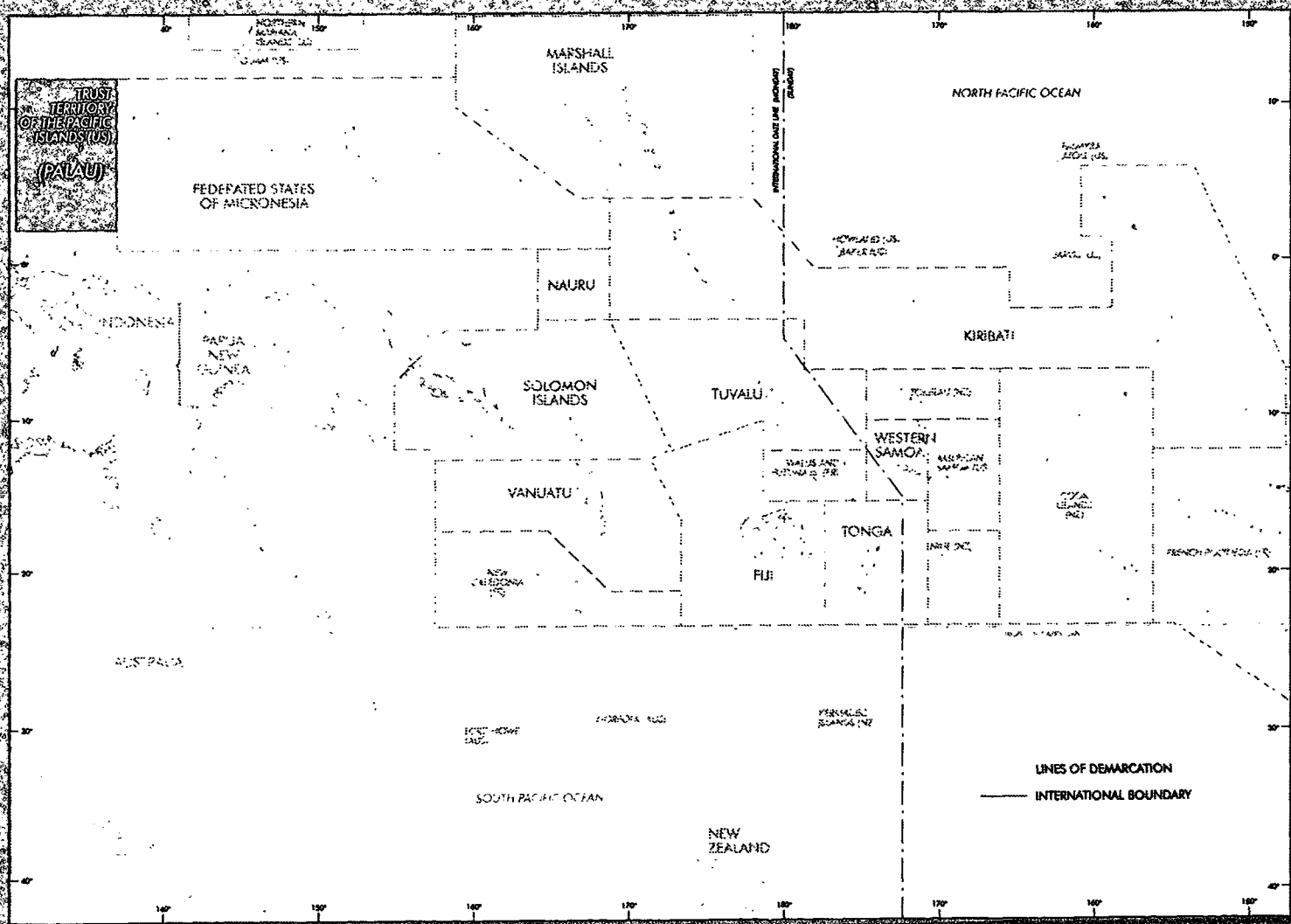
PREA

Pacific Regional Energy Assessment

Volume 7. Palau: Issues and Options in the Energy Sector



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

Abbreviations

ADB	Asian Development Bank
AIDAB	Australian International Development Assistance Bureau
BPW	Bureau of Public Works (Palau Government)
Compact	Compact of Free Association (between former members of TTPI and the USA)
EPA	Environmental Protection Agency (of Palau)
ESMAP	Energy Sector Management Assistance Program (Joint World Bank, UNDP, Bilateral)
FSED	Forum Secretariat Energy Division
IPSECO	International Power Systems and Engineering Company, Ltd
MRD	Ministry of Resources and Development
OMIP	Operation and Maintenance Improvement Program (USDOI)
OTIA	Office of Territorial and International Affairs (United States Department of the Interior)
PEDP	Pacific Energy Development Programme (UNDP)
PREA	Pacific Regional Energy Assessment
TTPI	Trust Territories of the Pacific Islands
USDOE	United States Department of Energy
USDOI	United States Department of the Interior

Currency

The official currency of the Republic of Palau is the United States dollar.

This report is based on the findings of a mission which visited the Republic of Palau from February 15 through February 23, 1991 visiting five of the sixteen states (Koror, Airai, Aimeliik, Peleliu and Ngiwal) as part of the joint World Bank, PEDP, ADB, and FSED *Pacific Regional Energy Assessment*. The mission team consisted of Mr Peter Johnston (Team Leader, PEDP), Mr Vilhelm Mϕrup-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 consultant).

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PALAU

ISSUES AND OPTIONS IN THE ENERGY SECTOR

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Abstract

The Government has not been formulating any clear national energy policies, and the report recommends that the Government strengthen the capabilities of the Energy Office for this purpose. The Government should ensure that energy is used efficiently, based on economic costs. The power supply systems are unable to meet their load satisfactorily because of poor maintenance and management. The report recommends that the Government raise tariffs, require all customers to pay for electricity, and delegate responsibility for electricity to a new government-owned, commercially-oriented Public Utilities Corporation. In the rural areas, the Government should take steps to standardize diesel generation equipment, maintain the equipment systematically, and establish a consistent policy on electricity tariffs. For the rural areas without diesel systems, the Government should consider solar photovoltaic systems, with an independent organization to provide fee-based maintenance services to individual users. The overall responsibility for petroleum supply should be assigned to the Energy Office, which should consider the benefits of a consolidated national tender for fuel supplies. The Government should establish safety and quality standards for the handling and storage of petroleum and LPG, and improve the condition of the Aimeliik fuel storage facilities. The Government should obtain independent evaluations of the environmental effects of the proposed waste-to-energy plant before proceeding with it.

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

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SUMMARY OF MAIN FINDINGS AND RECOMMENDATIONS

ENERGY SITUATION AND PRIORITIES

1. **Overall.** The Republic of Palau, located to the east of the Philippines, is the last remaining member of the Trust Territories of the Pacific Islands (TTPI) and thus remains under United States administration through a 1947 United Nations Trusteeship. The population of 15,000 is spread over six main islands with 68% concentrated on the capital, Koror. American grant assistance dominates the economy although there was substantial investment during the 1980s related to tourism and some fisheries development. Gross domestic product was last formally estimated in 1983 when per capita GDP was $2,300, probably reaching $3,200 by 1990 or double the corresponding figure for the rest of Micronesia. Real growth in GDP is expected to average between three and six percent per annum from 1990 through 1999.

2. Per capita energy consumption, particularly petroleum, is high by Pacific Island standards. Nearly the entire population (96% of households) is electrified. Power is highly subsidized by Government: the average tariff is 40% of total costs per kWh and revenues cover barely 20% of total costs. Overall, a disproportionately large part of Palau's financial resources has been directed to the energy sector to the detriment of development in other parts of the economy.

3. Imported petroleum products account for over 90% of primary energy use and 100% of commercial energy. The 1990 consumption of 1,460 kg of oil per capita, the highest of all Pacific Island countries, was approximately 30% by value of total imports and well over 500% of export earnings. Commercial energy use grew rapidly during the 1980s due largely to tourism and services; this trend is expected to continue. There are serious energy sector concerns, the most pressing being the need to restructure electric power supply to provide a reliable service with reduced levels of government subsidy and greatly improved management and technical skills of local staff. Palau has only limited options to reduce dependence on oil through local sources of energy or new technologies in the short term.

4. **Electricity.** There are a number of serious issues within the power sector. The government is becoming aware of these and there are indications that some are being addressed: a) the contract to manage the nation's main power plant (Aimeliik) has been costly for the services actually provided and has been poorly administered by the government; b) government has failed to provide the necessary tools and spare parts to enable the contractor to carry out effective maintenance at Aimeliik; c) the number of skilled or semi-skilled Palauans working at Aimeliik is too small to take over operations in August 1991 when the management contract ends, and their training has been poor; d) revenues cover barely one-fifth of the total cost of supply due to low tariffs, almost no metering of government offices and large commercial consumers, faulty metering, and non-payment of bills; e) poor maintenance of the distribution system resulting in worsening quality of power; f) generation, maintenance, distribution and billing are administered separately resulting in no overall management of the power sector; g) the billing system is

inadequate and monitoring of customer accounts ineffective; and finally h) there is little collection - and no analysis - of the basic data which are required by managers to make informed decisions on power investments, operation, and maintenance.

5. **Petroleum.** The main petroleum sector issues are: a) the lack of administrative structure or expertise to effectively manage petroleum matters overall; b) the need to immediately begin preparing for negotiation of a new agreement to replace the Aimeliik fuel supply contract expiring at the end of 1991; c) poor maintenance and utilization of the Aimeliik fuel storage facilities; d) lack of information required to monitor oil contract volumes and costs; e) lack of standards for petroleum product specifications, storage and handling; and f) excessive numbers of service stations.

6. **Household and Rural Energy.** In general there is very little information available on patterns of household energy use. Areas with state-run diesel power systems are typically restricted to six to twelve hours of operation per day. Revenues collected from the small state-run power plants are a small fraction of operating costs, maintenance generally poor, and power unreliable. Although about a hundred small stand-alone DC solar lighting systems have been installed in remote areas, these are not maintained either and have reportedly largely failed due to lack of spare parts, including lights. The responsibility for provision of rural power and its maintenance is not clear; it appears to be inconsistently handled by the government.

7. **Environmental Issues.** The most important environmental issue within the energy sector is a proposed waste-to-energy plant which could damage water quality, reefs, fishing industry, tourism and the fragile ecosystem. Generation of electricity from domestic or imported wastes is not an attractive option as Palau has sufficient generating capacity for some years. There have reportedly been minor oil spills within Palau's waters through deliberate bilge pumping and carelessness. The government environmental agency has an oil spill plan and some booms but there are no safety standards for oil storage and handling. At least one oil storage facility, a barge, is unsafe and some others are deteriorating. Some concern was expressed by environmental officials about polychlorinated biphenyls (PCB) in old transformers but most, if not all, has been removed.

8. **Institutional Issues.** Within the government, there is no overall responsibility for coordinating or overseeing national energy matters or the key subsectors of electricity and petroleum. As a result there are no clear policies, planning is negligible, and the basic data required for informed decision-making are not collected. The operation of Aimeliik power station since August 1991 is the overriding concern: Palauans are not ready to take over and the system could rapidly deteriorate if it is not run professionally.

PRINCIPAL RECOMMENDATIONS

9. **Power Subsector.** The following immediate measures are recommended:

a) establish a government-owned, commercially-oriented Public Utilities Corporation that combines the power sector responsibilities of the Bureau of Public Works and the Ministry of Administration;

b) install meters for all government and three-phase customers;

c) collect bills from all consumers and disconnect non-payers including government offices;

d) increase tariffs immediately to $0.15 per kWh with a 'lifeline tariff' of at least $0.10 per kWh for the first 100 kWh per month of household consumption;

e) engage a management and operation team[1] for two years for the Aimeliik power station with the goals of safe operation, completion of major overhauls of engines and transition to local management and staffing; and

f) establish a training program including overseas studies and apprenticeships.

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

g) determine actual costs of supply and increase tariffs from 1992 over a period of five years or less until average revenue is in line with actual costs;

h) establish more detailed budget and accounting systems, systematize data collection, prepare a 'system map' of the distribution system, and analyze loads and voltages in the system;

i) investigate the costs and benefits of rehabilitating the Malakal power station; and

j) purchase vehicles, tools, equipment and spare parts and rehabilitate the stores and workshop of the distribution section enabling it to undertake preventive maintenance and customer service.

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

a) assign overall responsibility for petroleum supply matters to the Energy Office of the Bureau of Public Works;

b) encourage the oil companies to evaluate the option of moving surplus tanks from Aimeliik to Malakal to allow supply to Palau with larger tankers;

c) establish guidelines to ensure that wholesale and retail margins are reasonable and review prices before and after Shell's entry into the market to ascertain whether price competition has developed;

d) tender for a new consolidated fuel contract as soon as possible including National Government, State Governments and Aimeliik demands;

e) after ascertaining the current pricing formulas of Mobil and Shell, establish a mechanism to verify fuel quantities and values for each cargo.

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

f) improve maintenance of the Aimeliik storage facilities;

g) establish firm guidelines for establishment of new service stations;

h) consider setting a higher fuel tax;

i) review the justification for the four existing grades of gasoline; and

j) establish standards for petroleum and LPG handling and storage.

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1 It is understood that two expatriate staff were contracted to oversee Aimeliik in late 1991 and arrangements were underway to employ two additional expatriate staff.

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

a) for rural state-run systems, extend the grids where economic, standardize diesel generation equipment as far as possible, maintain equipment systematically and establish a consistent policy on electricity tariffs;

b) install photovoltaic systems in those rural areas without diesel systems and establish mechanisms for systematic maintenance and regular billing; and

c) carry out household energy end-use surveys to determine patterns of energy use for planning conservation measures.

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

a) require annual surveys and marine certification of the petroleum storage barge and cease its use if unsafe;

b) coordinate development plans for Malakal to assure that the site remains available for future power generation needs without harmful effects on fish processing facilities;

c) obtain independent advice before proceeding further with the proposed Ngardmau waste-to-energy project; and

d) improve management of oil depot drainage to ensure that only clean water is discharged into public areas.

13. **Institutional Development.** The following immediate measures are recommended:

a) establish effective oversight of the proposed Public Utilities Corporation;

b) appoint an additional staff member to the Energy Office within the Bureau of Public Works to collect and analyze energy information, assist with energy planning and better administer the energy sector overall; and

c) verify the accuracy of the high level of petroleum fuel imports, determine in more detail the pattern of petroleum consumption and establish a practical plan for fuel savings.

I. ECONOMIC AND INSTITUTIONAL CONTEXT

ENERGY AND THE ECONOMY[1]

1.1 **Introduction.** Palau consists of about 340 tropical islands in the western Caroline group, East of the Philippines, between seven and nine degrees North latitude and 133 - 134 degrees East longitude. The larger islands are high and volcanic, the rest being raised coral limestone except for one atoll. The southernmost parts of Palau are closer to Indonesia than to the largest island, Babeldaop, which accounts for 80% of the total land area of 500 km^2 (200 mi^2). The administrative center, Koror, reportedly has the second highest population density (7,100 people/km^2) of any Pacific Island, exceeded only by Ebeye in the Marshalls.

1.2 One of seven original districts of the Trust Territory of the Pacific Islands[2], Palau opted in 1978 to become independent rather than be part of the Federated States of Micronesia. When the national constitution became effective in 1981 the Palau district became the Republic of Palau. On five occasions between 1983 and 1990, a majority of citizens voted in favor of a proposed "Compact of Free Association" with the United States which would guarantee a high level of financial support (about $30 million per year initially) for at least fifteen years in exchange for certain American rights; the required seventy-five percent approval has not been attained, however, and Palau is still administered by the U.S. in accordance with the U.N. Trusteeship. A constitutional ban on the use, testing, storage or disposal of nuclear weapons and the transit of nuclear powered vessels is the main unresolved issue. In October 1990, the United States Department of the Interior (USDOI) restricted Palau's powers of self-government by imposing veto power over proposed legislation and requiring USDOI approval of any contracts exceeding $250,000.

1.3 The constitution provides for a National Government and sixteen state governments for only 15,000 people. The national government is patterned on the U.S. model, with executive, legislative and judicial branches. The executive branch is headed by a President and Vice-President chosen by nationwide election, and the Cabinet consists of five appointed ministers. State governments have their own constitution, legislature and governor, and have the right to impose certain taxes. With little economic development outside of Koror State and adjacent Airai, most state governments depend heavily upon the national government for funding - mainly from block grants and the distribution of fishing

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1 This summary description is extracted from the Republic of Palau section of *"Macroeconomic Overview Report, Assessment of Performance and Growth Prospects: Republic of the Marshall Islands, Federated States of Micronesia, and the Republic of Palau"* (Pacific Islands Development Program, East West Center, May 1991) and portions of *"An Economic Overview of the Republic of Palau"* United Nations ESCAP Pacific Operations Center (EPOC), Vanuatu, November 1990, both prepared as background reports for this assessment.

2 The "Trust Territories of the Pacific Islands" were established in 1947 between the United States and the United Nations Security Council encompassing over two thousand islands of Micronesia. By late 1986, only Palau remained within the TTPI, constitutional governments having been established in the Republic of the Marshall Islands, the Federated States of Micronesia and the Commonwealth of the Northern Mariana Islands. Trusteeship administration is through the Office of Territorial and International Affairs (OTIA) of the U.S. Department of the Interior.

rights fees from foreign governments. The national legislature is termed the Olbiil Era Kelulau. The highest chief in Palau is the Ibedul whose prestige matches - and possibly exceeds - that of the President.

1.4 GDP was estimated at $31.6 million at current market prices in 1983. A crude estimate[3] of 1990 GDP is $50 million, with a nominal average annual growth rate during the 1980s of 6.8 percent. The economy is largely driven by government expenditures sustained by a high level of U.S. grant assistance. However, there has been substantial private sector development during the 1980s, with some growth in foreign direct investment and construction, and an increase in foreign workers. Tourism is Palau's leading productive sector accommodating just over 30,000 visitors in 1990, with growth a rate averaging over twenty percent per annum since the early 1980s. Palau's spectacular marine environment, the natural beauty of the unique Rock Islands and tropical remoteness provide potential for sustained growth in tourism. Fisheries output is also expected to grow. Currently, there are about 75 longline vessels based in Koror providing fresh tuna for Japan.

1.5 International trade statistics are not formally compiled. Although the Customs Office indicates total exports of about $0.6 million and imports of about $24.6 million (FOB[4]) in 1989, these are probably under-estimates. Freight and insurance costs are neither included nor reported separately as part of the balance of payments. There was a deficit of about $24 million in the trade balance in 1989. The principal 1989 imports were food and beverages ($8.5 million) and petroleum products ($5.9 million). In 1990, total imports were estimated as $27.5 million (FOB) and the value of petroleum imports roughly $7 million FOB or $8 million CIF including sales for international flights. The principal export is fish. Unofficial estimates indicate 1990 fish exports of over 1200 tonnes, which are believed to be mainly fresh tuna; therefore the value of exports in 1990 was likely to have increased substantially over 1989. Palau's imports probably exceed fifty percent of GDP indicating a high import propensity and an open economy with little marketed production for either domestic consumption or export.

1.6 Extension of infrastructure to less densely populated areas, particularly Babeldaop, is needed if the Republic is to achieve sustained growth and more balanced development. This will require substantial external funding. National government revenues consist primarily of U.S. grants through the USDOI for recurrent expenses, separate USDOI grants for a Capital Improvements Program (CIP) and various federal grants of the types available to American state governments. In fiscal 1989 total U.S. funding was $36.6 million. Both federal grant funding and CIP funding declined in 1990 but unspent monies from prior years can be drawn upon. Recent U.S. assistance represented 75% (1989) and 68% (1990) of total revenues. Revenues from local sources have increased steadily in recent years reaching $9.0 million in 1989 and $10.6 million in 1990 with $11.4 million projected for 1991. Aside from technical assistance and training, nearly all foreign aid has come from Japan, averaging approximately $3 million per annum during the 1980s.

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3 See Annex 2 for details.

4 The total value including cost, insurance and freight (CIF) is not available.

1.7 In 1983 the Government of Palau contracted for the construction of a power and bulk petroleum storage complex[5] in Aimeliik State at a cost of about $34 million. The Government borrowed $32.5 million from commercial banks, defaulted in 1985 and was sued by the guarantor banks. A U.S. District Court ruled in 1988 that Palau owed over $46 million (including interest) to the guarantors but this was overturned in early 1991 by the US Court of Appeal which decided that the U.S. Government has responsibility for Palau's liabilities under the Trusteeship. Under a 1989 Agreement (the Guam Accords) the U.S. may satisfy creditors in part with funds originally meant for fostering increased self-sufficiency in energy production.

1.8 Prospective growth in Palau is likely to be heavily influenced by government policy on foreign investment, particularly in tourism, and the government's capacity to utilize U.S. financial assistance effectively. The government favors implementation of the Compact, which would almost certainly have a favorable effect on the investment climate, but achieving this remains difficult. Much proposed investment is tourism-related, including a proposed $150 million airport which would allow direct jumbo jet flights from Japan. Continued growth of tourism and development of a substantial longline tuna fishery will require considerable upgrading and expansion of infrastructure. The government has experienced problems in maintaining and managing public utility services particularly in the power sector. The recent growth in the economy has led to the importation of increased numbers of foreign workers, many in the construction trades but also in services and other occupations. Currently, most tourism jobs are held by Palauans but, with continued rapid growth, an increasing share may be held by foreigners.

1.9 In view of the momentum in tourism-related investment and growth in visitor arrivals, moderate growth in the overall economy is likely during the 1990 - 2000 period. It is likely that government spending will remain at the same level in real terms, with or without Compact approval, either through continued U.S. grant assistance consistent with its U.N trusteeship responsibilities, or receipt of Compact monies, augmented if necessary by federal program grants. Depending upon the realization of major investments and success in developing tuna transshipment activities, real growth in GDP is expected to be between three and six percent per annum on average from 1990 to 2000, provided that there is a final resolution of Palau's power plant debt without significant adverse impact on future government spending. Growth at the higher end of the range is expected to occur if there is substantial foreign investment, primarily in tourism, including construction of the proposed airport.

INSTITUTIONAL FRAMEWORK

1.10 Energy is the responsibility of the Ministry of Resources and Development (MRD) which has one energy planner located within the Bureau of Public Works (BPW) who administers small project funds - totalling $17,000 in 1991 - available from the United States Department of Energy (USDOE). The Office of Planning and Statistics (OPS)

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5 See *"Issues Associated with Palau's Transition to Self Government"* (U.S. General Accounting Office, GAO/NSIAD Report 89 - 182 of July 1989) for details.

within the President's Office is responsible for national planning. The First National Development Plan for 1987 - 1991 prepared by OPS in 1986 contained a range of energy sector policies and strategies including plans to establish a public utilities corporation, meter all power consumers, raise tariffs above electricity costs, begin an energy conservation program, extend solar power systems to remote communities, etc. However, there was no mechanism for implementation and most goals have not been met. There is no overall responsibility for coordinating or overseeing national energy matters, electricity or petroleum. There are no clear policies, planning is negligible, and the basic data required for informed decision-making are not systematically collected.

1.11 **Petroleum.** Petroleum products are imported by Mobil and recently Shell through Guam. The BPW is responsible for operational aspects of petroleum while the Bureau of the National Treasury (Ministry of Administration) handles financial matters such as the payment of government fuel bills. There is no verification of costs or volumes by Customs officials. There is no administration of supply contracts.

1.12 **Electric Power.** Seven public electric power systems based on diesel generation provide power in nine of the sixteen states. About 98% of public electricity production is provided through the grid supplying Koror, Airai and Aimeliik from the Aimeliik power station which is controlled by the Bureau of Public Works of the Ministry of Resources and Development. The Public Utility Collection Agency is responsible for collecting electricity bills, but its computerized billing system is inadequate. Until August 1991, the power station was managed by a Philippines company (Gorones) under contract to the MRD; this has been replaced by direct hiring of individual expatriate staff. The individual states are responsible for operation, expenses and revenues of small remote systems. Although BPW are technically responsible for maintenance of generators, there is no budget for the remote systems. Repairs and investments are decided by the Vice President after requests from governors. Some equipment donated by Japan has apparently been allocated directly to each state with maintenance problems left to the national Government. In general, responsibilities for power are unclear, divided between two ministries and between national and state Governments. There is no commercial management of the power sector, a high degree of subsidization, little technical experience and poor management capacity.

II. ENERGY CONSUMPTION

THE STRUCTURE OF ENERGY CONSUMPTION

2.1 There has been no analysis of energy consumption patterns carried out in Palau since the early 1980s[6]. There is no information presently accessible on household energy use, but the 1990 Census Report, expected to be available before the end of 1991, will contain data on numbers of electrified households by type of service and cooking fuel use, each by State. The energy balances presented in the Statistical Annex for 1990 and 1995 are based on mission estimates. Total energy supplied in 1990 was about 22,500 tonnes of oil equivalent (TOE) of which 22,100 TOE was accounted for by imported petroleum products. The remaining 2% of energy used consists of biomass for cooking and drying. Biomass use appears to be extremely low, partly because of the extent of urbanization and extensive use of commercial energy (electricity, kerosene and LPG) for cooking. The actual use of wood is higher but no data are available to develop informed estimates. Inland petroleum consumption is about evenly split[7] between power generation (48%) and transport (47%) with small amounts for direct household, commercial and government use. Although tourism and tourism-related construction account for a considerable level of energy use, there are no data available for accurate estimates.

THE CONSUMPTION OF PETROLEUM PRODUCTS

2.2 As shown in Figure 2.1, petroleum consumption per person in Palau is the highest of twelve Pacific Island countries assessed during 1991. Consumption levels are more typical of large developed countries such as Australia or Japan than of island developing countries.

Petroleum Consumption in Pacific Island Countries

Tonnes consumed per capita in 1990

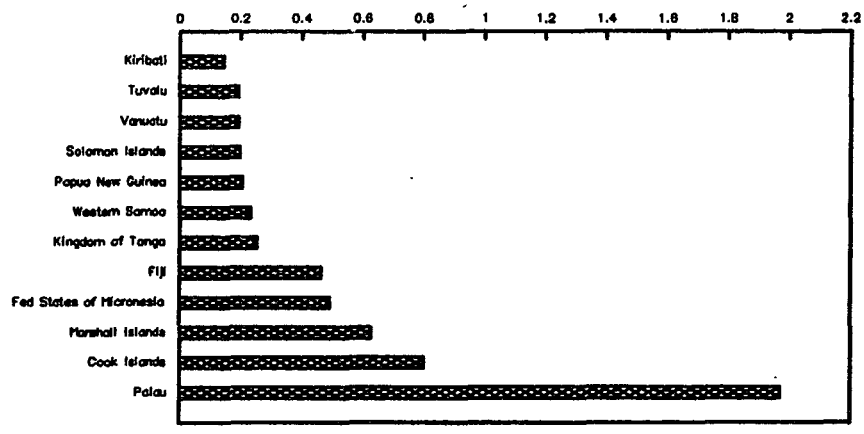

Figure 2.1
Source: Pacific Regional Energy Seminar, Apia, Western Samoa, October 1991

6 The most recent previous estimates are from the *"Territorial Energy Assessment"* (Report DOE/CP-0005/1, USDOE, December 1982) which stated that 30% of inland petroleum use was for electricity followed by unspecified amounts for fish processing with transport third.

7 The percentages are 38% and 54% respectively including international aircraft fuel sales.

2.3 The total 1990 petroleum consumption as shown in Table 2.1 was 8.3 million U.S. gallons (MG). This is reasonably consistent with reported import volumes of 6.3 MG plus inventories of 2.5 MG at the end of 1989 which dropped to nearly zero at the end of 1990. From 1986 through 1990, the average annual growth in petroleum fuel consumption has been 10%, the high end of a range of demand projections made by the UN in 1988[8]. The largest growth has been in transportation with jet fuel consumption tripling since 1986 due to increased scheduled cargo and passenger flights and charter flights to Tokyo for sashimi exports.

Table 2.1: Petroleum Consumption by Sector (1990)
(thousands of US Gallons)

Sector		Volume		Percentage
Electricity generation:				
urban	3,094			
rural (est)	86			
total		3,180		38.2%
Transportation				
road	1,918		23.0%	
air	1,524		18.3%	
sea	1,046		12.6%	
total		4,488		53.9%
Other Government Use		188		2.2%
Household and Other		470		5.7%
Total		8326		100.0%

Notes: 1) Sales volumes provided by Mobil & Shell differ from imports during the year.
2) Table includes bunkers and sales to international aircraft.

Source: Mission estimates.

2.4 Gasoline is used mainly in road transport with a smaller volume for inter-island boat travel, fishing and pleasure cruises. Demand grew by 10% per year during the five year period. Only "regular" gasoline was marketed until 1987 when Mobil introduced "super unleaded" followed by Shell which began sales of two grades of gasoline in 1990.

2.5 Shell entered the market in 1987 when it was awarded a contract to supply 50% of the Aimeliik Power Station fuel requirements. Shell then appointed Belau Petroleum as its local agent and this company began selling automotive diesel oil (ADO) to major customers in 1988 using a barge as floating storage. ADO use for electricity generation and fishing fleets has grown by 6.8% per year for the past five years. ADO for power generation has grown from 2.0 MG in 1985 to 2.3 MG in 1987 and 3.2 MG in 1990. ADO for fishing fleets accounted for 1.0 MG in 1990. Kerosene is mostly used for cooking and

8 *"Palau Petroleum Market Study and Contract Analysis"* (PEDP Report Palau 88 - 1, November 1988).

lighting in areas not connected to the electricity grid and has probably largely replaced biomass. 1990 LPG consumption was estimated at 34,000 gallons.

2.6 Demand for lube oil and aviation gasoline declined during the five year period. There are unconfirmed reports that local aircraft have been substituting gasoline for more expensive Avgas, which is a dangerous practice. The volume of Avgas imported appears to be low given the number of local flights, which indicates that there may be some substance to these reports.

2.7 Of the total 1990 Palau petroleum demand, direct government consumption accounted for 40% including fuel for power generation (38%). Transport accounted for nearly 54% of consumption of which 23% was for 2,600 commercial and private road vehicles, 18% for aviation, and 13% for sea transport including bunkers for the fishing fleet and about 500 outboard motor boats. The balance is consumed in construction, tourism and in the domestic market for lighting and home cooking. These uses probably account for more use than indicated in Table 2.1, as reliable sectorial information is lacking.

THE CONSUMPTION OF ELECTRICITY

2.8 Good station records are available on generation from the Aimeliik power station which accounted for about 98% of 1990 national generation of 47 GWh. Energy growth in the main grid was 16% from 1987 to 1988, 9% from 1988 to 1989, and 13% from 1989 to 1990. The maximum demand recorded at the power station is 7.15 MW with a typical weekday peak of 6.5 MW with minor seasonal variations. The minimum load is about 4 MW. The load factor (average load divided by peak load) is high at 0.74.

2.9 There are about 2,755 listed urban electricity consumers (2,406 residential, 269 commercial and 80 government) but the actual number of consumers is probably greater than this. Many consumers are unmetered including virtually all Government offices and many three-phase consumers whose consumption is grossly underestimated. Nearly half of all 1990 consumption was unmetered. Therefore there are no accurate estimates of electricity use patterns. From Table 2.2, it can be seen that over 41% of consumption is residential, and over 13% is commercial. From limited data[9] the remaining unmetered 46% may be used mainly by Government (25%) and commercial (21%) consumers but this appears to underestimate commercial use.

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9 *"The Final Audit Report on the Power Plant and Fuel Storage Facility, Republic of Palau"* (USDOI, Office of the Inspector General, Report 89 - 95 of 31 July 1989) estimated that in June 1988, Government accounted for 25% of electricity consumption, 21% was "other unbilled" consumption, and 54% was billed.

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

	Gross Generation	Technical losses (incl station use)	Electricity Consumption Residential	Commercial	Unmetered	Total
Aimeliik[1]	46.2	10.1	14.5	4.6	17.0	36.1
Rural[2]	1.0	0.3	0.6	0.1	n.a.	0.7
Total	47.2	10.4	15.1	4.7	> 17.1	36.8
Percentage			41%	13%	46%	100%

Notes: 1) Technical losses were measured in November 1990 as 15% of energy sent out. Residential & commercial breakdown based on October 1990 billings only.
2) Rural (Peleliu, Ngiwal, Angaur, Ngarchelong, Ngeremlengui, etc) are mission estimates.
3) n.a. indicates data not available.

Source: Mission estimates.

THE CONSUMPTION OF BIOMASS

2.10 There is no reliable information available on the consumption of biomass in Palau. Some officials estimate that 10% of the population cook with wood. At 1.4 kg per capita per day[10], the consumption is 772 tonnes per year, probably an underestimate since this is far lower than any other Pacific Island country.

DEMAND PROJECTIONS

2.11 Palau's economic growth is expected to be in fishing and tourism. Future growth in fuel consumption depends upon investment and activities in the above areas which may in turn depend upon perceived stability, in particular, the finalization of Palau's future relationship with the United States. Early resolution of the Compact of Free Association could result in considerable capital investment in various deferred projects such as a new capital administrative center and the proposed airport development. Similarly, an early resolution should lead to increased confidence on the part of overseas investors resulting in more foreign capital injection in tourism and fishing. Fuel demand projections are therefore indicative only; they are based on an assumption of real economic growth varying between three and six percent and on numerous discussions with government officials and the private sector.

2.12 *Petroleum demand.* Within the high demand scenario, petroleum fuel use is projected to grow at 6.2% per year overall during the 1990s which is slightly above real economic

10 This is typical of wood use per capita measured in energy end-use surveys in similar environments elsewhere in the region. See *"Energy Statistics Relevant to Household and Rural Energy Issues in the Pacific Islands"* (PEDP Report REG 90-5, October 1990).

growth. This projection assumes that: (i) real U.S. funding remains at least at current levels, (ii) Palau's legal status is finalized within several years, (iii) political stability improves, (iv) the 1991 court decision regarding Palauan liability for the IPSECO loan remains in force and (v) foreign investment in tourism and fisheries expands. Jet fuel use is assumed to grow at 7% per year due to tourism expansion, ADO at the electricity growth rate of 6%, gasoline and LPG at 6% and kerosene at 5%.

2.13 For the low growth scenario, both economic growth and fuel consumption are estimated as 3% per annum. US funding is assumed to continue at more-or-less current levels but investment in tourism and fisheries will not grow rapidly. Most fuel imports are expected to grow at 3% per year, slightly less for distillate.

2.14 *Bunker fuel.* Palau plans substantial growth in fish exports which could potentially result in a large bunker demand for distillate. Typical levels of fuel consumption[11] for tuna vessels are shown in Table 2.3 based on a recent study of ships operating in Pacific Island waters. If the economy grows at 6% per year and if bunkering for purse seiners and long liners grows from almost zero in 1990 to four million gallons per year by 1995, ADO demand overall would double in five years. An issue for Palau is whether this would require investment in on-shore storage. The Aimeliik tanks used for ADO can store sufficient fuel for about twelve months demand. Existing unused storage facilities (three MG) are more than adequate to accommodate a high level of bunkering, assuming investments which allow ships to berth at Aimeliik or shifting of excess tanks to a more convenient location in Malakal.

Table 2.3 Fuel Consumption Per Tuna Vessel
(Thousands of US gallons per year)

Vessel	Size	Fuel use
seiners	1,100 ton	515 - 660
long liners	100 ton	180 - 210
pole & line	n.a.	about 130

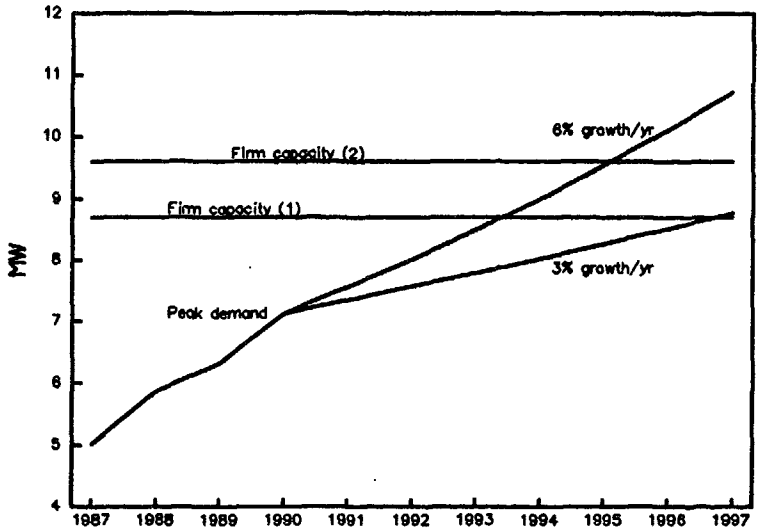
Note: n.a. indicates data not available
Source: Fuel Use in Tuna Fishing (FFA, PEDP, & FSED, 1989).

2.15 *Biomass.* Biomass use is expected to increase no more rapidly than the population growth rate of 2.2% per year. Electric cooking may be reduced as power tariffs and collections increase. Several companies are investigating the bulk import of liquid petroleum gas (LPG) which is more likely to substitute for electric cooking than wood, given Palau's income levels.

11 from *"Fuel use in Tuna Fishing"* (Forum Fisheries Agency, PEDP and FSED, 1989).

2.16 *Electricity.* An estimate of the requirements for investment in electricity generating plant requires a forecast of the future maximum demand. As shown in Figure 2.2, peak demand grew from 5 MW in 1987 to 7.1 MW in 1990, an average increase of 12% per year. The weekday peak, as shown in Figure 2.3, is relatively constant from about 9:00 a.m. through 8:00 p.m. except for about two hours at meal time. As discussed in Chapter III, the firm capacity of the main power system is between 8.7 and 9.6 MW depending upon the safety of foundations at Aimeliik and the extent to which this affects maximum output. Figure 2.2 indicates projected growth in maximum demand during the 1990s of 3% and 6% per year, which are below recent growth rates. The higher rate assumes low tariffs and continued tourism growth; the lower corresponds to the estimated effect of progressive tariff increases and lower economic growth. Palau will require new capacity by 1993 if growth is high and current firm capacity is limited to 8.7 MW. This could be delayed until 1997 if growth slows to 3% per year and the Aimeliik units can be run at full capacity. If some of the Malakal plant can be refurbished and considered firm, requirements for new capacity can be delayed further, as discussed in Chapter III.

Aimeliik Power System
Firm capacity and peak demand



Note: Firm capacity (1) is Aimeliik Unit 5 derated; firm capacity (2) is restored to full rating.

Figure 2.2

Aimeliik Daily Peak Load: January 1991

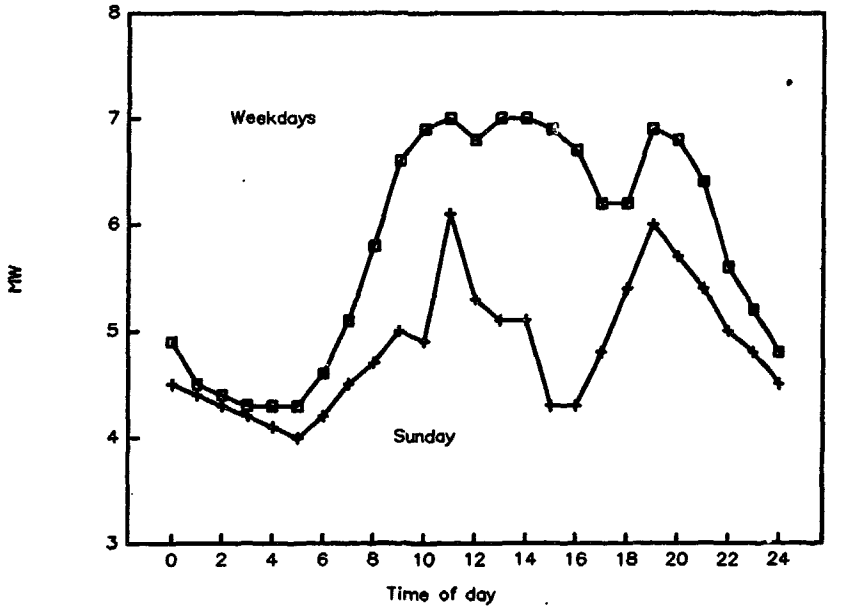


Figure 2.3

Sources for Figures 2.2 & 2.3 are mission estimates and Aimeliik station records.

III. ENERGY SUPPLY

OVERVIEW

3.1 Palau has an abundance of biomass with three-fourths of the land forested, abundant sun, some wind and waves, a small hydropower potential, and possibly an attractive ocean thermal resource. Energy resources were assessed by the US Department of Energy in 1982. The conclusions of this report are broadly the same as those of the USDOE nearly a decade ago: considering the status of the various alternative energy technologies, relative economics, the environment of Palau, and existing and planned energy infrastructure, Palau will remain dependent on petroleum imports for transport and power for the medium to long term. In remote communities on Babeldaop small scale hydropower may be favorable. Photovoltaic systems appear to be a good option for small electrical needs on the small islands. The USDOE also stressed energy conservation as an important energy source, a conclusion supported by this assessment.

URBAN ELECTRIFICATION

3.2 The power generation capacity in the seven public power systems is about 20 MW, all of which is diesel based. The main power station at Aimeliik with a capacity of 12.8 MW is designed for residual fuel oil (RFO) but RFO use has been discontinued because its higher operating and maintenance costs could not be offset by savings in fuel costs. A resort hotel and fish processing facilities have private generators. Several other commercial consumers also have stand-by diesel generators. A 14 MW plant in Airai State has not operated for some years.

3.3 From 1980 - 1985, generation was constrained by the capacity and reliability of the Malakal facilities as shown in Figure 3.1. From late 1986 onwards, generation grew rapidly as the new Aimeliik plant became operational. Data are not available for 1986.

Urban Power Generation (1980 - 1990)
(Malakal: 1980 - 1985; Aimeliik 1987 - 1990)

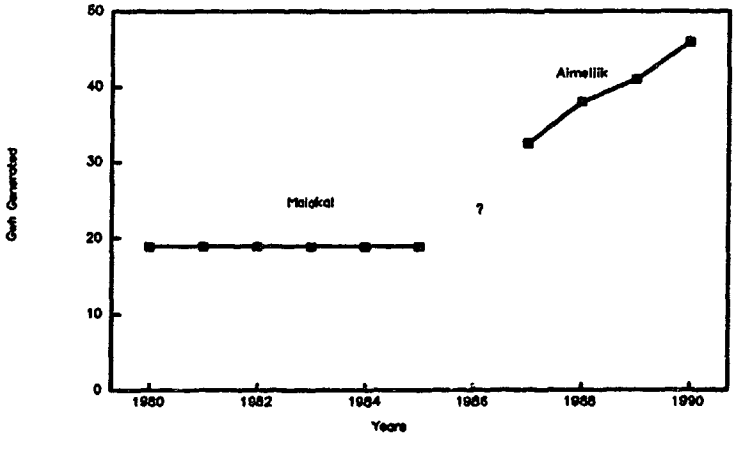


Figure 3.1

Note: 1980 - 1985 based on 16.4 GWh consumed plus (assumed) 15% losses.
Source: Aimeliik and Malakal station records.

3.4 There is some uncertainty about the extent to which capacity in the main Aimeliik power station and the old Malakal plant can be considered firm after possible foundation repairs (Aimeliik) and refurbishment (Malakal). It is recommended that this be resolved as firm capacity affects the timing and magnitude of new investments.

The Power Stations

Aimeliik Power Station

3.5 The Aimeliik power station, situated 25 km from Koror, generates all the electricity flowing through the main grid covering the states of Koror, Airai and Aimeliik. The station and a fuel tank farm were constructed on a $32.5 million turn-key contract with International Power Systems and Engineering Company, Ltd (IPSECO) of the U.K. The station was built to a high standard and the engines have a reasonable fuel economy for the size of the engines. Since commissioning in 1986, the station and tank farm were operated by an expatriate crew of sixteen persons from Gorones International Construction Corporation of the Philippines under a management and operation contract which expired in August 1991. In late 1991, several expatriates were hired by the government on direct contracts to supervise Palauan operating crews.

3.6 The power station has a rated capacity of 12.8 MW divided among four 3.2 MW Pielstick dual-fueled engine-generators (numbers 2 - 5) with medium speed 720 rpm Crossley Engines. The foundation and a generator are available for a fifth engine (number 1) which was canceled during construction of the plant. Experience from operations using RFO and distillate showed that the lower overall fuel price was more than offset by the higher cost of transporting and handling two types of fuel, electricity consumption of the preheaters and increased maintenance. The decision to switch away from RFO was sensible as RFO is better suited to larger engines, exhaust heat systems for preheating and access to RFO of reasonable price and quality. RFO available to the region during the 1990s is expected to have increased sulphur and ash content due to new Singapore refining techniques. Consequently environmental issues and maintenance costs related to RFO use can be expected to be even higher in the future.

3.7 Good preventive maintenance has kept unplanned outages of the engines to low levels. Outages caused by the plant's failure to meet demand are rare but faults on the 34.5 kV feeder to Airai and the 13.8 kV grid in Koror often result in the tripping of the plant. According to operating staff, that the problem arises because 85% of the load is on the Koror feeder so the engine governors are unable to avoid tripping on overspeed. While this is possible, the cause could also be incorrect earth fault relay setting or misadjustment of the governors. All four engines were due for a major overhaul during 1991 after 24,000 hours of operation. This was not done.

3.8 The capacity of three out of four engine-generators or 9.6 MW can be considered "firm capacity" if they are all run at the rated capacity of 3.2 MW each. In 1990 the peak load recorded at the station was 7.15 MW leaving a margin of 35% which is sufficient for several

years of load growth. However the contractor will operate not any of the engines above 2.3 MW due to cracks observed in one foundation (and expected in the future elsewhere) and high vibration levels. With this restriction, from 1991 the Aimeliik station will not be able to meet peak demand running three of the four engines.

3.9 A consultant who is familiar with the operation of a similar power plant investigated this serious issue for the Government in early 1991. His report[12] states that only two cracks are observed on engine block 5 near the end of the foundation. According to the consultant, Crossley has indicated that the vibration level observed at engine number 5 and the other engines is acceptable. A vertical crack under number 2 cylinder could lead to excessive wear on the shaft and main bearings. The horizontal crack at the far end is of minor importance. An inspection by a structural engineer should clarify the severity of the problem and the means to repair the block.

3.10 At 2.3 MW load, the temperature and pressure of the lube oil and jacket water were checked by the Government's consultant who stated that the results were not in accordance with Crossley's specifications. He concluded that the engines are being run incorrectly, probably due to insufficient maintenance of the auxiliary equipment resulting in scale buildup in the cooling systems. During operations, the consultant was unwilling to put more load on engine number 5 because of these results.

3.11 The Gorones management contract terms were very costly for the services provided. The contractor managed and operated the station with its own crew but the Government provided parts, fuel, supplies, equipment and all other consumables needed. In addition to salaries and wages, the contractor was paid a substantial fee of one cent per kWh of gross generation, amounting to $ 0.46 million in 1990. Other than the hiring of two expatriate staff in late 1991 and plans to hire several more, the plans for management and operation of the facility are not known.

3.12 A recent OMIP[13] assessment carried out for the USDOI characterized the proficiency of the Gorones crew as outstanding. The crew kept the plant clean and orderly and in apparently good order despite difficulties of getting approvals from BPW to purchase tools, spare parts and materials needed for operation and maintenance. However, the contractors could have provided better maintenance with only minor purchases of parts had these been supplied by the Government as the contract specified[14]. Although the contractor maintained that lube oil and cooling water readings have not changed since commissioning in 1986, this seems unlikely. There is no apparent negligence although the outdoor radiators do show progressive corrosion. The workshop and the stock of spare

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12 *"Facilities Systems Inventory: Aimeliik Power Plant, Palau"* (by W. F. Roberts for USDOI/BPW, 22 January 1991).

13 *"Republic of Palau Plan of Action: Operations and Maintenance Improvement Program"* (Louis Berger International and Barrett Consulting Group for USDOI & US Army Corps of Engineers, Dec. 1990). The most recent report for Palau is the *"Second Year Review: OMIP Team's Field Report"* of June 1991.

14 The approach used in Ebeye in the Marshall Islands, where the contractor purchases parts and bills the Government at cost, has been more successful and would probably have worked well with the Gorones crew.

parts, tools and materials have been kept properly but the special tools required for repairs and major overhauls are not available. Instrumentation in the control room was functioning and detailed station records were kept on a desktop computer. Key indicators on operations were written on wall boards providing an impression of good performance to visitors. The plant's total down time since 1986 was indicated to be only 3.5 hours, excluding faults in the grid, which is excellent. However, this value may not be accurate.

3.13 Station use exceeding seven percent of gross generation is high (and adds to the contractor's profits) but cannot be explained without further investigation. The electricity-consuming preheaters in the tank farm were shut off. The meters on the generators and the feeders are of good quality, are apparently accurate and do not reveal any obvious sources of excessive use.

3.14 The contractor continuously reported to BPW on operating performance, events, maintenance work and repairs carried out. At frequent intervals the contractor argued persuasively for approval of purchases of tools and parts. However, the available records indicate that the response from BPW has been vague, probably due to the lack of funds within its budget for operations and maintenance. In any case, the Government was unable to manage the contractor effectively, with the responsibility divided between the Ministry of Administration and BPW. An O&M contract of the type signed with Gorones requires active involvement and technical knowledge by the employer. Maintenance goals must be set by the employer and verified through frequent inspections, meetings and discussions with the contractor.

3.15 The contractual goals concerning training of local staff were been met. Fourteen to nineteen Palauans, half of them transported every week from the Malakal power station on Koror, were assigned from Monday through Thursday as trainees to the Aimeliik power station. The contractor was required to replace the expatriates with Palauans who completed training. On-the-job-training should have commenced in 1986; it did not begin until 1988 and has been ineffective: Palauans had not taken over a single position by mid 1991. As a consequence a Palauan crew was not ready to safely take over operation of the plant from August 1991 following the expiry of the Gorones contract.

3.16 The reasons for the failure of the training program may be cultural and morale related rather than technical:

a) the staff chosen from Malakal have not had the technical education which could be expected if younger candidates had been chosen and they may be reluctant to move from Koror to remote Aimeliik;

b) the working spirit at Malakal, a low-priority stand-by plant, seems to be much lower than at Aimeliik;

c) the expatriates had a different language and cultural background and may have been reluctant to provide their knowledge and relinquish jobs; and

d) Palauans were given routine work on the shifts rather than taking part in day-time repair and maintenance.

The Malakal Power Station

3.17 The Malakal power station two kilometers from the center of Koror has been restricted to peak and stand-by generation since the commissioning of Aimeliik in 1986. Since the control room was damaged by a 1990 cyclone, the operable generators have reportedly only been run at idle for one hour every Friday without being synchronized with the grid. The crew being trained Monday through Thursday at Aimeliik also work at Malakal on Fridays. The lack of supervision and technical skill is evident. The power station is in very poor condition.

3.18 Of the nine diesel generators, five with a total rated capacity of 6.65 MW are reportedly operable. Some, however, are heavily derated due to cooling problems. The engines are listed in Table 3.1.

Table 3.1: Malakal Diesel Generators (1991)

No.	KW and Type	Hours run	Comments
1	750 kW White Superior, 1972	72,000	generator failed in 1988
2	750 kW White Superior, 1972	91,000	operable
3	1000 kW Caterpillar	69,000	ran out of parts in 1987
4	vacant		
5	800 kW Caterpillar		stator burned out
6	900 kW Caterpillar, 1976	38,000	operable
7	1250 kW ALCO, 1981		damaged turbo charger
8	1250 kW ALCO, 1981	28,650	operable
9	1250 kW ALCO, 1981	18,130	operable
10	2500 kW ALCO, 1981		operable at 2200 kW

Source: Mission interviews.

3.19 The present installed capacity will exceed the expected load in the near future but the actual capacity available in an emergency situation is unknown. Without a clear decision on the future of the plant, there will be further unplanned deratings and reduced availability. The Malakal power station may be needed for peak power generation and stand-by capacity to overcome transmission limitations and breakdowns at Aimeliik. The site may be attractive for future power generation because of thermal limits on the heavily-loaded Aimeliik-Airai transmission line.

The Transmission and Distribution Grid

3.20 *System description.* From the Aimeliik power station a 34.5 kV transmission line extends over 20 kilometers on concrete poles to Airai north of Koror. A second five kilometer feeder on the same poles to Nekkeng substation carries only a small load of 50 kW as plans to extend transmission to northern Babeldaop have not been realized. Although development in the area is desired by the Government, load sufficient to justify transmission extension beyond Nekkeng is unlikely in the near future.

3.21 From Airai substation a 'temporary' 13.8 kV three km feeder has been built to Koror where it is integrated into the old grid. Between Public Works in Koror and the Malakal power station, a parallel line has been built partly on poles common to the older line, new sections having relatively lightly-loaded aluminum conductors whereas the older copper conductors are heavily loaded. The coupling of the substation at Malakal with the parallel lines has not been designed for the normal direction of power flow from Airai towards Malakal. A minor improvement in voltage and losses could be obtained by changing the coupling. This is recommended.

3.22 In late 1990 total technical losses were calculated[15] as 15% of energy sent out from Aimeliik. The 20 kilometer-long Feeder 2 to Airai carries about 7 MW at peak demand accounting for losses of 5.4% and the 10 MVA step-down transformer at Airai is already loaded to 80% of thermal capacity. Additional load would result in steeply rising losses. The 13.8 kV Koror feeder carries up to 6 MW, accounting for 4.5% losses including the old Koror grid. Distribution transformers seem to be generally undersized. Overall, technical losses are high mainly due to the distant siting of Aimeliik power station. The 13.8 kV Koror grid is heavily loaded, which leads to low voltage in Koror especially on the islands of Malakal and Arakabesan.

3.23 *System quality.* The state of the transmission and distribution system is below an acceptable standard and should be a matter of concern. Strong wind and heavy rain cause frequent earth faults, short circuits and broken conductors often leading to total blackouts. Tripping problems reportedly occur two or three times per week. The main reasons seem to be insufficient tree cutting along the transmission and distribution lines and lack of systematic preventive maintenance of the distribution grid. There are insufficient distances between some 13.8 kV conductors which are often slack due to frequent emergency repairs and improper jointing work. Many poles are loaded too heavily, especially angle poles which carry two 13.8 kV lines. The poles should be guyed or reinforced. In general, outages and voltage drops are too frequent and the system is too vulnerable to heavy winds.

3.24 The pole-mounted single-phase distribution transformers are not maintained regularly. Due to high humidity and salt contamination, corrosion is progressing rapidly and flash-overs are increasingly likely to occur. The purchase of replacement transformers and the number of outages could be reduced by transformer maintenance. Low voltages and frequent voltage fluctuations cause breakdown of air-conditioners, freezers, refrigerators, electric motors and other electric appliances. The low quality of service is confirmed by the fact that several major commercial customers require stand-by diesel generators.

3.25 *Distribution management.* The management and technical skills of the ten staff of the power distribution section are inadequate. The reliability and voltage quality of the distribution system could be improved substantially by implementing fairly simple and

15 *"An Evaluation of Technical and Non-technical Losses in the Power System Serving Palau's National Capital District"* (PEDP Report Palau 91 - 1, January 1991).

inexpensive monitoring and maintenance procedures. Maps of the transmission line and 75% of the distribution system exist but diagrams and system data are lacking. Consequently adequate assessment, planning and monitoring of the system cannot be carried out and fault location and repair are complicated and time-consuming. No monitoring of load, voltage and losses in the system is carried out and skills in distribution planning are lacking. Upgrading of transformers is reactive only - in response to complaints from customers about voltage levels.

3.26 No facilities exist for transformer maintenance, and meter adjustment equipment received several years ago has never been used due to lack of training. Stocks are inadequate and disorganized, the workshop and stores untidy and the lack of parts, vehicles and two-way radios prevent crews from being sent out on preventive maintenance or voltage monitoring.

3.27 Investments will be needed in the transmission and distribution system to provide for growing demand, improved service quality and reduced losses. A technical analysis should be carried out on the Koror distribution feeder, drop lines and the service connections of major commercial premises.

3.28 Part of the customer's problems with poor power quality and voltage drops originate in loose connections and overloaded wires. The Government should consider introducing customer service to help with measurements, trouble-shooting and - in the future - energy conservation. This would also improve the monitoring of the distribution system.

3.29 *Grid expansion.* If generation on Aimeliik increases, the following options exist:

a) a second 13.8 kV feeder from Airai to the center of Koror, probably a cable. Dividing the Koror grid into two feeders will reduce losses, voltage drops, and substantial risks of black-out and may be required in the near future. This would cost about $200,000.

b) extension of the 34.5 kV feeder number 1 from Nekkeng to Airai including a new step-down transformer. The feeder may have to be installed on new poles, as feeder number 2 must be kept in service. The approximate cost would be $1 million.

c) as a more expensive and complicated alternative to 1) and 2) above, Feeder number 2 could be extended to Koror, where a new step-down transformer should be installed. This could cost $1.5 - 2.0 million and possibly require an undersea cable.

Metering and Collection

3.30 Few of the large Government and commercial (three phase) consumers are metered but residential consumers appear to be nearly all metered. Thus, the largest loads in Palau, which are relatively few in number, are responsible for most of the 46% of final consumption that remains unmetered. The problem is most severe within Government offices which apparently pay nothing for electricity. However, some large commercial consumers receive estimated bills which appear to be well below actual consumption. Collections from users who are metered appear to be very good. In 1990, approximately 19.1 GWh were billed to consumers, and about $1.8 million was collected, for an average of

about 9.4 ¢/kWh, very close to the average tariff of 9.5 ¢/kWh. Apparently the disconnection policy is enforced effectively.

Power System Expansion

3.31 *Existing generating capacity.* The nameplate generation capacity in the main grid is 12.8 MW at Aimeliik and 6.6 MW in Malakal. Aimeliik output is restricted by the contractor to 9.2 MW at present and by the transmission capacity to 10 MVA. Malakal is not believed to be able to generate more than 3 - 4 MW, none reliably. The peak demand in 1990 was 7.15 MW giving a theoretical reserve margin of 170% with all plants at rated capacity. With Aimeliik restricted to 11.9 MW and Malakal unreliable, a realistic estimate of the reserve margin is 66%.

3.32 In a small utility system, the recommended reserve margin can be determined by calculating the 'firm capacity' (total capacity of reliable units minus the largest unit) allowing for the outage of one unit without power shortage at peak demand. With nine units on Palau, the firm capacity would be defined for each of the two power plants: 6.9 MW (2.3 MW x3) at Aimeliik with the present restrictions and 9.6 MW without restrictions, and between zero and four MW at Malakal depending on reliability. Without improved maintenance, the firm capacity could be as low as 8.7 MW but a firm capacity of 13.6 MW (9.6 MW at Aimeliik plus 4 MW at Malakal) could possibly be obtained by overhauling Malakal's engines and the electrical equipment.

3.33 *Future generation expansion.* In order to take into account the uncertainties of the load projections and the statistical nature of the peak load, it is advisable to add new generation capacity when the peak exceeds 90% of firm capacity. The annual load growth from 1987 through 1990 has been high, about 12%. Even with more moderate forecasts of 3% to 6% per year, higher power ratings from the installed capacity are required now. This can be done primarily by properly rating Aimeliik, and possibly refurbishing the engines at Malakal, and secondarily by investing in new transmission capacity from Aimeliik. With a load growth of 3% to 6% per year and improved maintenance, it is possible that no new generation capacity may be necessary until near the end of the decade although this situation could change if several units at Malakal are phased out.

3.34 It is recommended that the government monitor more closely the load growth and the power demand by customer category and establish realistic short and medium term forecasts. Prospective development projects requiring substantial power demand should be monitored closely and new generating or transmission capacity should only be approved based on confirmed projects.

3.35 *Power generation options.* Several options exist for new generation capacity when it is required:

a) Peak load engine-generators installed at Malakal. This may be the least-cost option with a short lead time and is attractive if a sudden demand growth occurs. However,

increased overall specific fuel consumption and the age of the four base-load engines seven to ten years from now should be carefully considered.

b) A fifth 3.2 MW engine at Aimeliik similar to the existing engines. This may require a new transformer in Airai and a new transmission line.

c) A 5 - 6 MW base-load low-speed engine-generator at Aimeliik running on residual fuel oil with exhaust boilers for preheaters and with low specific fuel consumption. This would require a new transmission line, reintroduction of RFO and a high technical maintenance standard.

d) Power generation using fuels other than oil, but this is not possible in the short term. Extensive biomass resources are available but the technology of small scale steam based generation is complicated. Transport costs of imported coal are probably prohibitive but better options may be available in the future..

3.36 Other renewable energy sources and waste burning options have been proposed; these are discussed in paragraphs 3.50 and 4.21; they do not provide short-term solutions to power needs.

RURAL ELECTRIFICATION

3.37 Small State-run diesel systems have been installed in Peleliu, Ngiwal, Melekeok and other locations, typically operating for six to twelve hours daily. For these systems, revenues are a small fraction (0 - 30%) of operating costs, maintenance is generally poor, and power generation is unreliable. Although nearly a hundred[16] solar lighting demonstrations have been installed in remote areas, these are also not properly maintained and have reportedly largely failed due to lack of spare parts and replacement lights. The responsibility for provision of rural power and its maintenance is not clear; it appears to be inconsistently handled. Several systems are described below. The grids are only lightly loaded and transmission and distribution do not present operational problems.

3.38 *Peleliu.* The island of Peleliu has a diesel system serving 150 residential consumers in the neighboring villages of Koska and Klouklubed who pay a fixed rate of $10 per month. Some meters are installed and at one time $0.05 was collected per kWh. The distribution system is fairly well maintained. An ice-making machine at the dock was supplied from the grid but now operates from its own diesel generator. The water supply plant also has a separate diesel engine. Power is supplied from 6:00 p.m. to 6:00 a.m.. The only operable engine-generator is a 205 kW Caterpillar dated 1969. No station records are kept but according to ammeter readings the peak load is 80 - 90 kW. Operating cost is about $4,000 per month with fuel consumption of approximately 550 liters per night.

3.39 A 100 kW Cummins diesel has been out of service for some years due to a broken generator. Three other engine-generators which have broken down in the past are in an open shed outside the power house. All generators were supplied second-hand by the Palauan Government. It is not known whether the engines had been overhauled properly before shipment to Peleliu. The State is responsible for the operation including revenue

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16 The 1989 TTPI Report indicates 86 federally-funded PV lighting systems mainly in rural Kayangel, Sonsorol and Hatohobei.

collection. Operators handle daily maintenance with repairs carried out by staff from Malakal power station upon request from the State which reimburses BPW. The Government of Palau is responsible for new investments and replacement of broken-down generators. No funds are budgeted for overhaul and preventive maintenance of the engines. Repairs or replacements are only carried out when blackouts occur or are imminent.

3.40 *Ngiwal.* In Ngiwal 52 houses are supplied with electricity used for lighting, radio, video, small washing machines and rice-cookers. Ten homes have refrigerators. Radio communication at the state office is solar powered. House connections were installed by BPW staff but the high voltage line has been extended by local people using very simple poles with a single phase conductor at the top. The power house has a single 100 kW Caterpillar D330 stand-by diesel generator used for base load. No station data are recorded but the load is about 30 kW (60 kW peak) judging from readings from a primitive ammeter. The system was established in 1972 and the engine, which is in very poor condition, has since been replaced once. Considerable quantities of lube oil leak onto the floor. The radiator also leaks so that one gallon of rain water has to be added every day. Corrosion and scales in the cooling system will lead to overheating and eventual breakdown of the engine. Problems now occur every second or third month requiring mechanics to be sent by boat from Koror but there is no preventive maintenance. Ngiwal state pays BPW for spare parts and the mechanics' daily expenses. About 2,000 liters per month of fuel is transported by drum from Koror. A 4,000 liter storage tank is not used as its pump has broken down.

3.41 Customers pay a fixed charge of six dollars per month which provides an annual revenue of $3,700. Some meters have been installed but they are not used for billing. Approximate annual operating costs are $17,000 as follows: diesel fuel ($9,240), fuel transportation ($3,900), maintenance ($2,628), and parts and miscellaneous expenses ($924). This excludes capital costs and wages of the operator during the service hours from 6:00 to 10:00 p.m. Total annual cost per consumer is estimated as $500 of which only 15% is recovered.

3.42 *Other diesel systems.* Melekeok state on Babeldaop has built a four kilometer primary distribution line and a generating facility to serve 64 customers financed by Japanese grant aid. In early 1991, its commissioning awaited a diesel-generator and transformer for which no provision had been made. A used 300 kW generator has since been provided by the national Government. Eventually, when a road is constructed, it is planned to connect the system with a thirty kilometer overhead line to the grid. The island of Angaur has a diesel system which operates six hours per day. Consumers were billed in the past but this has reportedly ceased. In Ngarchelong state in the northernmost part of Babeldaop a 50 hertz system is in service, Palau generally being 60 Hz. Other systems operate in Ngeremlengui state and on the island of Eil Malk, the latter being privately owned.

PETROLEUM PROCUREMENT AND DISTRIBUTION

Import Quantities

3.43 There are no reliable records of petroleum product imports. Information for 1990 volumes from Customs Department invoices, suppliers, and end-users are inconsistent indicating a range of 5.9 - 6.8 MG excluding jet fuel which adds 1.0 - 1.5 MG. From discussions with end users and suppliers, the high end of the range (6.8+1.5 = 8.3 MG) appears to be reasonable. Of the assumed 1990 total of 8.3 MG shown in the Statistical Annex, distillate accounted for 56%, gasoline 24% and jet fuel 18% with small amounts of other products. There are four grades of gasoline marketed, two "regular" grades accounting for about 60% and "super" unleaded 91 octane and 95 octane about 20% each.

3.44 Palau receives fuel at a reasonable landed cost, considering its supply logistics and the small domestic demand. However, the CIF cost could be reduced if physical constraints limiting the size of vessel at the Malakal port can be overcome. Present supply logistics depend upon local coastal tanker[17] (LCT) transshipment through Guam. If supply can be changed to larger 25,000 ton General Purpose (GP) tankers on a multi-port discharge pattern combining Palau with Guam or Saipan, prices could be reduced appreciably.

Storage capacity and condition

3.45 Palau has more than enough storage capacity for the foreseeable future with four fuel depots: a) a multi-product facility at Malakal Port owned and operated by Mobil Oil Micronesia; b) the former Happy World multi-product depot at Malakal now owned and operated by Shell's agent, Belau Petroleum Products; c) a small Mobil bulk aviation refueling installation at the airport; and d) the large Aimeliik facility at the power complex. Belau Petroleum Products is increasing capacity by refurbishing two 225,000 gallon tanks previously used to store coconut oil.

3.46 Products are received into the two Malakal depots directly from the LCTs which Mobil and Shell operate in Micronesia. The airport tanks are supplied via road tankers from the Malakal depots. The Aimeliik tanks store ADO for the generating plant and are filled by barge from Mobil's Malakal depot or by direct Shell import using a small LCT from Guam or Singapore. Shell's agent also uses a 200,000 gallon barge, which is normally moored at Malakal wharf. Details of available storage are shown in Table 3.2.

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17 Mobil currently uses the Golden Craig, a 7,000 deadweight tonne (DWT) LCT.

Table 3.2 Palau Petroleum Storage (thousands of US gallons)

Product	Total[1] Capacity	Monthly[2] Demand	Coverage (months)
Kerosene	855	127	6.7
Distillate	4,756	389	12.2
Gasoline	877	164	5.3
Unused	3,000	-	-
Total	9,484	694	13.7

Notes: 1) Includes Belau Petroleum, Mobil and Aimeliik.
2) Based on 1990 demand of Annex 1, Table 5; "Total" includes other products.

Sources: Mobil Oil, Belau Petroleum and Government of Palau.

3.47 The Aimeliik capacity exceeds current needs and is excessive, grossly under-utilized, poorly maintained, deteriorating and located at an inconvenient site distant from Koror. The installations on Malakal are well managed and maintained. Mobil is installing floating membranes on its gasoline tanks to reduce product losses and pollution through vapor discharges. Shell expects to commission the refurbished coconut oil tanks for ADO storage by the end of 1991. Continued use of the 200,000 gallon floating barge is a serious safety and environmental threat which should not be tolerated; the barge has reportedly not had an annual marine survey for a number of years. It is recommended that government require an annual survey and marine certification of the barge for use as safe floating storage. This would require considerable investment and thus accelerate refurbishment of the on-shore storage hastening removal of the barge.

3.48 Surplus Aimeliik fuel installation assets add to maintenance costs without contributing to income or security of supply. It is recommended that they be salvaged and sold. These include four 750,000 gallon tanks, transformers, switchgear, heaters, pumps and hoses. All other assets must be reconditioned if further deterioration is to be avoided. The remaining four tanks are due for cleaning which should be done on a regular basis. The three mooring buoys used for tanker discharge require reconditioning ashore before reuse. An additional buoy is required during reconditioning. It is recommended that the fuel facilities be equipped with fire extinguishers for use during emergencies. Government should consider converting the 10,000 gallon vertical tank inside the depot to water storage for fire fighting purposes.

3.49 Liquid petroleum gas (LPG) is not regulated. LPG is stored indoors in an unvented area with no fire sprinklers and inadequate separation from offices. The conditions are unsafe. It is recommended that LPG storage and handling standards be adopted and enforced.

Security of Supply

3.50 The Government is concerned with security of petroleum product supply and the means to improve it at reasonable cost. There does not, however, appear to be any threat to supplies to Palau. Government could improve security by requiring a minimum level of inventory (say three months) to be maintained by each marketer. However, the inventory and financing cost outweigh any obvious benefits and would increase prices to the consumer.

NEW AND RENEWABLE SOURCES OF ENERGY

3.51 **Biomass.** Vegetation on the high volcanic islands is varied, ranging from coastal mangrove swamps to substantial tree coverage up to sixteen meters high, to interior grasslands with palms and pandanus and densely forested inland valleys. As shown in Table 3.3, three-fourths of Palau was forested a decade ago, the most recent known date at which vegetation was surveyed. The amount of biomass available for fuelwood or other energy use is unknown but is extensive compared with the relatively low population. Access to land for energy purposes is often difficult in the Pacific Islands due to the developers' ignorance of traditional land tenure systems. This might be less of a difficulty in Palau because the traditional ownership of land has eroded since the Japanese regime.

Table 3.3: Summary of Biomass Resources of Palau (Hectares, 1979)

Land Class	Babeldaop	Other high islands	Coral and rock islands	Total
Forest	27,460	633	3,166	31,259
Secondary	515	79	133	727
Agroforest	924	6	179	1,109
Nonforest	7,834	451	239	8,524
Total	36,733	1,169	3,717	41,619

Note: See Annex 4, Table 10 for details.

Source: Vegetation Survey of the Republic of Palau (US Forest Service, 1987).

3.52 **Wood stoves.** There are no known power generation systems using biomass in Palau but the Palau Community Action Agency has provided about fifty "high efficiency" wood stoves in ten states since 1985. Earlier trials of South Pacific Commission wood-burning stoves reportedly failed due to rapid concrete deterioration.

3.53 **Hydro.** Over a dozen sites suitable for micro-hydropower have been briefly surveyed on Babeldaop. These range from 10 - 70 kW with a total of at least 400 kW and 1.2 GWh annual output. Construction and operating costs would be high and reservoirs difficult to build. Hydro can provide neither reliable power nor enough electricity to appreciably reduce fuel imports, although a number of sites could provide power sufficient for village demands.

3.54 **Wind.** Winds have been measured at the Koror weather station since 1950. The 1982 USDOE report indicates a range of 4.6 m/s average summer wind and 6.2 m/s for the winter with an annual average of 5.7 m/s (13 mph). However, wind is very site-specific and these are only broadly indicative of the resource. In addition to seasonal variations, wind power is unattractive considering the cyclone threat, present technology and economics. Maintenance is usually difficult on remote tropical islands due to corrosion and poor access to spare parts.

3.55 **Solar energy.** The solar resource is generally attractive in Palau and could provide small amounts of electric power to remote sites at lower overall costs than small diesel systems. Although solarimeters were reportedly installed some years ago, no data are readily available. However, records of sunshine hours indicate that insolation is in the range of 4.2 - 5.3 kWh/m^2 per day. About 100 small stand-alone photovoltaic systems have been installed, including 86 in individual homes and health clinics on Kayangel and the southwest Islands and a number for telecommunications purposes. There is no maintenance by the Government and only a small budget (under $20,000 per year from USDOE) for equipment and site visits.

IV. POLICY ISSUES AND PRIORITIES

PRICING ISSUES

Petroleum Product Prices

4.1 Table 4.1 shows wholesale petroleum prices in Koror in February 1991. Mobil offers the Government the lower price for all products whereas Shell has lower non-Government wholesale prices for unleaded gasoline and ADO. The prices of regular gasoline are the same for both companies, although the quality differs. Retail margins (the difference between retail and wholesale prices) for fuel sold in Koror ranged from 24.8 to 28.8 cents per gallon for unleaded gasoline, 22.9 to 31.9 cents for regular gasoline, 20.5 to 37.5 cents for ADO and 26.3 to 61.3 cents for kerosene. In remote areas, fuels are said to cost about double the Koror price. Retail margins in Fiji, which has a price control system, are much lower than Palau: typically 10 - 11 US cents per US gallon. Only a small portion of this difference can be explained by the larger Fiji market. There are no guidelines for prices in Palau nor any Government capability to oversee or administer prices. It is recommended that price surveillance be introduced in order to lower retail prices while maintaining fair returns to distributors.

Table 4.1 Palau Wholesale Petroleum Prices: 1991
(US cents per US gallon)

Product	Mobil Government	Mobil Non-Govt	Shell Non-Govt
Unleaded Gasoline	140.3	154.1	153.5
Regular Gasoline	124.4	148.0	148.0
Distillate (ADO)	133.0	145.4	140.0
Kerosene	137.6	164.6	n.a.

Source: Bureau of National Treasury, Government of Palau.

Power Tariffs and Utility Finance

4.2 The electricity tariff in Palau was increased from 6 ¢/kWh in 1982 to 9 ¢/kWh[18] in late 1983 where it remains today. This tariff is only sufficient to cover fuel costs. Revenue per kWh consumed is much lower due to the large percentage of unbilled energy, unmetered consumers, and underbilled customers. Although the exact subsidy to the Koror urban power system, including capital charges, is unknown some estimates are summarized in Table 4.2. In 1990, the Government subsidy to urban power was about $6.3 million or nearly 80% of total costs.

18 For all consumers the rate is 9¢/kWh for zero through 2,000 kWh per month and 10¢/kWh for all consumption exceeding 2,000 kWh.

Table 4.2 Electricity Subsidies: 1989 - 1990

	1989	1990
Cost (¢/kWh)	17.7	22.5
Revenue (¢/kWh)	5.0	5.0
Subsidy (¢/kWh)	12.7	17.5
Total subsidy	$4.1 m	$6.3 m

Source: Mission estimates (See Annex 1).

4.3 Reducing the deficit significantly will require installation of meters for all customers including large commercial users and government, calibration or replacement of older meters, and billing of all consumers for actual, not estimated (in fact underestimated), consumption. However, these measures would only reduce the subsidy by about $0.8 million per year initially plus perhaps another $1 million when government departments also pay for their use (planned from Fiscal Year 1992 beginning in October 1991). This would double revenues but reduce the subsidy by only one-third. Hence, the government must increase the tariff substantially to eliminate subsidies.

4.4 A 1986 tariff study recommended a new rate structure with minimum monthly charges of $7 for residential consumers and $25 for commercial consumers, a base fuel charge of 3¢/kWh increasing by 1¢/kWh for each 1¢/USG increase in fuel costs above 40¢/USG, and a non-fuel charge of 7¢/kWh for 1987 with scheduled increases of 1¢/kWh each year through 1990. If implemented, this would have resulted in an average charge of 15¢/kWh in mid 1988. The USDOI[19] has recommended immediate implementation of the proposed rate. Although a significant increase is required, the USDOI formula is unwieldy, provides no incentive to the utility to negotiate improved fuel prices, and does not protect the low-income consumer.

4.5 It is recommended instead that the tariff be *immediately* increased to a flat rate of 15 ¢/kWh with a 10 ¢/kWh "lifeline" tariff (if necessary) for residential consumption up to 100 kWh per month. *This is an interim measure only.* It is further recommended that a study be carried out as soon as possible to determine more accurately the real costs of power generation and distribution followed in 1992 by annual scheduled tariff increases over a period of five years or less until full costs are covered.

4.6 Metering and full collections from Government and commercial users would double revenues even at the existing tariff, as indicated in paragraph 4.3, but the subsidy to Palau's power consumers would still amount to about $4.5 million. This can only be recovered by a substantial increase in the tariff. To meet the estimated full 1990 cost (including capital charges) of 22.5 cents per kWh, the average tariff would have to rise by 13 cents - more than 135% of its current level. It may seem that such an increase would hurt consumers, especially low-income households. However, Annex 3 indicates that a lifeline tariff restricted to the first 100 kWh per month of residential consumption would adequately

19 See *"Final Audit Report on the Power Plant"*, op. cit.

protect low-income consumers while requiring a total subsidy amounting to only 6% of the current subsidy level. Most electricity consumption is by users who can afford to pay more than the current tariff. As shown in Table 2.2, residential consumers use only 41% of total consumption; the remaining 59% is by Government and large commercial users.

4.7 Higher tariffs will not adversely affect the government, since it is already paying the bulk of electricity costs in the form of subsidies. Raising the tariff to Government while reducing subsidies, and making departments financially accountable for electricity consumption is likely to reduce Government expenditure on electricity as the department heads reduce consumption to limit the impact of electricity on their budgets.

REGULATORY AND OTHER POLICY ISSUES

Overview

4.8 The energy chapter of the 1987 - 1991 National Development Plan identified as key sectorial issues the high cost of electricity generation, low electricity tariff rates and collection, the limited extent of the electricity grid, lack of reliable power in outlying states, problems of financing the Aimeliik power plant, wastage of electricity in urban areas, the high cost of energy for road and sea transport and limited use of renewable energy for remote communities. Two sectorial objectives during the planning period were met: provision of electricity from the Aimeliik plant and (to a limited degree) providing power through renewable energy technologies where feasible. Other objectives were not met including upgrading of the Koror grid, retiring the Malakal plant, finding funds to extend the grid throughout Babeldaop, upgrading power systems in five states, creating a public utility corporation, increasing revenue through effective billing and collection of power fees, improving docking facilities at Aimeliik for bunkering, and implementing energy conservation measures. Planned policies and strategies included immediate power billing of all government offices, an increased commercial electricity tariff set "several cents higher than the unit cost of production", and conservation measures such as insulation of air-conditioned buildings and restrictions on use of Government vehicles and boats.

4.9 It is recommended that the government pursue the policies stated in the 1987 - 1991 plan. These policies are also consistent with the earlier USDOE proposals. The Government is to be commended for introducing a draft Public Utilities Bill which should be finalized and implemented as soon as possible. It is recommended that the Government expand the duties of the Energy Office to include analysis of power sector issues, oversight of petroleum contracts, establishment of an energy sector database, supervision of the rural photovoltaics program and supervision of short-term experts brought in to advise on petroleum, power, or other energy matters. This may require an additional person.

Power Subsector

4.10 The main power sector regulatory issue is the commercialization of the urban power sector implying financial autonomy for the utility, i. e. allocating responsibility for tariffs and investment budgets to the board of directors, allowing commercial and development bank loans and defining a long-range policy for reducing government subsidies.

4.11 *Structure of the Proposed Public Utilities Corporation.* Draft legislation has been prepared by the Government to allow establishment of a Public Utilities Corporation (PUC). It is recommended that the Government clarify the intent and remove numerous ambiguities of the draft[20] to improve the likelihood of successful commercialized operations. Several other matters need to be clarified in the legislation or elsewhere including the maximum allowable level of subsidies and a timeframe for their removal, the relationship between the PUC and the States and the respective responsibility for power supply to remote areas, a policy on a national tariff or differing tariffs by geographical area, provisions for private shares and the proposed exemption of the PUC from taxes.

4.12 *Training.* An overseas education and training program is needed if local staff are to take over management of the Aimeliik facility. It is recommended that permanent PUC staff include a General Manager, a Commercial Manager, a Distribution Engineer or Superintendent, and Power Station Managers for both stations. Each power station requires a superintendent assisted by an electrician and one or two mechanics. The engineers and superintendents require overseas professional training and apprenticeships. The linesmen should be trained in preventive maintenance. Also recommended is transformer maintenance and meter adjustment training.

Petroleum Subsector

4.13 *Supply contract administration.* The "evergreen" Mobil supply contract is not being properly administered. There is no mechanism to assure that contract terms are being honored, correct import duties paid, volumes and qualities delivered are correct or contract terms equitable over time. It is recommended that a single government department be given overall responsibility for preparing tender documents, periodically calling supply tenders, evaluating bids, awarding contracts and administering the contracts. The Energy Office of the BPW is recommended for this role.

4.14 *Storage and handling standards.* There are no Government or oil industry regulations or standards for the storage and handling of petroleum products in Palau; to some extent this can be seen as condoning unsafe storage and handling practices and the deterioration of some depot facilities. Two distributors import liquid petroleum gas (LPG) in bulk containers from Guam to Palau for repacking into cylinders for local sale. The facilities for handling, storage and repacking are unsafe; they require upgrading to comply with the

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20 See *"Preliminary Comments on Bill SB 3-53 to Set Up a Public Utilities Corporation of Palau"* (PEDP Report Palau 91 - 2, June 1991) for details.

stringent safety standards enforced in most countries. Standards for petroleum and LPG should be adopted[21] as soon as possible and strictly enforced.

4.15 *Competition and proliferation of service outlets.* Recent changes in market share in Palau have been brought about in part by tolerance of substandard storage and by sales arrangements which are not open and at arms length. A 1988 study[22] suggested a restriction on service station approvals to avoid increasing inefficiencies in fuel retailing. Since then two additional service stations have opened, compounding the proliferation of uneconomic sites. With a small market, additional service stations reduce throughput per site requiring increased retail margins to be profitable as indicated by the recent increase in retail margins. Palau suffers from uncontrolled competition in the retail market which has raised prices to the consumer.

4.16 *Fuel quality and grades.* There are several issues regarding the quality of gasoline, distillate and aircraft fuel in Palau. There are four grades of gasoline marketed: Mobil sells 91 RON[23] regular and 95 RON premium unleaded whereas Shell sells 87 octane[24] regular and 91 octane unleaded premium. This range of grades adds to consumer costs while providing no benefits. Prices do not reflect quality differences. It is recommended that the government encourage marketers to offer no more than two grades of gasoline which satisfy the local vehicle mix. A single grade, possibly 93 RON unleaded gasoline, may suffice. The quality of distillate has been questioned by some Palauans. Contract specifications provide for low sulphur automotive distillate. Samples should be certified by an independent laboratory to confirm quality. There have also been allegations that road vehicle gasoline has been substituted for aviation gasoline for some domestic flights. It is recommended that the government investigate these allegations; if they are true, this practice should be halted immediately: the use of regular or premium gasoline in aircraft is dangerous. Honolulu and Guam have facilities for testing ADO and the fuel used in local flights. If necessary, the Government should consider legislation for minimum quality standards for various fuels, particularly where public safety is at risk.

4.17 *Data Collection and Analysis.* There is a lack of reliable information available from government offices or suppliers on fuel volumes and values. Data on fuel from suppliers were incomplete. Without independent government data, it is impossible 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.

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21 The FSED Petroleum Section plans to prepare a regional *"Standards for the Storage and Handling of Combustible and Flammable Liquids"* during 1992 specifically to address Pacific Island requirements.

22 *"Palau Petroleum Market Study and Contract Analysis"*, op. cit.

23 Research Octane Number provides a rough measure of the low-speed anti-knock properties of gasoline. The higher the octane number, the better the anti-knock quality.

24 In this case, "octane" is defined as 1/2 of (RON + MON) where MON = Motor Octane Number which gives a rough measure of the high-speed anti-knock properties of the gasoline. "Octane" can have different meanings depending upon the marketer.

4.18 *Training.* Training is required for all aspects of the petroleum industry including storage and handling, distribution, marketing, supply and pricing of fuels preferably beginning with the preparation of tenders for fuel supply to Aimeliik Power Station and the Government.

NEW AND RENEWABLE SOURCES OF ENERGY

4.19 Palau plans to expand the use of photovoltaic systems for remote islands. A major policy issue is how to establish an affordable mechanism for financing, designing, installing and maintaining PVs 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, possibly the most relevant example being the Tuvalu Solar Energy Cooperative Society (TSECS). Tuvalu, with only 9,000 people and a per capita GDP less than a fifth that of Palau, 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. Its success, after initial difficulties, is due to dedicated management, competent outside advice, decentralized technical and administrative resources, and fundamental emphasis on high quality maintenance and the ready availability of spare parts. If Palau proceeds with plans to better maintain current systems and to expand use of PVs, it is recommended that a similar approach be considered[25].

4.20 A possibility worth considering is a cooperative program with the Palau Community Action Agency which has agents in all sixteen states and some experience with PVs. The Micronesian Occupational College (MOC) in Koror has several PV training kits which are regularly used in the electrical trades courses. Local staff have the competence to run courses in PV installation and maintenance; it is recommended that their skills be used.

ENERGY CONSERVATION

4.21 In per capita terms, Palau consumes far more petroleum than other Pacific Island countries[26], over twice the typical patterns of use per person for power generation and transport. However, there are no data indicating detailed patterns of fuel use which could be used to develop practical policies to conserve energy. It is recommended that the government verify the accuracy of its petroleum import volumes, determine changes in the pattern of fuel imports in recent years, and carry out end-use studies of energy use in households, commerce and government offices. It is further recommended that this be

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25 *"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 could be useful for Palau.

26 Comparative data are available from the Pacific Regional Energy Assessment Overview report (World Bank, 1992).

followed by a study on practical means of reducing inefficiencies in petroleum fuel and electricity consumption. Possibilities for cost-effective savings could be considerable.

4.22 There is considerable potential for energy conservation even in the absence of detailed information on energy end-use. Simple but effective actions include cleaning air-conditioning filters, de-icing of refrigerators and freezers, reduced use of air-conditioning during non-business hours, improved ventilation, etc. Solar heating of water, conversion of cooking from electricity to kerosene or LPG, and replacement of incandescent lighting within residences should also be considered. The norm for lighting in Palau is generally outdated despite a "Thermal and Lighting Efficiency Standard" supposedly introduced in 1984. Electronic mini-fluorescent lamps are available which fit into existing fixtures and can reduce electricity use by up to 80%. In commercial and government buildings the slim type fluorescent tube with high frequency couplings can reduce consumption by 30%. In some places automatic daylight dimming could be introduced. It is recommended that these efficient lighting systems be used within government. Some savings could also be effected through restrictions on private use of Government vehicles.

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

4.24 For the power utility, investments in energy conservation will generally be more economic than investments in new generation capacity. As long as electricity is provided well below cost, a conservation programme will not be successful. In the longer term, conservation of electricity will benefit the utility by lengthening the period of time between new capacity additions which can be a significant financial benefit. 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 $1.0 million, the savings will be about $0.38 million[27]. 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 loads.

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27 At a 10% discount rate, the present value of a $1m investment 5 years from now is $1m/(1+10%)^5 = $620,921 for a saving of $379,079.

ENVIRONMENTAL ISSUES

Waste To Energy

4.25 It is understood that a 10 MW power plant which includes incineration of possibly hazardous wastes has been proposed for Ngardmau, presumably to supply the Aimeliik-Koror grid. There is no commercially-proven system which can meet the very small demand at the site[28] which may, however, be suitable for hydropower development. An expensive transmission system would be required at least as far as Aimeliik, and the Aimeliik-Koror transmission would experience higher losses adding to costs. The generation of electricity from domestic or imported wastes is not an attractive option for Palau which has sufficient power capacity for some years. Waste-to-energy technologies are not commercially available at the scale of Palau's near-term requirements and sophisticated controls are needed to prevent environmental degradation. Several companies have proposed Pacific Island waste-to-energy systems as a means to circumvent U.S. controls on disposal of hazardous substances. Promoters tend to promise that the process is safe but this is difficult to verify; where the wastes are safe, there is no economic reason to ship them at considerable expense to a distant country.

Petroleum Supply

4.26 The main pollution risks are related to tanker discharge, ship refueling, the storage barge and ships' bilges being pumped overboard within the Malakal anchorage area and Palau's territorial waters, possibly monthly. Mobil backloads its barge from on-shore storage in Malakal to supply ADO to the Aimeliik Power Station and Belau Petroleum backloads ADO from Shell stocks at the Aimeliik Power Station to its floating barge for on-shore marketing. These tanker discharge and barge operations present some risk to the environment particularly if carried out by unqualified operators. It is recommended that emergency provisions be developed to contain spillage from these operations. Continued use of the barge is the most serious threat. There were at least three oil spills on Malakal Island during a five-month period in late 1988: one at the mouth of the Malakal shipping channel, one at the boat yard and the third at the power plant. As a consequence, the Government drafted the 1989 "Palau Marine Pollution Emergency Contingency Plan" and passed legislation to form a task force to handle emergencies and introduce penalties for polluters. At least one company was recently fined $7,000 under these provisions.

4.27 *Oil Depot Drainage Controls.* All bulk fuel depots are equipped with drainage controls to ensure that only clean water is discharged into public areas. However, the separator pits should be properly managed to assure correct operation. Carelessness at the Aimeliik separator pit has caused spillage of oil during heavy rains.

4.28 *Service Stations and Backyard Garages.* Other sources of oil pollution are backyard garages and service station outlets some of which have no containment provisions; during

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28 The community has about 120 people in 28 houses. A 1984 U.S. Rural Electrification Administration (REA)/DOI study identified a nearby site as suitable for microhydro development.

periods of heavy rain, fuel and oil spilled onto the ground are flushed into public areas and pollute the environment. It is recommended that these outlets be closely policed as they are probably significant polluters.

Electricity Supply

4.29 *The Power Stations.* The Aimeliik power station is situated in a very remote area. No special environmental problems are apparent, apart from those mentioned above. Lube oil is recovered and reprocessed, not disposed of. The Malakal power station is near the fish processing facilities. Offices and residential buildings are also being built in the area. Although no noise and pollution problems have been reported, it is recommended that plans for the area be coordinated to assure that the site remains available for future power generation. This may require restrictions on location of fish canneries and residences. It is not known how lube oil is handled at the power station.

4.30 *Transformers.* BPW has completed a program of removing PCB from transformers; the chemicals have reportedly been shipped to Hawaii.

V. INVESTMENTS AND TECHNICAL ASSISTANCE PRIORITIES

5.1 Some of the policy recommendations made in the earlier chapters are not repeated here. This section emphasizes those areas where investments are needed whether financed by the Republic of Palau or through external assistance.

ENERGY PLANNING AND COORDINATION

5.2 Several activities are under negotiation to improve national development planning and administration. The following recommendations are not expected to add to the costs of the activities:

a) It is understood that UNDP is reviewing its national development planning projects and requests, including one pending from the Republic of Palau. It is recommended that the Palau project, if implemented, include an economist or financial advisor who can offer broad advisory services on power and petroleum costing issues; and

b) It is recommended that the USDOI-funded National Development Plan include medium-to-long term forecasts of power load growth.

POWER SUBSECTOR

5.3 **Institutional and pricing issues.** It is recommended that:

a) A study analyse the proposed Public Utility Corporation goals, structure, current costs of power generation and distribution, tariff policy, geographical responsibilities, staffing, legal status and relationship to Government. The cost, depending upon the source of assistance, could range from $50,000 - $80,000.

b) A formal training program, additional to ongoing on-the-job training, should be established for power sector management and operators. The cost is estimated to be $0.2 million to 0.25 million over 3 - 5 years[29] covering additional staff, scholarships, travel expenses, living allowances, etc.

5.4 **The Aimeliik Power Station.** It is recommended that immediate action be taken to:

a) Order a complete package of spare parts for a complete overhaul[30] of one unit and special tools for grinding, etc. The cost could exceed $150,000 including $100,00 for tools.

b) Engage a structural engineer to examine the cracks in the foundations, take samples of the concrete and recommend a repair method. The estimated cost is $10,000.

c) Engage a professional mechanical engineer approved by Crossley Engines to perform load tests and measurements on the engines up to 3.2 MW, if possible, and supervise

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29 The lower figures for funds and time required are mission estimates; the higher estimates are from the OMIP team.

30 The OMIP Palau Plan of Action suggests $1.0 million over 5 years for a more complete refurbishment of the Aimeliik generators and $0.55 million over 5 years for Malakal.

the overhaul of the first engine. This will prove the rating as well as the maintenance standard. The estimated cost is $25,000.

d) Engage an expatriate team consisting of at least a station manager (a licensed professional engineer), an electrical engineer and one or two diesel/mechanical engineers hired on individual contracts[31] by the Government to manage the operation of the station during a transition period until local management continue the training of local staff. There should be a considerable savings compared to the Gorones contract.

e) Select a Palauan O&M team to be trained on the basis of education, ability to be trained and interest and willingness to work full time at Aimeliik.

f) Assess means of reducing station use to 4% or less of gross generation. This should be done by the new operators at no added cost to the government.

5.5 **The Malakal Power Station.** The following actions are recommended:

a) In order to reduce unnecessary capacity and the equipment to be maintained, engine-generators 1 through 5 should be removed from the power house and discarded, the practice of transferring old engine-generators to the remote state systems being unsustainable. The cost would be minimal.

b) The power house should be cleaned up, better lighting installed at the work areas, a new workshop and storage area established inside the power house, the control panels and control room rehabilitated. Adequate tools and spare parts should be purchased. The cost estimate is $0.1 million.

c) The retained engine-generators should be overhauled to obtain the rated capacities and good availability. This could cost $0.5 million.

d) Part of the space in the power station should be reserved for future engine-generators. There is no extra monetary cost.

5.6 **Transmission and Distribution.** The following immediate actions are recommended:

a) Analyze short-term means of reducing voltage drops and losses on the Koror grid, including reconfiguring the parallel lines, capacitor banks and reconductoring the copper portions of the feeder through Koror. The cost would be about $25,000.

b) Analyze the relay settings at the power stations and the substations in order to minimize the risk of black-outs due to line faults with special attention to parallel operation of the plants. Divide the load between the two step-up transformers at Aimeliik and devise a revised protection scheme for the Koror grid with sectionalizers, fault indicators, etc. The estimated cost is $25,000.

c) Introduce load monitoring of the distribution transformers with one or two transformer-mounted voltage recorders supplemented with inexpensive hand-held volt meters and line-mounted small ammeters. Install inexpensive fault indicators on essential branching points of the Koror feeder. The estimated cost is $10,000.

d) Introduce a preventive maintenance program with improved management, supervision and training, investments in vehicles, tools, two-way-radios, spare parts, proper storage facilities, a workshop for repair and maintenance of transformers, switches etc. and portable mete control equipment. The cost would be about $300,000 per year for three years.

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31 This was in the process of being implemented in late 1991.

e) Establish a 'system map', preferably using simple standardized computer software which is easy to update. More emphasis should be on collection of system inventory data than on precise geographic information. Local personnel should take an active part. The cost would be about $50,000 excluding local wages.

5.7 The following medium-term actions are recommended:

a) Introduce customer services to handle complaints from customers and problems involving installations. The cost is estimated as $40,000 for a van, tools and instruments.

b) Analyze the transmission and distribution consequences of adding generating capacity at either Aimeliik and Malakal. If major investments in the transmission system are to be avoided, Aimeliik should not be expanded. The estimated cost is $50,000.

PETROLEUM SUBSECTOR

5.8 The following immediate actions are recommended:

a) **Fuel quality.** Government is urged to arrange quality tests on any products suspected of being substandard, especially fuel used for aviation purposes tests and distillate. If not paid by the oil industry, the cost will be nominal..

b) **Supply contracts.** Government should provide six months prior notice of intention to terminate of the existing Aimeliik supply contract and seek advice on new arrangements for a consolidated tender for Aimeliik and other national and state government demands. This could require a petroleum supply and pricing specialist for six man-months at a cost of $50,000 -$60,000. The specific tasks required are to:

1) work with two local counterparts within the Energy Unit of the Bureau of Public Works and the Ministry of Administration;

2) evaluate product contract prices for the last twelve to twenty-four months to confirm the accuracy of prices charged plus documentation of any adjustments to be pursued with the companies;

3) prepare new tender documents, their review with Government and issuing of tender invitations;

4) solicit interest by potential suppliers through correspondence, discussions and advertisements;

5) assist Government in evaluating bids and awarding new contract(s);

6) prepare spreadsheet pricing templates for the administration of the new contract(s) and training of the local officers in their use for administration of the contract(s); and

7) review the contract for operation and upkeep of the Aimeliik fuel installation and advice on modifications.

c) **Customs procedures.** Customs regulations and procedures should be modified as follows (the cost being minimal):

1) each customs entry should include the details of products received including description of fuel or product, quantity or volume received at ambient temperature, the total commodity value and the duty payable;

2) a Bill of Lading should accompany Customs Entries with the FOB prices for each item, the freight costs, insurance and ocean losses;

3) each product discharged should be supported by a refinery certificate verifying the quality of fuel;

4) to verify quantities of fuel being received, Customs should be notified by the supplier to complete "before" and "after" cargo discharge dipping of the bulk tanks and at the end of June and December each year, Customs should arrange with each company to complete stock dips of all bulk fuel tanks in each installation; and

5) Customs Entries should be correctly filled out and submitted to Customs by the importer with Customs duty paid on stamping of the entry by Customs; this procedure ensures that the entries are correctly completed, the correct duty is immediately paid by importers, and government has all necessary information on petroleum volumes and values for its own purposes.

d) **Supply logistics.** Government should investigate the costs and benefits of converting or moving surplus Aimeliik tanks and other assets to reduce prices by allowing accommodation of GP or MR tankers at the off-shore Malakal Island wharf area. This would require a marine survey to locate suitable anchorage off the regular shipping lane with provisions for sufficient vessel turning area. It is strongly recommended that both oil companies marketing in Palau be closely involved in this work. The estimated cost is $30,000.

e) **Storage condition.** Unused Aimeliik storage should be reconditioned to avoid deterioration. The estimated cost is about $50,000. An annual marine survey and certification should be required for the barge before allowing continued use as floating storage. This cost would be borne by the oil industry.

f) **Price and retail surveillance.** The Government should carry out a study to establish reasonable wholesale and retail price guidelines for fuels in Koror and remote areas and to establish guidelines for establishment of service stations. The estimated cost is $30,000.

HOUSEHOLD AND RENEWABLE ENERGY

5.9 The following immediate actions are recommended:

a) The government should obtain independent advice before proceeding further on the proposed waste-to-energy project. This could be made available at no direct cost to the Government from the UN Center on Transnational Corporations through UNDP in Fiji.

b) The government should establish a mechanism to regularly maintain existing photovoltaics systems. The estimated cost of a consultancy is $20,000.

c) The government should set aside sufficient resources and funds to systematically maintain photovoltaics systems. The estimated cost is $20,000 per year, much of which should be recovered through users' fees.

ENERGY CONSERVATION

5.10 The following are recommended:

a) The government should carry out household, government and commercial energy end-use surveys in Koror and selected rural communities to provide basic data for planning and conservation purposes. Direct mosts would be less than $5,000 if carried out through the FSED which is providing similar services elsewhere in the region.

b) Based on the end-use studies, the government should develop a plan with practical goals for reducing inefficiencies in petroleum fuel consumption where these are economically justified. A study would probably cost about $50,000.

c) The government and proposed Public Utilities Corporation should establish an energy conservation and management program to assist households and businesses to conserve on electricity consumption through advisory services, import duties and taxes which encourage efficient appliances, and assistance to importers on sources of efficient lights, refrigerators, stoves, etc.

ANNEX 1

POWER PRODUCTION COSTS: ESTIMATES FOR AIMELIIK POWER STATION

The estimated cost of power in Palau for FY 1990 is 22.5 ¢/kWh consumed[1] compared with estimated average revenue of about 5¢/kWh, as shown in Table 1. Costs include operating costs (fuel, lubricants, personnel costs, administration, spare parts, the cost of the Gorones management contract, and bad debts) and annual capital charges (interest and depreciation) for the utility's productive assets. Much of the data is estimated since detailed financial records do not exist. For example, bad debts are assumed to be equivalent to only two months' of billing in 1989 and 1990 based on the fairly high collection rate indicated in 1990, and 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 Ministries of Administration and Resources and Development. The estimated value of total assets was based mainly on initial construction cost estimates which include the Aimeliik power station, tank farm, and the Aimeliik-Airai transmission line and substations; it is not known to what extent these differ from actual construction costs.

Operating costs were much higher in 1990 than in 1989 (15.9¢/kWh compared to 10.3¢/kWh), due mainly to increased prices and volume in the total value of fuel and lubricants. The values of fuel and lubricants in both years are based on Ministry of Administration data on total expenditure. However, it is difficult to account for fuel costs in a facility as large as Aimeliik where fuel deliveries occur very infrequently: it is probable that large inventories left over from 1988 depressed the level of purchases in 1989 somewhat below actual consumption. The volumes of fuel consumed in the power station and in 1989 and 1990 are 2.9 million and 3.2 million gallons respectively.

The allocation of fuel costs between 1989 and 1990 as reported by government officials may be in error. If the average costs per gallon were the same for 1989 and 1990, the costs per kWh would be about 20¢ in both years. Per-unit fuel and per-unit capital charges in Palau are quite similar to other power systems in Micronesia, which vary between 19¢ and 26¢/kWh. The cost of the Gorones contract, however, at over $630,000, represented about 2¢/kWh of average costs and is 50% higher than the combined expatriate and local personnel costs for operating the similarly-sized and equipped power station in Majuro (Marshall Islands). Capital costs in 1990 were about 7¢/kWh but 7.4¢/kWh in 1989 due to the lower output that year.

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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.

ANNEX 2

ESTIMATED 1990 GDP

The last formal estimate of GDP for the Republic of Palau was carried out in 1983[1]. In current dollar terms GDP was $31.6 million, an increase of 82 percent from 1977 when GDP was estimated at $17.4 million. Average annual growth of GDP during the period 1977 - 1983 was 10.5 percent. Using price level indices of neighboring areas (because neither producer nor consumer price data are compiled in Palau), growth in real GDP during the 1977 - 1983 period amounted to about 3.5 percent per annum on average. Based on the factor cost approach to estimating GDP, components of 1983 GDP are as shown in Table 1.

Table 1: GDP by Factor Cost Component (1983)

Compensation of Employees	$18.99	million
Operating Surplus	11.45	
Consumption of Fixed Capital	1.10	
Indirect Taxes less Subsidies	0.03	
GDP at Market Prices	$31.58	million

Source: Palau's First National Development Plan: 1987 - 1991.

Estimates of GDP by expenditures on final demand, and by product originating in each industrial sector, were not derived in 1983. Employee compensation accounted for 60.1 percent of total GDP in 1983.

Based on the same 1983 relationship (compensation of 60% of GDP), 1989 wages and salaries of $28.3 million would imply a 1989 GDP of roughly $47 million. From 1983 to 1989 employee compensation increased at an average of 6.9 percent annually; assuming 6% growth in wages and salaries from 1989 to 1990, a rough estimate of GDP in current dollars would amount to $50 million. Since the government sector plays such a large role in the economy in terms of its recurrent and capital expenditures, which are largely funded through U.S. grant assistance, another way of roughly estimating GDP would be to take external assistance as a percentage of GDP and use this relationship to estimate 1990 GDP. In 1983 external assistance, including $1.3 million in Japanese foreign aid, amounted to $19.6 million. In relation to GDP, total external aid in 1983 represented 62 percent of the $31.6 million. In 1990, total external grants, including about $3 million in Japanese assistance, amounted to $31.57 million. Assuming the same relationship, total 1990 GDP would amount to roughly $50.9 million. Given these rough estimates, 1990 GDP is believed to be *about* $50 million.

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1 Source: Palau's First National Development Plan: 1987 - 1991. The 1989 TTPI Report indicated a GDP of $23.2 million for 1989 which is much too low and is ignored in this report.

ANNEX 3

AFFORDABILITY OF INCREASED ELECTRICITY CHARGES

Residential consumers. Average-income households in Palau spend about 8% of household income on electricity compared to 5% in the Marshall Islands, 7% in Fiji and over 10% in Kiribati and Tuvalu. Raising the average tariff will eventually result in less consumption by most consumers. 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 in the short term and reduction of non-essential uses. For example, users could at no cost switch off excessive 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 more difficult for consumers at the bottom of the income scale, since their already low consumption (less than 100 kWh per month) is concentrated in "essential uses" (basic 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 as follows: a small refrigerator (60 kWh/month) plus three 40 watt 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 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 Pacific Island countries[1], is a subsidized 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 subsidized tariff is designed to benefit only low income consumers, for ease of administration it would in fact apply to all residential consumers. However only consumers who use 100 kWh/month or less would benefit significantly from the subsidy; higher charges to other consumers would cancel the subsidy to them. A lifeline tariff has the advantages of being fairly easy to administer and not very

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

costly to the utility's other customers, since low-income domestic consumption is usually a very minor portion of total sales.

In Palau, a lifeline tariff would benefit the estimated[2] 23% of residential consumers who use 100 kWh/month or less and account for about 8% of all residential consumption. In total, the proposed subsidy would apply to about 9% of total electricity consumption (3.1 GWh of total 1990 consumption of 36.1 GWh), rather than to 100% of consumption as at present. A lifeline tariff of 50% of full costs, say $0.11 per kWh, with all other consumption charged at full cost would imply a total lifeline subsidy from the Government of $360,000, or under 6% of the 1990 estimated subsidy of $6.3 million.

Commercial consumers. Electricity in most of the commercial and industrial enterprises in Micronesia is usually a small proportion of total company costs, rarely exceeding 5%. Much more important to total costs in the retailing, construction, and service industries are such factors as labor, real estate, raw materials and the cost of goods sold. Increases in the cost of electricity in these commercial activities can be passed on to consumers without a significant increase in the price of the final product. In any case, there is evidence that the private sector in Palau (as in other countries) puts more importance on reliable electric service than on cheap electric service: commercial enterprises have invested in their own standby generating equipment to use when public power system fails.

The commercial sector, despite initial protests, 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 unlikely results of higher electricity tariffs.

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2 A mission review of October 1990 billing indicated that 23% of residential users consumed 0 - 100 kWh, 55% 101 - 500 kWh, 19% 501 - 2000 kWh and 3% over 2000 kWh.

ANNEX 4

STATISTICAL TABLES

TABLE 1
SELECTED DEVELOPMENT INDICATORS FOR THE REPUBLIC OF PALAU

		1985	1986	1987	1988	1989	1990
GDP[1] (US$ millions)		$33.2	na	na	na	na	$50
Per capita (US$)		$2,442	na	na	na	na	na
Total Imports[2] FOB (US$ m)		25.0	25.1	na	na	24.6	27.5
Total Exports[3] (US$ m)		0.46	0.50	na	na	0.56	na
Sea Area (km^2)	629,000						
Land Area (km^2)	494						
Wage & Salary Employment[4]		na	4,427	na	4,588	4,952	na
of which Government		na	na	na	1,456	1,666	na
of which alien workers		> 500	996	na	1,932	na	3,149
Ave Wage/Salary[5] (US$/hour)		na	na	na	na	$1.98	na
Economically Active		na	6,250	na	na	6,500	na
Total Population[6]		13,600	13,900	14,200	14,500	14,900	15,200
Urban[7] (%)		68%	68%	68%	68%	68%	68%

Overseas Development Assistance

Annual ODA[8] (US$ m)	$17.6	$24.3	$19.7	$30.4	$39.6	31.6
ODA (% GDP)	53%	na	na	na	na	63%
ODA[9] (% Current Government Expenditure)	80%	113%	89%	125%	171%	na
% Bilateral[10]	100%	100%	100%	100%	100%	100%
ODA per Capita (US$)	$1,295	$1,749	$1,389	$2,098	$2,658	$2,079

Sources:
1) Economic Overview of Palau (ESCAP Pacific Operations Centre, Nov 1990).
2) Republic of Palau Economy: Assessment of Performance and Growth Prospects (PIDP, EWC, April 1991).
3) Issues Associated With Palau's Transition to Self-Government (USGAO, July 1989).
4) Trust Territory of the Pacific Islands Annual Reports to the UN (1987, 1988, 1989, 1990).
5) UNDP Development Cooperation Reports for 1987, 1988.
6) South Pacific Economies Statistical Summary (South Pacific Commission #11 1987).
7) Preliminary estimates from Palau government.
8) 1986 Census of Population and Housing (Palau Office of Planning & Statistics, April 1987).
9) Mission estimates where sources differ (There are very large discrepencies.).

Notes:
1 1983 GDP (current market prices) $31.58 million. All GDPs since then are estimates. 1985 & 1989 estimates from source 4; 1990 is crude mission estimate (source 2).
2 1985 & 1986 from source 6; 1990 from source 7.
3 FOB. 1985 & 1986 from source 6; 1989 from source 7.
4 1986 from source 8; 1988 & 1989 from source 2.
5 Private sector. Government was $4.59; source 2.
6 1986 "mini-census" and 1990 census data adjusted to mid-year.
7 Koror considered urban. Percentages are same for 1986 and 1990 census. If Airai included, urban is 76%.
8 Mainly US funds: Dept of Interior, federal grants and capital improvement projects actual; 1990 estimated. 1986 – 1990 also includes estimate of $3 million per year from Japan.
9 Government expenditure 1985 – 1986 source 6, 1987 – 1989 source 4.
10 UN and other multilateral assistance very small, anout $100,000 per year.
na Indicates not available.

TABLE 2

SELECTED PROJECTIONS FOR THE REPUBLIC OF PALAU (1990 – 2000)

	1990	1995	2000
Population[1]:			
urban	10,400	11,400	12,600
rural	4,800	5,400	5,900
total	15,200	16,800	18,500
GDP ($ millions; 1990 prices)[2]:			
high growth (6% real)	50.0	66.9	89.5
medium growth (4.5% real)	50.0	62.3	77.6
low growth (3% real)	50.0	58.0	67.2
GDP/Capita[3]:	$3,289	$3,709	$4,197
Electricity Generation[4] (GWh):			
high (6%) growth rate	46.2	61.8	82.7
medium (4.5%) growth rate	46.2	57.6	71.7
low (3%) growth rate	46.2	53.6	62.1
Fuel Consumption[5] ('000 US gallons)			
Gasoline	1,969	2,459	3,086
Jet A1	1,521	1,948	2,518
Kerosene	61	74	91
ADO	4,667	5,828	7,315
IDO			
Lubes	71	98	132
Avgas	3	6	7
LPG	34	42	53
Others			
Total Inland	8,326	10,455	13,202
Bunkers	none	none	none
Total Palau trade	8,326	10,455	13,202
Annual percent change	–	4.7%	4.8%

Sources:
1) 1990 population from preliminary 1990 census results.
2) Government fuel data inconsistent; mission estimates based partly on oil companies.

Notes:
[1] Midyear medium growth scenario. Assumes urban growth remains 5.6% per year.
[2] GDP in 1988 constant dollars at market prices. Assumes 3% annual real growth from 1988 – 1990 then lower growth as Compact funds decline.
[3] In 1990 dollars. Assumes medium GDP growth.
[4] Mission estimates for urban system of Koror/Airai.
"Reduced growth" assumes tariffs increase to true cost by 1995.
[5] For medium economic growth rate of 4.5% per year.

TABLE 2a
PETROLEUM DEMAND PROJECTIONS, REPUBLIC OF PALAU: 1990 – 2000

Low Growth Scenario (Thousand US gallons)

Product	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline	1,969	2028	2089	2152	2216	2283	2351	2422	2494	2569	2646
Jet A1[2]	1,521	1567	1614	1662	1712	1763	1816	1871	1927	1985	2044
Kero[3]	61	63	65	67	69	71	73	75	77	80	82
ADO[4]	4,667	4807	4951	5100	5253	5410	5573	5740	5912	6089	6272
lubes	71	76	82	88	94	100	107	114	121	129	138
Avgas[5]	3	3	3	3	4	4	4	4	4	4	4
LPG[6]	34	35	36	37	38	39	41	42	43	44	46
Bunkers											
ADO	0	0	0	0	0	0	0	0	0	0	0
Total	8,326	8,579	8,840	9,108	9,385	9,670	9,964	10,267	10,579	10,901	11,232
Ave growth		3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%

Assumes economic growth of 3% per annum real.
(1) Gasoline 3% growth
(2) Jet A1 3% growth
(3) Kerosene 3% growth
(4) ADO and lubes 2.7% growth
(5) Avgas 4% growth
(6) LPG 3% growth

Medium Growth Scenario

Product	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline	1,969	2,058	2,151	2,248	2,351	2,459	2,572	2,691	2,816	2,948	3,086
Jet A1	1,521	1,597	1,678	1,763	1,853	1,948	2,049	2,157	2,270	2,390	2,518
Kero	61	63	66	69	71	74	77	80	84	87	91
ADO	4,667	4,877	5,098	5,329	5,572	5,828	6,096	6,379	6,675	6,987	7,315
IFO	71	76	81	86	92	98	104	110	117	125	132
Avgas	3	5	5	5	5	6	6	6	7	7	7
LPG	34	36	37	39	41	42	44	46	49	51	53
Bunkers											
ADO	0	0	0	0	0	0	0	0	0	0	0
Total	8,326	8,711	9,114	9,539	9,985	10,455	10,949	11,470	12,018	12,595	13,203
Ave growth		4.6%	4.6%	4.7%	4.7%	4.7%	4.7%	4.8%	4.8%	4.8%	4.8%

Note: All demands are mid points of low and high growth. 4.5% economic growth.

High Growth Scenario

Product	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline	1,969	2,087	2,212	2,345	2,486	2,635	2,793	2,961	3,138	3,327	3,526
Jet A1[2]	1,521	1,627	1,741	1,863	1,994	2,133	2,283	2,442	2,613	2,796	2,992
Kero[3]	61	64	67	71	74	78	82	86	90	95	99
ADO[4]	4,667	4,947	5,244	5,558	5,892	6,245	6,620	7,017	7,438	7,885	8,358
Lubes	71	75	80	85	90	95	101	107	113	120	127
Avgas	3	6	6	7	7	8	8	9	9	10	10
LPG[5]	34	36	38	40	43	45	48	51	54	57	61
Bunkers											
ADO	0	0	0	0	0	0	0	0	0	0	0
Total	8,326	8,843	9,389	9,969	10,585	11,240	11,935	12,673	13,457	14,289	15,174
Ave growth		6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%

Assumes real economic growth of 6% per annum.
(1) Gasoline 6% growth
(1) Jet A1 7% growth
(3) Kerosene 5% growth
(4) ADO 6% growth
(5) Avgas doubles in 1991 (assuming use of regular gasoline in aircraft ceases) then 6%/yr
(6) LPG 6% growth

General note: From 1985 – 1990, fuel use by volume grew at 8.4% per year, almost same as estimated nominal GDP.

TABLE 3

ENERGY BALANCE ESTIMATES FOR THE REPUBLIC OF PALAU (1990)
('000 TOE)

	Fuelwood	Coconut Residues	Total [1,2] Biomass	Electricity	Gasoline	Jet A1	ADO	Kerosene	Avgas	LPG	Petroleum	Total Energy
Primary Supplies												
Production	0.26	0.05	0.31									0.31
Imports					6.02	5.03	15.92	0.20	0.01	0.08	27.25	27.25
Bunkering/exports					(0.02)	(5.03)					(5.05)	(5.05)
GROSS AVAILABLE	0.26	0.05	0.31	0.00	6.00	0.00	15.92	0.20	0.01	0.08	22.21	22.52
Conversions												
Public Power Generation				10.72			(10.72)				(10.72)	0.00
Transformation losses				(6.81)								(6.81)
Station Use				(0.31)								(0.31)
Transmission/distribution Losses				(1.98)								(1.98)
NET SUPPLIED	0.26	0.05	0.31	1.62	6.00	0.00	5.21	0.20	0.01	0.08	11.49	13.42
Final Consumption												
Households	0.26	0.05	0.31	0.68				0.15		0.04	0.19	1.18
Transport					5.66		3.78		0.01		9.45	9.45
Government/Commercial				0.18	0.34		1.43	0.05		0.04	1.85	2.03
Industrial/Construction												
Agroindustries												
Unknown				0.76								0.76
TOTAL	0.26	0.05	0.31	1.62	6.00	0.00	5.21	0.20	0.01	0.08	11.49	13.41

Source: Mission Estimates 1990

Notes:

[1] Population 1990, urban 10,400, rural 4,800 (total 2868 hh – 5.27 persons/hh).

[2] Assumes 10% of population use biomass for cooking at 1.4 kgs/cap/day = 772 tonnes/year
Assumes biomass consumption as 80% wood, 20% coconut residues.

TABLE 3a

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

	Fuelwood (tonnes)	Coconut Residues (tonnes)	Total [1,2] Biomass (tonnes)	Electricity (GWh)	Gasoline (kUSgal)	Jet A1 (kUSgal)	ADO (kUSgal)	Kerosene (kUSgal)	Avgas (kUSgal)	LPG (kUSgal)	Total Petroleum (kUSgal)
Primary Supplies											
Production	618	154	772								
Imports					1,969	1,521	4,667	61	3	34	8,256
Bunkering/exports					(7)	(1,521)					(1,528)
GROSS AVAILABLE	618	154	772	0	1,962	0	4,667	61	3	34	6,727
Conversions											
Public Power Generation				46.20			(3,141)				(3,141)
Transformation losses											
Station Use				(3.70)							
Transmission/distribution Losses				(23.38)							
NET SUPPLIED	618	154	772	19.13	1,962	0	1,526	61	3	34	3,586
Final Consumption											
Households	618	154	772	8.03				46		17	63
Transport					1,546		1,107		3		2,656
Government/Commercial				2.13	416		419	15		17	868
Industrial/Construction											
Agroindustries											
Unknown				8.97							
TOTAL	618	154	772	19.13	1,962		1,526	61	3	34	3,586

Source: Mission Estimates 1990

Notes:

[1] Population 1990, urban 10,400, rural 4,800 (2868 hh – 5.27 persons/hh).

[2] Assumes 10% of population use wood for cooking at 1.4 kgs/cap/day = 772 tonnes/year
Assumes biomass consumption as 80% wood, 20% coconut residues.

TABLE 4

ENERGY BALANCE ESTIMATES FOR THE REPUBLIC OF PALAU (1995) ('000 TOE)

	Fuelwood	Coconut Residues	Total [1,2] Biomass	Electricity [3]	Gasoline	Jet A1	ADO	Kerosene	Avgas	LPG	Petroleum	Total Energy
Primary Supplies												
Production	0.29	0.06	0.35									0.35
Imports					7.52	6.44	19.88	0.24	0.02	0.10	34.19	34.19
Bunkering/exports						(6.44)					(6.44)	(6.44)
GROSS AVAILABLE	0.29	0.06	0.35	0.00	7.52	0.00	19.88	0.24	0.02	0.10	27.75	28.10
Conversions												
Public Power Generation				14.41			(14.41)				(14.41)	0.00
Transformation losses				(9.54)								(9.54)
Station Use				(0.22)								(0.22)
Transmission/distribution Losses				(2.44)								(2.44)
NET SUPPLIED	0.29	0.06	0.35	2.21	7.52		5.47	0.24	0.02	0.10	13.34	15.90
Final Consumption [4]												
Households	0.29	0.06	0.35	n.a.				0.24			0.24	0.59
Transport					7.06		4.00		0.02		11.08	11.08
Government/Commercial				n.a.	0.46		1.47			0.10	2.03	2.03
Industrial/Construction				n.a.								
Agroindustries												
Others												
TOTAL	0.29	0.06	0.35	2.21	7.52		5.47	0.24	0.02	0.10	13.34	15.90

Source: Mission Estimates 1990

Notes:

[1] Population 1995, urban 11,400, rural 5,400, total 16,800.
[2] Assumes 10% of population use biomass for cooking at 1.4 kgs/cap/day = 858 tonnes/year
Assumes biomass consumption as 80% wood, 20% coconut residues.
[3] Electricity projections for Aimeliik station only.
[4] Sector usage based on 1990 estimates.

TABLE 4a

ENERGY BALANCE ESTIMATES FOR THE REPUBLIC OF PALAU (1995) [4]
(Original Units)

	Fuelwood (tonnes)	Coconut Residues (tonnes)	Total [1,2] Biomass (tonnes)	Electricity [3] (GWh)	Gasoline (kUSgal)	Jet A1 (kUSgal)	ADO (kUSgal)	Kerosene (kUSgal)	Avgas (kUSgal)	LPG (kUSgal)	Petroleum (kUSgal)
Primary Supplies											
Production	687	172	858								
Imports					2,459	1,948	5,828	74	6	42	10,357
Bunkering/exports						(1,948)					(1,948)
GROSS AVAILABLE	687	172	858		2,459	0	5,828	74	6	42	8,409
Conversions											
Public Power Generation				57.7			(3,919)				(3,919)
Transformation losses											
Station Use				(2.6)							
Transmission/distribution Losses				(28.9)							
NET SUPPLIED	687	172	858	26.2	2,459		1,909	74	6	42	4,490
Final Consumption [5]											
Households	687	172	858	n.a.				74			74
Transport					2,287		1,394		6		3,686
Government/Commercial				n.a.	172		515			42	730
Industrial/Construction				n.a.							
Agroindustries											
Others											
TOTAL	687	172	858	26.2	2,459		1,909	74	6	42	4,490

Source: Mission Estimates 1990

Notes:

[1] Population 1995, urban 11,400: rural 5,400: total 16,800.
[2] Assumes 10% of population use biomass for cooking at 1.4 kgs/cap/day = 858 tonnes/year
Assumes biomass consumption as 80% wood, 20% coconut residues.
[3] Electricity projections for Aimeliik station only.
[4] Projections at medium growth scenario.
[5] Sector usage based on 1990 estimates.

TABLE 5
REPUBLIC OF PALAU PETROLEUM MARKET
1985–1990 IMPORT VOLUMES (THOUSAND US GAL)

	1985	1986	1987	1988	1989	1990
Product:						
Gasoline	1260	1344	1337	1483	1755	1969
Jet A1	630	504	466	560	860	1521
Kerosene	84	126	46	47	50	61
ADO	3360	3570	3844	4255	4512	4667
IDO						
IFO						
Lubes	76	42	38	42	56	71
Avgas	143	79	17	17	11	3
LPG	?	?	29	34	104	34
Others						
Total Inland Trade	5553	5665	5777	6438	7348	8326
Bunkers	0	0	0	0	0	0
Total Trade	5553	5665	5777	6438	7348	8326
Percent Increase	5	2	2	11	14	13

Notes: 1990 Volumes based on industry sales information cross–checked with sectorial usage information obtained from end–users and local sources.
1988 & 1989 volumes obtained are mission estimates.
1986 – 1987 values not available. Volumes provided obtained from PEDP.

TABLE 6

REPUBLIC OF PALAU PUBLIC ELECTRIFICATION

	1987	1988	1989	1990
Consumers (number)				
Residential	na	na	na	2406
Commercial	na	na	na	269
Government	na	na	na	80
Other	na	na	na	0
Total[1]	na	na	na	2755
Capacity (MW):				
Installed Diesel	12.8	12.8	12.8	12.8
Firm Diesel	8.64	8.64	8.64	8.64
Max Demand	5.0	5.9	6.3	7.1
Output (MWh):				
Generation Diesel	32,518	38,069	40,972	46,200
Station usage	2,596	3,282	2,989	3,696
Total sent out	29,922	34,787	37,984	42,504
Technical losses[2]	4,488	5,218	5,698	6,376
Non-technical losses[3]	14,961	15,654	15,193	17,002
Net Consumption[4]	10,473	13,915	17,093	19,127

Sources: 1) Mission estimates for Aimeliik only; data are extremely limited and inconsistent.

Notes: [1] 1990 is actually February 1991 but believed to be an underestimate.
[2] Measured (Nov 1990) as 15% of energy sent out.
[3] Unmetered consumption mostly inadequate metering. Includes street lights.
[4] Sales of electricity.

TABLE 7

REPUBLIC OF PALAU
ELECTRIFICATION PERFORMANCE INDICATORS (1990)

Fixed Assets (millions US$)	15.7
Average Revenue[2] (USc/kWh)	5.0
Average Cost (USc/kWh)	22.5
Capital	6.6
Fuel	8.9
Other operating	7.0
Estimated ROI[3] (%)	– 40%
Fuel Consumption[4] (litres/kWh)	0.266
Households Electrified[5] (%)	96%
KWh/year/consumer[6]	7,440
KWh/year/employee[7]	1.5 million
Employees/MW installed	1.8
Outages	
Number per week	over 3
Average duration (hours)	na
Customers affected (%)	na
Voltage drop / increase	10 – 20%
Electricity Tariff ($/kWh)	
Zero – 2,000 kWh/month	$0.09
Over 2,000 kWh/month	$0.10

Source: Mission estimates.

Notes:

1 Koror / Airai system.
2 Fixed Assets as of 30 December, 1990.
3 Rate of Return on estimated fixed assets.
4 Automotive diesel oil use calculated as 14.25 kWh per US gallon.
5 % of national households (1990 Census). 85% in 1986 mini census.
6 Consumption per household consumer.
7 Generation.
na Data not available.

TABLE 8

RURAL ELECTRIFICATION IN THE REPUBLIC OF PALAU

	1986	1990
Households supplied by grid[1]	127	over 200
Isolated rural consumers[2]		
number of states	12	
number of households	276	over 300 ?
Total rural households with electricity	403	over 500 ?
Percentage of all rural households	58%	over 60%
Rural GWh generated[3]	na	about 1
total in 1990	na	
per consumer	na	
% rural consumers metered	over 25%	na

Sources: 1) Census of Population & Housing 1986 (Palau Office of Planning & Statistics, 1987).
2) Census of Population & Housing 1990 (preliminary data only) and mission estimates.

Notes: [1] Rural consumers refer to all those outside Koror and Airai states.
[2] All those except consumers connected to Koror/Airai grid or Peleliu grid.
[3] Mission estimates; approximate only.

TABLE 9

NON-CONVENTIONAL ENERGY USE AND RESOURCES IN THE REPUBLIC OF PALAU

Systems Installed	1985	1990
Photovoltaics:		
number	na	86
kW_{peak}	na	na
Microhydro:		
number	na	na
kW	na	na
Biomass:		
number	na	na
kW	na	na

Resources		
OTEC[1]	Temperature differential (^0C)	22 – 24
	Distance offshore (km)	na
Tides	Mean range (metres)	na
Solar	Insolation ($kWh/m^2/day$)	4.2 – 5.3
	Average daily hours	
Hydro[2]	Potential (MW)	0.4 – 1.0
	Output (GWh)	over 1.2

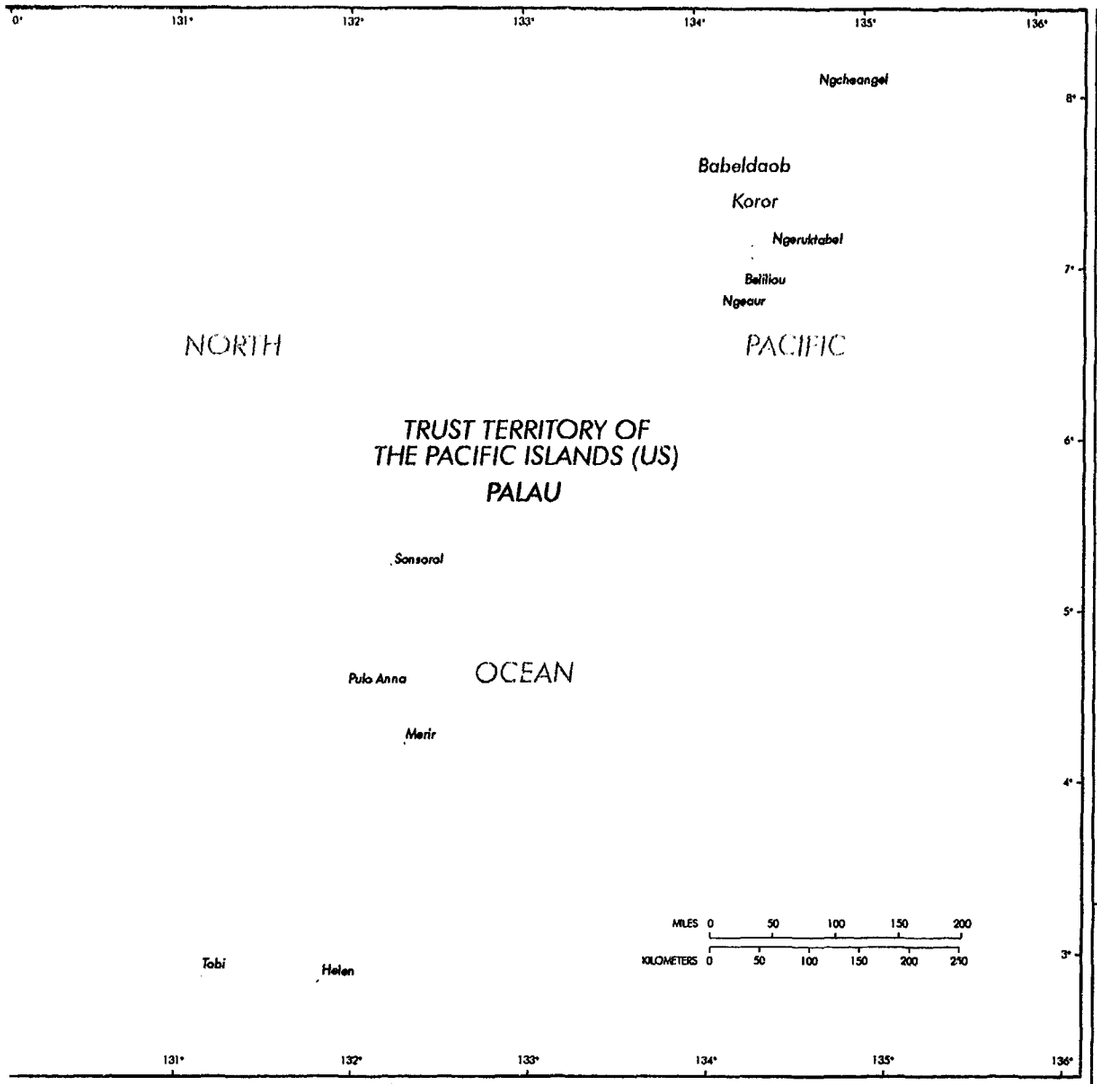
Sources: 1) 1989 TTPI report.
2) "Ocean Energy Guide" (ESCAP, 1990).
3) Territorial Energy Assessment (USDOE, Dec 1982).
4) Palau Micro-hydropower Assessment NRECA (1984).

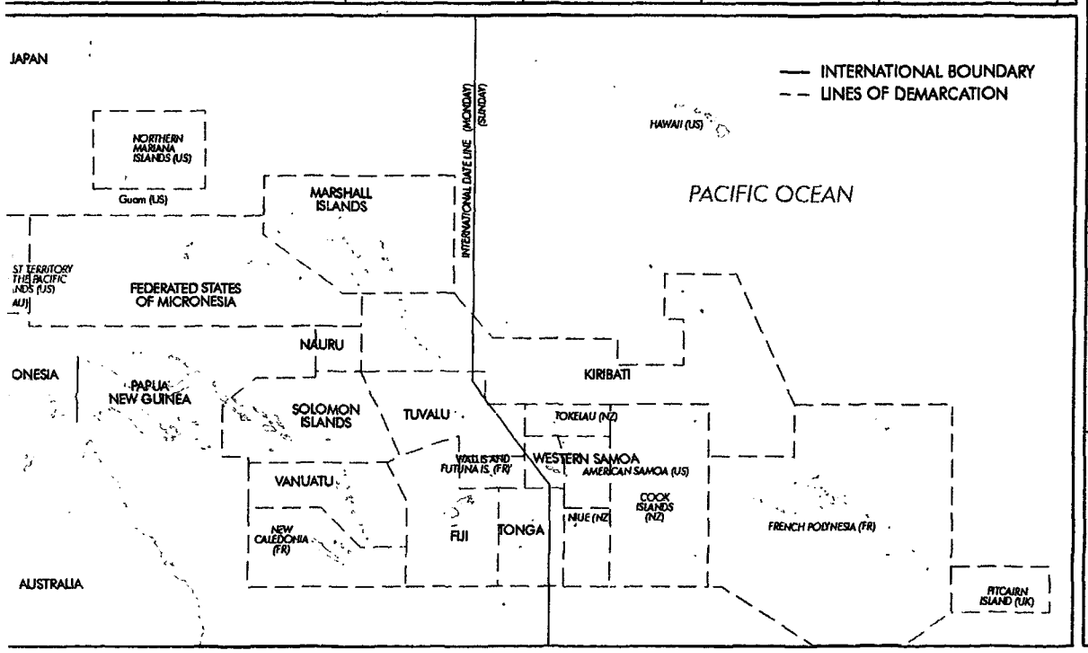
Notes: [1] Sea level to 1000 metre depth.
[2] Thirteen sites on Babeldaob island only.
na Indicates data not available.

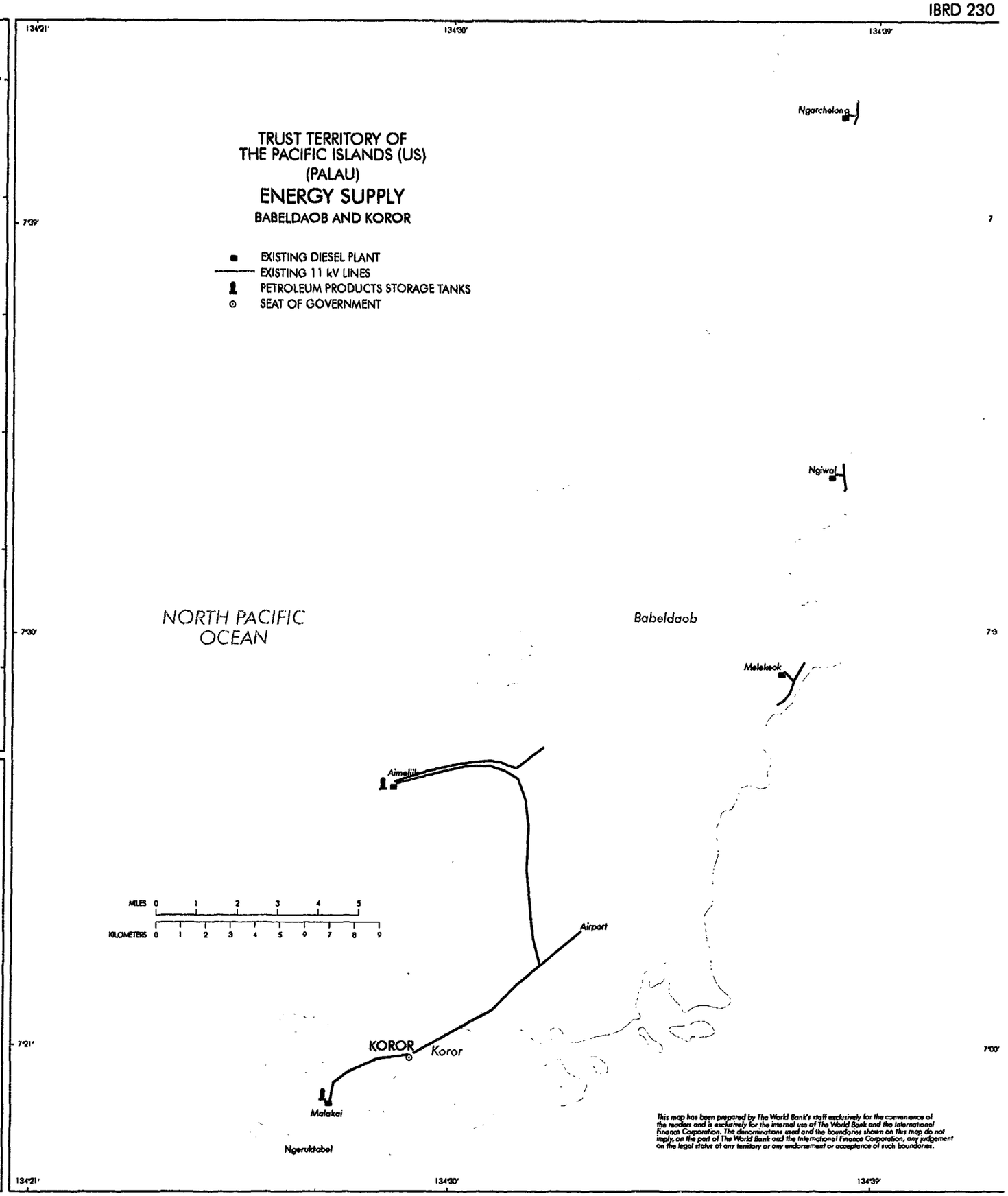
TABLE 10
BIOMASS RESOURCES OF PALAU
(Hectares, 1979)

Land class and type	Babelthaup	Other high islands	Coral Islands	Rock Islands	Total ha	(acres)
Forest						
Upland	21690	201	0	0	21,891	(54,094)
Swamp forest	1,617	15	47	1	1,680	(4,151)
Mangrove forest	4,025	205	435	43	4,708	(11,634)
Plantation forest	24	2	0	0	26	(64)
Rock Island forest	104	210	0	802	1,116	(2,758)
Limestone forest	0	0	1,175	57	1,232	(3,044)
Casuarina forest	0	0	451	0	451	(1,114)
Atoll forest	0	0	97	58	155	(383)
Palm forest	0	<1	0	0	<1	(1)
Total forest	27,460	633	2,205	961	31,259	(77,243)
Secondary vegetation	515	79	131	2	727	(1,796)
Agroforest						
Agroforest	8	0	2	6	16	(40)
Agroforest (w/coconut)	173	6	100	0	279	(689)
Coconut plantation	743	0	0	71	814	(2,011)
Total agroforest	924	6	102	77	1,109	(2,740)
Nonforest						
Marsh, fresh	448	<1	27	0	475	(1,174)
Marsh, cultivated	107	2	25	0	134	(331)
Marsh, saline	0	0	25	<1	25	(62)
Grassland	6,728	53	1	1	6,783	(16,761)
Strand	0	0	10	1	11	(27)
Cropland	140	59	4	0	203	(502)
Cropland/secondary vegetation	0	28	0	0	28	(69)
Urban	141	222	33	1	397	(981)
Urban/cropland	106	70	0	0	176	(435)
Urban/agroforest	0	0	61	0	61	(151)
Urban/secondary vegetation	0	3	0	0	3	(7)
Barren	149	5	26	0	180	(445)
Water	15	9	17	7	48	(119)
Total nonforest	7,834	451	229	10	8,524	(21,063)
Total area	36,733	1,169	2,667	1,050	41,619	(102,843)

Source: Vegetation Survey of the Republic of Palau
(US Dept of Agriculture, Forest Service PSW-22, June 1987)







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