4% which appears to exceed the economy's capacity to create new employment. The 1989 unemployment rate was 27%.

1.3 Under the Compact, FSM citizens may freely migrate to the U.S. Although no firm data exist, migration overseas is believed to be increasing with the rising population density and continued stagnant economic conditions, especially in Chuuk. Migration is expected to become an increasingly important economic safety valve during the 1990s[4].

1.4 Government expenditures constitute the primary driving force in the FSM economy. The dominant source of revenues to support public sector spending is U.S. Compact funding, the amount of which is essentially determined through the year 2001. Scheduled step-downs in Compact funds mean a decline in government revenues in real terms, unless private sector growth can generate sufficient local tax revenues to offset the decline in U.S.

---

1 This section is extracted and summarized from *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, Honolulu, May 1991), prepared as a background report for this assessment. The ADB's *Economic Report on the Federated States of Micronesia* (December 1990) and the FSM government's draft 1990-1994 *Second National Development Plan* (1990) were also very useful background documents.

2 Government estimates of GDP exist only for 1983 and 1988, and are considered provisional.

3 Weno (Chuuk), Lelu (Kosrae), Kolonia (Pohnpei), and Colonia (Yap).

4 Among states there is a large variation of GDP per capita. The 1988 per capita GDP for FSM was $1,523, but state GDP ranged from a low of $1,027 (Chuuk) to a high of $2,272 in Kosrae. Pohnpei and Yap are $1,732 and $2,209, respectively.

assistance, although this is considered unlikely. Increased foreign assistance from non-U.S. sources could partially offset the decline in U.S. funding.

1.5 The government's economic strategy is to stimulate private sector growth and development through fiscal intervention, targeting commercial fisheries as the leading development sector. Longline tuna transshipment facilities are planned as joint-ventures with foreign investors in each of the states. The viability of the industry will depend critically on the ability to service fishing fleets competitively at FSM bases, and to transport fish to export markets. Airfreight capacity will be a key variable in enabling the FSM to exploit the lucrative fresh fish market in Japan and the U.S.

1.6 FSM's tuna resource is abundant. In 1988 more than 190,000 tonnes of tuna were harvested, mainly by purse seiners. In addition, the longline fishery (about 15,000 tonnes in 1988) has the most potential for development for exports. Longliners catch deepwater tuna (best suited for sashimi) such as Bigeye and Yellowfin, of which the probable sustainable yield of FSM waters is believed to be well over 100,000 tonnes per annum. Current plans are for investment of over $30 million in new longline basing facilities to be constructed in Chuuk and Yap, a fish loining/packaging operation to process and export fish caught by purse seiners and smaller vessels of the local fishing fleet in Chuuk, and fishing transshipment facilities in both Pohnpei and Kosrae. In each state the longline fisheries ultimately expect to achieve peak monthly catches of 2,000 to 3,000 tonnes[5].

1.7 Agriculture, together with artisanal fishing, is at present a predominantly subsistence activity with little potential for growth. Tourism, however, is a promising development sector, but the rate of growth is likely to be influenced by the effectiveness with which government facilitates foreign investment, and the extent to which infrastructure problems are resolved, particularly the quality of water and electric power services. In the 1983-1989 period, visitor arrivals grew at an average annual rate of nearly 15%. Tourism development will depend largely on private sector initiative, and is likely to require significant Foreign Direct Investment (FDI) since, unlike the fisheries sector, government has largely opted not to become actively involved in tourism enterprises. Both fishing and tourism developments, if successful, could significantly alter the pattern of energy demand in FSM. Fisheries may require increased capacity for ADO bunkers, while expanded tourism would increase demand for air, land and sea transportation, as well as for electricity.

1.8 FSM's limited resource base remains largely undeveloped. Total exports ranged from $4.0 to $5.4 million between 1984 and 1988, including visitor expenditures, which in 1988 were estimated at about $3.1 million. Commodity exports in 1988 were only $2.3 million, principally copra, fish, trochus shells and handicrafts. The largest category of imports was food, beverages and tobacco, accounting for between 41 and 47 percent of total imports in the five-year period ending in 1988 and 35 percent in 1989 ($24.7 million FOB). With the very low volume of exports, there is a substantial trade deficit: about $86 million in 1988 after adding estimated freight and insurance costs[6].

1.9 In 1988 state and national combined government revenues amounted to $165.1 million, equivalent to nearly 115% of GDP. External assistance ($136.7 million), mainly U.S.

---

[5] An ADB fisheries sector review was underway as this report was being prepared. The review was not yet available but is believed to be not optimistic about prospects for large-scale commercial fishing in Micronesia.

[6] Imports in FSM are valued FOB.

Compact funds, accounted for 83 percent of total receipts and 118 percent of total expenditures ($115.5 million). In both 1988 and 1989, an overall budgetary surplus was achieved, mainly the result of the start of Compact funding in 1987 while transitional funding, especially for Capital Improvement Program[7] (CIP) projects, was still being received for projects funded under the former UN Trusteeship. Future total receipts are expected to decline as U.S. federal program grants are discontinued[8]. Total government revenues from domestic sources in 1988 amounted to $20.6 million, about 12.5% of expenditures. Fishing rights fees amounted to $7.7 million in 1988 and about $10.3 million in 1989.

1.10 Externally generated revenues other than U.S. assistance amounted to only $0.4 million in 1988. Although FSM can expect to receive some technical assistance from the Asian Development Bank (which it joined in 1990) and several other international organizations and some bilateral aid from Japan and other countries, Compact funds will be the primary source of revenue for government, and via government spending, income to the FSM economy. Under the Compact, however, U.S. grant funds are scheduled to decline at five year intervals, to about $60 million per year in constant-dollar terms by 1997 from about $86 million per year in the 1987-1991 period[9].

1.11 Throughout the 1990s, FSM will thus be hard pressed to maintain total government expenditures in real terms at 1988 and 1989 levels ($115.4 and $125.8 million, respectively). If local tax revenues are optimistically assumed to increase at 15% per annum on average, and other revenues including fishing rights fees to increase at 5%, total government revenues in real terms would amount to about $107 million in 1995 and $103 million in 2000[10].

1.12 In an attempt to accelerate development of the productive sectors of the economy, the FSM national government is issuing $300 million in medium-term government notes in the U.S. capital market, pledging future Compact funding as security. The Medium Term Notes program will in effect allow the national and state governments to borrow against diminishing future Compact receipts to finance increased expenditures (mainly for development projects) in the present. By early 1991, approximately $28 million from the program had been obligated[11]. It is understood that proceeds from the sale of notes will be allocated among the states and the national government according to the same formula used to disburse annual Compact payments.

---

[7] The Capital Improvement Program is a long term USDOI-funded program to improve infrastructure quality and maintenance.

[8] Federal program funding dating from the pre-Compact period was $33.4 million in 1988 and $19.9 million in 1989. However, beginning in fiscal 1990, only $2.85 million per annum in non-Compact U.S. program funding is expected.

[9] The FSM may be eligible for additional Compact funding up to $40 million, contingent on the FSM government demonstrating adverse impact on the economy of Title IV (Compact Agreement), which relates to certain changes made to U.S. trade and tax provisions relating to the FSM after the Agreement was originally negotiated.

[10] Assuming an average inflation rate of 5% per annum. These projections do not include non-U.S. foreign assistance.

[11] Capital expenditures amounted to about $19.6 million (17 percent) of the total 1988 government budget of $115.5 million.

1.13 While the Medium Term Notes program will permit funds to flow at a faster rate into productive sectors of the FSM economy, it raises several matters for concern. Firstly, it will involve a substantial net interest cost to FSM, much of which will come due at the end of the Compact period. Secondly, it is questionable whether FSM can absorb a vastly increased rate of investment without increasing the risk of project failures, particularly in view of the limited resource base and the fact that the development planning process in the country is to a large extent decentralized. There is a significant risk that the program could result in a net loss of national resources by the end of the Compact period. Thirdly, as the bond issue may lead to a potentially rapid increase in the money supply, the prospect of increased inflation is real.

1.14 Growth in real GDP in FSM through the 1990s is expected to range from 2%-4% per annum on average, with the lower rate premised on achieving limited success in developing a national fishing industry but no significant increase in the rate of foreign investment.

INSTITUTIONAL FRAMEWORK

1.15 **Overall.** There is no effective national government structure with overall responsibility for the energy sector. The Department of Resources and Development (R&D) is responsible for energy planning and disbursing U.S. grant funds to the states for photovoltaic and other rural energy and conservation projects, but apparently does not identify issues and constraints and makes only limited attempts to develop policies and strategies. The Office of Planning and Statistics (OPS) is responsible for the five-year development planning process including energy issues but relies on others for energy sector data and analysis. Nevertheless, the draft Second National Development Plan[12] contains a good assessment of the national energy situation and identifies a number of worthwhile initiatives including proposals to strengthen the role of national government in energy planning, fuel tendering, and assisting the states in management of the energy sector, especially in relation to the commercialisation of state power utilities.

1.16 Energy planners were appointed to the national government and each state in 1981, initially funded by the USDOE (now ended), but the position is vacant in Chuuk and has been abolished in Yap. Energy planners are still employed in Pohnpei and Kosrae, with primary responsibilities to oversee photovoltaic and other rural energy projects. However, there is little budgetary support for design, planning, travel, or maintenance.

1.17 **Petroleum.** Petroleum products are imported by Mobil Oil (Guam) with bulk storage facilities in Weno (Chuuk), Kosrae, Pohnpei, Yap, and Ulithi (Yap). The proliferation of service stations, all privately owned, in each state is partly responsible for high onshore costs; savings to consumers should result if the number were reduced. There is no wholesale or retail price control and no legal requirements for product quality, storage, or handling. Each state's Customs Department calculates tax revenues based on oil company submissions but does not verify the volumes of fuel imported or their value. A supply contract negotiated with Mobil in 1982 is still in effect on Chuuk and Pohnpei, and similar contracts have been in effect in Kosrae and Yap since 1987, but none has ever been effectively administered by the state governments concerned.

1.18 **Power.** Electricity is generated and distributed by the Public Works Departments of Chuuk, Kosrae, and Pohnpei and by the Department of Public Utilities & Contracts in

[12] The Second National Development Plan (1990-1994) was produced in draft in 1990 but has not been officially released.

Yap. All utilities are under local management and rely to a very limited extent on expatriates. In all states, management responsibility for power operations is fragmented among several Ministries, with Public Works generally responsible for operation and maintenance, while Treasury/Finance departments oversee billing, revenue collection, and financial management. Such fragmented responsibilities often lead to inefficiencies and inappropriate budget allocations, both of which increase the utilities' operating deficits and their need for direct subsidy support from the respective governments. Some states, notably Chuuk and Pohnpei, have taken steps to correct these problems by consolidating power utility management under new government-owned corporations. However, training efforts and the level of staff development in all utilities are poor, and are areas that have yet to be seriously addressed.

II. ENERGY CONSUMPTION

THE STRUCTURE OF ENERGY CONSUMPTION

2.1 No household energy end-use surveys or industrial censuses have been carried out in FSM from which energy use could be derived, nor are any studies of energy end-use in government or commerce. A Household Income and Expenditure Survey[13] was carried out in 1988 and 1989, but contains no energy consumption data. Accordingly, the national energy balances (Statistical Annex) are estimated. About 88% of all energy use in the FSM is derived from petroleum, 11% from biomass, and 1% from hydro. About 60% of all imported petroleum is used for transportation, 33% for electricity generation, 5% by government[14] and 2% by households.

CONSUMPTION OF PETROLEUM PRODUCTS

2.2 Petroleum product imports have increased from 12.4 million U.S. gallons (MG) in 1986 to 15.9 MG in 1990, an average annual rate of 6.4%, excluding a negligible amount of ocean bunkers[15]. The 1990 import level corresponds to about 1040 barrels per day. Of the inland demand (87% of total demand), low sulphur automotive diesel oil (ADO) accounted for 6.4 MG (46%), jet fuel[16] for 2.3 MG (17%), gasoline for 4.1 MG (30%), and kerosene 0.3 MG (2%). The balance of inland demand was made up of minor products such as aviation gasoline, lubricating oil, and solvents. International ships' bunkers of ADO added 2 MG or 13% to total demand. Government accounts for over half of the total petroleum use by state for power generation, construction, and transportation in Kosrae and Yap, and 30%-35% in Chuuk and Pohnpei.

2.3 Growth in petroleum imports has varied considerably by state. Whereas import volumes in Chuuk and Yap have been nearly static since 1986 and have increased only slightly in Kosrae, the increase in Pohnpei has been exceptionally high, averaging almost 17% per year. The growth in Pohnpei is concentrated in the transportation sector, with both gasoline and jet fuel use increasing markedly, possibly due to the relocation of the national capital to Palikir outside of Kolonia and an increase in Air Micronesia's scheduled and chartered air traffic through Pohnpei. Imports of ADO also increased significantly in Pohnpei during the period, mainly due to increased fishing activity.

2.4 Estimates of fuel consumption by economic sector are summarized in Table 2.1. The same breakdown in Tonnes of Oil Equivalent (TOE) is shown in the 1990 energy balance (Tables 3 and 3a) in the Statistical Annex.

---

[13] *Results of the Household Income and Expenditure Survey in the Federated States of Micronesia, 1988-1989, Final Report*, UNDP Project TTP/86/203, February 1990.

[14] For uses other than electricity generation or transportation.

[15] Historically insignificant, ocean bunkering in FSM will become much more important in the 1990s if the states' plans for fisheries developments are realised.

[16] The entire volume of jet fuel is treated as re-exports, that is, fuel used for international flights, although some is used for inter-state travel.

Table 2.1: FSM Petroleum Consumption by Sectors, 1990
(volumes in thousands of U.S. gallons)

SECTOR	TOTAL FSM		CHUUK		KOSRAE		POHNPEI		YAP	
	Volume	percent	Volume	percent	Volume	percent	Volume	percent	Volume	percent
Urban electricity	5251	33.1	1570	26.8	652	47.5	1924	32.4	1105	40.7
Rural electricity	46	0.2	na		na		na		46	1.7
Total electricity	5297	33.3	1570	26.8	652	47.5	1924	32.4	1151	42.4
Road transport	4800	30.2	2141	36.5	168	12.2	1806	30.4	685	25.2
Air transport	2334	14.7	1105	18.8	103	7.5	903	15.2	223	8.2
Sea transport	2422	15.2	783	13.3	356	25.9	1058	17.8	225	8.3
Total transport	9556	60.1	4029	68.6	627	45.7	3767	63.5	1133	41.8
Government	735	4.6	138	2.4	70	5.1	115	1.9	412	15.2
Household	299	1.9	132	2.2	23	1.7	127	2.1	17	0.6
Totals	15887	100.0	5869	100.0	1372	100.0	5933	100.0	2713	100.0

na = not available
Sources: State Departments of Public Works, state Departments of Budget, Planning and Statistics, and state Customs offices.

2.5 **Electric Power Generation.** Electricity production, which accounts for 33% of petroleum fuel use, is entirely from ADO except for a small amount of hydro output (3.7% of FSM electrical energy production in 1990) on Pohnpei and a few photovoltaic installations in three states. Urban electrification, defined as all electricity produced (including power from privately-owned standby generators) in the main urban area of each state, consumed about 5.3 MG in 1990. Diesel-powered rural electrification on Ulithi and Woleai in Yap consumed about 46,000 gallons; an unknown but small amount was consumed in private generators on other islands throughout FSM.

2.6 **Transportation.** The transport sector accounted for 60% of FSM's 1990 petroleum consumption as follows: road transport 30%, air including international 15%, and sea including bunkers 15%.

2.7 *Road transport.* Per capita consumption of gasoline appears to be higher than elsewhere in Micronesia[17], possible because road mileage (both paved and unpaved roads) is higher, especially in Pohnpei. Road vehicles used 4.8 MG of fuel, highest in Chuuk at 2.1 MG (42.9 gallons per capita), followed by Pohnpei at 1.8 MG (54.5 gallons per capita). The growth rate in automotive fuel consumption from 1986-1990 was highest in Pohnpei (over 15% per year) followed by Kosrae (almost 12% per year), but in Chuuk and Yap was close to zero. Growth in gasoline demand in Chuuk is constrained by the poor quality of roads; improvements to the road infrastructure there are likely to result in substantially increased gasoline demand. Based on the reported plans of some states to upgrade main road networks (in Pohnpei and Yap, major improvements have recently been completed or are

[17] For example, 1990 fuel use per capita for road transport in FSM (48 gallons) was significantly higher than in the Marshall Islands (25 gallons).

underway), gasoline consumption in FSM is expected to increase in the 1990s at a somewhat higher rate than population and economic growth.

2.8 *Air transport.* Fuel used for air transportation is mostly dual purpose kerosene (also called aviation turbine fuel, avtur or Jet A1) with a minor volume of aviation gasoline used by private air services. The total volume of 2.3 MG is consumed by Continental/Air Micronesia, the main carrier providing commercial air services to the FSM. The promotion of the states as bases for joint venture tuna fishing companies may considerably increase air traffic in Pohnpei and Chuuk, which hope to serve the sashimi markets in Japan and Honolulu[18].

2.9 Air Micronesia is a long-established carrier operating a Boeing 727 aircraft four to five times a week on regularly-scheduled flights stopping at most of the main islands between Honolulu and Guam. When traffic warrants, a DC-10 is used. Air Micronesia prefers to use Guam as a refuelling stop using FSM as little as possible, uplifting only 0.2 MG of a total 2.6 MG per month[19], due to high costs.

2.10 *Sea Transport.* Sea transportation consumes 15% of fuel demand or 2.4 MG, mainly distillate (nearly 2 MG[20] of bunkers for fishing vessels in 1990) except for a small volume of gasoline used for fishing, local transportation and pleasure. About 0.2 MG of ADO were used in Chuuk, and lesser amounts in other states, by government-owned inter-island transport vessels. However, growth in demand for ADO since 1986 has come mainly from the fishing industry, a trend which will accelerate if the states' plans for fisheries development come to fruition during the 1990s.

2.11 **Government and commercial use.** Direct government and commercial fuel consumption (not for electricity production) of 0.74 MG or 4.6% of total FSM demand includes construction, road maintenance, direct heating and other uses. This is mainly ADO.

2.12 **Household and Other.** Household consumption comprises mainly lighting and cooking estimated at slightly under 0.3 MG of kerosene and an unknown but probably very small amount of liquid petroleum gas[21], mostly in locations without electricity, and 25,000 gallons of gasoline and ADO, adding up to just under 2% of total FSM fuel use.

CONSUMPTION OF ELECTRICITY

2.13 Because of poor metering and billing in most states, only limited data exist on consumption trends for electricity. Billing records are nonexistent in Chuuk, and are extremely sparse in Yap, where the billing system was not functioning between June 1990 and the first quarter of 1991. Billing records exist in Kosrae, but are not collated or

---

[18] A Japanese company which freights fish from Micronesia to Japan using a Boeing 727 aircraft already uses Chuuk occasionally for this purpose.

[19] Average monthly figures for 1990 were provided by Air Micronesia.

[20] 480,000 gallons in Chuuk, 356,000 in Kosrae, 1,050,000 in Pohnpei, and 81,000 in Yap.

[21] The estimate of kerosene use by households (275,000 U.S. gallons) is based on household energy end-use surveys carried out in other Pacific Island countries during the 1980s which indicate that FSM households would consume 250 - 450 thousand gallons of kerosene, probably closer to the low estimate. Imports of LPG in FSM do not appear in the available records, but it is assumed that small quantities are used.

summed and therefore cannot be used for analysis of consumption patterns. In Pohnpei, however, a computerized billing system in use since October 1990 provides tentative results[22]. Estimates of end-use consumption are therefore based on the latest billing records where available, although in some cases an entire year had to be extrapolated from a single month's records. Estimates for consumption growth are based on recent generation data which are reasonably complete, with records kept since 1987 in all states. Consumption in years prior to 1990 is estimated based on gross generation and assumed levels of transmission/distribution losses and station use.

2.14 Growth in energy consumption and peak output in the FSM averaged about 7.1% per year between 1987 and 1990, varying considerably by state. Growth was lowest in Chuuk at 4.1% per year with a peak load in 1990 of 3.4 MW. Growth in both Pohnpei and Yap averaged about 6.7% per year, with 1990 peak outputs of about 5.2 MW and 2.5 MW respectively. In Kosrae, energy consumption grew at an average annual rate exceeding 15% per year, and peak output grew from 770 to 1,300 kW, probably a reflection of the extension of the power grid during that period.

2.15 As shown in Table 2.2, consumption for FSM overall is evenly split between residential and commercial/government with a high percentage of unmetered use in all states. Unmetered consumption includes "estimated" sales and unbilled consumption, both of which are highest in Chuuk where virtually all customers are unmetered, and accounts for over half and about a third, respectively, of consumption in Yap and Kosrae. In percentage terms, unmetered consumption is least in Pohnpei, due to a more effective billing system.

---

[22] Prior to October 1990, Pohnpei used a manual billing system which apparently operated well, although it was not capable of aggregating customer records conveniently for analysis.

Table 2.2: Summary of Electricity Generation and Consumption, 1990 (GWh)

	Gross Generation	Technical losses incl station use	Electricity Consumption Residential	Commercial[1]	Unmetered[2]	Total
Chuuk	20.6	3.7	na	na	16.9 (100%)	16.9 (100%)
Kosrae	8.5	1.5	2.7 (39%)	2.2 (31%)	2.1 (30%)	7.0 (100%)
Pohnpei	25.1	4.5	8.3 (40%)	8.9 (43%)	3.4 (17%)	20.6 (100%)
Yap[3]	13.2	2.4	2.6 (24%)	1.8 (17%)	6.4 (59%)	10.8 (100%)
Total	67.4	12.1	13.6 (25%)	12.9 (23%)	28.8 (52%)	55.3 (100%)

Notes: 1. Includes billed government consumption.
2. Includes both "estimated" and unbilled consumption, plus streetlights.
3. Includes Ulithi and Woleai. Billing data are estimates based on December 1989 and first six months of 1990; the billing system has not functioned since June 1990, but was scheduled to resume during 1991.

na = not available. Sources: state Departments of Public Works and mission estimates.

2.16 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 diesel stations elsewhere) and transmission/distribution losses are assumed to be 14% of energy sent out in each system, based on the condition and loading of the distribution system.

2.17 Although billing records are incomplete, they suggest that the average consumption of electricity per residential consumer in FSM is high by Pacific Islands standards: almost 300 kWh/month in Kosrae, 250 in Yap, and over 400 kWh per month in Pohnpei, compared to 50 - 100 kWh per month typical in other countries in the region[23]. Average consumption in Chuuk is unknown but it is believed to be comparable to the rest of FSM. Although the causes of high residential (and commercial) consumption are not known in detail, it is clear that much of it is wasted. There is no incentive for households to conserve electricity. For example, air-conditioners are widely used in an uncontrolled manner in spaces that are not insulated or well enclosed. Due to low tariffs, household lighting relies extensively on incandescent rather than more efficient but more expensive fluorescent fixtures. For the same reason, the use of electricity for cooking is probably much higher than it is in other Pacific Island countries[24], although cooking with other fuels such as kerosene and LPG is more efficient. Most commercial cooking is probably done with electricity since the use of

[23] 100 kWh/month in Fiji in 1990, for example, 65 in Kiribati, and 28 in Tuvalu. In PNG, where consumption is skewed by relatively high-income expatriate households, average monthly household consumption is 260 kWh.

[24] Electricity is seldom used for cooking in Pacific Island countries such as Fiji, Kiribati, and Tonga, where electricity is not highly subsidised.

LPG is extremely limited. It can be expected that if the government subsidies to electricity drop and tariffs rise to full cost, such uses will be curtailed. It is recommended that measures be taken to assist residential consumers to reduce consumption and lessen the impact of tariff increases, such as encouraging more efficient use of air-conditioners, switching to fluorescent lighting, etc.

2.18 There are about 5,830 consumers, as shown in Table 2.3, of which about 80% are residential and 20% commercial or government.

Table 2.3: Number of Electricity Consumers by Category, 1990

	Residential Metered	Residential Unmetered	Commercial Metered[1]	Commercial Unmetered[1]	Total
Chuuk[2]	0	1310	0	390	1700
Kosrae	772	na	142	na	914
Pohnpei	1599	na	481	na	2080
Yap	870	100	151	13	1134
Total	3241	1410	774	403	5828
Share	56%	24%	13%	7%	100%

Notes: 1) Includes government.
2. A 1990 government survey of customers in Chuuk (Moen) produced estimated bills for 1075 residential customers and 25 commercial customers. Both counts are believed to be well below the true number of customers of each category connected to the power supply. The above are mission estimates based on the per capita consumption patterns of Pohnpei.
na = not available. Source: state Departments of Public Works

2.19 With high residential loads and probable heavy use of electricity for cooking, the peak load in each state[25] occurs in the evening (6:00 - 9:00 pm), except in Yap, where the peak occurs in the afternoon (1:00 - 3:00 pm) due to a high daytime air-conditioning load (also present but smaller in Kosrae and Chuuk), as shown in Figure 2.1. Load factors[26] are high (above 0.75) in Chuuk, Kosrae, and Yap, and about 0.65 in Pohnpei but will probably decline as tariffs increase and average consumption falls. However, they have shown little variation since 1987, indicating that peak load has been increasing at roughly the same high rate (about 7% per year overall) as electricity consumption.

[25] Daily load curve data are extremely limited in all states and unavailable in Pohnpei. These estimates of peak load are provisional only.

[26] The ratio of average load to peak load (kW).

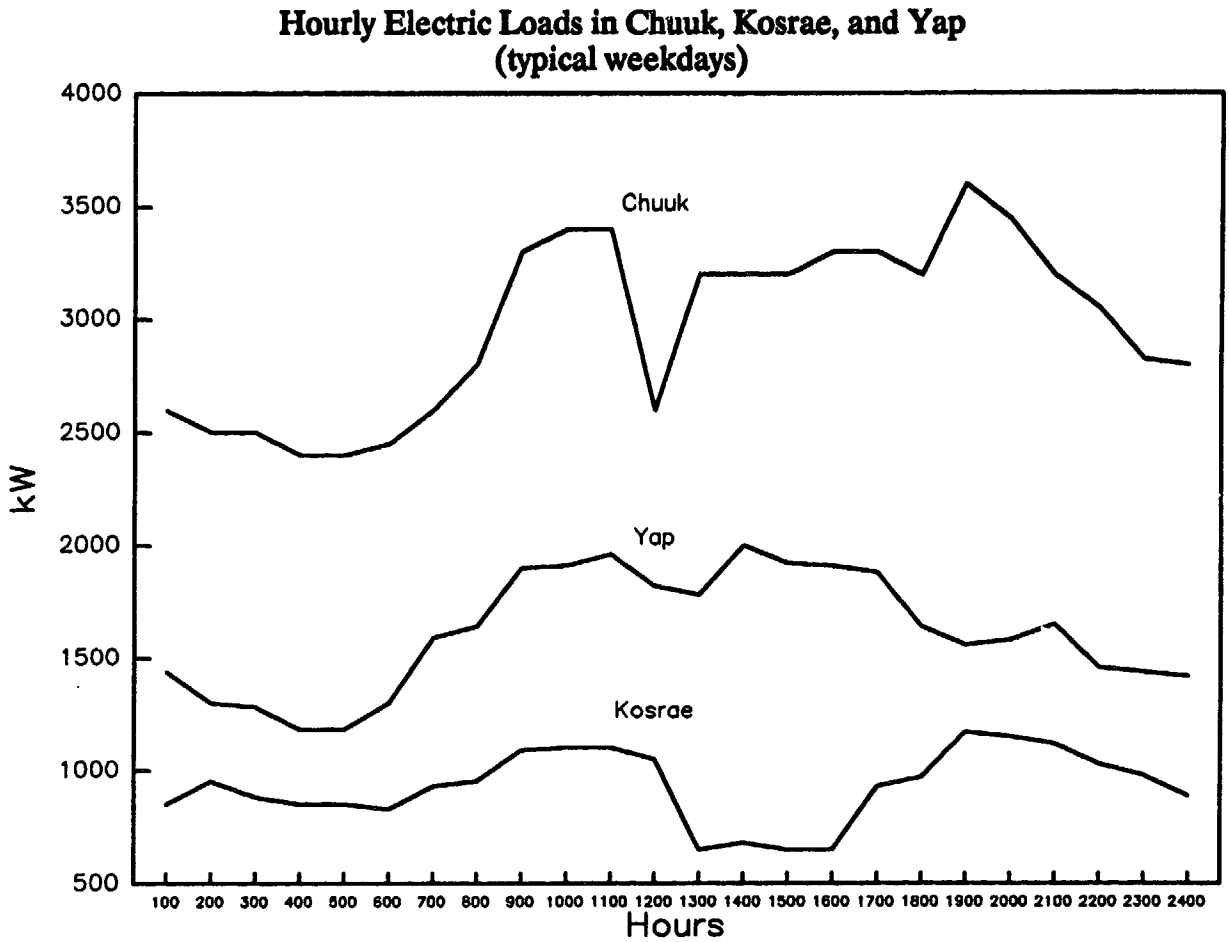


Figure 2.1

2.20 As shown in Figures 2.2 - 2.5, with scheduled capacity additions in 1991 and 1992 in Chuuk and Pohnpei respectively, all states except for Kosrae will enjoy large capacity reserve margins through the 1990s even under sustained high growth in power demand. As a result of the commissioning of a new 1.5 MW diesel engine/generator in Kosrae in November 1990, which due to a lack of synchronization equipment cannot be operated in parallel with the other smaller machines, there is a marked "lumpiness" in available capacity and additions are still needed to provide increased security of supply.

2.21 The higher of the two growth rates in demand shown in each of Figures 2.2 - 2.5 corresponds to the trends of 1986 - 1990; the lower corresponds to the estimated effect of progressive tariff increases.

Firm Capacity and Peak Demand (MW): Chuuk

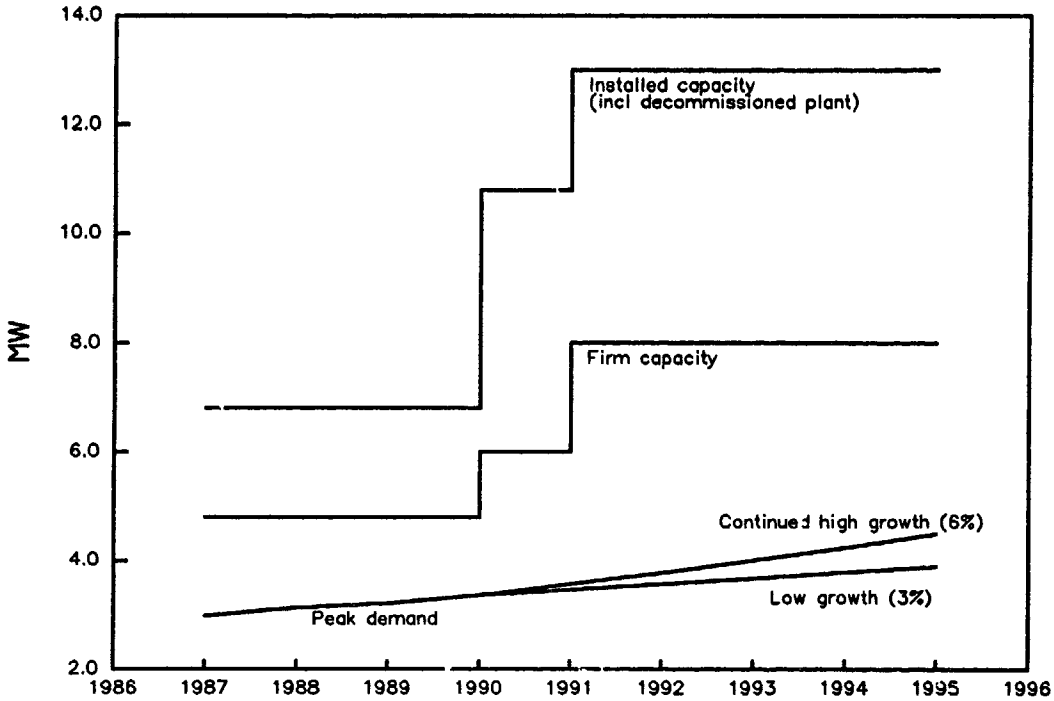


Figure 2.2

Firm Capacity and Peak Demand (MW): Kosrae

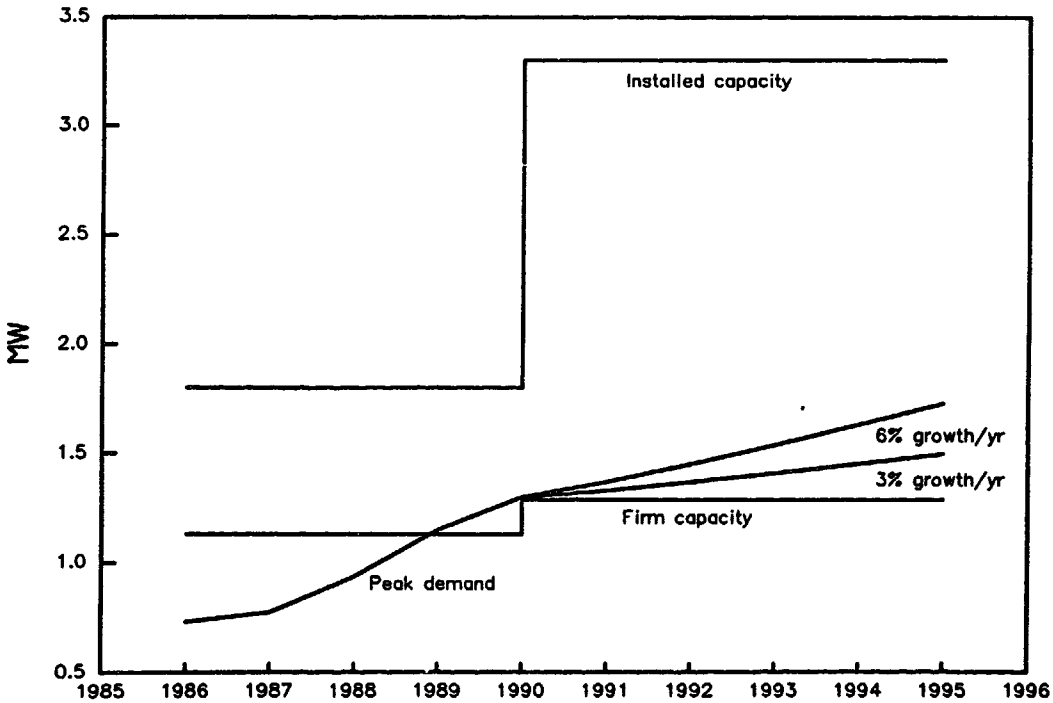


Figure 2.3

Firm Capacity and Peak Demand (MW): Pohnpei

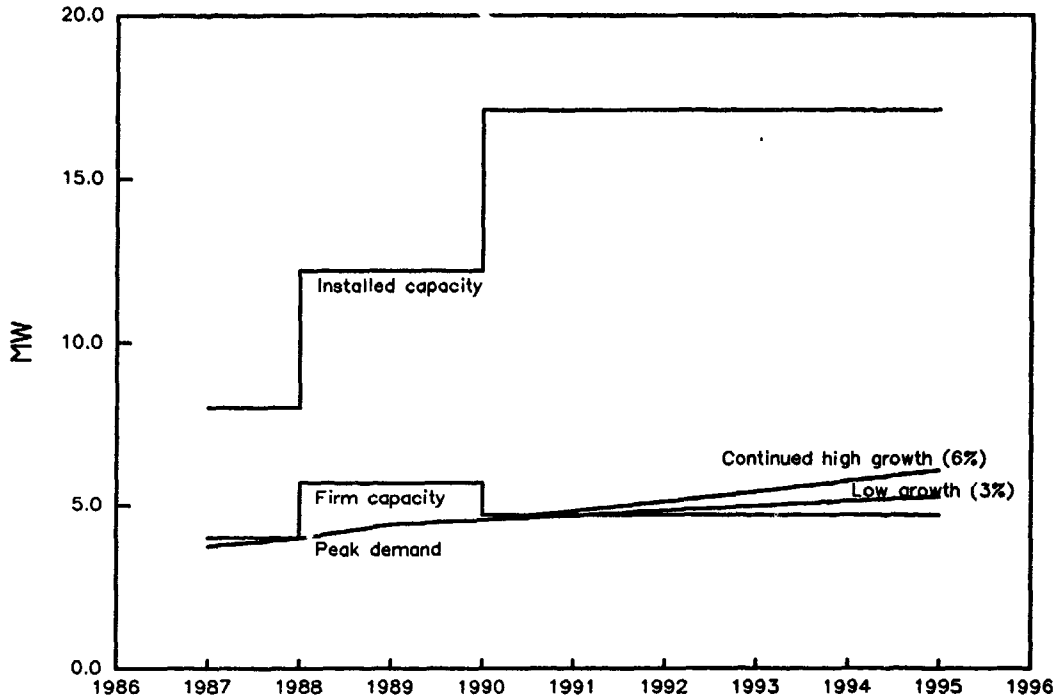


Figure 2.4

Firm Capacity and Peak Demand (MW): Yap

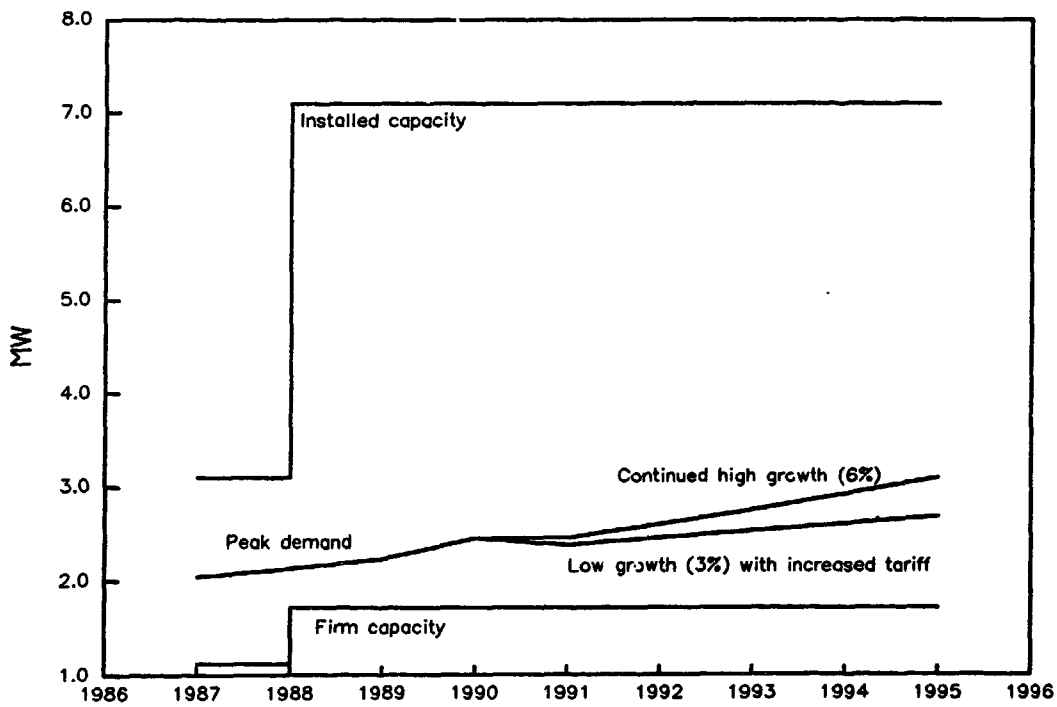


Figure 2.5

CONSUMPTION OF BIOMASS

2.22 The percentage of households which cook primarily with fuelwood in FSM is not known. Based on recent censuses and household energy end-use surveys[27] carried out in neighboring countries and in the region, it is estimated that 10%-20% of families in FSM cook primarily with fuelwood and consume 1.6 kg/capita/day (3.3 lbs) of biomass, and that all other households use 0.25 kg/capita/day (0.5 lbs) for occasional cooking and other uses, for a total of 16,500 tonnes in 1990. Copra drying consumes an estimated 6,000 tonnes of coconut wastes based on the average 1974 - 1988 copra production[28] of 2,500 tonnes with 2.4 tonnes of biomass to dry a tonne of copra. Only a minority of the total consumption of approximately 22,500 tonnes of biomass is coconut wastes since wood fuel is abundant. Overall, biomass accounts for slightly under 11% of primary energy, compared to 30 - 60% for most South Pacific island countries.

DEMAND PROJECTIONS

2.23 *Inland trade and aviation.* Real GDP growth in the 1990s is assumed to range between 2% and 4% per year. For the high growth case, inland fuel consumption is estimated to grow at 6% overall through the year 2000 (5% and 6% for ADO and gasoline respectively and 9% for Jet A1; 2% and 3% for kerosene and avgas respectively). Power generation would grow at 6%, or nearly the 1986 - 1990 rate, and 3% in the low growth case. The low growth case assumes an average annual increase of 3% for ADO used in power generation, road transport fuel growing at 3%, jet fuel increasing at 6% and kerosene and avgas growing at 1% each.

2.24 *Ships' bunkers.* Both projections would change significantly if major projects such as the fisheries projects now proposed by the states are successful. As the states' expectations for tuna fishing are optimistic and tuna fishing is fuel-intensive, it is difficult to estimate 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.

Table 2.4: Fuel Consumption Per Tuna Vessel
(Thousands of U.S. gallons per year)

Vessel	Size	Fuel use
seiners	1100 ton	515 - 660
long liners	100 ton	180 - 210
pole & line	n.a.	about 130

n.a. = data not available
Source: *Fuel Use in Tuna Fishing* (Forum Fisheries Agency, PEDP, FSED, 1989).

---

27 See *Energy Statistics Relevant to Household and Rural Energy Issues in the Pacific Islands* (PEDP Report REG 90-5, October 1990).

28 1989 - 1990 data were unavailable.

2.25 Existing storage capacity in each state is adequate for needs through the 1990s if past trends in petroleum demand continue (see para 3.99). However, the states' optimistic plans for fisheries development could raise FSM's aggregate throughput of ADO bunkers by up to 70 million gallons annually (if all fuel were purchased in FSM, which is unlikely); comparatively modest fisheries development could raise bunkers by 15-20 million gallons annually by 1995, more than doubling FSM's 1990 fuel consumption. An increase of 15 million gallons annually would necessitate additional investment in on-shore storage facilities, so much so that fuel storage considerations are likely to be a powerful constraining factor in the development of fisheries. With or without rapid developments, however, it is expected that growth in petroleum demand will be concentrated in ADO and jet fuel as these products are required by fishing and tourism, both potential growth sectors in FSM.

2.26 *Electricity.* As shown in Figures 2.2 - 2.5, existing and scheduled new capacity is adequate in all states except Kosrae through the 1990s even under conditions of continued high growth. In Kosrae, further investment in new capacity (a new 1.5 MW generator was installed in October 1990), is required as soon as possible[29]. However, under conditions of steadily rising tariffs to eventually reach full cost, the high consumption growth rates of the past are not expected to continue, but to fall to about 3% per year. Thus the need for new capacity would be still further delayed, assuming existing equipment is refurbished and then adequately maintained.

[29] Investment in equipment to allow the new plant to run in parallel with the older existing machines is also recommended (see para 3.32).

III. ENERGY SUPPLY

OVERVIEW

3.1 Over 80% of the land area of FSM is under biomass (see Statistical Annex, Table 11) in the form of forests, secondary vegetation, and mixed coconut and scrubland. FSM also has an abundance of sun, waves, and possibly an attractive ocean thermal resource, although no temperature gradient profiles are known to have been measured. There are hydropower resources in Pohnpei and Kosrae which have been exploited to a limited extent. These and various other resources were assessed by the U.S. Department of Energy (USDOE) for FSM in 1982[30]. The conclusions of this report are broadly the same as those of the USDOE: considering the status of the various alternative energy technologies, relative economics, the environment of the FSM, and the existing and planned energy infrastructure, the urban population of each state will remain dependent on petroleum for transport and power for years to come. However, the USDOE also stressed energy conservation as an important energy source. In remote islands, photovoltaic systems appear to be the most feasible option for small electrical needs.

ELECTRICITY

3.2 Electric supply growth has averaged 4.1% per year since 1987 in Chuuk, 6.7% in Pohnpei and Yap, and over 15% in Kosrae or 7.1% in FSM overall, trends which could continue if electricity charges remain well below the cost of production. Despite recent new capacity additions in some states, all state power utilities are trying to cope with serious technical problems, in both their generation and transmission/distribution systems. Much of the equipment is aging, was acquired second-hand, and has been poorly maintained. Nevertheless available capacity, including newly ordered equipment, is adequate to meet load for a number of years in all states except Kosrae. Including 2 MW of hydro capacity in Pohnpei, installed capacity in the four public systems is about 37.6 MW (to increase to 42.3 MW by the end of 1992). Most of the major commercial consumers have stand-by diesel generators due to frequent power outages and low voltage from the public power supply.

3.3 Some technical comments apply to all states. Pole-mounted single-phase distribution transformers are not maintained. Due to high humidity and salt contamination, corrosion is progressing fast and flash-overs are likely to occur. The number of outages and the need to purchase replacement transformers[31] could be reduced by routine maintenance. Low voltages and voltage fluctuations are often caused by undersized distribution transformers, service connections, and housewiring. Apart from excessive losses in the distribution system, low voltage can cause breakdowns of air-conditioners, freezers, refrigerators, electric motors and other electrical appliances. A bank in Kolonia (Pohnpei) has purchased a generator to run continuously during office hours because of low voltage in the public power supply. Resources spent on repair and replacement of electric appliances as well as investments in stand-by generators by consumers trying to provide their own power during blackouts could be better spent on improved power and distribution system maintenance.

---

30 *Territorial Energy Assessment* (Report DOE/CP-0005/1, December 1982) which covered the FSM and other islands.

31 There is a considerable number of scrapped transformers in DPW's warehouse.

3.4 Poor maintenance of power stations, observable to varying degrees in all states but especially severe in Chuuk and Pohnpei, appears to have four major causes:

a) only a small portion of the funds necessary for purchasing necessary materials and spare parts is allocated in the annual budget. Maintenance funds are generally released only in response to engine failures or similar crises, and there is no provision for preventive maintenance;

b) due to the state governments' poor creditworthiness with overseas suppliers, spare parts are often purchased from unauthorized dealers, or prepayment has to be made when purchasing from authorized dealers. Consequently, purchase procedures are cumbersome and slow, and the quality of the goods purchased is questionable;

c) staff qualifications are far below those needed to operate and maintain the power system satisfactorily. With a limited budget, staff frequently improvise parts and procedures to keep the power system running, but without adequate training, improvisation can and often does lead to failure; and

d) the workshop, tools, and spare parts are below the standard required for serious maintenance and repair work.

3.5 These problems can be addressed through better training at all levels of utility operations including senior managers, and through reorganization of the utilities to allow managers greater autonomy in the budgeting process.

3.6 Part of customers' problems with poor power quality and voltage drop originate in the service connections, i.e., loose and overloaded connectors. The utilities should measure voltages on customer premises and make necessary corrections, and advise consumers on economical ways to reduce electricity consumption; an additional benefit would be improved monitoring of the distribution system.

3.7 The supply of power in each state, including rural electrification, is discussed below.

Chuuk State

3.8 Public electricity supply is provided on Moen by the Department of Public Works (DPW) which is also responsible for water, sewerage, and roads. The overriding condition that affects every aspect of DPW operations is the lack of staff training and experience, even at senior levels. The Division of Power, headed by a graduate electrical engineer assisted in the power plant by an expatriate engineer, has approximately 35 people in three departments: fifteen in Power Generation (two foremen, seven operators, three electricians and three mechanics), fifteen in Power Distribution and five in Electric Service. The operators and linesmen have no formal training and on-the-job training has not been adequate. The supervisors were trained mainly on-the-job, and the department heads are trades specialists with only limited vocational training. Consequently, operations and maintenance in the power station and distribution network are inefficient and ultimately too costly.

3.9 **Power generation.** The Moen Power Station produced about 31% of national electricity output in 1990. Installed capacity is 10.8 MW, comprising machines of a wide variety of makes and vintages: one 1,155 kW Nordberg, vintage 1960 (poor condition); two 2,000 kW Caterpillars (900 rpm) vintage 1990 (good condition); two 800 kW Caterpillars (1200 rpm), vintage 1980, one unit dismantled, the other used occasionally on standby; and two 2,035

kW ALCO engines, vintage 1975 and installed (refurbished) at Moen in 1986, one unit permanently dismantled. Average fuel efficiency (11.5 kWh/gallon) is poor. The power station is situated approximately two kilometers from the harbor, from which diesel fuel is transported daily by road.

3.10 The Caterpillar generator sets and associated electrical equipment were delivered on a turn-key basis. Spare parts are easily obtained, but training and after-sales service are reportedly poor. Although these models are designed as peaking (standby) units, they are operated on baseload duty. Therefore, increased failures, downtime and shortened life can be expected. Indeed, four 800 kW Caterpillar engines that were operating in 1984 have been removed for this reason.

3.11 The standard of maintenance and general appearance of the engines and generators is poor, although attempts are made to keep to recommended service intervals. Mechanics carry out engine repair work in a workshop area that is too small, and spare parts and tools are lacking. Considerable quantities of oil are spilled, collecting in cable trenches. The control room is poorly insulated against noise, and is cluttered with unused control panels and other instruments. Cooling water is reportedly taken from the public water system without chemical treatment, so that scales build up in the heat exchangers causing overheating and consequent derating of the engines.

3.12 **Power Distribution.** The grid from the power house substation to the Nantaku area, government buildings, and the hospital consists of an old 4.16 kV section and a more recent 13.8 kV line extending to the populated areas on the shore. The total length of the overhead lines on wooden poles is approximately 40 kilometers (24 miles). A detailed system evaluation was carried out in 1985. It is recommended that this be updated soon including preparation of maps.

3.13 The 4.16 kV system has two short feeders (numbers 1 and 2) built as a double circuit overhead line to Nantaku. Upgrading the system to 13.8 kV has been scheduled for completion by early 1992 at a cost of $270,000. However, as apparently no staff from DPW are to participate in the work, an opportunity for staff training in distribution line construction will be missed.

3.14 The 13.8 kV system has three feeders each of 8 km (5 miles) or less: heavily loaded number 3 to the southeast coast; number 4 to the airport and northeast coast; and number 5 inland to the west. Due to the short distances, voltage drops in the 13.8 kV system are not believed to be serious. The 13.8 kV lines have been extended to most villages on Moen, but many households are not connected. Extension to additional households is included in the Second National Development Plan, but is of lower priority than upgrading the presently overloaded 4.16 kV network. The condition of the 13.8 kV grid is generally acceptable, but there is insufficient tree and foliage cutting. Temporary repairs date from the early 1980s; it is recommended that permanent repairs be included within a preventive maintenance program. Strong wind and heavy rain cause frequent earth faults, short circuits, and broken conductors throughout the system, often leading to island-wide blackouts of two hours or more. Faults caused by falling trees cannot be totally avoided in view of the difficulty of obtaining permits from land owners to cut trees, but improved efforts could be made to keep the lines free from branches and foliage.

3.15 The old 4.16 kV grid is in poor condition. The poles are heavily stressed as they carry a 4.16 kV double circuit, a 13.8 kV circuit, and two telecommunication cables. Many pole-mounted transformers are corroded. The system is heavily loaded and suffers from high losses and voltage drops. It is recommended that the entire system be upgraded to 13.8 kV.

3.16 The 4.16/13.8 kV substation at the power house is poorly engineered and hazardous, as it was not designed for two voltage levels. Circuit breakers are installed on the five feeders, on two 3,000 kVA transformers operated in parallel, and on the two ALCO-generator feeders. The other generators have only disconnectors in the outdoor substation as their circuit breakers are installed in the indoor control panels. Two old 2,500 kVA transformers are kept as spares.

3.17 No diagram of the substation is available and essential information about design and performance is lacking. Upgrading the 4.16 kV distribution system cannot properly be carried out without rehabilitating the substation first. Old (1930s vintage) oil-tank circuit breakers are insufficient to control the system; others are reported to be out of operation and spare parts for their repair are lacking. At a minimum, it is recommended that all circuit breakers be maintained and the oil checked regularly, as a reported reason for system black-outs is the improper functioning of relays at the circuit breakers.

3.18 **Management.** The quality and reliability of the distribution system depends on improvements in the technical skill of the staff and the resources spent on rehabilitation and preventive maintenance. Skills can be improved through methodical on-the-job training and maximum involvement of staff in rehabilitation of the 4.16 kV network and similar projects.

3.19 Although old maps of the distribution lines may exist, updated diagrams and system data are lacking. The staff are familiar with the system configuration from daily experience, but are not capable of assessing, planning, or monitoring the system, and fault location and repair are unnecessarily complicated and time-consuming. There is no monitoring of load, voltage, or losses in the system and inadequate skills in distribution planning. The upgrading of transformers usually occurs only after a customer complains about poor voltage. These inadequacies can be eliminated by fairly simple record keeping and planning methods. No facilities for transformer maintenance and meter calibration exist. Stocks of essential parts are inadequate, but a serious attempt is being made to organize stores properly.

3.20 **Metering, billing, and revenue collection.** Consumers in Chuuk are not metered, and there are no data on the number of customers connected, let alone their consumption. However, it is understood that the state government has purchased a number of single-phase and three-phase meters for installation during 1991. It is recommended that this effort continue as a high priority until all consumers, including the government itself, are metered and are receiving timely and accurate bills[32].

3.21 **Power System Expansion.** Installed capacity in the Moen power house is 10.8 MW, peak demand is 3.4 MW and firm capacity is 6 MW. In February 1991, 8 MW of capacity (nameplate rating) was operational, but effective capacity was less due to cooling problems. DPW staff are of the opinion, which appears to be reasonable, that some of the older equipment will have to be scrapped in the near future. Even allowing for a substantial derating of the older machines, however, the 1991 reserve margin[33] remains ample at around 75%.

---

[32] The Department of Public Works is attempting to increase revenues in the interim by billing consumers based on a 1990 survey of appliance ownership.

[33] Firm capacity over peak demand expressed as a percentage, where firm capacity is the total installed operational capacity less the capacity of the largest generating unit.

3.22 If all engines were refurbished and their full ratings restored, firm capacity would increase to 8.8 MW and the reserve margin to 159%, indicating that existing capacity is sufficient to meet likely growth during the 1990s. However, maintaining an adequate reserve margin depends primarily on good maintenance and a stock of spare parts sufficient for timely repairs. With more than half of the capacity consisting of relatively old engines which are increasingly difficult to service, only 6 - 7 MW of the capacity in Moen can be considered "firm". Therefore new capacity will be needed when peak demand on the power system approaches 5.5 or 6 MW well towards the end of the 1990s.

3.23 The Chuuk state Office of Planning and Statistics predicts substantial but unquantified demand increases during the early 1990s, mostly from fisheries and tourism development. However, commensurate rapid increases in peak load are not expected to occur even if all development goals are realized, since the developments are unlikely to place coincident demands on the system. Delays in some or all of the projects are probable, particularly when the largest investments are concentrated within a few years, as is presently planned for fisheries. Investing in excess capacity to meet future load which never materializes is an expensive mistake which can be avoided with proper planning and realistic assessments of future demands. It is too early for Chuuk to begin planning power system expansions to cater for major new economic developments, since available capacity is sufficient to cover contingencies until 1995 or later. It is recommended that government carefully monitor load growth and the energy consumption of each customer category and establish realistic short and medium term forecasts of both economic development and probable growth in peak demand. The need for new generation or transmission capacity should be determined only on the basis of approved and confirmed projects.

3.24 A new 900 rpm 2.2 MW Caterpillar was due to be shipped to Moen by mid-1991 at a landed cost of approximately $0.8 million. The generator is apparently one of two intended to replace the two aging ALCO units, which are to be overhauled and transferred elsewhere. As no island other than Moen within Chuuk state is currently electrified, it is difficult to see where the ALCO units could be usefully deployed within the state, but it is possible that Pohnpei or Yap (which use equipment of the same make) might be interested in taking the units if offered at a low cost. However, these units would provide the most benefit to Chuuk if they were overhauled and used for baseload duty, which would be far less expensive than replacing them with new capacity as planned. If properly maintained, the refurbished ALCO units should provide at least ten more years of reliable service; the benefit of new capacity purchased now is therefore practically nil. A critical precondition for reliable service is, however, proper maintenance supported by good staff training. Considerable savings to the state would result from avoiding investments in new capacity in favor of utilizing existing capacity more effectively. These savings may mean the difference between a reliable power system that consumers can afford and one which becomes an increasing burden on limited state finances.

3.25 It is recommended that the ALCO units be overhauled by an experienced contractor, preferably jointly with the utilities on Pohnpei and Yap so that better terms can be negotiated. The contract should include training and employment of local staff in the overhaul work as well as a performance guarantee for the operating life of the overhauled engines of at least five years. A professional engineer should be engaged to supervise the contractor. Based on the tendered costs and the expected residual lifetime, an economic and financial comparison of the overhaul option and the purchase of new generators can be made.

3.26 If the purchase of the Caterpillar unit cannot be cancelled, the inoperable ALCO unit should be kept for spare parts for the operable one, which should remain in service for

several more years with adequate maintenance. It is recommended that the Nordberg engine not be overhauled, but be scrapped when major repairs become necessary.

3.27 **Rehabilitation of the distribution system.** Low voltage and losses are concentrated in the 4.16 kV grid to the Nantaku area, which DPW plans to upgrade to 13.8 kV. This upgrade is justified as it will improve service quality, reduce losses and maintenance cost, and simplify the system.

3.28 It is recommended that further investments be based on detailed technical analysis of the distribution system, including mapping, measurements of loadings and voltages at critical points and an evaluation of losses. Possible use of capacitors should be investigated. A protection scheme for the system should be designed, covering the circuit breakers in the substation, sectionalizers, and simple fault indicators on the lines. Automatic reclosers in the grid are not likely to be necessary. Technical assistance is needed for the analysis and design work required.

Kosrae State

3.29 Kosrae's power system is the smallest in FSM, serving less than 1,000 consumers and accounting for less than 13% of FSM's gross generation in 1990. The generation and distribution of electricity is the responsibility of the state Department of Public Works, although in early 1991 plans were being made to reorganize the power system as an independent utility. There are 14 station operators and mechanics working in the powerhouse at Tofol, entirely local except for an expatriate chief mechanic. The Department of Public Works employs five electricians to maintain the distribution system.

3.30 **Generation.** Total nameplate generation capacity in the power house is 3.3 MW, but firm capacity is only 1.3 MW since almost half of the installed capacity consists of one engine/generator set and all of the smaller sets have been derated. Installed plant comprises one 1.5 MW Caterpillar 900 rpm diesel set installed in November 1990, two 300 kW White Superior sets (both derated to 200 kW) installed in 1984 and three 400 kW Caterpillar 900 rpm sets (each derated to 300 kW), of which two were installed in 1984 and one in 1980. In 1990, Kosrae produced about 8.5 GWh (see Table 6 in the Statistical Annex) and peak load was 1.3 MW.

3.31 Baseload generation is provided by the 1.5 MW machine operating alone; due to a lack of synchronization equipment, the older generators cannot be operated in parallel with it. The addition of the 1.5 MW machine in November 1990, which more than doubled installed capacity, did not add commensurately to firm capacity[34]. Actual reserves - the difference between firm capacity and peak load - are negative. Between 1986 and 1990, load grew at approximately 12% per year, indicating a reserve deficit of about 150 kW in 1991 and 300 kW in 1992, if the growth trend continues. New capacity is needed as soon as possible.

3.32 It is recommended that in planning for new capacity, an effort be made to optimize the configuration of the power house in light of the present "lumpiness" in the capacity mix. In particular, planners should attempt to make use of the older units as peaking capacity by synchronizing them with the existing and future baseload units; otherwise a much larger increment of new capacity will be required to ensure an adequate reserve margin. It is

[34] Firm capacity is a measure of the minimum or "worst case" capacity assumed to be available at all times, and is usually calculated as the sum of *derated* installed capacity less the capacity of the largest unit.

recommended that a study be undertaken to determine whether the technical condition of the older machines would permit synchronization and whether such a step would be financially feasible.

3.33 **Management.** Training is carried out on-the-job, mainly by the expatriate chief mechanic. In February 1991, one of the White Superior engines was partially dismantled for overhaul by the local staff, and was awaiting spare parts. However, the power house staff (except for the foreman and the chief mechanic) lack professional qualifications. A formal training program in both the mechanical and electrical trades is recommended.

3.34 Station records are kept reasonably well: a report of basic operating statistics including energy generation, power demand, fuel and lube use is prepared every month. Technical specifications for the baseload 1.5 MW power plant and the 13.8 kV distribution system are probably available since all of those items were installed in 1990. Therefore, construction drawings are up to date; it is recommended that maps of the new system be prepared if these are not already available and be kept up to date.

3.35 **Metering, billing, and revenue collection.** Customer records are maintained by the Department of Finance, which is also responsible for reading meters and issuing bills. According to the billing records of November 1990, there are 914 metered customers, of which 772 or 85% are residential and the rest are commercial or government. The number of unmetered and unbilled consumers is unknown. However, billing methods do not appear to be effective: as of November 1990, uncollected revenues were equivalent to more than a year of billings. It is recommended that collection procedures be tightened through more rigorous enforcement of disconnection policy and that a meter survey be undertaken to ensure that all consumers are metered.

3.36 **Distribution.** The distribution system consists of three 13.8 kV feeders extending from the power house substation at Tofol: two along the north end of the island to the airport and Lelu and another southwards to Utwe (see map, after Annex 4). These extensions were completed in 1990 and are in excellent condition; losses are assumed to be light. An extension of the line between Utwe and the airport to complete the circumference of the island is reportedly planned, but timing is uncertain. The condition, loading, and losses of the heavily loaded feeder to Lelu is unknown, but upgrading of the feeder is reportedly underway.

3.37 The government of Kosrae has plans to transfer responsibility for managing and operating the power sector from the Department of Public Works to an autonomous power utility which is expected to be established by December 1991. To assist the new utility and to address the capacity deficit, it is recommended that a power development study be carried out in Kosrae to determine: (1) the tariff level which should be charged to recover costs, (2) realistic future load growth trends under rising tariffs, (3) the suitability of the older machines in the power house to serve as peaking units, and the cost of installing synchronizing equipment, and (4) the optimal addition of new capacity to the power house given the present capacity mix.

Pohnpei State

3.38 The generation and distribution of Pohnpei's public electricity supply is the responsibility of the state Department of Public Works (DPW). With no engineering background, no managerial or technical support and inadequate funds, the DPW's Chief of Utilities (who is also responsible for water and sewerage), is overburdened. The Power Division employs twenty operators, six mechanics, four electricians, five linesmen and

seven assistant linesmen. An expatriate electrical engineer has been hired by USDOI on contract to manage the Nanpil hydro station.

3.39 Total public generation capacity is 17.3 MW, comprising eleven diesel engine-generators totalling 15.5 MW and a run-of-river hydro plant of 1.8 MW. These facilities are the largest in FSM, producing about 37% of the national public power output in 1990. The diesel capacity is installed in three locations: on a barge moored near the fuel depot and airport, at the inland power station Nanpohnmal, and at a trailer installation at the Palikir national Government Complex, which is meant to be stand-by capacity and is owned and operated by the national government. Most large commercial consumers have stand-by diesel generators. Due to a number of serious breakdowns, derating of units, and the dry season, only 6.6 MW was available in February 1991; it is understood that available capacity dropped to 4.7 MW in May (taking into account the temporary outage of one 1.1 MW machine at Nanpohnmal for repair). If urgent refurbishment and repair work is completed, firm capacity will be 6.6 MW; otherwise, it is only 4.7 MW (as shown in Table 3.1)[35].

3.40 **The ALCO Barge Diesel Power Station.** Four medium-speed ALCO diesel-generators originally rated at 2 MW each and manufactured around 1975 are installed on a barge moored in the harbor one kilometer from Kolonia. Due to overheating, the generators have been derated to 1.9 MW, and are normally not operated continuously above 1.8 MW. The barge with the plant was acquired second hand from Canada by the USDOI and reconditioned in the U.S. before delivery in 1986.

3.41 The condition of the plant is extemely poor; it was never properly commissioned after delivery to Pohnpei. Unit 1 has never been in service and has been cannibalized for spare parts for the other engines. The generator of Unit 2 has burned out, probably due to an incorrect setting of the generator breaker relay, and was to be shipped to the U.S. for a $76,000 repair which is likely to take six months. Unit 3 is also out of service awaiting spare parts. In February 1991, only Unit 4 was operating; it is understood that by April or May of 1991, Unit 4 was also taken out of service.

3.42 The barge itself is not maintained and is heavily corroded. A serious leakage could be fatal to the power plant. During a typhoon several years ago the power house was damaged, but has been repaired to an acceptable standard. The outdoor 13.8 kV switchyard is placed on the foredeck. A single feeder transmits power to the substation at the original (derelict) power station in Kolonia.

3.43 **The Nanpohnmal Diesel Power Station.** The Nanpohnmal station is situated inland approximately five kilometers from Kolonia and the port facilities, with a total installed capacity of 5.8 MW comprising six high-speed (1,200 rpm) Caterpillar diesel sets. Units 1, 2, and 3 are 800 kW D399 sets and Units 4, 5, and 6 are 1,135 kW T3516 sets. The station is designed for peak load and stand-by operation, but has been forced to operate on baseload duty because of a shortage of operable capacity at the barge. The 800 kW units are due for

[35] Counting only capacity at the barge (6 MW) and at Nanpohnmal (5.8 MW), and assuming that the largest machine in *each* power station is out of service. As the power stations in Pohnpei are interconnected, however, it can be argued that this definition is unreasonably restrictive. An alternative method of computing firm capacity in this case, suggested by a power sector consultant with considerable experience in the region, is to sum the available capacity in the two power stations, subtract the largest unit of the interconnected system, and multiply the difference by 0.8. This method, considered fair for an interconnected system, yields a higher firm capacity rating for Pohnpei: 7.8 MW *vs* 4.7 MW under the previous definition.

6,000 hours overhaul in 1991, while the 1,135 kW units are new. In February 1991, Unit 4 was out of service for repair.

3.44 All of the engine/generator sets including control boards and other electrical equipment were delivered turn-key from Hawaii. Spare parts are easily obtained, but after-sales service and training is reportedly inadequate. The wall separating the control room and the engine hall is poorly insulated and noise in the control room is unacceptably high.

3.45 As the engines are fairly new, the standard of maintenance cannot be evaluated, but as of mid-1991 no steps have been taken to begin overhauls. Small high-speed engines need regular and timely overhauls if an acceptable life is to be obtained. Operation of the units continuously on baseload duty will require special attention to maintenance.

3.46 **Nanpil Hydro Power Station.** Nanpil is a highly automated run-of-river hydro station located near Kolonia, commissioned in 1988. It is equipped with two generators of 725 kW and 1,335 kW capacity, although the design of the intake limits output to 1.8 MW at maximum flow. The plant's energy output was designed to be 4,000 MWh per average hydrological year, or about 19% of the gross generation on Pohnpei in 1988. However, flows since 1988 have not met expectations, and generation in 1989 and 1990 amounted to only 3,300 and 2,300 MWh respectively.

3.47 The plant is supervised by an expatriate electrical engineer who is working full time under a USDOI contract. Eight local operators work in four shifts. One operator must be stationed at the intake to remove materials when the plant is operating. The local crew are proficient at running the station, which has achieved an excellent availability of 99.5% when water is flowing (about half the year). Continued good operation of the plant will require permanent supervision by a trained engineer. Because there are lengthy dry periods, the plant does not contribute to Pohnpei's firm generating capacity, but when operating saves overall costs by reducing fuel use and some maintenance expense on the diesel engines, at no negative environmental impact.

3.48 **Palikir Stand-by Generator.** A 1.6 MW Caterpillar stand-by engine/generator is located at Palikir, owned and operated by the national government. Primarily a back-up unit for the national government offices, it is installed in a mobile container, connected to the 13.8 kV grid and sometimes used to supply power to the state grid. It has been out of service during part of 1991 for unknown reasons.

3.49 **The Distribution System.** The distribution grid consists of an old 4.16 kV system in Kolonia town and a recently-constructed 13.8 kV system which circles the island. The total length of the overhead lines is approximately 160 km (100 miles) and the number of poles exceeds 2,000. The 4.16 kV system comprises two feeders from the substation located at the derelict power station in Kolonia, where a 1,500 kVA 13.8/4.16 kV step-down transformer is installed. Another substation is located at Nanpohnmal with a 3,750 kVA 13.8/4.16 kV step-down transformer. Feeder No. 2 has been extended to the 4.16 kV busbar at Nanpohnmal, indicating that Kolonia town is supplied from two sides. An old transformer is kept in reserve at Nanpohnmal.

3.50 The 13.8 kV system includes a six kilometer (3.6 mile) overhead line which forms a "backbone" between the ALCO barge, which generates at 13.8 kV, and the Nanpohnmal diesel power plant. From the "backbone", the 13.8 kV grid has been extended to the new parts of Kolonia, Sokehs, Palikir, the hospital and the Nanpil hydro plant. A 60 km (36 mile) ring along the coastal road was completed in 1989. The northern part of the 13.8 kV system was built around 1980 with wooden poles, while the recently-completed southern

part was built with concrete poles in order to increase durability and resistance to falling trees.

3.51 There has been a moratorium on the connection of new consumers in Pohnpei since mid-1990 to restrain demand growth due to limited capacity. It is understood that the backlog of requests for new connections exceeded 200 in early 1991.

3.52 The condition of the 13.8 kV grid is fairly good outside Kolonia, but as in other states there is insufficient tree cutting and foliage clearance along the line which contributes to frequent earth faults, short circuits, and broken conductors. The old 4.16 kV Kolonia grid, however, is aging and overloaded. Power cuts occur about twice a week on average, primarily because of a lack of systematic, preventive maintenance of the lines, poles, transformers and switches. There are insufficient distances between the 4.16 kV conductors which are often slack due to frequent emergency repairs. There are many heavily loaded poles throughout the 4.16 kV system, i.e., poles carrying 13.8 kV, 4.16 kV and up to four telecommunication cables as well as transformers and a number of service drops. Most of the poles are fifteen years old and are recommended to be checked for rot; some angle poles should be guyed or reinforced if possible. The cross-arms suffer from rot but these are changed when detected. Line repairs are carried out every Saturday when scheduled power cuts of four to six hours' duration are announced.

3.53 Overloading of the 4.16 kV system causes low voltage and high losses. Voltage drops are severe (greater than 10%), and the system is vulnerable to outages due to heavy winds and earth faults. The frequent black-outs are reportedly due to poorly functioning relays at the circuit breakers. Circuit breakers are installed at all feeding points of the 13.8 and 4.16 kV grid, but isolation of faulted lines can be difficult to obtain with low short-circuit power in the generators and with parallel 13.8 and 4.16 kV lines between two generating points. It is recommended that the two 50-ampere fuses protecting the 60 km line around the island be replaced with relay-operated circuit breakers (preferably with automatic reclosure) in order to clear distant line faults. At present, however, every short-circuit or earth fault reportedly causes the whole system to black-out.

3.54 **Management.** Staff skills in monitoring power plant and distribution performance, troubleshooting, and planning are not adequate to overcome the technical problems facing the power system. However, even if skilled technical manpower were available, both managerial skills and the information necessary for effective management are absent. The records that management need to make informed decisions, such as daily operating data and periodic technical status reports are not available.

3.55 Similarly, technical specifications about the system are lacking. For example, construction maps of the distribution lines exist, but are out of date. Consequently fault location and repair are complicated and time-consuming. No monitoring of load, voltage, or losses in the system is carried out, and no skill in distribution planning exists. Further, there are no facilities for transformer maintenance and meter adjustment. Although stocks of many essential parts are depleted, a serious attempt has been made to organize the stores. Lack of parts, vehicles, and tools prevent dispatching of crews for preventive maintenance, monitoring of voltages, or customer service.

3.56 **Metering, billing, and revenue collection.** Metering of customers in Pohnpei is far better than in other FSM states, with state and municipal government offices metered. In

1989 there were 1,739 metered customers and 61 unmetered[36]; by 1991, the number of metered customers had risen to 2,080. Unaccounted-for consumption, which includes streetlighting, was less than 14% of gross generation in 1990, but is much higher in other states (e.g., nearly 100% in Chuuk, where metering is poorest). A computerized billing system began operating in October 1990, speeding up the billing process and providing improved sales accounting and customer record keeping.

3.57 Despite the new billing system, however, revenue collections are poor, especially from government offices. Of a total estimated billing in 1990 of $740,000 from all customers, only $500,000, or 68%, was collected. However, among government accounts (municipal, state, and national), total billing in 1990 was about $150,000, whereas collections were about $12,000, or just 8%. It can be expected that collections will improve as the Finance Department learns to use the new billing system more effectively and the disconnection policy is more rigorously enforced. It is recommended that improved collections from government accounts be enforced, possibly through special measures such as assigning responsibility for the payment of electricity bills to the heads of the respective consuming departments and giving explicit authority to the utility to disconnect any government account for nonpayment.

3.58 **Firm capacity.** Installed, available, and firm capacities of the public power supply are shown in Table 3.1.

Table 3.1: Existing Generating Capacity in Pohnpei (MW)
February 1991

	Installed	Available Feb 1991	Firm capacity	Available after repair[2]	Firm after repair
ALCO Barge	8.1	1.9	0.0	3.8	1.9
Nanpohnmal	5.8	4.7[1]	4.7	5.8	4.7
Nanpil hydro	1.8	0.0	0.0	1.8	0.0
Palikir stand-by	1.6	0.0	0.0	1.6	0.0
Total	17.3	6.6	4.7	13.0	6.6

Notes: 1) In February 1991, one 1,135 kW unit was down for temporary repairs.
2) Assuming two ALCO machines refurbished, and Palikir and one machine at Nanpohnmal repaired.
Source: mission estimates.

3.59 The nameplate capacity of 17.3 MW appears to be excessive for Pohnpei's needs, as peak demand was about 5 MW in January 1991. However, available capacity (6.6 MW) in the first quarter of 1991 was less than 40% of what is installed; by June 1991, Pohnpei was completely dependent on the "standby" Nanpohnmal station. Three engines (one each on the barge, Nanpohnmal, and at Palikir) are expected to be repaired, following which available capacity would be 13 MW. Unless repairs of those machines and the others on the barge are carried out quickly, however, it is possible that Pohnpei will be unable to meet the load in the very near future. A breakdown of another engine in the Nanpohnmal will force frequent power cuts, if they are not already necessary.

3.60 Installed *available* capacity in Pohnpei is presently 4.7 MW, peak demand is 5 MW and, assuming urgent repairs are accomplished soon, firm capacity will be 6.6 MW. The

[36] As reported in the Pohnpei State Statistical Yearbook for 1990.

run-of-river hydro capacity cannot be considered "firm" as no water storage exists. The stand-by unit at Palikir similarly cannot be included as its purpose is to provide standby power to the capital. With firm capacity of 6.6 MW, the 1991 reserve margin is reasonable at around 32%. New capacity will be needed when peak demand approaches 6 MW, which at the present rate of demand growth would occur in 1995. However, the adequacy of any reserve margin depends on ensuring high reliability of the engines. Firm capacity would be quickly reduced below 6.6 MW if the present neglect of maintenance continues.

3.61 If all engines including Unit 1 on the ALCO barge were refurbished and their full ratings restored, firm capacity would increase to 10.7 MW and the reserve margin to 114%, indicating that existing capacity is sufficient to meet any reasonable increase in growth during the 1990s. Additional capacity in this case would be needed when peak demand approaches 10 MW, which at the present rate of demand growth would occur well after the year 2000. However, it is likely that some of the refurbished engines would need to be replaced before the end of the century.

3.62 **Future Expansion.** The Pohnpei state Office of Budget, Planning and Statistics (OBP&S) has predicted an increase in demand during 1991 - 1992 of 5.8 MW based on twenty-two identified developments, more than doubling peak demand to 10.8 MW by the end of 1992. Such rapid development is unlikely, but even if it did occur, it would not raise peak demand by a commensurate amount, since the developments are unlikely to place coincident demands on the system. Comments regarding a similar issue in Chuuk (para 3.23) apply here. In 1991, it is too early for Pohnpei to begin planning power system expansions to cater for major developments which are uncertain, since available capacity is sufficient to cover reasonable contingencies until 1995. New generation or transmission capacity should be planned on the basis of approved and confirmed projects.

3.63 Despite the uncertainty of load projections, the government must make urgent decisions about the best way to meet future power demand. Options include:

a) *Refurbishment of the ALCO barge.* If no serious rehabilitation work is undertaken soon, the barge and its entire power capacity will have to be scrapped. On the other hand, refurbishment of all four engines to the full capacity of 8 MW would leave Pohnpei with a high percentage of fairly old engines. The maximum time before replacement becomes necessary is not known, since the extent of overhaul in 1985 is unclear and no records have been kept on maintenance and later repairs.

b) *Replacement of the ALCO barge.* A 5 or 6 MW baseload low-speed engine/generator burning less expensive RFO could replace the ALCO barge. The engine could run on residual fuel oil with exhaust boilers for preheaters and with low specific fuel cost. However, to be economic, this option would require a peak demand of 10 - 15 MW, introduction of RFO, and a high degree of technical skill for maintenance. The unit could be delivered turn-key on a new barge prepared for two engines if an on-shore site is not available. This option is not recommended for the short to medium term.

c) *Nanpohnmal addition.* Two new medium speed engine-generators rated at approximately 2.5 MW each could be installed in two steps in a new power house at Nanpohnmal. This, the option recommended by OPB&S, is easy to implement and administer. The project will require a 13.8 kV substation at Nanpohnmal and at

least one new feeder[37]. The new feeder(s) should be connected to the 13.8 kV ring around the island which should be separated from the Kolonia grid.

A proposal for the supply of new engine/generators by Japanese grant aid has been presented to the state government by Japanese commercial interests. The turnkey project including power house and step-up transformer is estimated to cost $5.5 million excluding a 13.8 kV switchyard and new distribution lines. It is recommended that the government compare the costs of this option with refurbishment before committing itself to the Japanese proposal.

d) *Hydro.* The per-kW cost of the Nanpil run-of-the-river hydro plant (about $4,000) is much higher than diesel plant (about $1,000), and its capacity cannot be relied upon. The state has received a proposal for the design and construction of a new hydro power plant at Lehn Mesi (1,080 kW) and at Senipehn (210 kW), funded through Japanese grant aid. The high initial cost combined with the prospect of insufficient year-round water flows on Pohnpei probably make the small hydro option unattractive compared to diesel.

Another option under consideration is increasing the catchment area of the existing Nanpil plant at a cost of some $6 million. Additional output is not known, since detailed hydrological studies have not been completed. The economic viability of this option, which appears to be doubtful based on the present estimate of costs, should be evaluated when engineering studies are completed.

e) *Coal.* Transport costs of imported coal, which has been suggested as an option, are probably prohibitive. The expected demand for new capacity during the next decade is too small to justify considering coal as a serious option, and it is not recommended.

3.64 It is recommended that, subject to the results of a detailed technical investigation, option (a) be adopted, i.e., that three of the ALCO engines be overhauled by an overseas experienced contractor, if a reasonable tender for the work can be obtained. As a first step, it is recommended that the barge be inspected by a naval expert. Then one or two contractors should be asked to tender for the refurbishment including training, employment of local staff, and a post-overhaul performance guarantee. A realistic expectation of at least five years of service from the machines after overhaul is required to make the option attractive. It is recommended that a professional engineer be engaged to supervise the contractor. Based on the contract cost and the expected residual lifetime of the machines, an economic comparison of refurbishment and purchase of new capacity at Nanpohnmal can be made.

3.65 **Transmission and Distribution.** The most urgent action required to improve distribution service quality is rehabilitation of the 4.16 kV system in Kolonia, for which a proposal for Japanese grant aid has been submitted to the state government by Japanese commercial interests. The proposal is to upgrade the entire 4.16 kV system to 13.8 kV within a 24-month construction period. If this project is carried out, it is recommended that all wooden poles be replaced with concrete poles, and new insulators, conductors, transformers, switches etc. be installed. Automatic reclosing systems and ring main

[37] An additional benefit of a new feeder is improvement of the reliability of the grid since total black-outs due to simultaneous distribution faults would be rare.

operation should be adopted. The total cost including 1,200 concrete poles and 51 miles of conductors is estimated at $6.4 million, of which $3.7 million is for materials.

3.66 While the proposal appears to be an effective way to improve service quality, reduce losses and maintenance costs, and add spare capacity to the grid, the main work will evidently be done by foreign consultants and contractors. It is recommended that the rehabilitation be carried out in smaller steps with the assistance of the local staff within a period of three to five years. This is an excellent opportunity to train staff.

3.67 In addition to distribution rehabilitation, the loading and voltage in drop lines and service connections in major commercial consumer premises should be analyzed. A distribution system protection scheme should be designed, including circuit breakers, switches, and fault indicators on the lines to enable better planning and maintenance and faster repair when necessary.

Yap State

3.68 The public electricity supply is provided on the three main islands of Yap by the Department of Public Utilities and Contracts (PU&C). The Division of Power within PU&C has approximately 35 people engaged in three departments: eighteen in power generation, fifteen in distribution and two in electric service. In addition, PU&C has ten people in administration and nine in billing, who have recently been moved from the Department of Finance. Ulithi and Woleai islands have small diesel power systems which are operated by the local authorities. Yap's power utility operations are well organized. However, technical, financial, and administrative skills should be improved.

3.69 **The Colonia Power Station.** The total capacity in Colonia is 7.1 MW and produced about 20% of the national public power output in 1990; in addition, some commercial consumers and the hospital have stand-by diesel generators. The power station is situated approximately two kilometers from the harbor, from which diesel fuel is transported daily by road. Due to severe mechanical problems in some machines, the presently operational installed capacity (nameplate rating) is 4.4 MW. All of the operational units have been substantially derated due to cooling problems. Load shedding was necessary for several days in February 1991, even with loads of only 1.5 - 2 MW. The peak load recorded in December 1990 was 2.4 MW.

3.70 The Colonia plant comprises six diesel generators:

a) Two 2,035 kW ALCO engine/generators (units 1 and 2, 900 rpm), manufactured in Canada in 1975 and reportedly refurbished and shipped to Yap in 1987/88. Unit 1 has a dismantled roller bearing at the generator shaft. The engine has recorded 61,000 hours, 3,300 since an overhaul in September 1990. Four out of nine fan-motors have been removed for repair in Guam. Unit 2 is in service[38], but as five out of nine fan motors have been removed for repair, the engine is derated to 1,100 kW.

b) Two 750 kW White Superior engine/generators (units 3 and 4, 600 rpm). Unit 3 was installed in 1974 and is in service, but oil leaks from the cylinder heads and elsewhere. According to station records, the unit is not operated above 540 kW. Unit 4, installed in 1971, has been out of service for six years with essential parts

[38] The hour meters on units 2 and 5 indicate 5,600 and 4,600 hours respectively, both of which are probably an order of magnitude low.

including cylinder heads, exhaust tubes, cooler, and all instruments on the control panel dismantled or removed. The unit is unlikely to be returned to service.

c) Two 800 kW Caterpillar engine/generators (D399 sets, units 5 and 6, 1,200 rpm), both installed in the late 1970s. Unit 5 is not operated above 580 kW. Unit 6 has recorded 53,000 hours and is operated at a maximum of 600 kW. Although designed as standby units, both have been operated on baseload duty because of the critical capacity situation in the plant.

3.71 Effective plant capacity, allowing for machines out of service and deratings, was only 2,820 kW in February 1991, and load shedding was necessary. Technical assistance by a diesel specialist is recommended to investigate reasons for the deratings.

3.72 Despite insufficient workshop area, spare parts, tools and expertise, maintenance efforts in Yap are better than in other FSM power stations. Routine service and overhauls are carried out at the manufacturers' recommended intervals. Cooling water is reportedly supplied from the public water system, but is treated in a chemical filter process before entering the radiators. It is recommended that the effectiveness of the filtering process be investigated.

3.73 Although staff have maintained the ALCO engines competently, the machines experienced many problems in 1990. A turbo-charger has been replaced, a cam shaft broke, and fan motors continue to break down, a problem which might be solved by installing complete new radiators. The main bearings of one engine continue to wear out prematurely, indicating either a bent shaft or improper alignment of the engine-generator; it is recommended that a specialist be engaged to determine a solution. Similar troubles with ALCO generators have been experienced in Pohnpei (4 engines) and in Chuuk (2 engines). It is recommended that both the recruitment of specialist help and contracting for refurbishments be coordinated with the other two states.

3.74 It is recommended that the dismantled White-Superior (Unit 4) not be refurbished because of its age, but be retained for spare parts. Unit 3 may have a limited lifetime, but should be kept running as long as possible, at least while the ALCO engines are being refurbished.

3.75 Spare parts are easily obtained for the two Caterpillar units, but as experienced in other states equipped with similar machines, after-sales service and training has reportedly been poor. Operation of these units on continuous baseload duty requires special maintenance procedures.

3.76 It is recommended that a formal training program be established in the mechanical and electrical trades, mainly on-the-job for technicians but including coursework away from Yap for senior engineers. It is further recommended that funding be sought for construction and supply of an adequate workshop and stores area.

3.77 **The Distribution System.** The distribution system consists of two primary overhead feeders, one 13.8 kV and one 4.16 kV, extending from the substation at the power station to most of the area in three main islands. The total length is approximately 80 kilometers (50 miles). The majority of poles are wooden but extensions since 1987 and the upgrading of the 4.16 kV lines in Colonia have used concrete poles.

3.78 The 13.8 kV system consists of three secondary feeders: number 1 is split into two lines outside of the powerhouse compound: one to the airport and to the south, and one to

the west coast. The load on number 1 secondary feeder is 500 kW. Number 2 extends to Colonia and to the north east, loaded at 800 kW. Number 3 secondary feeder extends to the Hospital. It was disconnected in February 1991 due to load shedding, possibly because the hospital has a standby generator.

3.79 The distance to the load center in Colonia is only 2 kilometers (1.2 miles), and the maximum distance to the rural districts with small demands is approximately twenty kilometers (twelve miles). Consequently voltage drops in the 13.8 kV feeders are probably moderate. The 13.8 kV system has been extended to most villages in Yap Proper, but many households have not yet been connected. There are plans to extend the 13.8 kV grid to the remaining villages on the three main islands. The condition of the 13.8 kV grid is generally good, especially the new sections with concrete poles. Tree and foliage cutting is a matter for concern, but in contrast with the other FSM states, cutting is done every three months.

3.80 The outdoor 4.16/13.8 kV substation is simple and adequate. A single 4.16 kV cable from the power station's busbar is connected to the step-up transformer. A spare transformer is stored in the original wooden crate. The three feeders are protected with circuit breakers. However, the relays have not been set correctly, as instruments and expertise are not available, and many line faults cause complete black-outs. Insufficient attention appears to be paid to the control panels, with many instruments giving imprecise readings, and others dismantled or absent. For example, there is no metering of the main feeder to the substation. The hourly recorded demand is therefore extremely unreliable. The pole-mounted single-phase distribution transformers need regular maintenance, which is understood by PU&C.

3.81 **Management.** The Distribution Section consist of fifteen personnel: one trades technician, seven linesmen, three electricians, one tradesman, and three in administration. Technical skill levels in the operation and maintenance of the distribution system are significantly higher than in the other FSM states. The manager of the section has a good practical knowledge on operation and maintenance. Training is needed on relay setting, transformer maintenance, hot-line work and safety.

3.82 A map of the 13.8 kV grid is available and load is monitored by simple line-mounted ammeters. Changes in loadings and system configuration should be recorded regularly if adequate assessment, planning, and monitoring of the system are to be carried out. On a small system like Yap's, fairly simple methods are adequate for good planning. Fault indicators have been purchased to reduce the time spent on fault location. It is recommended that sectionalizers be installed in the grid to reduce outage times.

3.83 Facilities for transformer maintenance and meter calibration are being used. Stocks of many essential parts are inadequate, but stores are well organized. An excellent bucket truck with drilling equipment is available, but it must be shared between two crews. In general, lack of vehicles, parts and tools inhibit dispatching of crews for preventive maintenance, monitoring of voltage, and customer service. It is recommended that the management and the crew be provided more funds and better equipment, as they have shown the ability and willingness to do a good job.

3.84 **Firm capacity.** The nameplate generation capacity of 7.1 MW appears to be adequate to meet the peak load of 2.4 MW with a comfortable reserve margin, but severe breakdowns and deratings reduce the effective installed capacity to about 2.8 MW and firm capacity to only 1.7 MW. Therefore the reserve margin is actually negative.

3.85 PU&C have a well-founded concern about the future availability of the older engine generators. If all engines except the White Superior are rehabilitated, firm capacity will be 4.4 MW and the reserve margin 85%, but this ample margin is dependent on preventive maintenance and a sufficient stock of spare parts to enable fast repairs. With all capacity comprising fairly old engines which are difficult to repair, only about 4 MW should be considered "firm" after rehabilitation. Therefore, new capacity should be added when peak load approaches 3.5 - 4 MW, which will not occur until well after 1995 even if recent growth trends of 6%-7% per year continue.

3.86 The two ALCO engines should be investigated to see if they can be economically refurbished. The two Caterpillars should be overhauled in order to restore their nameplate output. The vintage White-Superior engine, which is too old to be worth overhauling, should be scrapped as soon as major repairs become necessary, but it will be needed during the overhauls of the other engines.

3.87 The OPB&S expects substantial demand increases for the early 1990s, based on several planned projects. However, as in other states expecting rapid development, the impact of new projects on electricity demand is likely to be below expectations; decisions to invest in new generation or transmission capacity should be based on realistic short and medium term forecasts which reflect only approved, confirmed projects.

3.88 **Power generation expansion options.** Options for additions to power generation capacity to meet increases in demand in the short term include:

a) *Purchase of new diesel capacity.* New capacity and the refurbishment of existing capacity are the only practical options available to Yap during the 1990s. Two medium speed engine-generators rated at approximately 2 MW each can be installed in two steps in the power house when old engines are phased out. This option is easy to implement and administer, but total costs are estimated at $4-$5 million depending on the type of engine. It is recommended that the government call competitive tenders based on a feasibility study which outlines Yap's least cost power development options and directly compares the purchase of new capacity to the refurbishment option.

b) *Replacement of diesel with nonconventional imported fuels.* Use of imported waste or tires for combustion for power generation have been suggested but this is technically complicated, is not an economic option, and carries severe environmental risks. It is not recommended.

c) *Replacement of diesel with local renewable resources.* Indigenous fuelwood and other biomass resources are available, but are probably not sufficient to sustain a major power project economically. The wind regime is too limited for power generation with present wind turbine technology, and maintenance is difficult on tropical islands due to corrosion problems. Yap may have significant wave and ocean thermal resources, but the technology is still experimental and hence is not a practical option for Yap in the foreseeable future.

3.89 **Transmission and Distribution.** The distribution system is in good condition, as major upgrade work is in progress or has been completed. The remaining task is to complete the planned extensions and connection of new consumers. The grid can be extended without technical problems, but connection of distant rural households presents a financial burden to the state, as the consumers cannot afford to pay the full costs of the connections. It is recommended that the OPB&S refrain from connecting new consumers in rural areas.

3.90 It is recommended that a distribution protection scheme be designed, covering the circuit breakers in the substation, relays, sectionalizers, and simple fault indicators on the lines. Automatic reclosures in the grid are not likely to be necessary. Loss-limiting capacitors should also be considered. It is recommended that technical assistance be obtained for the design of such improvements.

Rural Electrification

3.91 **Chuuk.** Among the states of FSM, Chuuk's population is the largest and most dispersed, several lagoon and atoll islands having more than 1,000 inhabitants each. However, electrification outside of Moen is very slight. For example, the island of Uman south of Dublon with some 2,000 inhabitants has no public power supply, but a few small generators are operated privately. As on other outer islands, kerosene is used for lighting and cooking, and open-fire cooking is common, but wood is reportedly becoming scarce. Commercial fuel use is mainly gasoline for outboard engines used in fishing and transport.

3.92 A centralized diesel station on Uman cannot be justified in view of the small load and the limited cash income of the inhabitants; the same can be said for other outer islands in Chuuk and other states. Grid-based electrification would not be practical technically, as supply and maintenance would be even more difficult in the outer islands than on Moen itself, and the mainly subsistence economy of the outer island people could not support the expenses. Photovoltaic systems would be more appropriate and are recommended as the least cost method of providing for small electric loads by outer island households.

3.93 *Dublon (Tonoas).* Until the Second World War, Dublon was the main commercial and administrative center in the Truk lagoon; today only 4,000 people live on the island. In order to redevelop Dublon, a large pier has been built with U.S. assistance and Japan has recently donated a modern fishery plant with freezing storage and ice making facilities. No other commercial activities are evident. The population depends on subsistence and income derived from Moen. The public power system has been out of service since Typhoon Nina struck in 1987 and it has not been repaired. The power house is in good condition, but the doors are locked and, as far as is known, the equipment inside has not been inspected. As the machinery has been out of service for at least four years without attendance, refurbishment may be impossible because of corrosion of the machinery and deterioration of the electrical equipment. The 2 kilometer (1.2 mile) 13.8 kV transmission line to the pier and the village area at the lagoon seems to be fairly intact, but has not been kept clear of foliage. In the village area the distribution system has deteriorated.

3.94 A power station at the Junior High School comprises three generators (unsynchronized): a 100 kW Onan which has been out of service for several years; a 175 kW Caterpillar D300 in working order; and a third engine of unknown size or condition transferred from Moen power station.

3.95 Despite the reportedly high priority of electrification of outer islands, no funds have been allocated for the reconstruction of the Dublon system. Some privately-owned generators have reportedly been installed. The Japanese-assisted fishery plant is the only attempt to develop industrial and commercial activities on Dublon which could benefit from a rehabilitated electricity supply. The plant has its own diesel generators. One of two Shinko diesels (6 cylinders, 1800 rpm) is operated at approximately 50 kW, serving one freezing store. As the other engine has been out of service with a broken cooling system for a long period, the fishery plant cannot be utilized as intended, and no ice is produced. Fishermen collect ice in Weno, which is costly in both time and fuel.

3.96 **Kosrae and Pohnpei.** Electrification requirements or capacities in Pohnpei's outer islands are unknown. However, 13.8 kV lines have been extended around the full circumference of Pohnpei, and on the north side of Kosrae they extend up to the airport and to Utwe in the south, but evidently few connections have been installed outside of the main urban areas. Consumers within reach of the line (1000 feet) who are willing to pay a reasonable connection fee covering at least the cost of materials (possibly with the assistance of government) should be connected. Hook-up of rural households at greater distances from the line should be given low priority considering the added financial burden on the utilities.

3.97 **Yap.** Small diesel powered systems are operating on Ulithi and Woleai atolls. At Ulithi, two Caterpillar generators of 150 kW each provide power 24 hours a day. Poles reportedly suffer from rot, and in general the maintenance standard is poor. At Woleai, the high school and government offices are supplied for eight hours daily by two 80 kW generators. A typhoon has damaged part of the system.

PETROLEUM PROCUREMENT AND DISTRIBUTION

3.98 Mobil Oil has been the long-standing supplier of petroleum products to Micronesia, with coastal bulk storage on all the main islands supplied by company owned and operated local coastal tankers, using Guam as the hub and transshipment center. In the FSM there are bulk facilities in the main islands of Chuuk, Kosrae, Pohnpei, and Yap, with small facilities (98,000 U.S. gallons) at Ulithi in Yap. Due to Mobil's long standing presence in the Micronesian market, these assets are largely depreciated and therefore provide relatively low cost storage. The nature of the market, very small volumes dispersed over a wide area of ocean, and Mobil's efficient supply logistics have made it extremely difficult for competitors to establish themselves on any of the Micronesian islands. Mobil therefore enjoys a monopoly throughout FSM which is unlikely to be challenged in the near future.

3.99 Mobil's storage facilities in each state are adequate to meet demand in the near to medium term, assuming the economy grows at 2% - 4% per year. However, if the economic developments promoted by the state governments are realized during the 1990s, especially fisheries and tourism, existing fuel storage will not be adequate[39]. Most facilities are in reasonable condition except in Chuuk: the main tanks in the bulk fuel depot there are rusting and could deteriorate quickly if neglect continues. It is recommended that the facility be painted.

[39] An alternative to onshore basing of bunkering and servicing facilities for expanded fishing operations is "at sea" bunkering and servicing of the fishing fleet, which might well require less investment.

3.100 Currently, stock cover varies by state and product but is rarely less than two months, as shown in Table 3.2.

Table 3.2: FSM Petroleum Fuel Storage by State in 1990 (U.S. Gallons)

	Kerosene	Distillate	Gasoline (regular)	Gasoline (unleaded)
CHUUK				
Total Capacity	219,199	873,905	219,129	88,293
Average monthly demand	102,000	214,000	161,000[a]	na
Storage capacity (months of consumption)	2.2	4.1	1.9	
KOSRAE				
Total Capacity	50,000	500,000	100,000	0
Average monthly demand	31,500	66,500	8,800	0
Storage capacity (months of consumption)	1.6	7.5	11.3	0
POHNPEI				
Total Capacity	239,146	873,900	219,129	88,293
Average monthly demand	84,083	280,000	119,000[a]	na
Storage capacity (months of consumption)	2.8	3.1	2.6	
YAP				
Total Capacity	95,057	406,972	160,819	0
Average monthly demand	17,840	142,420	29,416	0
Storage capacity (months of consumption)	5.3	2.9	5.5	0

Note: a) Regular and unleaded combined.
b) na = not available.
Source: Oil companies.

3.101 **Import quantities.** A comparison of the volumes and values of petroleum imports in each state in 1990 and 1989 and imports by product in 1990, obtained from Customs Department records, are shown in Tables 3.3 and 3.4.

Table 3.3: Total FSM Fuel Import Volumes and Values by State, 1990 and 1989 (volumes in million USG, values in US$ millions)

	1990 Volume	FOB Value	% FSM Volume	1989 Volume	FOB Value	% FSM Volume
Chuuk	5.5	4.2	36.2	4.9	3.7	39.8
Kosrae	1.5	1.2	9.9	1.2	0.9	9.8
Pohnpei	6.1	4.7	40.1	4.5	3.1	36.6
Yap	2.1	1.6	13.8	1.7	1.2	13.8
Total	15.2	11.7	100.0	12.3	8.9	100.0

Source: Oil companies.

Table 3.4: 1990 Petroleum Imports by Product (million USG)

(volume)	DPK	%	ADO	%	Gasoline Regular		Gasoline %	Unleaded	Other %
Chuuk	1.1	41	2.4	30	1.6	43	0.3	75	<0.1
Kosrae	0.2	7	0.9	11	0.4	8	0.0	0	<0.1
Pohnpei	1.1	41	3.4	42	1.4	38	0.1	25	0.1
Yap	0.3	11	1.4	17	0.3	8	0.0	0	<0.1
Total	2.7	100	8.1	100	3.7	100	0.4	100	<0.4

Note: < indicates "less than". "DPK" = Duel Purpose Kerosene.
Source: Oil companies.

3.102 **Competition.** The lack of overseas competition in petroleum supply has not been severely detrimental to FSM as the terms of Mobil's current supply agreements with each state are generally reasonable, given the small volumes involved. It may not be in government's interest to promote new market competition as this may increase, rather than reduce, onshore prices unless new economic developments such as increased tourism and commercial fishing activity substantially raise the total market volume. In all states, there is a proliferation of retail outlets for the limited volume of gasoline sold in FSM, resulting in high fixed costs which are reflected in the unusually high onshore component of gasoline prices. Retail margins, which are not controlled by the states or national government, currently average about 40 per gallon (some four times higher than retail margins in Fiji, for example). Fewer outlets handling higher volumes of gasoline will significantly reduce the per-gallon fixed costs of retailing. It is therefore recommended that the states or national government introduce retail pricing guidelines that will in effect limit growth in the number of retail outlets.

3.103 **Terms of Supply.** The governments of Pohnpei and Chuuk have held "evergreen" supply contracts with Mobil since 1982. In Yap, the five-year supply contract signed in 1987 and Mobil's lease on the fuel depot land both expire in March 1992, under terms of supply similar to those in Pohnpei and Chuuk. However, it is understood that the Yap government has had disagreements with Mobil during this period and consequently plan to call tenders for supply from 1992. Kosrae has a five-year agreement signed in 1986, which however was pending completion of the government's bulk storage facility and did not become effective until 1 October 1990. The bulk storage facility is operated by Mobil on a five-year contract,

also effective 1 October 1990. The Kosrae supply contract terms are similar as those of the other states.

3.104 The four FSM state contracts are similar to Mobil's agreements elsewhere in Micronesia, being based on Mobil's Singapore posted price, Worldscale/AFRA freight rates, a varying transshipment freight rate from Guam, and a fixed-percentage onshore margin which does not appear to be cost-related. The agreements are difficult for the state governments to administer, as they require a considerable knowledge of the petroleum market and daily information on price component fluctuations. Mobil has reportedly never provided the necessary data and the governments have never tried to monitor the contracts, relying on the supplier for accurate pricing. Contracts renegotiated now and in the future could be expected to provide slightly better terms[40] but, equally important, should be based on formulas yielding prices which are easily verifiable by the states.

3.105 It is recommended that the state governments obtain specialist advice on how to reduce supply costs in the short term under existing market constraints. For the longer term, it is recommended that national government investigate the possibility of replacing the four separate state agreements with a single tender for a combined national volume to achieve improved supply prices in each state. A national tender could provide potentially significant cost benefits due to the higher volume. However, it would require the full cooperation of all states and considerable effort over perhaps eighteen months on the part of the national government to prepare. If preparations for a national tender were to begin by late 1991, a new national supply agreement could take effect by early 1993.

3.106 **Security of Supply.** The states and national government wish to increase the security of petroleum supply to FSM at reasonable cost. The government of Pohnpei announced in mid-1991 efforts to formulate an "Emergency Energy Preparedness Plan" designed to reduce the impact of possible disruptions in the overseas petroleum market. While full security against rapid price escalations or supply disruptions is not available on any terms, onshore storage requirements can be increased to mitigate the effect of disruptions when they occur. In the long term, security depends on the availability of storage capacity to provide adequate inventories of fuel to handle most emergencies.

3.107 The states or national government can increase the security of supply by constructing additional storage facilities as "reserves". However, the direct involvement of governments in oil storage has not proved to be an effective policy elsewhere in the region, as government-owned storage facilities tend to be ill-maintained and are very expensive for the governments concerned. A variant of this option is to invite tenders for the construction and operation of reserve storage facilities but this would involve a costly duplication of investment, since existing storage in FSM could also contribute to reserve capacity. A preferred alternative, if increased security is desired, is to mandate a minimum stock holding level (e.g., three months' stock cover for each product) to be maintained by the oil supplier. Although higher inventories will raise financing costs to Mobil which will be passed on to consumers in higher prices, it is the cheapest of the alternatives for increasing supply security. There is no evidence, however, that FSM has suffered from supply constraints, and mandated reserves are probably not necessary.

---

[40] A 1987 assessment (PEDP Report FSM 87-2) for the national government on the FSM petroleum market and the supply agreement in effect in Pohnpei recommended that several provisions be re-negotiated. These included methods used to determine the FOB (Singapore) prices and the fixed-percentage onshore margin. It is understood that the Forum Secretariat Energy Division Petroleum Section is providing advice in the latter part of 1991.

NEW AND RENEWABLE SOURCES OF ENERGY

3.108 Ethanol from local biomass has been suggested as a transport fuel for FSM. Although the technical potential may exist, the high costs of production experienced in other countries relative to the price of petroleum fuels have prevented a viable market from developing. The same high or higher costs would apply in FSM. However, FSM is well endowed with renewable resources which could, to a limited extent, be exploited for the production of electricity. These are discussed below.

3.109 *Hydro.* Hydro resources have been developed to a limited extent in Pohnpei, where an extension to the existing Nanpil hydro plant is planned, and in Kosrae, where construction of a 35 kW microhydro scheme was started and abandoned in the late 1980s. Other potential hydro resources exist in both states, especially in Pohnpei where prefeasibility studies showing significant potential have been carried out on all of the major river systems. Hydro cannot provide power reliably year-round but could save substantial amounts of fuel. It is recommended that further technical and economic/financial studies of hydro potential be carried out in both Kosrae and Pohnpei.

3.110 *Biomass.* As shown in table 3.5, biomass resources were extensive throughout FSM in the early 1980s, the most recent time that vegetation was extensively surveyed. However, biomass could not be developed as fuel for large-scale electricity production without risk of serious degradation of the environment, especially erosion and contamination of coral areas. Small-scale biomass fired steam electric plants are feasible, however, if developed in conjunction with an agro-industry such as a copra plantation which produces biomass (husks) as a waste product. Since suitable sites for such developments are probably few in FSM, it is not recommended that biomass development for energy be pursued at this time.

Table 3.5: Summary of Biomass Resources of FSM (hectares, 1983)

Land Class	Chuuk	Kosrae	Pohnpei	Yap	Total
Forest	986	7,066	19,683	3,882	31,617
Secondary vegetation	252	1,272	1,843	553	3,920
Agroforest	2,378	2,585	11,865	2,538	19,366
Nonforest	554	263	2,102	2,743	5,662
Total	4,170	11,186	35,493	9,716	60,565

Note: See Statistical Annex, Table 10 for details.
Source: Vegetation Survey of Pohnpei, Truk, Kosrae, and Yap (US Dept of Agriculture, Forest Service; PSW-17, 18, 20 & 21; 1986/1987)

3.111 *Ocean thermal energy.* In theory, a 1 MW Ocean Thermal Energy Conversion (OTEC) plant in an open-cycle design could produce both electricity and about 500,000 gallons of fresh water per day. Unfortunately, the technology is not yet proven and capital

investment in a prototype would be high: over $18 million on present estimates[41]. OTEC systems are not expected to be commercially available this century.

3.112 *Solar energy.* The solar resource is generally attractive in FSM except in Pohnpei, where rainfall and cloud cover are unusually high. Radiation is sufficient, even in Pohnpei, to provide small amounts of electricity to remote consumers using photovoltaic (PV) systems at lower overall costs than small diesel systems. There has been considerable activity in PV development (both for electrification and telecommunications) on islands inside and outside the Chuuk lagoon, with about 50 installations reported. However, there is no maintenance by government nor any budget for equipment and site visits. All states except Yap have plans to expand the use of photovoltaic systems in rural areas, mainly remote islands. Pohnpei plans to electrify outer islands based at least in part on photovoltaics[42], and Kosrae has prepared a proposal for installation of 20 PV systems in areas beyond the reach of the grid extension to Utwe. In Chuuk, plans for further PV projects are unclear.

3.113 *The potential for energy conservation.* A large amount of electricity used by households in FSM is wasted due to inefficient appliances (cooling, freezing, water heating and lighting), especially air-conditioners. A considerable potential for energy conservation exists through proper maintenance and operation of existing equipment and by phasing out inefficient appliances. Cooking with electricity is extremely inefficient; conversion to LPG or kerosene would reduce energy conversion losses.

3.114 Simple and inexpensive means are available to reduce electricity wastage. For example, incandescent lights can be replaced with much more efficient fluorescent lights which fit into the same fixtures. Such fluorescent lights are not presently marketed in the FSM, but could be introduced with appropriate tariff legislation and other inducements to private importers. In commercial and government buildings, slim-type fluorescent tubes with high frequency coupling can reduce consumption by 30%, and in some places automatic daylight dimming could be introduced.

3.115 Yap, with the highest power tariff in the FSM, appears to have done more than the other states to promote electricity conservation. government buildings are ventilated by fans with air-conditioners installed only in special rooms and operated only during office hours. Fluorescent lights are more common than incandescent and energy conservation information brochures are distributed to power consumers.

---

41 *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).

42 The Legislature is reported by the state Office of Budget, Planning and Statistics to support diesel-based electrification as well as photovoltaics for the outer islands.

IV. POLICY ISSUES AND PRIORITIES

PRICING ISSUES

Petroleum Product Pricing

4.1 The CIF cost of petroleum products, which is not recorded by government but can sometimes be obtained from the petroleum suppliers, was reportedly about $12.8 million[43] in 1990. It is not possible to judge whether FSM pays reasonable prices for petroleum products unless Customs procedures are amended so that more reliable and complete information is collected. Even then, the state supply agreements cannot be monitored effectively to assure that CIF prices are consistent with the agreement because a) there is a lack of baseline data, b) the states and national government lack the skills to do so, and c) government does not have regular access to independent price information[44]. Minor variations in Customs entry procedures would yield much of the independent information required by government concerning imports and the consumption of petroleum products. However, a concerted effort to train government officials in price monitoring is also required and is recommended.

4.2 The state governments' wholesale prices compare well with other Pacific Island countries. However, retail pump prices are much higher, mainly because of high retail mark-ups over the wholesale price. For gasoline, as shown in Table 4.1, mark-ups are about 45/gallon in Chuuk, Kosrae, and Yap, and 40 in Pohnpei[45]. For ADO, the margin varies between 25 and 49 in Chuuk, Pohnpei, and Yap, and in Kosrae it is 94. In Fiji, retail margins for both gasoline and ADO are on the order of 11 U.S. cents per gallon. The higher retail margins throughout FSM are due in part to the proliferation of low-volume retail distributors and a lack of price monitoring or guidelines by the government.

---

[43] Estimates based on inconsistent government and oil company data.

[44] This information is, however, available at no cost through the Petroleum Section of the FSED as part of its normal service to governments.

[45] Retail prices charged by different retail outlets in each state vary by up to 5 cents per gallon, indicating that prices may not be well regulated by the market.

Table 4.1 Fuel Prices by State, early 1991
(U.S. cents per U.S. gallon)

Product	Government Wholesale	Non-Govt Wholesale	Retail	Retail Margin
CHUUK				
Unleaded Gasoline	151.7	155.0	200.0	45.0
Regular Gasoline	97.5	150.0	195.0	45.0
ADO	116.0	153.0	190.0	37.0
Kerosene	128.3	142.0	180.0	38.0
KOSRAE				
Regular Gasoline	103.6	154.7	200.0	45.3
ADO	110.0	156.4	250.0	93.6
Kerosene	129.3	158.2	225.0	66.8
POHNPEI				
Unleaded Gasoline	151.7	155.0	195.0	40.0
Regular Gasoline	97.5	180.0	215.0	35.0
ADO	116.0	153.0	178.0	25.0
Kerosene	128.3	162.0	187.0	25.0
YAP				
Regular Gasoline	103.6	154.7	210.0	45.3
ADO	110.0	156.4	205.0	48.6
Kerosene	129.3	158.2	205.0	48.8

Notes: Prices in February, 1991. Retail prices are the lowest of the sites surveyed. Prices include duty and tax except for government wholesale ADO which excludes excise tax of 5/gallon. Taxes in retail prices include import tax (5/gallon, except kerosene at 3% ad valorem), excise tax (5/gallon), and a gross receipt tax ($80 on the first $10,000 of gross revenue and 3% on the balance).

Source: Oil company data and retail price survey carried out by the mission in February 1991.

4.3 It is recommended that government establish petroleum retail pricing guidelines. Following consultation with Mobil and retailers, it is also recommended that a formula be established and enforced for calculating maximum wholesale and retail prices. It is recommended that legislation be adopted which provides penalties for non-compliance by suppliers or retailers and that government monitor prices to ensure that all parties conform to the agreement.

4.4 An analysis of the profitability of three or four representative service station retail sites is recommended to establish a reasonable retail margin. These margins, differing for each product, should 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, Mobil's profitability should be evaluated to establish a fair and reasonable formula for calculating wholesale prices.

Power Tariffs and Utility Finance

4.5 **Power tariffs and revenue collections.** Both the level and the structure of tariffs vary considerably by state, as shown in the Statistical Annex (Table 8). For consumers using 300 kWh per month, electricity is cheapest in Chuuk (essentially free), followed by Pohnpei ($9/month), Kosrae ($15), and Yap ($27), if bills are paid. The most recent tariff change in FSM was in Kosrae in 1984; in Pohnpei, the tariff hasn't changed since the 1960s.

4.6 Revenue collections are poor in all states, since disconnections for nonpayment are not adequately enforced and responsibilities for billing and collections are fragmented. Despite adequate billing systems in Kosrae and Pohnpei, collections are no more than 70% of billings; in Yap the normal collection rate is not known, as no bills were issued for much of 1990 and early 1991 because of a failure of the billing system. In Chuuk, most customers are unmetered and collections are generally not enforced. Whereas total consumption in Chuuk averaged more than 1,400 MWh per month in 1990, total revenue collected between September and December 1990 reportedly[46] averaged $5,700 per month, or about 0.4 per kWh. In spite of an effort in 1991 to bill some users based on their estimated consumption, fragmented management responsibilities impede the most determined collection efforts: bills are issued by the Department of Public Works but payments are made to the Department of Finance, which has no record of the bills issued by DPW. It is recommended that billing and revenue collection be placed immediately under a single authority, collection procedures be tightened, meters be installed for all consumers, and a disconnection policy for non-payment be rigorously enforced for all accounts, including the government.

4.7 **Utility finance.** In all states, power utility revenues are below 20% of the estimated total costs of electricity production including depreciation of assets[47], as shown in Table 4.2, and are at most 30% of operating costs. Subsidies to the power sector in each state derive from U.S. assistance, which has donated virtually all capital equipment installed in the post-WWII period and which specifically provides funds for fuel costs each year[48].

Table 4.2: Financial Performance of the State Power Utilities, 1990

State	Ave Revenue (/kWh)	Ave Cost (/kWh)	% Recovery of Costs	Estimated ROI (%)	Total subsidy $ million
Chuuk	0.4	20.2	2	- 39	3.4
Kosrae	3.5	19.0	18	- 21	1.1
Pohnpei	2.5	26.2	10	- 20	4.8
Yap	0.4	21.4	2	- 38	2.6

Notes: ROI = Return on Investment, the ratio of profits or losses to revalued net fixed assets in service. The utilities' losses and their respective values of assets are mission estimates, as these data are not calculated by the utilities.

Source: Mission estimates.

[46] Finance Department records.

[47] See Annex 3 for an analysis of costing.

[48] Section 214 of the Compact Agreement provides an annual grant of about $3.5 million in 1987 dollars for energy-related expenditure, mainly purchase of fuel for power generation.

4.8 Extensive subsidization of the power sector for the past 40 years in FSM has left a legacy of inefficiency, high costs, low reliability, and low quality of power. Whatever economic benefits might have been expected from an overseas-donated public power system, they have not materialized: growth potential in key economic sectors is still constrained by, among other factors, the quality of power. Users who depend on power have installed standby generators because the public power supply is simply not adequate. As U.S. assistance diminishes in accordance with the Compact Agreement, the states will increasingly bear the burden of run-down and oversized power systems that they cannot afford. Elimination of subsidies by raising the tariff, 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. Increased efficiency and reliability will limit the rise in costs to consumers that result from higher tariffs, through reduced need for backup equipment, fewer replacements of damaged appliances due to low voltage, and fewer power cuts. Gradual tariff increases and corresponding reductions in subsidies over a five-year period, combined with assistance to consumers to conserve energy, is recommended in all states to mitigate the short term disruptive effects of raising the tariff to full cost recovery. As discussed in Annex 4, a lifeline tariff restricted to the first 100 kWh per month of residential consumption would adequately protect low-income consumers while requiring a total subsidy of only 5% of the current subsidy level.

Regulatory and Other Policy Issues

Overview

4.9 Key policy issues include FSM's complete dependence on petroleum products for power generation; pricing electricity far below cost; inefficiency, lack of organisation, and low return on capital investment in the power sector; high fixed costs in the gasoline retail market; absence of government oversight of the petroleum market generally; and absence of a central government agency with responsibility for energy. To complicate matters, the responsibilities of the respective states and the national government for energy purchasing, production, and regulation are not clear, resulting in poorly coordinated government action on important issues and often inaction. It is recommended that national government assume a much larger role in national energy strategy than at present by taking responsibility for creating and updating a comprehensive energy supply and demand data base, coordinating energy policy among the states and assisting them to develop energy plans, reorganise the power sector, reduce the growth rate of the petroleum import bill, and use solar energy to provide reliable power to outer island population centers. It is recommended that an officer responsible for energy be appointed in each state, not necessarily on a full-time basis, to serve as the principal liaison between the national and state governments on energy matters, to handle administration of the state petroleum supply agreements[49], and compile state energy data.

4.10 It is recommended that an energy office be established with two permanent senior-level national energy positions (a national energy planner and a rural energy officer) and suitable support staff, located within the Department of Resources and Development. The energy planner would be responsible for national government activities in the energy sector and oversee national energy policy development and implementation, concentrating on the

[49] This function would be transferred to the energy office in the event that the four state supply agreements were replaced by a national agreement, thus sharply reducing the number of skilled personnel required to administer the government petroleum supply.

petroleum and power sectors. He or she would assist the states to reorganize utility management, establish training programmes, identify financing for needed technical refurbishments, and establish effective billing and revenue collection systems. In order to improve coordination of power utility development, it is recommended that the national planner be appointed a member of the Boards of the respective state power utilities. The rural energy officer would coordinate disbursement of aid funds for rural energy projects (mainly photovoltaics) among the states and would assist the states in project implementation including the setting up of appropriate state institutional structures and training personnel. It is recommended that a petroleum expert be hired for a year or more to assist the states with training, supply contract administration, storage standards, and establishing wholesale and retail pricing guidelines; and to assume responsibility for negotiations and vetting of tenders if a national petroleum supply tender is called. To support this activity, it is recommended that funds be provided for petroleum consultancies as needed.

Petroleum Subsector

4.11 **Engineering and safety.** With the rapid increase in population and urbanization in all states and increasing concern with environmental issues, the absence of any petroleum industry guidelines is conspicuous. It is recommended that relevant regulations be updated to ensure adequate anti-pollution provisions. Existing regulations do not address the appropriateness of the design of the facilities nor do they cover operations to safeguard lives, to minimize the risks of fire and provisions for fighting fires. There have apparently been no attempts made to remedy this situation. It is recommended that the states or national government adopt suitable standards[50] for storage, handling and transport of fuels and enforce them rigorously.

4.12 It is recommended that all states restrict developments within and around their oil storage facilities and ban completely any new developments within ten meters of the oil installation boundaries. In Pohnpei, a new hotel and a fisheries project have recently been constructed in the vicinity of the Mobil bulk fuel depot and Dekehtik port area, creating a hazard for both. A reclamation project is proceeding in an area adjoining the tank farm; it is recommended that the project be altered to observe a ten meter minimum clearance from the depot boundary. In Chuuk, the depot facilities are badly rusting and require maintenance, but they are located away from encroaching developments. In Kosrae, the new facilities appear to be in excellent condition and well located.

4.13 The physical condition of the depot in Yap is acceptable, but the separation distances between tanks and between the facility and other installations are not adequate. At some retail sites, pumps are installed within buildings, causing vapor accumulation and consequent fire hazards. It is recommended that this be prohibited.

4.14 **Service stations.** It is recommended that the number of service station outlets in each of the states be limited for safety, environmental and economic reasons. In most states an increase in the number of existing stations should not be allowed; two or three sites would be economically optimal. If other companies want retail outlets to compete against Mobil,

---

[50] Work begun by PEDP (to be completed by FSED's Petroleum Section) 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 likely that the document will be completed during 1992. It can be further modified by the government to suit local requirements.

sites can be obtained through negotiations with owners assisted, if necessary, by franchise legislation which limits the number of retail outlets that can be owned by one company.

4.15 **Price monitoring.** Neither the states nor the national government administer petroleum supply agreements or monitor prices, and thus must rely on the supplier to ensure that the prices conform with the respective supply agreements. It is recommended that a suitably-qualified person be appointed to monitor Mobil's prices and to train personnel to monitor fuel deliveries in the states. This would require routine collection of relevant data from Mobil, checked against other sources, on FOB (Singapore) prices, transhipment costs in Guam, freight costs, onshore storage costs, etc. Such an effort is worth the expense, as other countries in the region have found that monitoring fuel deliveries has resulted in significant savings[51]. Price monitoring should include review and regulation of onshore wholesale and retail margins, which should be limited in order to discourage growth in the number of low-volume onshore distribution facilities.

4.16 **Products and Quality Control.** Six grades of fuel are marketed on Pohnpei and Chuuk and five in the other two states. The five common grades are Regular Gasoline, Jet A1, Lighting Kerosene, Low Sulphur Automotive Distillate Oil (ADO) and a small amount of Aviation Gasoline (RON[52] 100/130). Over 90% of the gasoline marketed in FSM is 90 RON regular (leaded), with a small amount of 95 RON premium gasoline marketed in both Pohnpei and Chuuk. Marketing more than one grade of gasoline where volumes are small adds to freight, storage, and retailing costs and leads to increased prices for all gasoline sold. It is recommended that the government assess the benefits and cost of adopting a single "compromise" grade of gasoline that will suit the needs of the majority of consumers: a 93 RON unleaded grade is suggested.

4.17 It is recommended that all states verify that fuel deliveries meet the specifications of the supply agreements and keep the general public informed of changes in fuel grades or qualities when they occur. Each cargo of fuel received should be supported by shipping documents including a refinery certificate validating the quality of fuel being supplied. It may be necessary for the states or national government to engage experts to enforce fuel quality requirements. It is recommended that fuel be tested at least once a year in Guam or Manila where independent laboratories are available, and that the supplier be required to obtain the states' prior approval of any changes in the specifications of fuel being supplied.

4.18 **Data Collection and Analysis.** There is a lack of reliable petroleum market information. Accurate data on import volumes and values, consumption levels by sector, and other data are not available from government offices; most information on fuel comes from Mobil and a few major consumers and is incomplete. Without independent data, it is not possible to cross-check innumerable inconsistencies. However, with minor procedural changes, the Customs Department should be able to document import volumes, duty paid, CIF values and re-exports. The recommended changes are as follows:

a) A customs official in each state should supervise the dipping of the individual bulk tanks before and after each tanker discharge of fuel. All volumes should be calculated at ambient temperature. All tank valves should be locked and sealed by

---

[51] The Forum Secretariat Energy Division's Petroleum Section may be able to assist in these areas.

[52] All references to octane are RON or Research Octane Number. The RON of a specific gasoline is determined in a special laboratory test engine under "mild engine-severity" conditions giving a rough measure of the low-speed knock properties of the gasoline.

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.

c) All Customs Import Entries should have verified supporting shipping documents[53] 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[54].

Power Subsector

4.19 The electric utilities in all states are institutionally fragmented: responsibilities for management, revenue collections, customer service, plant maintenance, etc., are shared among several different government ministries. Typically, responsibility (but not budgeting authority) for operations and maintenance comes under the state Department of Public Works while billing and revenue collection is under the state Ministry of Finance. Personnel are selected and appointed by the state Public Services Commission, and budgeting is often controlled directly by a state Parliamentary committee. Thus there is a lack of managerial accountability in the power sector which has three adverse effects:

a) *poor collections and cost recovery*. Since billing and revenue collection have no relationship with the utility's budget, utility operations are not affected by inadequate billing or poor collections. Disconnections for nonpayment rarely occur since there is no financial incentive to enforce them, and the rate of collections and cost recovery do not improve (see para 4.5);

b) *inadequate budgeting for preventative maintenance*. Since the budgets of the utilities are often controlled directly at a political level rather than by the engineers responsible for operation and maintenance, the need for budgetary allocations for routine and preventative maintenance is often unrecognized. The budgetary process tends to respond only *after* a breakdown has occurred, not before; there is

---

[53] 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.

[54] 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.

insufficient maintenance of operating equipment, leading to frequent outages and shortened equipment life; and

c) *inadequate planning*. There is no capability within the engineering staff, whose responsibilities are limited to operating and maintaining the existing power system, to anticipate future investment requirements or to prepare options to meet capital costs. Procurement to meet growing load is often delayed until outages have begun to occur due to insufficient capacity; options for adding capacity quickly are usually very limited and more costly than the 'least cost' solution that might be available through careful planning.

4.20 To address these problems, it is recommended that management responsibility for electricity operations be consolidated under one authority in each state. After consolidation, the new authorities would be responsible for billing and revenue collection, personnel recruitment, and capacity planning, in addition to operations and maintenance. Control of utility revenue accounts would be transferred to the authorities, as would budgeting and tariff determination responsibilities, subject to oversight by the government civil service. It is recommended that new legislation be implemented in each state to establish the new authorities and to confer upon them the legal rights and responsibilities of autonomous operation.

4.21 During 1990, a USDOI/Army Corps of Engineers consultancy team visited all four FSM states to assess general needs for rehabilitating infrastructure including the power sector. As a result, an "Operations & Maintenance Improvement Program[55]" (OMIP) has been proposed for the power sector in the FSM which includes a recommendation, similar to the above, to form a power authority in each state. Since 1990, the states have made varying degrees of progress towards preparing legislation and implementing autonomous authorities. Pohnpei approved legislation in early 1991 and is likely to have an operating authority by late 1991 or early 1992. Chuuk and Kosrae drafted legislation which by early 1991 had not been approved, and Yap was administratively transferring (without legislation) billing and revenue collection responsibilities from the Ministry of Finance to the Division of Public Utilities and Contracts.

4.22 In June 1991, the Pacific Energy Development Programme commissioned a consultant to visit each state in FSM to assist them to identify appropriate corporate structures and manpower requirements for the proposed new authorities[56]. Among other recommendations, the consultant suggests that the state power authorities adopt similar structures and management tools, such as reporting practices, record keeping systems, and computer software to reduce development costs and facilitate sharing of data and expertise and other forms of cooperation among the authorities. This recommendation is endorsed.

4.23 Development of the state power authorities along similar lines would facilitate the eventual formation of a national power utility, which may eventually be desirable. It is recommended that the feasibility of forming a national power utility be studied, to determine whether the benefits of standardized operations resulting from national

---

[55] *Plan of Action* (Draft): *Operations and Maintenance Improvement Program*, October 1990. Louis Berger International and Barrett Consulting Group, for the U.S. Department of the Interior and the U.S. Army Corps of Engineers. There is one report for each state plus an FSM overview. The most recent report is the *Second Year Review: OMIP Team's Field Report for the Federated States of Micronesia* (June 1991).

[56] *Proposed Organizational Structure and Manpower Requirements of the FSM State Power Utilities* (PEDP Report FSM 91-1, forthcoming, 1991).

management would justify the costs of the considerable reorganization that would be required. A national utility in FSM would also make it easier for the country to qualify for low interest loans and technical assistance to the power sector from multilateral lenders.

NEW AND RENEWABLE SOURCES OF ENERGY

4.24 *Photovoltaics.* As the FSM has not developed a coordinated program among the states for photovoltaic (PV) installations, there are no means to determine priorities or to ensure that available aid funds (mainly U.S., but including some French and Australian assistance) are distributed efficiently to the states. It is recommended that the national government take a more active role in PV project coordination by appointing a rural energy project manager within the proposed energy office, responsible for assisting the states to design projects, secure funding, and train personnel to install and maintain PV equipment.

4.25 A key policy issue is how to establish an effective mechanism for financing, designing, installing and maintaining PV installations so 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 (TSECS). Tuvalu, with only 9,000 people and a per capita GDP one fourth that of FSM's, has established a relatively successful independent, commercially-oriented 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 TSECS began with aid finance but now relies primarily on users' fees to cover O&M costs. Its success is due to dedicated management, competent outside advice, decentralized technical and administrative resources, and emphasis on high quality maintenance and the ready availability of spare parts. If the states or national government proceed with plans to expand the use of PVs, it is recommended that a similar approach be considered[57].

4.26 *Biomass.* The FSM has abundant biomass resources with 75% of the country forested. The small amount of biomass presently used for domestic cooking and crop drying is not expected to diminish and its per capita use may well increase as the cost of commercial fuels rises. Its use as a domestic cooking fuel might have broader appeal if a design for an affordable and reliable cooking stove for mass production were available. The USDOE *Territorial Energy Assessment* for the FSM (1982) reports that a USDOE-sponsored project to promote use of "smokeless stoves" in FSM was successful, but it is not known to what extent such stoves are still in use. An investigation of successful stove designs for FSM would be useful for rural energy planning and is recommended.

4.27 Use of biomass for centralised electricity generation is not recommended, because of insufficient market mechanisms and infrastructure to cope with fuel harvesting and because of the high potential for degradation of soil and water supplies.

4.28 *Other renewable energy sources.* Hydro resources have been developed to a limited extent in Kosrae and Pohnpei and significant resources exist for further development. It is recommended that further investigation of the hydro resources of both states be carried out to determine their potential to supplement grid-based electricity or to provide power in remote communities of the main islands. Wind resources in FSM are insufficient for

---

[57] *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 FSM program.

reliable power generation[58], but the 1982 *Territorial Energy Assessment* recommends considering its use for water pumping. Other technologies such as OTEC, wave, and tidal power are still experimental and have extremely limited potential for FSM in the foreseeable future. It is recommended that these not be pursued at this time.

ENERGY CONSERVATION

4.29 Consumers have no incentive to save electricity due to heavily subsidized prices. If electricity tariffs are substantially increased as recommended, there may be initial resistance from the general public and a strong inducement for them to reduce electricity use. It is recommended that simple but effective means of conserving electricity be promoted by government, such as cleaning air conditioner filters, de-icing of refrigerators and freezers, time controls on air conditioners, solar heating of water, etc. In all states, timely government action could mitigate consumers' difficulties with rising tariffs by working 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 recommended in concert with any increase in electricity tariffs and collections.

4.30 Little is known about energy end-use consumption patterns among categories of users such as businesses, government, and rural and urban households, since end-user surveys are not known to have been carried out in FSM. It is recommended that household and commercial/government energy use surveys be undertaken to help design future biomass, urban energy conservation, and rural energy planning programs.

4.31 Within the state power utilities, investments in energy conservation will generally be more economic than investments in new generation capacity. In the long term, conservation of electricity benefits utilities by lengthening the period of time between new capacity additions. Deferment of major investment is of very significant financial benefit to a 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 savings will be approximately $0.38 million[59]. Deferring investment allows available funds to be used for other purposes until they are needed for the investment. In the short term, the benefits of energy conservation will be felt in fuel savings and possibly a reduction in losses at peak hours.

ENVIRONMENTAL ISSUES

4.32 **Petroleum Supply.** The main threats to the environment in the oil industry in all states are the risks of spillage and pollution of ground water and the lagoon area during tanker discharges, ships' bunkering operations and transfers from bulk tanks to the powerhouse tanks. Adopting and enforcing suitable regulations for oil-handling facilities and procedures to be followed may reduce the number and severity of spills. However, tankers call into each FSM port at a frequency of approximately once per month, and regulations provide no protection when a mishap occurs, if equipment is not immediately available to

---

[58] A 1.5 kW demonstration wind-powered electric generator was installed in Yap in 1983 but drew as much power from the grid as it put in, and was abandoned in 1985.

[59] At a 10% discount rate. The present value of a $1 million investment five years from now is $1 million/$(1+10\%)^5$ = $620,921, for a saving of $379,079.

deal with it. To ensure that the industry can respond to emergencies, each of Mobil's storage facilities in FSM 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 locked trailer kept on stand-by at the location of every facility.

4.33 It is recommended that industry compliance with normal international operating requirements be enforced. These requirements specify pre-discharge tests on pipelines, hoses, tanks, communication equipment, etc., minimum manning levels to ensure that all equipment is used properly, and specific training for spill prevention and clean-up operations. It is further recommended that periodic tests on equipment be rigorously carried out.

4.34 Mobil's bulk fuel depots are equipped with drainage controls to ensure that only clean water is discharged into public areas. However, the management of the separator pit is a critical part of this control; if the pit is not emptied of fuel after each discharge, fuel will overflow into the neighboring properties and the sea during periods of heavy rain.

4.35 It is recommended that national government draft a "Marine Pollution Emergency Contingency Plan" to provide for a coordinated response by appropriate government agencies and the private sector to oil pollution emergencies and to specify penalties for polluters. Other than bulk fuel depots that are not equipped with drainage controls, service stations, back-yard garages and ships' bilges are typically the main sources of pollution in urban waters. Regulations should be revised to cover these and the local authorities should be briefed on any changes.

4.36 A further source of oil pollution in all states is the improper disposal of used oil from vehicles, power generators, and other engines. The small volume involved in FSM makes impractical some methods of disposal including recycling used in developed countries, but there are affordable alternatives which are environmentally acceptable. These include incineration, burning used oil with fuel in the powerhouse, and using oil to mark playgrounds or to spray unpaved rural roads to control dust (although such use should be closely supervised and restricted to the drier periods of the year).

4.37 **Electricity Supply.** The power stations in all states are located sufficiently distant from residential areas that noise and air pollution problems are minimal, although the power station in Kosrae is located quite close to government offices. Transformers containing PCB fluids have reportedly been removed from Kosrae, Pohnpei, and Yap, but are not known to have been removed in Chuuk. Low voltages in all states, in combination with poor maintenance, leads to the break-down of compressors in air-conditioners, refrigerators and freezers, leading to excessive pollution from CFC gases.

4.38 In Chuuk and Yap, lube oil is leaking into the sumps in the powerhouse, from where it passes into cable ducts and leaks outside, threatening ground water supplies. In Pohnpei, the ill-maintained ALCO-barge presents a serious environmental hazard. The floor of the engine hall is covered in oil, in places in pools. Spillage causes pollution of the harbor; if the barge deteriorates further, serious environmental damage could result.

V. INVESTMENT AND TECHNICAL ASSISTANCE PRIORITIES

5.1 The following priorities are recommended for technical assistance and investment to refurbish the energy infrastructure in FSM, and to address some of the deficiencies identified in the report. Most of the recommendations made in previous chapters which involve little or no external costs (e.g., policy changes) are not repeated here. As FSM has recently become a member of the Asian Development Bank, Annex 2 contains a suggested scope of work for ADB assistance and potential financing of projects.

ENERGY PLANNING AND COORDINATION

5.2 The FSM does not need a fully-fledged Energy Ministry to handle energy matters effectively. However, it is recommended that the government appoint a competent senior official within the Department of Resources and Development to oversee the energy sector. He or she should have sufficient government backing to be able to implement accepted recommendations. If no qualified FSM citizen is available to fill the post, it is recommended that an expatriate energy expert be appointed for 12 - 24 months to advise the government and train a local counterpart. Although in the long term the official is expected to be mainly concerned with power sector issues, complex negotiations with oil companies to improve supply conditions, prepare for a possible national tender, and to renew contracts which expire in 1992 justify the appointment of a petroleum expert for 12 - 24 months. This is recommended, as discussed below.

5.3 Two expatriate advisors, each appointed for 24 months, would cost in total in the range of $240,000 - $280,000.

POWER SUBSECTOR

5.5 *Generation.* Technical assistance is recommended to investigate whether refurbishment of any of the eight second-hand 2 MW ALCO engine generator sets in FSM (two in Chuuk, four in Pohnpei, and two in Yap) is technically and financially feasible. It would be advantageous to organize a single national tender for this investigation and subsequent overhaul work, if warranted. The technical assistance should include appointment of an experienced mechanical engineer to supervise the feasibility study for all three states. The cost of the technical investigation, including three months of supervision, would cost approximately $50,000.

5.6 In Kosrae, a power development study is recommended to determine the tariff level required to recover costs; realistic future load growth trends under rising tariffs; the suitability of the older machines in the power house to serve as peaking units; the cost of installing synchronizing equipment; and requirements for new capacity. Such a study would cost at least $50,000.

5.7 *Distribution.* It is recommended that the 4.16 kV line segments serving the urban areas in all states be upgraded to 13.8 kV in order to reduce losses and improve voltage to consumers. Technical assistance is recommended for analysis of load flows, voltages and losses in all 4.16 kV distribution systems. It is recommended that revised designs for substations be developed in Chuuk and Pohnpei and protection schemes using circuit breakers, sectionalizers, fault indicators, etc., be designed with the objectives of ensuring

safe operation and maintenance of substations, minimizing the risk of system-wide outages due to line faults, and reducing the outage time and the number of consumers affected by line faults and maintenance work. It is recommended that inexpensive fault indicators be installed on branching points of all 13.8 kV networks and that the potential of capacitor banks to reduce voltage drops and electrical losses be analyzed, with concurrent load monitoring of the distribution transformers with one or two transformer-mounted voltage recorders supplemented with inexpensive hand-held and line-mounted volt meters. Most of the results could be obtained through computer analysis of loading data, apart from some equipment needed to optimize the location and number of capacitor banks and to measure voltages.

5.8 It is recommended that a 'system map' for each state be established, preferably on a desktop computer. This need not be sophisticated considering the relative simplicity of the distribution systems. The emphasis should be on collection of system inventory data, not exact geographic information which can be extremely costly. It is recommended that utility personnel be actively involved in the implementation and should later take over complete responsibility for maintenance of records and maps. The initial cost of developing the map and carrying out the recommended evaluations of the distribution system would be at least $100,000 each for Chuuk and Pohnpei and somewhat less for the other states.

5.9 *Training.* In view of moves to 'corporatize' the utilities, an education and training program with time away from FSM for both managers and engineers is recommended so that local staff can take over responsibility for running the utilities within the 1990s. Minimum permanent power utility staff in each state 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 prepared and approved by the Board of Directors of each utility. The senior engineers should attend formal courses in relevant engineering disciplines; overseas training and apprenticeships should be established as soon as possible. It is recommended that linesmen and station operators be trained in preventive maintenance, and senior managers be trained in accounting, investment planning, and personnel management. Outside assistance programs could sponsor appropriate staff members or recruits for overseas technical courses of up to one year; longer courses would be handled by FSM or U.S. scholarship programs. There are technical courses for linesmen, power station operators, mechanics, electricians, etc., of 1 - 2 months duration available through other power utilities in the region such as those in Papua New Guinea and Fiji; outside assistance programs could provide funds for travel and subsistence for such training at comparatively little cost. Assistance required for both technical and professional power sector training in the FSM would be likely to exceed $100,000 per year for five years.

5.10 *Accounting and record keeping.* Technical assistance is recommended to support the utilities in creating and maintaining adequate financial accounts and operating records of the type and standard suited to commercial corporations. It is recommended that accounting and record keeping procedures and formats be standardized in all FSM power utilities to simplify oversight of operations by national authorities and to facilitate the exchange of expertise and data among the state utilities. Assistance required to support these efforts, involving design of procedures, collection of initial data, and training of staff is estimated at $25,000 - $35,000 per utility including software costs, if all states are assisted under a single contract.

5.11 *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 the national government on subsidy policy. The work would combine well with assistance to create standard accounting and record keeping systems. The estimated combined cost is $200,000 for all states or $100,000 if done without the accounting and record keeping work.

5.12 *Metering and billing.* All consumers in all states, including all government consumers, should be metered and billed for their consumption. Technical assistance is recommended especially for Chuuk and Kosrae to design and install new computerized billing systems which, to save costs, should be based on the same software; it is recommended that eventually all states adopt the same billing software and collection procedures. The systems in use or under development in Pohnpei and Yap could be used as a model for all states. The estimated cost is $75,000 for all states.

5.13 *Dublon (Chuuk).* It is recommended that a feasibility study of rehabilitating the Dublon power system be carried out, to include a technical investigation of the power facilities and an assessment of needs on Dublon. The estimated cost is $20,000.

Petroleum Subsector

5.14 It is recommended that a petroleum expert be appointed for at least 12 months to assist FSM in improving fuel supply terms and administration. The expert would assist the states and national government to negotiate improved supply conditions with Mobil, and to extend, renegotiate, or replace existing contracts as necessary; to assess the feasibility of organizing a national supply tender by 1992; and if a national tender is feasible, to negotiate the terms and conditions of a national supply contract. In addition, it is recommended that the expert be required to provide training to local counterparts in the states and national government to conduct negotiations and monitor contracts. An expatriate petroleum expert would cost in the range of $60,000 - $100,000 per year, depending on the source of assistance.

5.15 It is recommended that standards be adopted for the siting and operation of petroleum storage facilities and that land use in the vicinity of storage sites be strictly regulated in all states. The FSED Petroleum Section is working to develop petroleum storage and handling standards appropriate for the Pacific Islands region. It is recommended that the government approach the FSED for assistance in specifying such standards. It is likely that assistance from FSED will be available to FSM at no cost to the government.

5.16 It is recommended that retail gasoline prices be monitored and pricing guidelines be established and enforced in all states. It is further recommended that a study be undertaken of the gasoline retail market in FSM to determine: (1) the optimum number of retail service stations to operate in each state and (2) the optimum number of grades and octane ratings of gasoline to be marketed, in order to minimize costs to consumers. A consultancy for a study of the retail gasoline market in the four states, including proposals for establishing retail price monitoring and regulation, would cost $50,000 - $100,000.

Household and Renewable Energy

5.17 *Photovoltaics.* Technical assistance is recommended to help establish a long-term photovoltaic program including assessment of staffing needs, suitable equipment and

appliances, and establishment of a permanent organization. The estimated cost is $30,000 excluding any expenditure on measuring the solar resource.

5.18 *Hydro.* It is recommended that further investigation of hydropower development opportunities be carried out or completed on selected sites in Pohnpei and Kosrae. Feasibility study and design costs would vary according to site conditions, but would be in the range of $500 to $1,000 per kW of a proposed scheme.

5.19 *Biomass.* Monitoring of the biomass resources of all states, especially forests and mangroves, is recommended to prepare for and mitigate the long term effects of possible increased use of biomass resulting from higher user charges for electricity and other forms of commercial energy. It is recommended that a forest cover survey in all states, costing $80,000 - $100,000, be completed every ten years.

5.20 *Conservation.* It is recommended that the national government and proposed power utility corporations establish an energy conservation and management program to assist households and businesses to reduce wasteful electricity consumption, through advisory services, import duties, taxes which encourage efficient appliances, and assistance to importers on sources of efficient lights, refrigerators, stoves, etc. A consultancy to train local officials to carry out energy audits, develop promotional materials, and advise on appropriate tariffs for energy-using appliances in each state would cost $50,000.

5.21 *Wind.* Further monitoring and analysis is recommended of the wind regime in the FSM, possibly through the services of the Forum Secretariat Energy Division (FSED). However, due to the expected poor wind regime, this recommendation has low priority. The estimated cost is $30,000 for a two-year study at one site, or less if part of a regional assessment program.

5.22 *Household and rural energy planning.* It is recommended that the government carry out household energy end-use surveys in the urban areas and selected rural communities of the four states to provide basic data for planning energy assistance programs for low income households. The local cost would be about $2,000 per survey if carried out and funded through the FSED, through which funds are available to meet the majority of costs.

ANNEX 1

STATISTICAL TABLES

TABLE 1
SELECTED DEVELOPMENT INDICATORS FOR THE FSM

		1985	1986	1987	1988	1989	1990
GDP [1] (US$ m)		$120.5	$128.1	$136.1	$144.7	na	na
Per capita (US$)		$1,383	$1,428	$1,473	$1,520	na	na
Total Imports [2] (US$ m)		41.4	44.2	41.9	67.7	na	na
Total Exports [3] (US$ m)		5.1	4.0	4.0	5.4	na	na
Inflation Rate [4]		na	na	na	na	na	na
Sea Area ('000 mi ^{2})	965						
Land Area (mi ^{2})	270						
Wage & Salary Employment [5]		na	na	na	na	12,560	na
Ave Wage/Salary [6] (US$/hour)		na	na	na	na	$3.17	na
Economically Active		23,336	24,270	25,240	26,250	27,300	na
Total Population [7]		87,100	89,700	92,400	95,200	98,100	101,000
Urban [8] (%)		na	na	29%	29%	na	na

Overseas Development Assistance

Annual ODA [9] (US$ m)	$100.0	$115.0	$126.0	$136.7	$114.4	na
ODA (% GDP)	na	90%	93%	94%	na	na
ODA [10] (% Current Government Revenue)	na	na	90.2%	82.8%	73.4%	na
Bilateral [11]	100%	100%	99.8%	99.8%	96.7%	na
ODA per Capita (US$)	$1,148	$1,282	$1,364	$1,436	$1,166	na

Sources: 1) Economic Report on the Federated States of Micronesia (ADB, December 1990).
2) The Second National Development Plan (Office of Planning & Statistics, FSM, 1990).
3) Mission estimates.

Notes:
1 Provisional, current market prices.
2 FOB, excludes petroleum products except 1988 ($4.063 million).
3 FOB
4 Neither consumer nor producer price indices are compiled in the FSM.
5 From mission estimates, based on preliminary data released from a February 1990 manpower survey.
6 Mission estimate from sources 1 and 2. Approximate only.
7 Estimate assuming 1990 is correct and 3% pa growth; census dates and accuracy differ state-by-state.
8 Urban defined as Kolonia (Pohnpei), Weno (Chuuk), Colonia (Yap) & Lelu (Kosrae).
9 Exact figures unavailable.
10 Source 1.
11 Source 1.

TABLE 2

SELECTED PROJECTIONS FOR FSM (1990 – 2000)

	1990	1995	2000
Population[1]:	100,789	115,600	132,400
GDP ($ millions; 1988 prices)[2]:			
high growth (4% real)	150.5	183.2	222.8
medium growth (3% real)	150.5	174.5	202.3
low growth (2% real)	150.5	166.2	183.5
GDP/Capita[3]:	$1,494	$1,510	$1,528
Electricity Generation[4] (GWh):			
1987 – 1990 growth rate	67.4	94.9	133.6
reduced growth rate	67.4	78.1	90.5
Fuel Consumption ('000 USG):			
Gasoline	3,824	5,109	6,412
Jet A1	2,232	3,271	4,728
Kerosene	284	322	347
ADO	7,854	10,265	12,529
IDO			
IFO			
Lubes	112		
Avgas	62	66	73
Solvent			
LPG			
Others			
Total Inland	14,369	19,033	24,090
Bunkers	none	none	none
Total FSM trade	14,369	19,033	24,090

Sources: 1) Total population from Second National Development Plan (FSM, 1990).
2) Govt fuel data inconsistent; mission estimates based partly on oil companies.

Notes: [1] Midyear medium growth scenario.
[2] GDP in 1988 constant dollars. Assumes 2% annual real growth from 1988 – 1990.
[3] In 1988 dollars. Assumes medium GDP growth.
[4] Mission estimates for grid systems of Chuuk, Kosrae, Pohnpei & Yap. "Reduced growth" assumes tariffs increase to true cost by 1995.

TABLE 2a
Petroleum Demand Projections, Federated States of Micronesia
Low Growth Scenario
('000 USgal)

Product[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline[2]	4,091	4,214	4,340	4,470	4,604	4,743	4,885	5,031	5,182	5,338	5,498
Jet A1[3]	2,274	2,410	2,555	2,708	2,871	3,043	3,226	3,419	3,624	3,842	4,072
Kero[4]	299	302	305	308	311	314	317	321	324	327	330
ADO[5]	8,429	8,682	8,942	9,211	9,487	9,772	10,065	10,367	10,678	10,998	11,328
Avgas[6]	60	61	61	62	62	63	64	64	65	66	66
Total	15,153	15,669	16,204	16,759	17,336	17,935	18,556	19,202	19,873	20,570	21,295

Notes:

(1) 1990 figure for Pohnpei, Chuuk, Yap and Kosrae
(2) Gasoline 3% growth
(3) Jet A1 6% growth
(4) Kerosene 1% growth
(5) ADO 3% growth
(6) Avgas 1% growth

Medium Growth Scenario[1]

Product	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline	4,091	4,275	4,468	4,671	4,885	5,109	5,344	5,591	5,851	6,125	6,412
Jet A1	2,274	2,445	2,628	2,827	3,040	3,271	3,520	3,788	4,078	4,390	4,728
Kero	299	303	308	313	317	322	327	332	337	342	347
ADO	8,429	9,766	9,118	9,484	9,866	10,265	10,680	11,114	11,566	12,037	12,529
Avgas	60	61	62	64	65	66	68	69	70	72	73
Total	15,153	15,850	16,585	17,359	18,174	19,033	19,939	20,894	21,902	22,966	24,090

Notes:

(1) All demands are mid points of low and high growth.

High Growth Scenario

Product[1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline[2]	4,091	4,336	4,597	4,872	5,165	5,475	5,803	6,151	6,520	6,912	7,326
Jet A1[3]	2,274	2,479	2,702	2,945	3,210	3,499	3,814	4,157	4,531	4,939	5,383
Kero[4]	299	305	311	317	324	330	337	34[illegible]	350	357	364
ADO[5]	8,429	8,850	9,293	9,758	10,246	10,758	11,296	11,86[illegible]	12,453	13,076	13,730
Avgas[6]	60	62	64	66	68	70	72	74	76	78	81
Total	15,153	16,032	16,966	17,958	19,011	20,131	21,321	22,586	23,931	25,362	26,885

Notes:

(1) 1990 figure for Pohnpei, Chuuk, Yap and Kosrae
(2) Gasoline 6% growth
(3) Jet A1 9% growth
(4) Kerosene 2% growth
(5) ADO 5% growth
(6) Avgas 3% growth

TABLE 3

ENERGY BALANCE ESTIMATES FOR THE FEDERATED STATES OF MICRONESIA (1990)
('000 TOE)

	Fuelwood	Coconut Residues	Total Biomass	Hydro	Electricity[4]	Gasoline	Jet A1	Kerosene	ADO	IFO	Avgas	LPG	Petroleum	Total
Primary Supply														
Production	0.99	5.09	6.08	0.62										6.70
Imports						12.50	7.56	0.97	28.45		0.18		49.66	49.66
Bunkering/exports														
GROSS SUPPLIED	0.99	5.09	6.08	0.62	0.00	12.50	7.56	0.97	28.45	0.00	0.18	0.00	49.66	56.35
Conversion														
Public Power Generation				(0.62)	18.50				(17.88)				(17.88)	0.00
Transformation losses					(12.81)									(12.81)
Station Use					(0.26)									(0.26)
Transmission/Distribution Losses					(0.76)									(0.76)
NET SUPPLIED	0.99	5.09	6.08	0.00	4.67	12.50	7.56	0.97	10.57		0.18		31.77	42.52
Final Consumption					4.67									4.67
Households[1,2]	0.99	3.11	4.10		n.a.			0.97					0.97	5.07
Transport														
Air							7.56				0.18		7.73	7.73
Sea						11.86			7.47				19.33	19.33
Road						0.64			3.10				3.74	3.74
Government/Commercial					n.a.									
Industrial/Construction					n.a.									
Agroindustries[3]		1.98	1.98											1.98
Other					n.a.									
TOTAL	0.99	5.09	6.08		4.67	12.50	7.56	0.97	10.57		0.18		31.77	42.52

Notes:

(1) Cooking and lighting. No indicative data available (11,802 hh & 8.54 people/hh). Population growth = 3%/yr. Assume hh growth = 2%/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).
Assume 20% of all households cooking entirely/mainly with biomass assume:
100,789 people * 0.2 * 1.6 kg/capita/day * 365 days / 1,000 kgs/tonne 11,772 tonnes
Total cooking (assumed to be 80% coconut waste, 20% other biomass)

(3) Agroindustries: 1990 copra production assumed approx. average 1974 – 1988 production of 2500 tonnes
Fuel consumption for drying assumed at 2.4 tonnes coconut residues/tonne copra produced (open fire drying) 6,000 tonnes

(4) Includes Pohnpei, Chuuk, Yap and Kosrae

Source: Mission Estimates 1990

TABLE 3a

ENERGY BALANCE ESTIMATES FOR THE FEDERATED STATES OF MICRONESIA (1990)
(Original Units)

	Fuelwood (tonnes)	Coconut Residues (tonnes)	Total Biomass (tonnes)	Hydro	Electricity[4] (GWh)	Gasoline (kUSgal)	Jet A1 (kUSgal)	Kerosene (kUSgal)	ADO (kUSgal)	IFO (kUSgal)	Avgas (kUSgal)	LPG (kUSgal)	Petroleum (kUSgal)
Primary Supply													
Production	2,355	15,419	17,773	2.49									
Imports						4,091	2,274	299	8,429		60		15,153
Bunkering/exports													
GROSS AVAILABLE	2,355	15,419	17,773	2.49		4,091	2,274	299	8,429	0	60	0	15,153
Conversion													
Public Power Generation					67.37				(5,298)				(5,298)
Transformation losses													
Station Use					(3.08)								
Transmission/Distribution Losses					(9.00)								
NET SUPPLIED	2,355	15,419	17,773	2.49	55.29	4,091	2,274	299	3,131		60		9,855
Final Consumption													
Households[1,2]	2,355	9,419	11,773		n.a.			299					299
Transport													
Air							2274				60		2,334
Road						3,881			919				4,800
Sea						210			2212				2,422
Government/Commercial					n.a.								
Industrial/Construction					n.a.								
Agroindustries[3]		6,000	6,000										
Other					n.a.								
TOTAL	2,355	15,419	17,773			4,091	2,274	299	3,131		60		9,855

Source: Mission Estimates 1990

Notes:

(1) Cooking and lighting. No indicative data available (11,802 hh & 8.54 people/hh). Population growth = 3%/yr. Assume hh growth = 2%/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).
Assume 20% of all households (20,160 people) cooking entirely/mainly with biomass:
20,160 people * 1.6 kg/capita/day * 365 days / 1,000 kgs/tonne 11,773
Total cooking (assumed to be 80% coconut waste, 20% other biomass)

(3) Agroindustries: 1990 copra production assumed approx. average 1974–1988 production of 2500 tonnes
Fuel consumption for drying assumed at 2.4 tonnes coconut residues/tonne copra produced (open fire drying) 6,000

(4) Includes Pohnpei, Chuuk, Yap and Kosrae

TABLE 4

ENERGY BALANCE ESTIMATES FOR THE FEDERATED STATES OF MICRONESIA (1995)

('000 TOE)

	Fuelwood	Coconut Residues	Total Biomass	Hydro	Electricity[4]	Gasoline	Jet A1	Kerosene	ADO	IFO	Avgas	LPG	Petroleum	Total Energy
Primary Supply														
Production	1.15	5.58	6.73	0.62										7.35
Imports						15.61	10.67	0.99	34.64		0.20		62.13	62.13
Bunkering/exports														
GROSS SUPPLIED	1.15	5.58	6.73	0.62	0.00	15.61	10.67	0.99	34.64	0.00	0.20	0.00	62.13	69.48
Conversion														
Public Power Generation				(0.62)	22.74				(22.12)				(22.12)	0.00
Transformation losses					(15.68)									(15.68)
Station Use					(0.33)									(0.33)
Transmission/Distribution Losses					(0.95)									(0.95)
NET SUPPLIED	.15	5.58	6.73	0.00	5.78	15.61	10.67	0.99	12.53		0.20		40.01	52.52
Final Consumption					5.78									5.78
Households[1,2]	1.15	3.60	4.75					0.99					0.99	5.74
Transport						15.61	10.67		12.53		0.20		39.02	39.02
Government/Commercial														
Industrial/Construction														
Agroindustries[3]		1.98	1.98											1.98
Other														
TOTAL	1.15	5.58	6.73		5.78	15.61	10.67	0.99	12.53		0.20		40.01	52.52

Notes:

(1) Cooking and lighting. No indicative data available (11,802 hh & 8.54 people/hh). Population growth = 3%/yr. Assume hh growth = 2%/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).
Assume 20% of all households cooking entirely/mainly with biomass assume:
100,789 people *0.2* 1.6 kg/capita/day * 365 days / 1,000 kgs/tonne 11,772 tonnes
Total cooking (assumed to be 80% coconut waste, 20% other biomass)

(3) Agroindustries: 1990 copra production assumed approx. average 1974–1988 production of 2500 tonnes. Assumed constant over next 5 years.
Fuel consumption for drying assumed at 2.4 tonnes coconut residues/tonne copra produced (open fire drying) 6,000 tonnes

(4) Includes Pohnpei, Chuuk, Yap and Kosrae

Source: Mission Estimates 1990

TABLE 4a

ENERGY BALANCE ESTIMATES FOR THE FEDERATED STATES OF MICRONESIA (1995)

('000 TOE)

	Fuelwood (tonnes)	Coconut Residues (tonnes)	Total Biomass (tonnes)	Hydro (GWh)	Electricity[4] (GWh)	Gasoline (kUSgal)	Jet A1 (kUSgal)	Kerosene (kUSgal)	ADO (kUSgal)	IFO (kUSgal)	Avgas (kUSgal)	LPG (kUSgal)	Petroleum (kUSgal)
Primary Supply													
Production	2,729	16,918	19,647	2.49									
Imports						5,109	3,211	306	10,265		69		18,960
Bunkering/exports													
GROSS SUPPLIED	2,729	16,918	19,647	2.49	0.00	5,109	3,211	306	10,265	0	69	0	18,960
Conversion													
Public Power Generation				(2.49)	84.14				(6,553)				(6,553)
Transformation losses													
Station Use					(3.85)								
Transmission/Distribution Losses					(11.24)								
NET SUPPLIED	2,729	16,918	19,647	0.00	68.44	5,109	3,211	306	3,712		69		12,407
Final Consumption					68.44								
Households[1,2]	2,729	10,918	13,647		n.a.			306					306
Transport						5,109	3,211		3,712		69		12,101
Government/Commercial					n.a.								
Industrial/Construction					n.a.								
Agroindustries[3]		6,000	6,000										
Other					n.a.								
TOTAL	2,729	16,918	19,647		68.44	5,109	3,211	306	3,712		69		12,407

Notes:

(1) Cooking and lighting. No indicative data available (11,802 hh & 8.54 people/hh). Population 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).
Assume 20% of all households in 1995 (23,370 people) cooking entirely/mainly with biomass:
23,370 people * 1.6 kg/capita/day * 365 days / 1,000 kgs/tonne 13,648 tonnes
Total cooking (assumed to be 80% coconut waste, 20% other biomass)

(3) Agroindustries: 1990 copra production assumed average 1974–1988 production of 2500 tonnes. Assumed constant to 1995.
Fuel consumption for drying assumed at 2.4 tonnes coconut residues/tonne copra produced (open fire drying) 6,000 tonnes

(4) Includes Pohnpei, Chuuk, Yap and Kosrae

Source: Mission Estimates 1990

TABLE 5
FEDERATED STATES OF MICRONESIA PETROLEUM MARKET
1985–1990 DEMAND VOLUMES (KL)

	1986	1987	1988	1989	1990
Product:					
Avgas/Avtur	113	134	110	40	50
Kerosene	278	275	274	275	276
Gasoline	3,244	3,536	3,837	4,074	4,091
ADO	7,108	6,979	7,096	7,243	8,429
Jet A1	1,598	1,777	1,926	2,142	2,297
IFO					
Lubes	89	92	110	72	122
Solvents					
LPG					
Others					
Total Inland Trade	12,430	12,793	13,353	13,846	15,265
Bunkers[1]					
Avgas/Avtur					
ADO					
IDO					
IFO					
Total Bunkers					
Total Trade	12,430	12,793	13,353	13,846	15,265

Sources: Oil companies.

Note: (1) Data on bunkers (minor in FSM) are not available.

TABLE 6

FEDERATED STATES OF MICRONESIA NATIONAL PUBLIC ELECTRIFICATION
(Chuuk, Kosrae, Pohnpei and Yap State Systems)

) Chuuk Power System

	1985	1986	1987	1988	1989	1990
Consumers (number [1])						
Residential metered	na	na	na	na	na	70
Residential flat rate	na	na	na	na	na	–
Gov/commercial metered	na	na	na	na	na	30
Commercial flat rate	na	na	na	na	na	–
Estimated	na	na	na	na	na	1100
Total	na	na	na	na	na	1200
Capacity (MW):						
Installed Diesel	na	na	8.3	8.3	8.3	9.9
Firm Diesel	na	na	2.8	2.8	2.8	6.5
Max Demand	na	na	3.0	3.1	3.2	3.4
utput (MWh):						
Generation Diesel	na	na	18,285	19,171	19,626	20,607
Station usage	na	na	822	863	883	927
Total sent out	na	na	17,463	18,308	18,743	19,680
Technical losses [2]	na	na	2,445	2,563	2,624	2,755
Non-technical losses [3]	na	na	na	na	na	13,325
Net Consumption [4]	na	na	na	na	na	3,600

Kosrae Power System

Consumers (number)						
Residential metered	na	na	na	na	na	772
Residential flat rate/est.	na	na	na	na	na	–
Govt/commercial metered	na	na	na	na	na	142
Commercial flat rate/est.	na	na	na	na	na	–
Estimated	na	na	na	na	na	–
Total	na	na	na	na	na	914
Capacity (MW):						
Installed Diesel	na	1.80	1.80	1.80	1.80	3.30
Firm Diesel	na	1.13	1.13	1.13	1.13	1.29
Max Demand	na	0.73	0.77	0.94	1.15	1.30
Output (MWh):						
Generation Diesel	na	4,791	5,075	6,154	7,671	8,489
Station usage	na	216	228	277	345	382
Total sent out	na	4,575	4,847	5,877	7,326	8,107
Technical losses	na	641	679	823	1,026	1,135
Non-technical losses	na	471	435	1,268	2,033	2,135
Net Consumption	na	3,464	3,733	3,786	4,267	4,837

Sources: 1) Pohnpei State Yearbook (199) and mission estimates; All State data are extremely limited and inconsistent.

Notes: 1) The number of consumers is unknown. Chuuk State Government estimate over 90% unmetered. All figures are rough guesses.
2) Estimated as 14.5% of energy sent out.
3) Unmetered consumption including street lights.
4) Sales of electricity.

TABLE 6 (continued)

FEDERATED STATES OF MICRONESIA NATIONAL PUBLIC ELECTRIFICATION
(Chuuk, Kosrae, Pohnpei and Yap State Systems)

3) Pohnpei Power System

	1985	1986	1987	1988	1989	1990
Consumers (number [1])						
Residential metered	na	na	na	na	na	1599
Residential flat rate	na	na	na	na	na	–
Gov/commercial metered	na	na	na	na	na	481
Commercial flat rate	na	na	na	na	na	–
Estimated	na	na	na	na	na	–
Total [2]	na	1438	1518	1739	1798	2080
Capacity (MW):						
Installed Diesel	na	na	na	15.30	15.30	15.30
Firm Diesel	na	na	na	8.64	8.64	8.64
Max Demand	na	na	3.75	3.98	4.41	5.22
Output (MWh):						
Generation Diesel	na	na	20,683	21,956	24,331	25,098
Station usage	na	na	931	988	1,095	1,129
Total sent out	na	na	19,752	20,968	23,236	23,969
Technical losses [3]	na	na	2,765	2,936	3,253	3,356
Non-technical losses [4]	na	na	3,787	2,432	na	3,402
Net Consumption [5]	na	na	13,200	15,600	na	17,211

4) Yap Power System

Consumers (number)						
Residential metered	na	na	na	na	na	770
Residential flat rate/est.	na	na	na	na	na	100
Govt/commercial metered	na	na	na	na	na	138
Commercial flat rate/est.	na	na	na	na	na	13
Estimated	na	na	na	na	na	–
Total	na	na	na	na	870	1021
Capacity (MW):						
Installed Diesel	na	na	7.10	7.10	7.10	7.10
Firm Diesel	na	na	4.35	4.35	4.35	4.35
Max Demand	na	na	2.04	2.13	2.24	2.45
Output (MWh):						
Generation Diesel	na	na	10,852	11,429	11,922	13,181
Station usage	na	na	531	559	584	645
Total sent out	na	na	10,321	10,870	11,338	12,536
Technical losses	na	na	1,445	1,522	1,587	1,755
Non-technical losses	na	na	na	na	na	6,386
Net Consumption	na	na	na	na	na	4,395

5) Chuuk, Kosrae, Pohnpei and Yap

Consumers (number)						
Residential	na	na	na	na	na	3,311
Commercial/Government	na	na	na	na	na	804
Estimated	na	na	na	na	na	1,100
Total	na	na	na	na	na	5,215
Capacity (MW):						
Installed Diesel	na	na	na	32.50	32.50	35.60
Firm Diesel	na	na	na	16.87	16.87	20.73
Max Demand	na	na	na	10.15	11.00	12.37
Output (MWh):						
Generation Diesel	na	na	na	58,710	63,550	67,375
Station usage	na	na	na	2,687	2,907	3,083
Total sent out	na	na	na	56,023	60,643	64,292
Technical losses	na	na	na	7,843	8,490	9,001
Non-technical losses	na	na	na	na	na	25,248
Net Consumption	na	na	na	na	na	30,043

TABLE 7

FEDERATED STATES OF MICRONESIA
STATE ELECTRIFICATION PERFORMANCE INDICATORS (1990)

	CHUUK	KOSRAE	POHNPEI	YAP
Fixed Assets (millions US$)[1]	8.7	5.2	22.5	6.3
Average Revenue (USc/kWh)	0.4	3.5	2.5	4.1
Average Cost (USc/kWh)	20.2	19.0	26.2	23.2
Capital	7.2	8.3	12.7	9.1
Fuel	9.3	8.2	8.0	8.7
Other operating	3.8	2.6	5.5	5.4
Estimated ROI[2] (%)	−38.6	−20.9	−19.9	−38.0
Fuel Consumption[3] (kWh/USG)	11.5	13.0	13.1	12.4
Households Electrified[4] (%)	22.3	> 95.0	42.7	41.9
KWh/year/consumer[5]	3,000	3,432	5,196	2,933
KWh/year/employee[6]	588,781	446,805	597,578	387,673
Employees/MW installed	4.6	5.8	3.7	5.4
Outages				
Number	50−100/yr	50−70/yr	>100/yr	>100/yr
Average duration (hours)	1−3	1−3	1−3	1−3
Customers affected (%)	50−100	100	100	100
Voltage drop/increase	10−20%	na	5−10%	10−20%

Source: Mission estimates.

Notes:

1) Fixed Assets as of 30 December 1990. Covers grid systems of each State only. Includes Nanpil hydro station in Pohnpei.
2) Rate of Return on estimated fixed assets.
3) Ratio of total output produced and automotive diesel oil used. Pohnpei includes output from Nanpil hydro station. 1989 data for Chuuk.
4) % of State households.
5) Consumption per household consumer. Data are from available billing records and actual consumption is probably much higher, particularly in Chuuk where few customers have been billed in recent years.
6) Generation.

TABLE 8

FEDERATED STATES OF MICRONESIA ELECTRICITY TARIFF STRUCTURE (1990)

	Residential	Commercial	Government
CHUUK			
Estimated bills ($/kWh)[1]	$0.06	$0.10	$0.10
Minimum ($/month)	$4.00	$4.00	$4.00
Flat rates ($/month)	$1.50	na	na
KOSRAE			
Metered customers ($/kWh)[2]	$0.05	$0.05	$0.05
Minimum ($/month)	na	na	na
Flat rates ($/month)	na	na	na
POHNPEI			
Metered customers ($/kWh)[3]			
0 – 1,000 kWh/month	$0.03	$0.03	$0.03
1,001 – 10,000 kWh/month	$0.08	$0.08	$0.08
>10,000 kWh/month	$0.23	$0.23	$0.23
Minimum ($/month)	na	na	na
Flat rates ($/month)	na	na	na
YAP			
Metered customers ($/kWh)			
0 – 1,000 kWh/month	$0.09	$0.09	$0.09
>1,000 kWh/month	$0.11	$0.11	$0.11
Minimum ($/month)	$5.00	$20.00	$20.00
Flat rates ($/month)	$17.00	$32.00	$32.00

Notes:

1) Most consumers in Chuuk were unmetered at the time of the mission's visit. 1,200 single–phase and 60 3–phase meters are reportedly to be installed in mid–1991.
2) All consumers are reportedly metered in Kosrae.
3) All consumers are now reportedly metered in Pohnpei; 61 were reported unmetered in 1989.

TABLE 9

NON-CONVENTIONAL ENERGY RESOURCES AND USE IN THE FEDERATED STATES OF MICRONESIA (1990)

Systems Installed	Chuuk	Kosrae	Pohnpei	Yap	Total
Photovoltaics[1]					
number	50	none	22	18	90
kW_{peak}	3.5		2.4	1.3	7.1
Hydro[2]					
number	na	1	1	na	2
kW	na	35	2,000	na	2,035
MWh	na	0	2,487	na	2,487
Biomass					
number	na	na	na	na	na
kW	na	na	na	na	na

Resources		Chuuk	Kosrae	Pohnpei	Yap	Overall
OTEC[3]	Temp. difference (^{0}C)	na	na	na	na	23–24
	Dist. offshore (km)	na	na	na	na	1–10
Tides	Mean range (metres)	na	1.6	1.0	0.6	0.6–1.6
Solar	Insolation (kWh/m^2/day)	na	na	na	na	na
	Average daily hours	na	na	na	na	na
Hydro	Potential (MW)	none	0.5	6.4	none	6.9
	Output (MWh)	none	800	16,700	none	17,500

Sources: 1) *Territorial Energy Assessment* (USDOE, Dec 1982).
2) *Ocean Energy Guide* (ESCAP, 1990)
3) Mission estimates.

Notes: [1] Chuuk includes 30 communications systems. Percentage operating unknown. Excludes about 2 kW of new systems being installed.
[2] The minihydro station in Kosrae has never operated. Pohnpei (Nanpil) 1990 data.
[3] Sea level to 1000 metre depth.

TABLE 10
BIOMASS RESOURCES OF THE FEDERATED STATES OF MICRONESIA
(Hectares, 1983)

Land class and type	Pohnpei	Chuuk	Kosrae	Yap	Total hectares	Total acres
Forest						
Upland	12548	677	5,090	2,556	20,871	51,573
Swamp forest	214	0	345	155	714	1,764
Mangrove forest	5,525	306	1,562	1,171	8,564	21,162
Plantation forest	6	1	0	0	7	17
Dwarf forest	1	0	69	0	70	173
Casuarina forest	0	0	0	0	0	0
Atoll forest	6	0	0	0	6	15
Palm forest	1,383	2	0	0	1,385	3,422
Total forest	19,683	986	7,066	3,882	31,617	78,127
Secondary vegetation	1,843	252	1,272	553	3,920	9,687
Agroforest						
Agroforest	1,945	66	1,659	1,515	5,185	12,812
Agroforest (w/coconut)	9,796	2,312	926	864	13,898	34,343
Coconut plantation	124	0	0	159	283	699
Total agroforest	11,865	2,378	2,585	2,538	19,366	47,854
Nonforest						
Marsh, fresh	149	234	25	165	573	1,416
Marsh, cultivated	0	0	0	0	0	0
Marsh, saline	29	0	0	6	35	86
Grassland	1,476	174	17	2,175	3,842	9,494
Strand	0	5	0	0	5	12
Cropland	79	3	2	46	130	321
Cropland/secondary vegetation	0	0	0	0	0	0
Urban	180	129	51	244	604	1,493
Urban/cropland	62	0	67	61	190	469
Urban/agroforest	0	0	0	0	0	0
Urban/secondary vegetation	0	0	0	0	0	0
Barren	2	5	2	8	17	42
Water	125	4	99	38	266	657
Total nonforest	2,102	554	263	2,743	5,662	13,991
Total area	35,493	4,170	11,186	9,716	60,565	149,659

Source: Vegetation survey(s) of Pohnpei, Truk, Kosrae and Yap
(US Dept of Agriculture, Forest Service; PSW–17, 18, 20 & 21; 1986/1987)

TABLE 11

FSM ENERGY SECTOR CAPITAL INVESTMENT PLANS: 1990–1991

Externally Financed Technical Co–operation Projects and Activities

Activity	Source of Finance	Assistance Committed	Year	Project Status	Begin–End Dates	Description and Location of Project
Chuuk						
2.2 MW Caterpillar genset	US Govt	$0.8m	1991			Delivery to Chuuk of engine/generator addition to the Moen power station. (Installation not included.)
Kosrae						
1.5 MW Caterpillar genset, radiators, switchgear	US Govt	$0.9m	1990	work completed		Purchase and installation of new 1.5 MW Caterpillar genset and related equipment; extension of power house, of power lines, new substation.
Power house building extension, installation, dist extension, etc.		$1.0m	1990			
Pohnpei						
none planned before end 1991						
Yap						
none planned before end 1991						

ANNEX 2

SUGGESTED SCOPE OF WORK: ADB TECHNICAL ASSISTANCE AND POTENTIAL FINANCING OF PROJECTS

As detailed in Chapters III (Energy Supply) and IV (Policy Issues and Priorities), the four state power systems in the FSM need to resolve urgent problems, both technical and institutional. To generalize the main technical problems, the utilities appear to have generating capacity greatly in surplus of their needs but which, because of serious breakdowns due to poor maintenance, is insufficient to meet load throughout the year in three states[1]; the urban 4.16 kV distribution grids are over-loaded and ill-maintained, causing excessive voltage fluctuations and power losses, and should be upgraded to 13.8 kV. Institutional problems, evidenced by poor budgeting for maintenance and spare parts, poor training of personnel, poor billing and poor revenue collection, relate mainly to the fragmentation of utility management responsibilities across two or more Ministries with no overall control over utility operations or planning. Load growth in 1987 - 1990 has been high (over 6% in all states) and tariffs are well below costs, resulting in very large operating deficits covered by subsidies, mainly from U.S. assistance. Many desirable reforms in the power sector will not be possible without large (but gradual) tariff increases and reduced subsidies, in concert with institutional restructuring.

The following four main areas are suggested for ADB technical assistance and possible projects for Bank finance in the FSM:

1. **Technical investigations.** *Generation.* The states of Chuuk, Pohnpei, and Yap each have two or more second-hand 2 MW ALCO medium-speed generators, refurbished and supplied in about 1986 with U.S. assistance. All of the ALCO machines are required for baseload power but are in need of overhaul if they are to continue in service. However, the extent of the refurbishments in 1986 is unknown, and maintenance records since 1986 have not been kept. A technical study is needed to determine whether they are technically and financially worth overhauling, or should instead be replaced. A negative result would imply an immediate need for new baseload equipment in Yap, Pohnpei, or both. In Pohnpei, additional investigation should be made of the feasibility of refurbishing the barge; an examination by a naval inspector is recommended. An investigation should also be made of the potential for further hydro development in Pohnpei. In Kosrae, a new 1.5 MW Caterpillar engine/generator was installed in November 1990 and is relied upon for 100% of power requirements (peak load is 1.3 MW); for technical reasons, other machines in the power house (insufficient in themselves to meet load) cannot be operated in parallel with the new machine at this time and several of them require refurbishment. A technical study is needed to determine the feasibility of refurbishing the old machines and synchronizing their outputs with the new Caterpillar. A negative result would imply that Kosrae requires additional baseload capacity.

Distribution. The distribution systems in Chuuk, Pohnpei, and Yap[2] all have aging 4.16 kV segments serving their most populated areas, and it is recommended that these be

---

1 Kosrae, Pohnpei, and Yap; in Chuuk, firm capacity is presently adequate but will decline rapidly if maintenance continues to be neglected.

2 Distribution upgrading work has recently been completed in Kosrae.

upgraded to 13.8 kV (see Chapter III for details). Assistance is needed in the three states to develop the technical specifications for this work.

2. **Power development study.** FSM is notable for its lack of power sector planning. A load forecast should be developed for each state, based on reasonable projections of economic developments. A ten-year least-cost capacity replacement/expansion plan should be designed to meet the projected load, covering both generation and transmission/distribution.

Closely allied with this effort, a detailed financial review of the power sector in each state, including an asset valuation study, should be carried out to determine costs and required tariffs.

3. **Support for utility reorganization.** Chuuk and Pohnpei[3] have prepared legislation to form a public power utility in each state; Kosrae and Yap are moving in similar directions by consolidating utility operations within a single government department. The new organizations will need to develop new accounting methods and financial reporting systems, new methods of recording technical and financial data and keeping records, and in some states will need to computerize some operations, especially billing. Technical assistance is required to help the utilities to set up such operations and train staff to use and maintain them. Appointment of a Bank-funded utility financial expert for each state utility should be considered.

ADB technical assistance is needed in all states to advise on utility corporate structures, manpower requirements, the relationship between the utility and the rest of government, etc. Existing legislation should be reviewed and amendments recommended, if appropriate. The concept of consolidating the four state power utilities into a national utility, as has been suggested by Pohnpei, should also be evaluated.

4. **Possible projects for Bank finance.** In all states, considerable refurbishment, replacement, and/or expansion of capital equipment is required soon. Much of the work could be financed through U.S. assistance as in the past; however, the potential extent and terms of future grant assistance for the power sector is not known. Under conditions of centralized management in well-restructured utilities, combined with gradually rising tariffs and a determined effort to reduce government subsidies, it is reasonable to expect that grant aid would be directed away from the power sector, forcing it to rely increasingly on loan finance for capital projects. Such projects would include new power generating facilities in all states and transmission/distribution refurbishments in Chuuk, Pohnpei, and Yap.

---

[3] Passed by Parliament in Pohnpei in February 1991.

ANNEX 3

ESTIMATED POWER PRODUCTION COSTS IN EACH STATE IN THE FSM

The estimated cost of power in the FSM for FY 1990 ranges between 19.0 cents (Kosrae) and 26.2 cents per kWh consumed[1] compared with estimated average revenue ranging between 0.4 cents (Chuuk) and 3.5 cents (Kosrae), as shown in Tables 1 - 4. Costs include operating costs (fuel, lubricants, personnel costs, administration, spare parts, bad debts, etc.) and annual capital charges (interest and depreciation) for the utilities' productive assets. Much of the data is estimated since detailed financial records do not exist. For example, bad debts in each State were estimated based on a simple ratio of the latest available month's total collections and total billings, and an assumption that the ratio in each State is fairly constant throughout the year; administration is assumed to be 5% of operating costs (excluding bad debts). These values should be revised with appropriate financial records when they become available. Fuel costs, spare parts, and personnel costs are based on records from the relevant Ministries. The estimated values of total assets were based on initial construction cost estimates where available; otherwise on "typical" values per kW (generating plant) or per mile (distribution assets) from other countries in the region. Asset values should be revised with actual construction cost figures, if available.

Chuuk. Revenue collections were extremely low in 1989 and 1990 -- about four-tenths of a cent per kWh consumed -- because few customers are metered or pay electricity bills. Operating costs were higher in 1990 than in 1989 (13.04c compared to 11.82c), due mainly to increased prices and volume in the total value of fuel and lubricants. Capital costs accounted for 7.6c and 7.2c/kWh consumed in 1989 and 1990 respectively; higher in 1989 because total consumption was less. Final cost per kWh consumed was 19.4 cents and 20.2 cents per kWh consumed in 1989 and 1990.

Kosrae. Of all States, revenue collections were highest per kWh consumed in Kosrae, but still recovered only 3.5 cents/kWh in 1990 and 3.4 cents in 1990 of costs totalling 19 cents/kWh consumed in 1990 and 21.1 cents in 1989 including capital costs. Operating costs appear to be lower, at 10.75 cents/kWh in 1990 in Kosrae compared with 13 - 14 cents in the other States, but are probably underestimated as they do not include consumables or maintenance equipment. There is no record of such expenditures, and they are difficult to estimate. A more thorough accounting of operating costs in Kosrae should be carried out; the estimate could easily increase by one or two cents per kWh consumed.

Pohnpei. Revenue collections in 1990 were about 2.5 cents per kWh consumed, down from 3.8 cents in 1989 due to an increase in nonpayment of bills; actual billings increased. Capital costs, at 12.7 cents per kWh consumed, were higher than other States' due to the presence of the Nanpil hydro station, valued at $7.2 million but producing energy only part of each year and adding some 2.6 cents to the cost of power per kWh consumed.

Yap. Collections in Yap in 1990 were as poor as in Chuuk, due to a lengthy breakdown of the billing system in that year. Collections in 1989, however, were almost 3 cents per kWh consumed. Operating costs were 12.3 cents in 1990 and an extraordinarily high 21.5 cents in 1989, reflecting a staggering value for bad debts in that year of almost one million dollars, reported in the Yap Government's audited accounts[2]. The low value of bad debts shown for

1 "kWh consumed" includes metered sales, estimated sales and unbilled consumption - i.e., all energy which comprises the total consumption of electricity customers. Thus it excludes technical losses which are treated as part of the cost of operation.

1990 reflects the low billing in that year. These figures illustrate the importance of bad debts on a utility's costs and the value of enforcing collections through a rigorously-applied disconnection policy.

Capital costs were relatively high at 9.1 cents in 1990 and 10.1 cents in 1989, reflecting the large amount of reserve capacity (mostly inoperable) in the Yap power system.

---

2 *Financial Statements and Independent Auditor's Report, Year Ended September 30,1989,* Touche Ross International.

Table 1
CHUUK POWER SYSTEM
PRO FORMA OPERATING INCOME AND EXPENDITURE ACCOUNT FOR ELECTRIC UTILITY OPERATIONS YEAR ENDED SEPTEMBER 30

				FY 1990		FY 1989	
GWh gross generation				20.607		19.626	
GWh final consumption (1)				16.925		16.119	
REVENUE							
Electricity sales		(2)		$68,838		$68,838	
Other utility income				$0		$0	
Total utility revenue					$68,838		$68,838
Sales revenue per kWh sold, cents				0.41		0.43	
EXPENDITURE							
1. **Operating Costs**							
Fuel and Lubricants		(3)		$1,568,215		$1,281,596	
Salaries & personnel costs		(4)		$157,500		$157,500	
Bad Debts		(5)		$147,600		$147,600	
Consumables		(6)		$200,000		$200,000	
Equipment		(6)		$10,000		$10,000	
Maintenance		(6)		$25,000		$25,000	
Taxes				--		--	
Insurance				--		--	
Professional fees				--		--	
Travel				--		--	
Other expenses incl administration		(4)		$96,036		$83,705	
Total operating costs					$2,206,351		$1,905,400
Total operating cost per kWh sold, cents				13.04		11.82	
2. **Capital Costs, annuitised at 6%**							
Generation							
Asset	Value		Life (yrs)				
Power plant & switc(7)	$6,900,000		15	$906,072		$906,072	
Power Station buildings	$3,000,000		25	$234,680		$234,680	
Residential buildings	(no data)		30	$0	$1,140,752	$0	$1,140,752
Distribution							
Asset	Value		Life (yrs)				
Distribution system	$1,000,000		25	$78,227		$78,227	
Plant machinery etc in 1990:	(no data)		5	$0	$78,227	$0	$78,227
in 1989:	(no data)		5				
Total annual capital costs					$1,218,979		$1,218,979
Total capital cost per kWh sold, cents				7.20		7.56	
Total Costs (operating plus capital costs, generation plus distribution)					$3,425,330		$3,124,380
SURPLUS of EXPENDITURE over REVENUE:					$3,356,492		$3,055,542
Total cost per kWh sold, cents				20.24		19.38	

Notes:

(1) Includes unbilled consumption, streetlighting, and losses due to faulty estimation of power bills, which together accounted for more than 13 GWh of energy sent out in 1990.

(2) Data on actual utility revenues in Chuuk are extremely scarty, but collections are reportedly very low. According to the Dept of Finance, collections averaged just over $5,700/month in the last four months of 1990. This average has been applied to all of 1990 and 1989.

(3) Does not include fuel or lube used in Dublon. Based on usage reported in power house records and average prices of $0.84/USG and $4.70/USG for fuel and lube oil respectively in 1990, and $0.73 and $2.60 in 1989.

(4) Based on 35 permanent staff reported in the Division of Power, and an assumed average annual salary of $4,500. Administrative personnel costs are included under "Other expenses including administration". Administration is estimated at 5% of operating costs excluding bad debts.

(5) There are no data on bad debts, and very limited information on billing in general. However, based on a recent household survey, it is estimated that about 300,000 kWh per month is being billed to consumers which, at 6c/kWh (the reported residential tariff), is valued at $18,000. Since collections average $5,700 (see above), approximately $12,300 is uncollected per month, or $147,600 per year. As there are presently no means to enforce collections, the whole of this amount is written off as "bad debts".

(6) There are no records of expenditures on equipment, consumables for routine maintenance, or spare parts. The values shown are the mission's estimates of appropriate expenditures for these items.

(7) No breakdowns of the initial cost of Chuuk's electricity-producing plant were available to the mission. The initial cost of installed plant is valued at $1,000/kW. The transmission/distribution system is valued at $40,000 per mile for a total of 25 miles, or $1,000,000.

Table 2
KOSRAE POWER SYSTEM
PRO FORMA OPERATING INCOME AND EXPENDITURE ACCOUNT FOR ELECTRIC UTILITY OPERATIONS YEAR ENDED SEPTEMBER 30

			FY 1990		FY 1989	
GWh gross generation			8.489		7.671	
GWh final consumption (1)			6.972		6.300	
REVENUE						
Electricity sales		(2)	$241,879		$153,600	
Other utility income			$0		$0	
Total utility revenue				$241,879		$153,600
Sales revenue per kWh sold, cents			3.47		2.44	
EXPENDITURE						
1. **Operating Costs**						
Fuel and Lubricants		(3)	$570,151		$470,693	
Salaries & personnel costs		(3)	$75,414		$74,602	
Bad Debts		(4)	$72,000		$178,000	
Taxes			–		–	
Insurance			–		–	
Professional fees			–		–	
Travel			–		–	
Other expenses incl administration		(5)	$32,278		$27,265	
Total operating costs				$749,843		$750,560
Total operating cost per kWh sold, cents			10.75		11.91	
2. **Capital Costs, annuitised at 6%**						
Generation						
Asset	Value	Life (yrs)				
Power plant & switc(6)	$3,381,623	15	$348,181		$348,181	
Power Station buildings	$2,000,000	25	$156,453		$156,453	
Residential buildings	(no data)	30	$0	$504,635	$0	$504,635
Distribution						
Asset	Value	Life (yrs)				
Distribution system (7)	$918,000	25	$71,812		$71,812	
Plant machinery etc in 1990:	(no data)	5	$0	$71,812	$0	$71,812
in 1989:	(no data)	5				
Total annual capital costs				$576,447		$576,447
Total capital cost per kWh sold, cents			8.27		9.15	
Total Costs (operating plus capital costs, generation plus distribution)				$1,326,290		$1,327,007
SURPLUS of EXPENDITURE over REVENUE:				$1,084,411		$1,173,407
Total cost per kWh sold, cents			19.02		21.08	

Notes:

(1) Includes unbilled consumption, streetlighting, and losses due to faulty metering, which together account for more than 2 GWh of energy sent out in 1990.

(2) Actual reported sales revenue for FY1989 (source: Independent Auditors' Report – Touche Ross International); revenue for FY1990 based on sale of electricity estimated from power station generation records.

(3) From power station monthly reports, FY1989–90.

(4) It is reported in the "Independent Auditor's Report on General Purpose Financial Statements, Year Ended September 30, 1989" for Kosrae that utility collections (presumably including water and sewerage) were $153,577; collections for electricity must have been somewhat less. This is equivalent to less than 70% of the electricity bills issued that year ($213,351). As shown in the list of consumers' bills for the month of November 1990 (provided by OPS), accumulated unpaid bills amounted to approximately $250,000, of which $72,000 (30% of the total electricity bills for FY1990) is assumed to have been incurred in FY1990, and the balance ($178,000) in previous years. The whole of unpaid bills are defined as "bad debts" since there are reportedly no disconnections for nonpayment of electricity bills in Kosrae.

(5) There are no data for Administration expenses. Administration is assumed to be 5% of other operating expenses, excluding bad debts.

(6) Includes reported value of new 1500 kW Cat genset and associated works installed in November 1990 (source: OPS). Other plant valued at $1,000/kW.

(7) Valued at $40,000/mile of the transmission/distribution system, including conductors, transformers, poles, and service drops.

Table 3
POHNPEI POWER SYSTEM
PRO FORMA OPERATING INCOME AND EXPENDITURE ACCOUNT
FOR ELECTRIC UTILITY OPERATIONS
YEAR ENDED SEPTEMBER 30

				FY 1990		FY 1989	
GWh gross generation				25.098		24.331	
GWh final consumption (1)				20.219		19.983	
REVENUE							
Electricity sales		(2)		$506,421		$633,000	
Other utility income				$0		$0	
Total utility revenue					$506,421		$633,000
Sales revenue per kWh sold, cents				2.50		3.17	
EXPENDITURE							
1. Operating Costs							
Fuel and Lubricants		(3)		$1,614,589		$1,211,257	
Salaries & personnel costs		(4)		$525,584		$525,584	
Bad Debts		(5)		$235,000		$293,738	
Consumables		(6)		$200,000		$200,000	
Equipment		(6)		$10,000		$10,000	
Maintenance		(6)		$25,000		$25,000	
Taxes				--		--	
Insurance				--		--	
Professional fees				--		--	
Travel				--		--	
Other expenses incl administration		(4)		$118,759		$98,592	
Total operating costs					$2,728,932		$2,364,171
Total operating cost per kWh sold, cents				13.50		11.83	
2. Capital Costs, annuitised at 6%							
Generation							
Asset	Value		Life (yrs)				
Diesel plant/switchg(7)	$15,300,000		15	$1,575,330		$1,575,330	
Hydro plant/switchgear	$7,200,000		30	$523,072		$523,072	
Power Station buildings	$3,000,000		25	$234,680		$234,680	
Residential buildings	(no data)		30	$0	$2,333,083	$0	$2,333,083
Distribution							
Asset	Value		Life (yrs)				
Distribution system	$2,920,000		25	$228,422		$228,422	
Plant machinery etc in 1990:	(no data)		5	$0	$228,422	$0	$228,422
in 1989:	(no data)		5				
Total annual capital costs					$2,561,505		$2,561,505
Total capital cost per kWh sold, cents				12.67		12.82	
Total Costs (operating plus capital costs, generation plus distribution)					$5,290,436		$4,925,675
SURPLUS of EXPENDITURE over REVENUE:					$4,784,015		$4,292,675
Total cost per kWh sold, cents				26.17		24.65	

Notes: (1) Includes unbilled consumption, streetlighting, and losses due to faulty estimation of power bills, which together accounted for more than 5 GWh of energy sent out in 1990.

(2) Data provided by the Dept of Finance on actual revenue collections in Pohnpei are limited to the period from 10/90, when a new computerised billing system was installed. These data show average monthly collections of about $42,000, or just over $500,000 per year (1990). Revenue data for 1989 based on the old manual billing system are limited to six months, but indicate that collections were somewhat better than in 1990.

(3) From Dept of Public Works records.

(4) Data for 1990 based on Dept of Public Works budget documents. Figures for 1989 are unavailable, but assumed similar to 1990. Administrative personnel costs are included under "Other expenses including administration" Administration is estimated as 5% of operating costs excluding bad debts.

(5) There are no data on bad debts, and very scanty information on billing in general. However, based on an analysis of four months' billing data at the end of 1991 the estimated ratio of collections to the total amount billed is about 88%, with the balance assumed to be written off as bad debts. This ratio is applied to both 1990 and 1989.

(6) There are no records of expenditures on equipment, consumables for routine maintenance, or spare parts. The values shown are the mission's estimates of appropriate expenditures for these items.

(7) No breakdowns of the initial cost of Pohnpei's electricity-producing plant were available to the mission, with the exception of the Nanpil hydro station commissioned in 1987 with a reported initial cost of $7,200,000. The initial cost of installed diesel plant is valued at $1,000/kW. The transmission/distribution system is valued at $40,000 per mile for a total of 73 miles, or $2.9 million.

Table 4
YAP POWER SYSTEM
PRO FORMA OPERATING INCOME AND EXPENDITURE ACCOUNT FOR ELECTRIC UTILITY OPERATIONS YEAR ENDED SEPTEMBER 30

			FY1990		FY1989	
GWh gross generation			13.181		11.922	
GWh final consumption (1)			10.781		9.751	
REVENUE						
Electricity sales	(2)		$46,825		$288,167	
Other utility income			$0		$0	
Total utility revenue				$46,825		$288,167
Sales revenue per kWh sold, cents			0.43		2.96	
EXPENDITURE						
1. Operating Costs						
Fuel and Lubricants	(3)		$934,692		$741,556	
Salaries & personnel costs	(4)		$178,853		$184,241	
Bad Debts	(5)		$23,413		$997,064	
Consumables			$163,527		$157,542	
Equipment			$6,629		$4,652	
Maintenance			–		$23,944	
Taxes			–		–	
Insurance			–		–	
Professional fees			$2,625		$591	
Travel			$6,641		–	
Other expenses incl administration	(4)		$7,490		$7,988	
Total operating costs				$1,323,869		$2,097,778
Total operating cost per kWh sold, cents			12.28		21.51	
2. Capital Costs, annualised at 6%						
Generation						
Asset	Value	Life (yrs)				
Power plant & switc(6)	$7,100,000	15	$731,036		$731,036	
Power Station buildings	$2,000,000	25	$156,453		$156,453	
Residential buildings	(no data)	30	$0	$887,489	$0	$887,489
Distribution						
Asset	Value	Life (yrs)				
Distribution system	$1,200,000	25	$93,872		$93,872	
Plant machinery etc in 1990:	(no data)	5	$0	$93,872	$0	$93,872
in 1989:	(no data)	5				
Total annual capital costs				$981,361		$981,361
Total capital cost per kWh sold, cents			9.10		10.06	
Total Costs (operating plus capital costs, generation plus distribution)				$2,305,230		$3,079,139
SURPLUS of EXPENDITURE over REVENUE:				$2,258,405		$2,790,972
Total cost per kWh sold, cents			21.38		31.58	

Notes:

(1) Includes unbilled consumption, streetlighting, and losses due to faulty metering, which together accounted for more than 6 GWh of energy sent out in 1990.

(2) Actual utility collections of $49,289.08, including power and water, were recorded in FY1990 by the Finance Office, the low value due to a breakdown of the billing system. From billing data (same source) water bills are about 5% and electricity bills about 95% of the total. FY1989 revenue collection from "Independent Auditors' Report", Year Ended Sept 30 1989, Touche Ross International.

(3) Does not include fuel or lube used in Ulithi or Woleai. Source: Office of Budget and Statistics.

(4) Personnel costs include billing, power generation, and power distribution; administration personnel costs are included in "Other expenses incl administration". In accordance with PU&C practice, 6.25% of PU&C administration is allocated to power operations. Source: Office of Budget and Statistics.

(5) No data on 1990 bad debts, i.e., accounts receivable from electricity sales which have been written off by the Finance Dept, were available to the mission. An average annual collecton rate of about 50% of billings has been assumed; the balance allocated to "bad debts". 1989 data obtained from Touche Ross International.

(6) No breakdowns of the initial cost of Yap's electricity-producing plant were available to the mission. The initial cost of installed plant is valued at $1,000/kW. The assumed value of the transmission/distribution system is equally arbitrary.

ANNEX 4

AFFORDABILITY OF INCREASED ELECTRICITY CHARGES

To what extent can the general public and the business community in the FSM 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, experience elsewhere indicates that people are generally 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 strong evidence that this experience also applies to the FSM[1].

1. *Residential consumers.* Average household electricity consumption in FSM (250-400 kWh/month) is high by Pacific Islands standards but lower than it is in the Marshall Islands (700 kWh/month) or Palau (600 kWh/month), although the RMI has about the same per capita income as FSM (higher in Palau) and both countries have generally higher electricity tariffs. As shown in Figures 1 and 2 below, residential consumption in FSM is not skewed toward the high consumption bands to nearly the same extent that it is in the other two countries. For example, in the RMI about 60% of residential electricity in 1990 was consumed by households using more than 1,000 kWh per month, compared to only 22% and 15% in Pohnpei and Kosrae respectively[2]. About 43% and 35% of residential usage in Kosrae and Pohnpei was consumed by households using between 200 and 500 kWh/month.

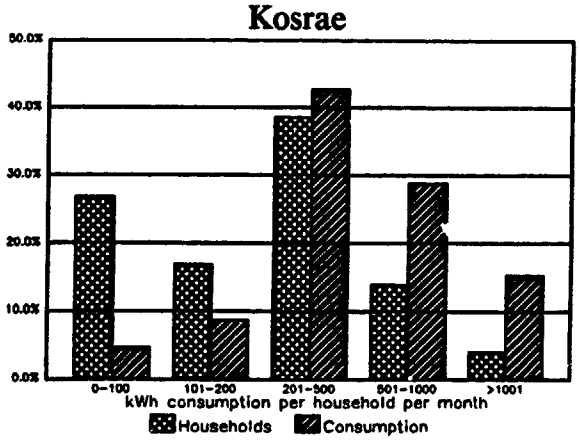


Figure 1

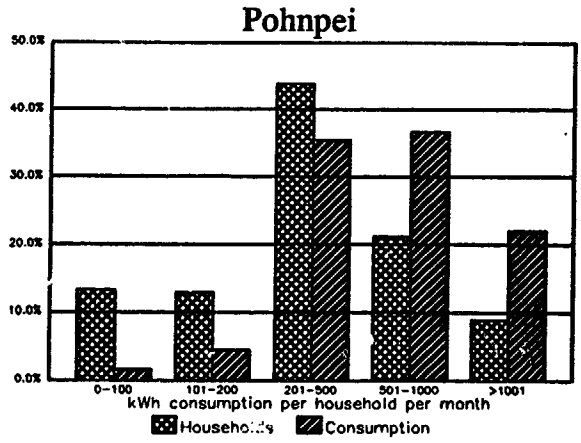


Figure 2

FSM households spend significantly less of their income on electricity than do households in the RMI, Palau, and other Pacific Island countries. In 1989, annual household income in Pohnpei averaged about $6,400 or a little less than $533 per month; in Kosrae it was about $8,740 or $728 per month[3]. For an average-income family in Pohnpei consuming 300 kWh/month, expenditure on electricity is $9 or 1.7% of monthly income; in Kosrae the

1 The following presents data for Pohnpei and Kosrae, but the pattern for the other states is similar.

2 based on available billing data, which are known to be poor in Kosrae but reasonably complete in Pohnpei. However, the proportional distribution of bills in Kosrae presented here is believed to be valid.

3 From *Results of the Household Income and Expenditure Survey in the Federated States of Micronesia, 1988-1989, Final Report*, UNDP Project RTP/86/203, February 1990, p. 27. Monthly household income in Chuuk

corresponding figures are $15 and 2.1%. Average-income households in the Marshall Islands spend about 5% of household income on electricity, 7% in Fiji, and at least 10% in Kiribati and Tuvalu. As there is no discernable economic reason for the lower expenditure in FSM, it is probably due to the comparatively poor quality and the unreliability of power produced in FSM, characteristics severe enough to constrain consumption. If the technical standards of the power systems in FSM were to improve significantly, households could be expected to increase purchases and use of appliances and consumption would rise; i.e., households in FSM would spend a significantly larger share of their income on electricity.

Raising the tariff, however, will have the opposite effect, i.e., induce reductions in consumption by most consumers through reductions of wasteful uses. Hence the issue of raising tariffs in FSM is very closely intertwined with improving the quality of power; it would be a mistake to proceed with one without the other. The more that power quality improves in the FSM, the easier will average-income households agree to absorb tariff increases, since better services will accompany households' higher costs.

The effect of a tariff increase on residential consumers who use 100-300 kWh per month or more is expected to be a mixture of increased expenditure (especially in the short term) and reduction of non-essential uses. For example, users could at no cost switch off non-essential lighting and air-conditioning, could close windows and doors in air-conditioned spaces, then (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, thereby limiting the financial impact of the tariff increase to each consumer. Such a response to higher tariffs 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, to the benefit of the country overall.

However, adjustment will be much more difficult for consumers at the very 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. It is estimated that 100 kWh/month provides for such "essential uses" a follows: a small refrigerator (60 kWh/month) plus three 40W incandescent light bulbs (not efficient but common in low-income households due to their low initial cost) used for six hours per night (22 kWh/month) plus two 20W fluorescent lights (7 kWh/month) plus radio, fan, etc. (11 kWh/month). Therefore, it is recommended that residential consumers using 100 kWh per month or less be protected from the tariff increases applied to other consumers by means of a "lifeline" tariff.

A lifeline tariff, in fairly common use in developing countries[4], 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. Although 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

averaged $378 ($4,536/yr) and $481 ($5,772/yr) in Yap. Average monthly income in FSM was $465 ($5,580/yr).

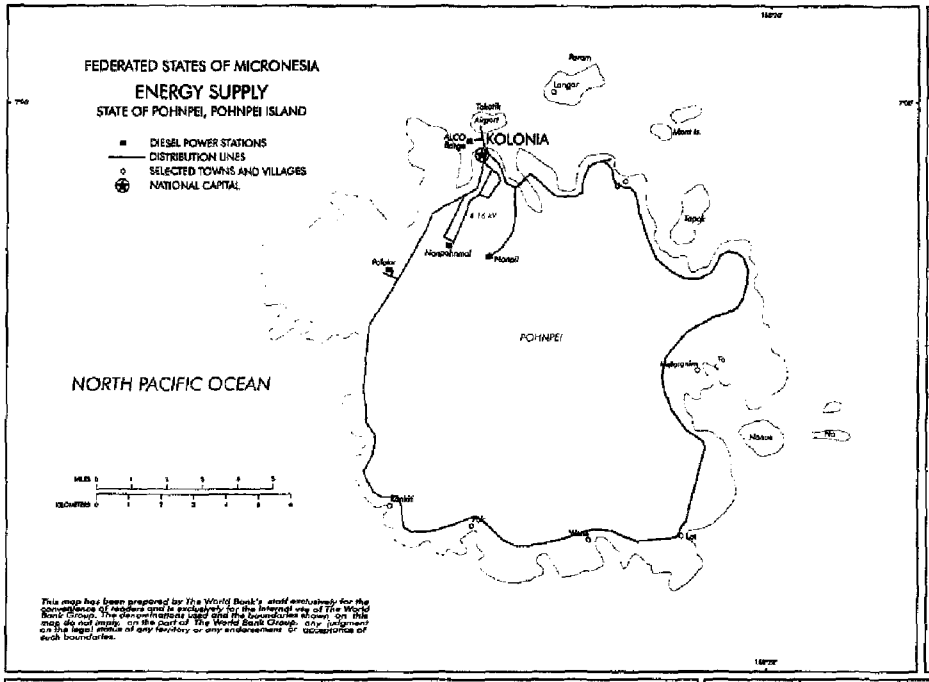
4 Countries in the Pacific region with "lifeline" rate structures for residential consumers are: the Cook Islands (initial block 120 kWh/month), Papua New Guinea (100 kWh), Tuvalu (100 kWh), and Vanuatu (60 kWh).

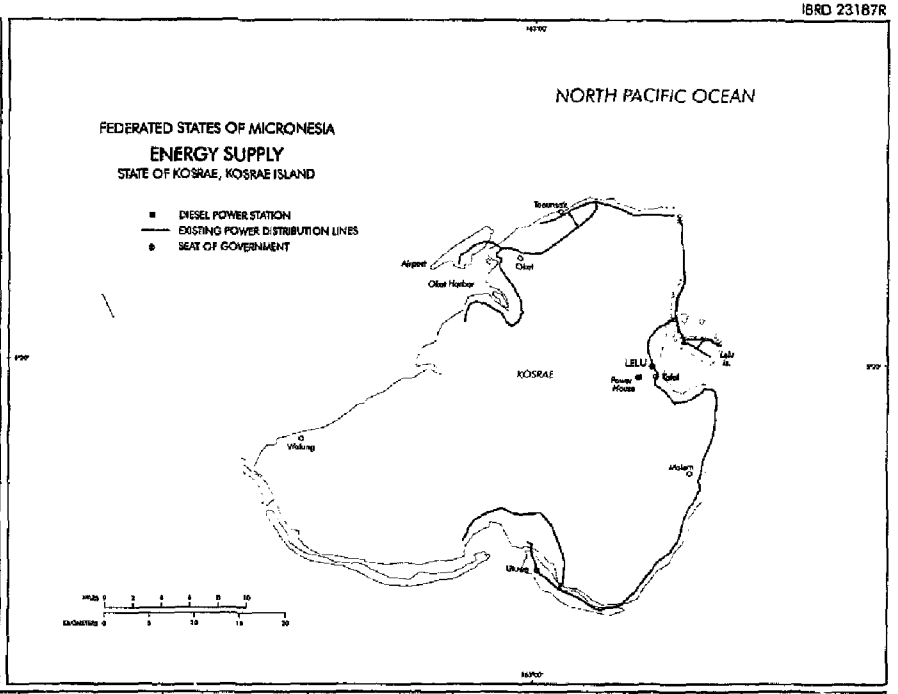
consumers who use 100 kWh/month or less would benefit significantly from the subsidy; higher charges to other consumers would cancel the subsidy to them. A lifeline tariff has the advantages of being fairly easy to administer and not very costly to the utility's other customers, since low-income domestic consumption is usually a very minor portion of total sales. In FSM, a lifeline tariff would benefit the estimated 20% of residential consumers who use 100 kWh/month or less and account for an estimated 2%-5% of all residential consumption. In total, the subsidy would apply to roughly 10% of total electricity sales (5.6 GWh of total sales of 55.3 GWh), rather than to 100% of sales, as at present. A lifeline tariff of 50% of full costs, say $0.10 per kWh, with all other consumption charged at full cost would imply a total subsidy from the state governments of $560,000, or only 5% of the total 1990 subsidy of roughly $11.2 million.

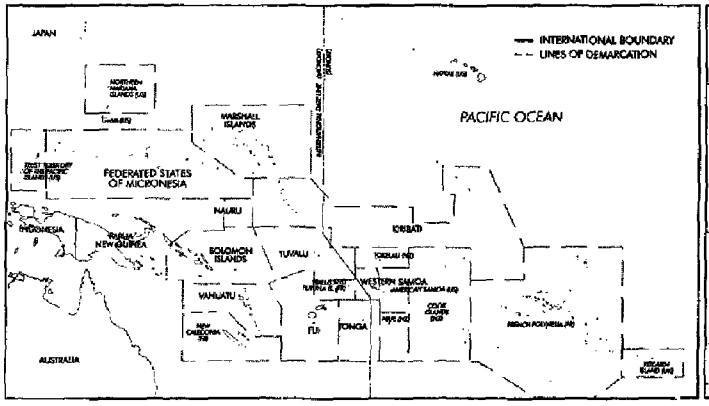
2. *Commercial consumers.* Electricity in most of the commercial and industrial enterprises found in the FSM and elsewhere in Micronesia is usually a small proportion of their total costs, rarely exceeding 5%. Increases in the cost of electricity in these commercial activities can be passed on to consumers without a significant increase in the price of the final product. In any case, there is evidence that the private sector in the FSM (as in other countries) puts more importance on reliable electric service than on cheap electric service: many commercial enterprises in all states have invested in their own standby generating equipment to use when public power system fails.

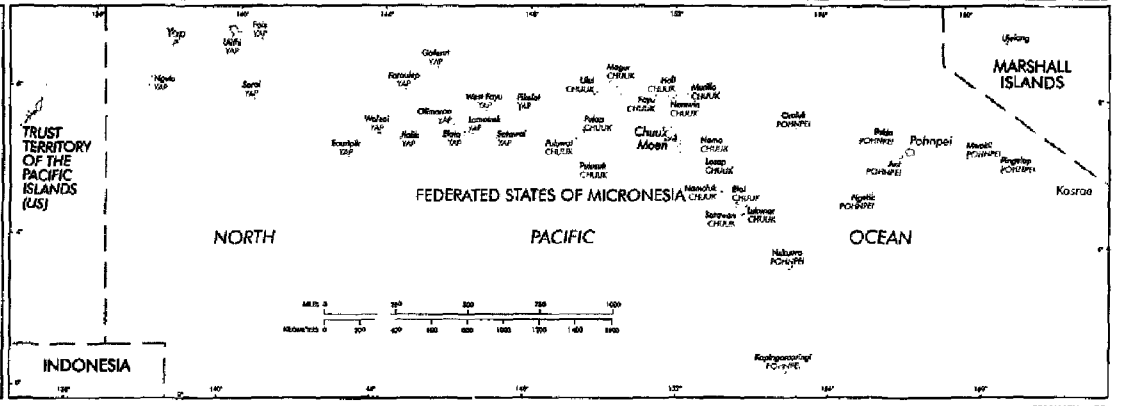
The commercial sector, despite initial vocal complaints, can be expected to respond to higher electricity tariffs in a variety of ways, including investment to improve the efficiency of electricity consumption and perhaps raising the price of what they produce or sell, although final product prices will not be affected significantly. Substantially lowered production or employment or much higher prices for consumer goods are very unlikely results of higher electricity tariffs.

IBRD 23187R

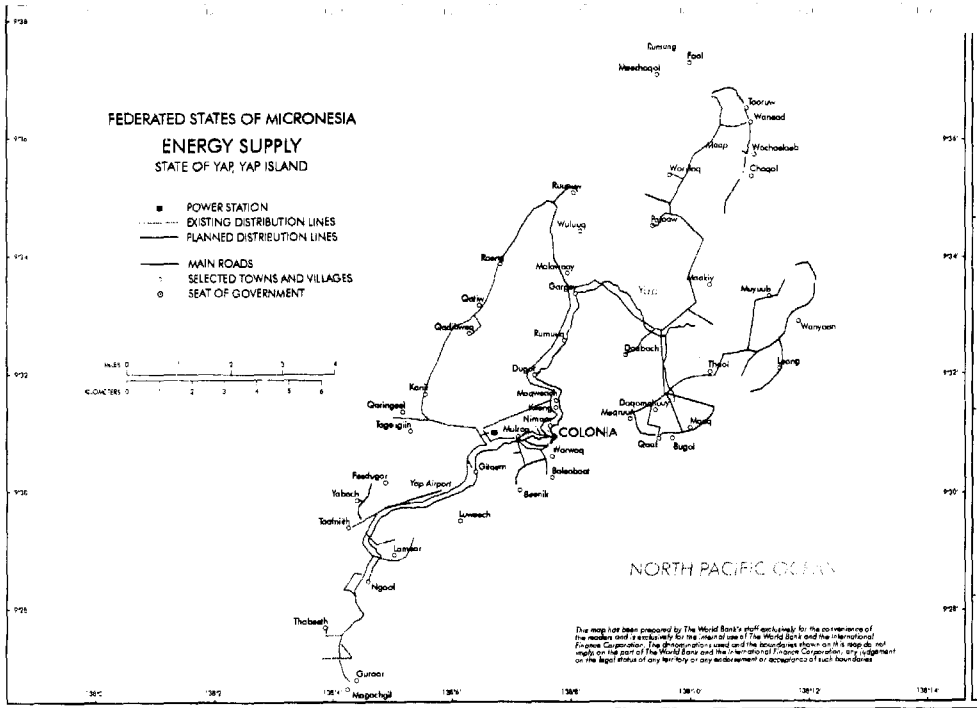


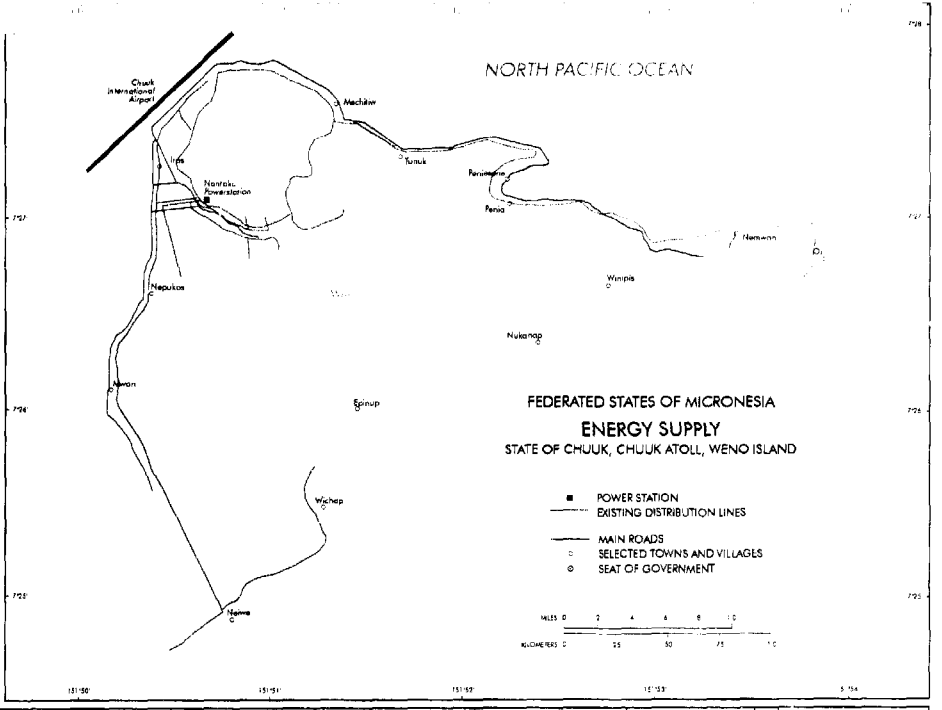


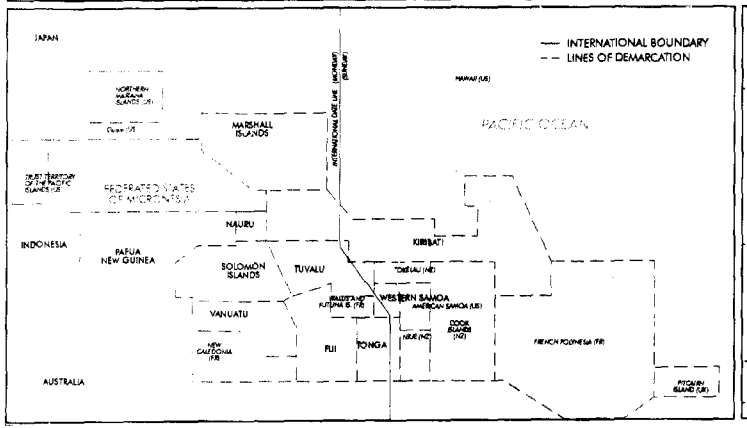


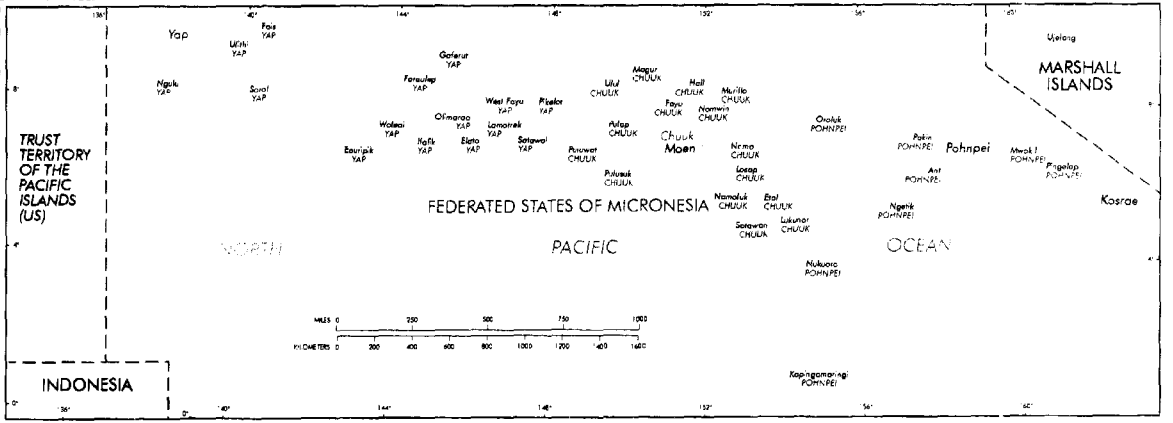


FEBRUARY 1992


FEDERATED STATES OF MICRONESIA
ENERGY SUPPLY
STATE OF YAP, YAP ISLAND
POWER STATION
EXISTING DISTRIBUTION LINES
PLANNED DISTRIBUTION LINES
MAIN ROADS
SELECTED TOWNS AND VILLAGES
SEAT OF GOVERNMENT
COLONIA
Yap Airport
NORTH PACIFIC OCEAN
This map has been prepared by The World Bank's staff exclusively for the convenience of the readers and is exclusively for the internal use of The World Bank and the International Finance Corporation. The designations used and the boundaries shown on this map do not imply on the part of The World Bank and the International Finance Corporation, any judgment on the legal status of any territory or any endorsement or acceptance of such boundaries.


NORTH PACIFIC OCEAN
Chuuk International Airport
Nantaku Powerstation
FEDERATED STATES OF MICRONESIA
ENERGY SUPPLY
STATE OF CHUUK, CHUUK ATOLL, WENO ISLAND
POWER STATION
EXISTING DISTRIBUTION LINES
MAIN ROADS
SELECTED TOWNS AND VILLAGES
SEAT OF GOVERNMENT


JAPAN
INTERNATIONAL BOUNDARY
LINES OF DEMARCATION
HAWAII (US)
PACIFIC OCEAN
MARSHALL ISLANDS
FEDERATED STATES OF MICRONESIA
NAURU
KIRIBATI
INDONESIA
PAPUA NEW GUINEA
SOLOMON ISLANDS
TUVALU
TOKELAU (NZ)
WESTERN SAMOA
AMERICAN SAMOA (US)
VANUATU
FIJI
TONGA
NIUE (NZ)
COOK ISLANDS (NZ)
FRENCH POLYNESIA (FR)
NEW CALEDONIA (FR)
AUSTRALIA
PITCAIRN ISLAND (UK)


TRUST TERRITORY OF THE PACIFIC ISLANDS (US)
INDONESIA
MARSHALL ISLANDS
Yap
Ulithi YAP
Fais YAP
Ngulu YAP
Sorol YAP
Gofarut YAP
Faraulep YAP
Woleai YAP
Olimarao YAP
West Fayu YAP
Lamotrek YAP
Piisilor YAP
Satawal YAP
Ifalik YAP
Eliato YAP
Eauripik YAP
Ulul CHUUK
Magur CHUUK
Hall CHUUK
Murilo CHUUK
Fayu CHUUK
Namonis CHUUK
Pulap CHUUK
Chuuk Moen
Pulusuk CHUUK
Pototwat CHUUK
Nama CHUUK
Losap CHUUK
Namoluk CHUUK
Etal CHUUK
Satawan CHUUK
Lukunor CHUUK
Nukuoro POHNPEI
Kapingamarangi POHNPEI
Oroluk POHNPEI
Pohn POHNPEI
Pohnpei
Ant POHNPEI
Ngatik POHNPEI
Mwoki I POHNPEI
Pingelap POHNPEI
Kosrae
Ujelang
FEDERATED STATES OF MICRONESIA
PACIFIC
OCEAN