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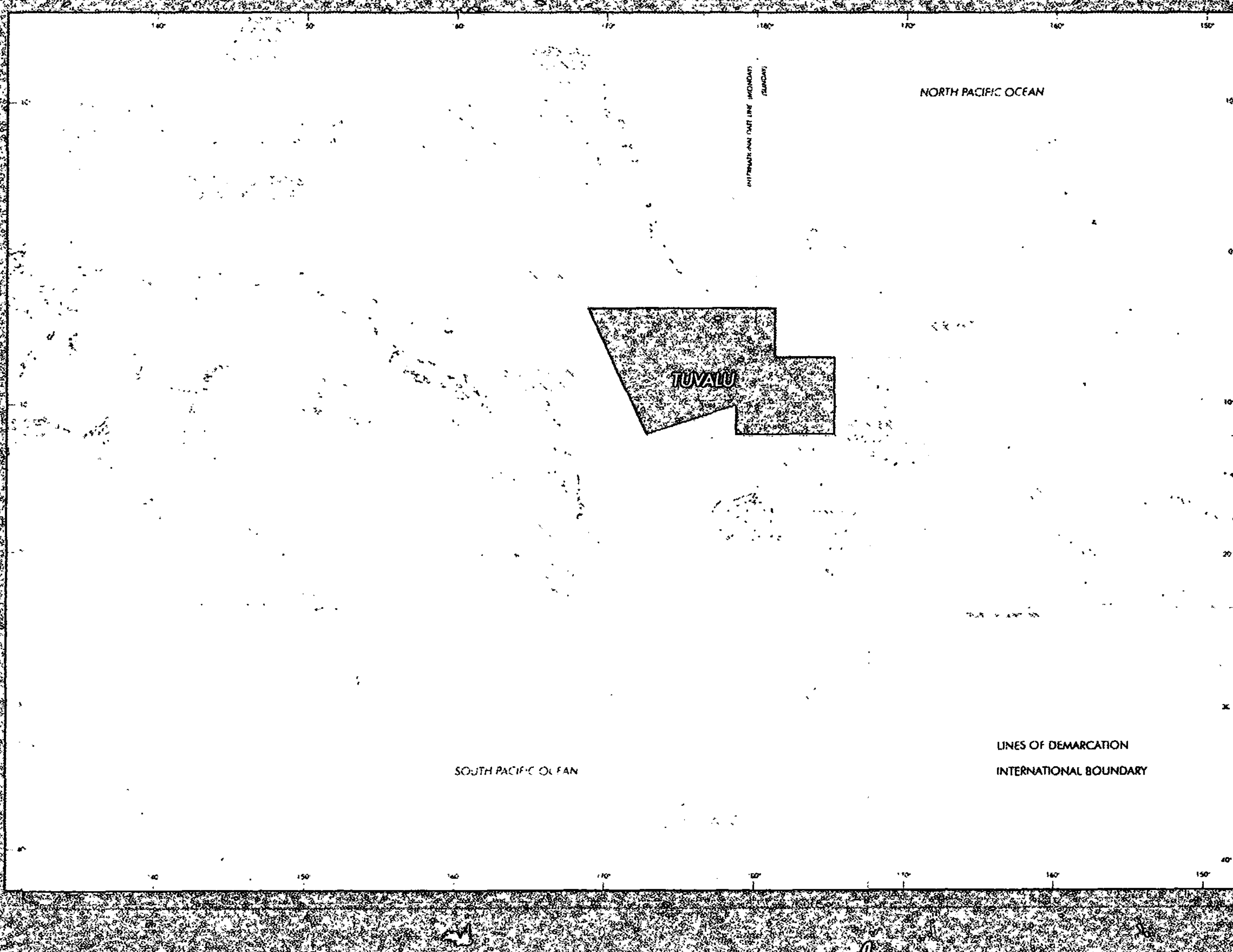
PREA

Pacific Regional Energy Assessment

Volume 11: Tuvalu: Issues and Options in the Energy Sector



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

CURRENCY EQUIVALENT

US$1.00 = A$1.23
(Tuvalu uses the Australian dollar.)

FISCAL YEAR

January 1 - December 31

ACRONYMS

ADB	-	Asian Development Bank
FSED	-	Forum Secretariat Energy Division
MFAEP	-	Ministry of Foreign Affairs and Economic Planning
MFCP	-	Ministry of Finance, Commerce, and Public Corporations
MLWC	-	Ministry of Labor, Works and Communications
OPM	-	Office of the Prime Minister
PEDP	-	Pacific Energy Development Programme
SOPAC	-	South Pacific Applied Geosciences Commission
TEC	-	Tuvalu Electricity Corporation
TMS	-	Tuvalu Maritime School
TSECS	-	Tuvalu Solar Electric Cooperative Society Ltd.

ABBREVIATIONS

kgoe	-	kilograms of oil equivalent
LCT	-	local coastal tanker
MR	-	medium range
PV	-	photovoltaic
TOE	-	tons of oil equivalent

This report is based on the findings of an energy assessment mission, which visited Tuvalu in February, 1991. The mission comprised Andres Liebenthal (mission leader - World Bank), Herbert Wade (renewables specialist - consultant), William Matthews (petroleum specialist - consultant), Michael Charleson (power engineer - consultant), Douglas Macdonald (power economist - consultant), and Chuck Filiaga (assistant power planner - PEDP).

Pacific Islands Series
Report No. 1
Volume II

TUVALU

ISSUES AND OPTIONS IN THE ENERGY SECTOR

August 31, 1992

Abstract

Tuvalu is constrained by its limited natural resources, the distances between its islands as well as from major international markets, and a lack of skilled management and implementation capacity. Though there has been some success with renewable energy resources, Tuvalu will remain dependent on imported petroleum. The report recommends that the government improve its monitoring of petroleum pricing, pay attention to environmental concerns, and investigate the possibility of reducing imported LPG's price. The power utility, TEC, and the Solar Cooperative, TSECS, should focus on making a better use of their assets, with a cautious expansion of capacity. For TEC, this implies an increase in the tariff along with a reduction in system losses, implementation of a system of records, and improvement in its accounting system. The government should complete the details of the corporatization of TEC. TSECS has successfully operated solar photovoltaic systems in the outer islands. The report recommends that TSECS's staff be given further training, and the tariff be raised so that it covers capital and operational costs. For program continuity, the report recommends that the government recruit a qualified Tuvaluan to work with and be trained by the expatriate Energy Planner.

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

TUVALU

ISSUES AND OPTIONS IN THE ENERGY SECTOR

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Tables

ENERGY CONVERSIONS AND MEASUREMENTS

	Unit	Typical Density kg/liter	Typical Density l/tonne	Gross Energy MJ/kg	Gross Energy MJ/liter	Oil Equiv toe/unit (net)
Biomass Fuels						
Fuelwood (5% mcwb)	tonne			18.0		0.42
Coconut Residues (air dry)/a						
Shell (15% mcwb)$_{\text{harvested}}$	tonne			14.6		0.34
Husk (30% mcwb)$_{\text{harvested}}$	tonne			12.0		0.28
Average (air dry$_{\text{husk and shell}}$)/b	tonne			14.0		0.33
Coconut Palm Wood (air dry)	tonne			11.5		0.27
Charcoal			30.0		0.70	
Vegetable and Mineral Fuels						
Crude Oil	tonne			42.6		1.00
Coconut Oil	tonne	0.910	1,100	38.4		0.90
LPG (propane)	tonne	0.510	1,960	50.0	25.5	1.17
Ethanol	tonne			27.0		0.63
Gasoline (Super)	tonne	0.730	1,370	46.5	34.0	1.09
Gasoline (Unleaded)	tonne	0.735	1,360	46.5	34.2	1.09
Aviation Gasoline (Avgas)	tonne	0.695	1,440	47.5	33.0	1.12
Lighting Kerosene	tonne	0.790	1,270	46.4	36.7	1.09
Power Kerosene (Avtur, DPK)	tonne	0.795	1,260	46.4	36.9	1.09
Automotive Diesel (ADO)	tonne	0.840	1,190	46.0	38.6	1.08
High Sulphur Fuel Oil (IFO)	tonne	0.980	1,020	42.9	42.0	1.01
Low Sulphur Fuel Oil (IFO)	tonne	0.900	1,110	44.5	40.1	1.04
Electricity (MWh)						
Fuelwood /c	MWh					0.93

Fuel Conversion Efficiency

Diesel: Text uses actual where known, otherwise:
Average efficiency for small (< 100 kW output) diesel engine 0.46 l/kWh (22%).
Average efficiency of large (>100 kW output) modern diesel 0.284 l/kWh (36%).
Average efficiency of low speed, base load diesel (Pacific region) 0.30-0.33 l/kWh (28-32% eff).

Energy Measurements

Area: 1.0 km^2 = 100 hectares = 0.386 mi^2
1.0 acre = 0.41 hectares
Mass: 1.0 long tons = 1.016 tonnes
Energy: 1 kWh = 3.6 MJ = 860 kcal = 3412 Btu = 0.086 kgoe
1 toe = 11.83 MWh = 42.6 GJ = 10 million kcal = 39.68 million Btu
1 MJ = 238.8 kcal = 947.8 Btu = 0.024 kgoe = 0.28 kWh

/a Average yield of 2.93 air dry tonnes residues/tonne copra produced (Average NCV 14.0 MJ/kg) mcwb = moisture content wet basis. NCV = net calorific value.
/b Proportion: kernel 33%, shell 23%, husk 44% by dry weight.
/c Assumes conversion efficiency of 9% (biomass-fuelled boiler).

EXECUTIVE SUMMARY

1. Tuvalu is composed of nine low-lying coral atolls scattered in the Central Pacific Ocean, with a land area of 26 km^2, and an Exclusive Economic Zone of 0.9 million km^2 of ocean. The population is about 9,000, of which approximately one-third live on the capital island, Funafuti. Tuvalu's main natural economic resources are coconut trees and fish.

2. Over the period 1986-89, the performance of the Tuvalu economy has fluctuated considerably; real per capita GDP in 1989 was lower than in 1986. In 1989, Tuvalu experienced an international trade deficit, equal to approximately two-thirds of its GDP, which was financed mainly by international aid and remittances from expatriate workers. In 1989, fuel imports were approximately 16% of total imports, but they amounted to more than 400% of total exports.

3. The Tuvalu Trust Fund, which was established in 1987 with grant aid totalling A$25 million, supports the economy, but, due to certain restrictions in the Fund's charter, it is unlikely that Tuvalu will be able to withdraw any money from this Fund in 1991.

4. Some fundamental constraints on Tuvalu's economy are the limited natural resources, the distances between the islands as well as from the major international markets, and a lack of skilled management and implementation capacity. In the medium term, Tuvalu's prospects for economic growth will depend upon the future of copra production and revenue from fishing, including licensing income from international fishing companies. Assuming sound management of the limited resources, a practical investment program, and technical assistance in selected areas, overall economic growth of 3-5% per year is possible.

5. The three known non-conventional indigenous energy resources in Tuvalu are solar energy, ocean energy, and wind energy. Of these, only solar energy has had any technical or economic success in the Pacific region. The continuing development of solar energy resources for water heating and electricity production at the residential or small commercial level is appropriate. Hence, it is recommended that programs for data gathering related to wind and ocean energy be continued, but the physical development of these resources be held off until they are proven commercially in the Pacific island environment. Diesel powered generation is the principal economically and technically viable source of electricity for Funafuti. In addition, solar photovoltaics is economically appropriate for most outer island electrification. This situation is not expected to change over the next ten years.

6. An important constraint is that there is no Tuvaluan to work with the current expatriate Energy Planner. For program continuity, it is recommended that GOT recruit, as soon as possible, a suitably qualified Tuvaluan to work with and be trained by the Energy Planner.

Petroleum Subsector

7. Imported petroleum products are the basis of all of Tuvalu's commercial energy consumption. Most of these products are consumed directly, while about half of the imported ADO is used to generate electricity. The total 1990 LPG

consumption is estimated to be about 7.6 tonnes, and LPG has made few inroads into the household cooking market. On the outer islands, most of the energy consumption is based on traditional biomass products, with some solar energy for lighting. In view of this situation, the main prospects for improvement in this subsector lie in better monitoring of petroleum pricing, attention to environmental concerns, and a possibility of reducing the price of imported LPG.

8. GOT should monitor the BP ex-depot wholesale prices of petroleum products to ensure that these prices reflect efficient procurement and supply norms. The mission recommends that GOT acquire from BP detailed price build-up information on a regular basis, and analyze it with assistance from a regional energy agency.

9. The health, safety and environmental practices need to be augmented, principally by controlling the oily water disposal at the BP depot, and improving the unsafe storage and dispensing facilities at the Fusi Co-op and other retail outlets. It is recommended that GOT seek the assistance of specialized experts from a regional energy agency.

10. Since the LPG price is very high under the current system of the import of small filled cylinders from Fiji, it is recommended that a pre-feasibility study of the benefits of importing LPG in bulk or large containers, combined with local decanting, be carried out.

Electricity Subsector

11. The main theme of this report for this subsector, for both TEC and TSECS, is better use of the existing assets, with a cautious expansion of capacity.

TEC

12. TEC's Funafuti power system serves 429 consumers (1990), of which 402 are household consumers. Total electricity sales in 1990 were 1,120 MWh, which represented a per capita consumption, in Funafuti, of about 370 kWh per year. Overall sales are projected to grow by 4.4% per year for the period 1990-2000, with residential sales increasing at an annual rate of 2.5%, commercial sales at 5.3%, and Government sales at 4.6%. Growth beyond 1993 has been projected to grow only at about 1.5%.

13. The recommended expansion plan for TEC is based on a conservative definition of firm capacity. This plan calls for the installation of another 150 kW unit in the existing station in 1992, and for the installation of another unit after 1995. The plan also includes the addition of a third 350 kVA main transformer (including 11 kV circuit breakers, relay protection and control) within the next two years. The total cost of this expansion until 1995 is estimated at about US$135,000 (in 1991 prices).

14. TEC's station use and distribution losses, at about 18-20%, are high. Thus, there is a substantial potential for cost savings through reduction in system losses. As an initial step towards the reduction of system losses, it is recommended that TEC carry out an investigation to establish the level of system

losses and the contribution of each source. Once an accurate figure for the system loss is available, further investigation would be necessary to establish the sources and identify appropriate measures to reduce the losses. It is also recommended that TEC take measures to improve the system power factor.

15. TEC has some cooling problems that limit the output of two of its generators. To remedy the cooling system problem, it is recommended that TEC arrange for an experienced engineer to analyze the situation and recommend modifications.

16. It is essential that TEC's maintenance of the generating units and all auxiliary units be carefully planned and programmed. Further, above average stocks of materials and parts should be on hand for both planned maintenance and unexpected breakdowns.

17. TEC's generating and distribution system can be efficiently operated by a small staff using straightforward procedures and systems. The present staff level of 24 might reasonably be increased to 29-30, but the planned full complement of 34 staff is too large. Instead, TEC should provide additional training for staff at all levels.

18. Since TEC does not maintain adequate records, it is recommended that TEC implement, on an urgent basis, a simple, but comprehensive, system of records will assist management in identifying the areas of operations that need improvement, determining plant and equipment expansion needs, and assessing TEC's financial condition.

19. TEC should improve its accounting system so that its annual budget includes depreciation charges, calculated on revalued fixed assets. This would enable TEC's management to assess the relative worth of future capital investments and the effectiveness of potential engineering innovations or even of improvements in O&M. Since TEC (and Tuvalu as a whole) does not have an accountant, one option is that GOT recruit one accountant immediately, whose services would be shared by a number of government agencies, including TEC and TSECS. As an interim measure, the GOT should consider the use of UN volunteers as accountants.

20. In view of the December, 1990 corporatization of TEC, its assets and operations need to be separated from those of GOT. To accomplish this, GOT should decide (i) the value at which the fixed assets are to be transferred to TEC, (ii) the appropriate financial (debt:equity ratio) and shareholder structure for TEC. (iii) whether or not TEC is required to pay corporate income tax, (iv) the general nature of the relationship between GOT and TEC, and in particular, the extent of the autonomy to be granted to TEC to determine its own capital expenditure and revenue (tariff) policy.

21. As a further step following upon TEC's corporatization TEC's Board of Directors, in consultation with the General Manager, as appropriate, should determine TEC's objectives, establish clear policies, and determine the responsibilities and authority of the General Manager. Further, the Board should set targets or goals to be reached in a given time period.

22. Since TEC makes a loss when capital charges are included in expenditures, increases in electricity tariffs will be necessary. TEC's should consider (i) automatic fuel price adjustment, (ii) different tariffs for residential and non-residential consumers, and (iii) the need for the tariffs to recover the full costs of electricity, including capital charges and insurance costs, in order to ensure the financial viability of the utility.

TSECS

23. TSECS provides solar energy on a fee-for-service basis to about 300 households on seven of the eight outer islands. Solar lighting kits have also been installed on eight community meeting houses. Approximately two-thirds of the solar capacity is operational, largely due to system failures in the 170 units installed in a first phase. By year-end 1991, the combined solar PV capacity will generate approximately 44 MWh of electricity annually.

24. Over the years, TSECS has evolved to the point where it is able to properly administer and maintain about 300 outer island solar installations. TSECS has proven itself capable of operating and maintaining the systems, and maintaining general customer satisfaction. It is working well and no change in its structure or mode of operation is recommended. In particular, no attempt should be made to merge TSECS and TEC. Though the general competence of TSECS is good, TSECS would benefit from further training of its staff.

25. TSECS should attempt to secure maintenance contracts for GOT solar installations in the outer islands, notably in communications and health. This will help to better utilize TSECS resources. However, because operational costs are a significant part of its tariff, TSECS should not attempt to increase its staff or facilities, particularly office and workshop space, which would increase operational costs, unless near term financial returns are clearly the result.

26. Funding for the general increase in the capacity of solar systems for those customers able to pay will be needed after 1993. Though aid will be sought, these systems will be provided to wealthier customers, and their ability to pay may be sufficient to allow initial capital investment to be from loans rather than grants. New capital investment of about A$150,000 per year for five years is expected to be needed for this purpose.

27. The present level of TSECS tariffs provides for operation and maintenance costs, but is inadequate for the replacement of the solar panels at the end of their useful life (10-15 years). It is recognized that the existing level of service is insufficient to warrant full charges to customers. However, a general upgrading of installations to a uniformly adequate level of service is underway, and as services improve, TSECS should strive to raise its monthly fee to A$10.00 per month.

28. For solar PV systems, a system for reclaiming lead from spent lead acid batteries should be placed into effect to prevent possible environmental damage.

Biomass, Wind and Ocean Energy Development

29. Given the experimental nature of these energy resources, it is recommended that, at present, no efforts be made to develop these forms of energy in Tuvalu.

I. THE ECONOMIC AND INSTITUTIONAL CONTEXT

Energy and the Economy

1.1 Tuvalu is composed of nine low-lying coral atolls in the Central Pacific Ocean with a total land area of 26 km^2, and an Exclusive Economic Zone of 0.9 million km^2 of ocean. The nine islands are scattered, with the northernmost island more than 550 km away from the southernmost island. The total population is about 9,000, of which approximately one-third live on the capital island, Funafuti. The principal natural economic resources of Tuvalu consist of coconut trees and fish.

1.2 Over the period 1986-89, the performance of the Tuvalu economy has fluctuated considerably, with real GDP growth of 3% in 1987, 14% in 1988, and a decline of 13% in 1989. In 1990, GDP is estimated to have grown by 4%. With a population growth rate of 1.5% per annum, real per capita GDP in 1989 was lower than in 1986. In 1989, Tuvalu experienced an international trade deficit, equal to approximately two-thirds of its GDP, which was financed mainly by international aid and remittances from expatriate workers. In 1989, fuel imports were approximately 16% of total imports, but they amounted to more than 400% of total exports. A few major indicators are shown in the Statistical Appendix, Table 1.

1.3 The Tuvalu economy is supported by the Tuvalu Trust Fund, which was established in 1987 with grant aid totalling A$25 million; currently, the Fund's offshore investments are valued at A$35 million. Withdrawal of monies from this Fund is restricted by its charter, which requires that the Fund's value be maintained in real terms. As a result, it is unlikely that Tuvalu will be able to withdraw any money from this Fund in 1991.

1.4 Some fundamental constraints on Tuvalu's economy are the limited natural resources, and the distances between the islands as well as from the major international markets. In addition, in recent years, Tuvalu has been able to use only about 50% of the foreign aid offered for capital investment projects because of (i) a lack of skilled management and implementation capacity, and (ii) cash flow difficulties arising from the requirement of some donors that the GOT provide initial project finance and then seek reimbursement from the donors.

1.5 In the medium term, Tuvalu's prospects for economic growth will depend upon the future of copra production and revenue from fishing, including licensing income from international fishing companies. Assuming sound management of the limited resources, a practical investment program, and technical assistance in selected areas, overall economic growth of 3-5% per year is possible.

Institutional Framework

1.6 The management of the energy sector centers around the Ministry of Foreign Affairs and Economic Planning (MFAEP) and the Ministry of Finance, Commerce, and Public Corporations (MFCP). Within MFAEP, in the Department of Planning and Statistics, there is a an Energy Planner, currently a member of the U.S. Peace Corps, who is the focal point for energy planning, evaluation, and coordination. There is no Tuvaluan to work with the current expatriate Energy

Planner. Though the three volunteers who have been in the post have done well, the two year term of the volunteers is inadequate for program continuity. Further, it is unlikely that this post can be filled indefinitely by volunteers. Therefore, it is recommended that GOT recruit, as soon as possible, a suitably qualified Tuvaluan to work with and be trained by the Energy Planner.

1.7 BP South-West Pacific, based in Suva, Fiji, is the sole petroleum marketer in Tuvalu. There is no written agreement between BP and GOT.

1.8 Electricity generation and distribution on the main island of Funafuti is under the Tuvalu Electricity Corporation (TEC). TEC was incorporated in December, 1990. Prior to this change, this agency was known as the Tuvalu Electricity Authority (TEA), and it was a Division of the Ministry of Labor, Works and Communications (MLWC). At present, MLWC has oversight responsibility for TEC, but this responsibility is in the process of being shifted to MFCP.1/

1.9 In 1984, the Tuvalu Solar Electric Cooperative Society (TSECS) was formed with assistance from the Save the Children Foundation and USAID. TSECS is a commercial enterprise, registered under Tuvalu's Cooperative Society Act, which promotes solar electricity for household lighting on the outer islands. TSECS is governed by a Management Committee, which consists of eight members, one from each of Tuvalu's eight larger islands.2/ The Management Committee is the governing body of TSECS and sets user fees. Each island has its own branch. Members of the Management Committee are elected annually to their posts by their respective branches. The day-to-day operations and project implementation are the responsibility of a Management Team, located in Funafuti, which consists of a manager appointed by the Management Committee and three technical/support staff who are appointed by the TSECS manager. On each island, TSECS has a Branch Technical Agent, who is responsible for the day-to-day maintenance and monthly fee collections. Each island also has a Branch Committee, which is composed of local co-op members. The Branch Committees act as arbiters of local disputes and makers of policy for their specific island. The GOT plays a limited role in the management of TSECS. The Management Committee is directly responsible to the Registrar of Cooperative Societies located in the MFCP. As a result, all project funds to TSECS are channeled through this Ministry.

1/ By December 1991, oversight had been shifted to MFCP.

2/ Niulakita, the southernmost island, with a population of only 61, is too small to support solar photovoltaic power at this time.

II. ENERGY CONSUMPTION

Introduction

2.1 Imported petroleum products provide all of the commercial energy consumed in Tuvalu. While about half of the automotive diesel oil (ADO) is used to generate electricity, the remainder of the petroleum products are consumed directly in transportation, fisheries, or household use (cooking and lighting). On the outer islands, most of the energy consumption is based on traditional biomass products, though the use of solar energy for lighting is increasing. The energy balance for Tuvalu is presented in the Statistical Appendix, Tables 3a and 3b.

Petroleum Products

2.2 In 1989, Tuvalu's import of petroleum products for inland consumption, i.e., excluding jet fuel and aviation gas, amounted to 1,459 kl or 1,268 toe (Statistical Appendix, Tables 3a and 3b), equivalent to about 112 kg/capita, which is relatively low for the Pacific Islands. The largest component (about 36%) of petroleum inland consumptions has been automotive diesel oil (ADO) for operating the larger shipping and fisheries vessels, followed by motor spirit (about 26%), which is used mainly in outboard and other small marine engines for local transport and fishing, and ADO (about 26%) for use in power generators (Statistical Appendix, Table 3). Most households on the outer islands use kerosene for cooking and lighting, while on Funafuti, most households cook with kerosene but use electricity for lighting. In comparison with kerosene, the consumption of LPG (butane) is much lower, given the small number of houses with gas stoves, and the relatively high price of LPG. In 1989, Tuvalu's import of jet fuel and aviation gas, which are sold to the international airlines that refuel in Tuvalu, amounted to 656 kl, equivalent to approximately 45% of the total petroleum trade.

2.3 The total 1990 LPG consumption is estimated to be about 7.6 tonnes, and LPG has made few inroads into the household cooking market.

2.4 The total petroleum consumption is projected to increase at about 4% per year from about 1,500 kl in 1989 to approximately 2,300 kl in 2000 (Statistical Appendix, Table 4a). The growth rate of ADO for use in power generation by TEC is projected to be about 3%, while the growth rate to ADO "to others" is projected to be about 4%. The growth rate for motor spirit is projected to be about 4%, kerosene 2%, and LPG also at 2%.

Electricity

2.5 The power system on Funafuti, operated by TEC, serves 429 consumers (1990), of which 402 are household consumers. Total electricity sales in 1990 were 1,120 MWh, which represented a per capita consumption, in Funafuti, of about 370 kWh per year. Virtually 100% electrification has been achieved on this island.3/ In 1990, of TEC's total energy sales of 1,120 MWh, sales to the

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3/ The other eight islands do not have conventional electricity supply, though some households do have solar electricity for lighting.

Government were about 37%, residential sales about 25%, and commercial and large residential consumers accounted for the remaining 38% of sales. Electricity sales have grown at an average rate of over 7% a year since 1986 (Statistical Appendix, Table 6). The number of consumers increased at an average rate of over 5% per year, while the number of electrified households increased at an average rate of about 8% per year.4/ The consumption pattern is heavily skewed, with the ten largest consumers accounting for about 45% of sales, and the next ten largest consumers accounting for about 12% of sales (January, 1991). Though the average overall consumption per consumer is 2,400 Kwh per year, more than 85% of the consumers are below this level of sales.

2.6 There does not appear to be any seasonal variation in energy demand or peak load. The daily peak lasts about 2 hours in the evening, driven primarily by residential lighting and small appliance load. Accordingly, there is little scope for moderating the peak demand by structural changes in the electricity tariff.

Load Forecast

2.7 Any load forecast for a supply system as small as TEC's inevitably has a wide margin of error because a single development project can cause a sudden and marked increase in electricity demand. The summary load forecast for TEC presented in Table 2.1 is subject to this caveat. No attempt has been made to develop alternative contingency projections of load growth, given the scarcity of reliable information about future development. Based on the available information, overall sales are projected to grow by 4.4% per year for the period 1990-2000, with residential sales increasing at an annual rate of 2.5%, commercial sales at 5.3%, and Government sales at 4.6%. The 4.4% annual growth rate reflects mainly a sharp increase of more than 10% per year in demand in the period 1991-93, due to the Government's Telecoms project and a commercial hotel project. Growth beyond 1993 has been projected at a much lower annual rate of about 1.5%.

2.8 The residential consumption on Funafuti is projected to grow at an average annual rate of 2.5% from 1990 to 2000. On Funafuti, the number of consumers is likely to remain stable, because this densely populated island has limited room for population growth, and most of the existing houses are already electrified. Thus, growth in residential consumption will only occur as increases in personal incomes lead to the purchase of more electrical appliances. This growth in sales will be tempered by increases in electricity tariffs, which will be necessary if TEC is to cover both its capital and operating costs.

2.9 The only major commercial development anticipated in the near future is a 16-room hotel, which is likely to start operating in mid-1992. In the Pacific islands region, it is common and also desirable that such establishments use solar hot water heating, and it is recommended that this hotel follow this practice. Based upon the typical energy demand for such a hotel, given solar

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4/ While the historical system records of TEC are limited and unreliable, it has been possible to gather sufficient data to establish the general growth in electricity consumption, and some patterns of consumption among the different types of consumers.

water heating, its estimated annual consumption will be about 150 MWh when it is in full operation.

Table 2.1: SUMMARY ENERGY SALES FORECASTS

Year	Government	Commercial /a	Domestic /b	Total
	----------------------------	MWh	----------------------------	
1990	412	424	284	1,120
1991	448	433	304	1,185
1995	602	643	332	1,577
2000	647	709	362	1,718
Av. annual growth (%) 1990-2000	4.6	5.3	2.5	4.4

/a Private consumers, commercial and residential exceeding 200 kWh/month.
/b Private consumers consuming less than 200 kWh/month.

Source: Mission projections; Annex 2.

2.10 Reliable detailed information, such as the likely date of completion or probable electrical demand, about planned Government projects is generally not available, even for projects that are scheduled for completion in 1991. An exception is the new Telecoms development, which is expected to consume about 150-170 MWh per year when it is fully operational in about 1993. Other planned near-term Government developments include a chicken processing plant, extensions to the craft building, including a kitchen, a new airport terminal building, a building for the Education Department, ward extensions at the hospital; further into the future, there are plans for major modifications and extensions to the hospital, and an expansion of the main Government building. All of these projects are dependent upon overseas assistance. Accordingly, many of them are likely to be delayed by several years. As each of these projects signifies a major increase in the load on TEC's system, it is important to provide appropriate incentives to encourage energy conservation or the use of alternative technologies, such as the use of solar hot water heaters. To provide the correct signals, it is recommended that TEC consider the adoption of a two-part tariff for its current and prospective larger customers. The forthcoming tariff study should provide an appropriate basis for designing and introducing such a tariff. (See paragraph 4.14)

2.11 In the absence of adequate information on the demand and load pattern of future developments, the projections of peak demand must necessarily be imprecise. The peak demand projections (Table 2.2) have assumed that the daytime demand, particularly from air conditioning, will increase, and this would tend to increase the load factor. However, the new hotel is expected to have a large evening demand coincident with the peak, and this, together with the peak demand of the new domestic consumers in the south, is expected to result in a slight overall decline in the load factor during the next two years. A subsequent gradual improvement is expected in 1993-2000. On this basis, the load factor is projected to decline from the present level of about 66% to about 59% in 2000. The overall level of station use and energy losses has been assumed, conservatively, to remain at the present level of 18%, in the absence of any firm project and timetable to reduce this level.

Table 2.2: GENERATION AND PEAK DEMAND PROJECTIONS

Year	Generation (MWh)	Peak Demand (kW)
1990 (Actual)	1,366	235
1991	1,446	273
1995	1,924	376
2000	2,096	407
Average annual growth rate (%) (1990-2000)	4.4	5.6

Source: Mission projections.

Solar Energy

2.12 TSECS provides solar energy on a fee-for-service basis to about 300 households 5/ on seven of the eight outer islands. Solar lighting kits have also been installed on eight community meeting houses. However, many of the 170 units installed in the initial phase experienced system failures and are in being replaced.

2.13 By year-end 1991, based on the assumptions that (i) all 342 currently enrolled members of TSECS are out-fitted with two-panel household systems, and (ii) all system upgrades and repairs have been completed, it is estimated that the total solar PV capacity (including household and meeting hall lighting and dispensary refrigeration units), will generate approximately 46 MWh of electricity annually, which will be approximately 10% of total 1991 household electricity consumption.

2.14 By the end of 1993, it is expected that over 500 households will have lighting kits installed. The market for rural households desiring and able to afford PV lighting is estimated to be 600-700, of the approximately 1,000 households in the islands, and this number is expected to be reached before the year 2000. In view of the growing energy demand from the consumers, a trend toward more powerful PV systems, capable of operating VCRs and household refrigerators, is expected to begin after 1993, and come close to its full potential by 2000.

5/ In June 1990, 265 systems were installed or in development, and 77 households were awaiting delivery and installation of lighting kits.

2.15 Solar PV refrigerators were introduced in Tuvalu in 1987 for use in medical dispensaries in the outer islands. Ten refrigerators were installed under this project, each with a six-panel system, which were later upgraded to a ten-panel system. GOT is the owner of these refrigerators, and TSECS is pursuing a service contract for regular maintenance.One refrigeration unit was also provided for Motufoua Secondary School with funds from France.

Biomass

2.16 Coconut husks, shell and fronds together with other woods are used for cooking, most often in open fires, and for some copra drying. On Funafuti, kerosene has increasingly replaced wood fuel for cooking. On the outer islands, the biomass fuel used in cooking is approximately 4,800 kg per household per year. While there does not appear to be any problem of sustainability with biomass, the burning of coconut tree by-products represents a loss of nutrients that would have been available to enrich the soil if they were returned to the ground as compost.

2.17 In the period 1983-88, Save the Children Foundation conducted a project to replace the traditional open fire with a concrete stove, primarily to provide convenience and comfort in cooking. This project was not successful, and most of the stoves are reportedly no longer in use.

III. ENERGY SUPPLY

Introduction

3.1 Tuvalu depends almost entirely on imported petroleum and diesel-generated electricity to meet the demand for energy on Funafuti; on the outer islands, the demand for energy is met by biomass, and to a much lesser extent, solar power. This pattern of supply is expected to continue in the medium-term. In the long term , it may be possible to develop other resources such as wind power or ocean energy.

Petroleum Products

3.2 All of Tuvalu's supplies are acquired through the BP supply network, *via* a drop-off of small parcels at the BP Funafuti terminal on a multi-port local coastal tanker (LCT) voyage originating at the Vuda terminal in Fiji. The typical LCT parcel drop size for Funafuti is 150-200 tonnes every 6 to 8 weeks. The LCT usually has been the "Pacific Explorer," of about 1,600 DWT, which typically follows three-port discharge circuits such as:

(a) Vuda (load) - Tarawa - Funafuti - Wallis
(b) Vuda (load) - Funafuti - Tarawa - Santo

The supply sources for Fiji are Australia, New Zealand and Singapore. While most of the petroleum is imported from Australia, the pricing is based on Singapore as the source of the product. Thus, oil companies' actual freight costs are less than the allowed freight costs from Singapore.

3.3 Only three products are received in bulk: motor spirit, dual-purpose kerosene/jet A1 and ADO. The Funafuti marine receiving terminal, owned and operated by BP, has a capacity of approximately 600 tonnes for these three products. Aviation gasoline is received in drums and pumped into one of the two aviation fuelling trailers. There is a dedicated terminal for jet fuel only. In addition, there are two ADO trailers, which are used for delivery to TEC and for bunkering ships.

LPG

3.4 At present, small amounts of LPG (butane) are imported in 9, 13, 18, and 50 kg bottles from Fiji. The total 1990 volume is estimated at approximately 7.6 tonnes, which serves a small number of households. Since the LPG payload is less than half the total weight being shipped, this leads to high transportation costs, which is one of the factors behind the very high price of LPG in Tuvalu, averaging approximately A$2.40 per kg over 1988-90.

Electricity

Funafuti Power System

3.5 The TEC system comprises a diesel powered generating station, with four 150 kW sets, and an underground 11 kV distribution system supplying five substations, from which power is distributed to the consumers at low voltage by underground cables. Power system statistics for 1990 are shown in Table 3.1. By any standards, the TEC operation is very small.

Table 3.1: TEC POWER SYSTEM STATISTICS (1990)

Installed capacity diesel	4 x 150 kW	=	600 kW
Peak demand			263 kW
Generation			1,401 MWh
Load factor			60.8 %
Sales			1,120 MWh
Losses including station use /a			20.1 %
Power factor			0.8
			(0.7 - 0.84)

/a Losses measured as percentage of gross generation.

Source: TEC.

3.6 The present diesel power station was completed in 1982 with the commissioning of four 150 KW diesel generators. TEC is currently experiencing operational problems that limit the output of two of these generators, apparently due to inadequacies in the cooling system; otherwise, the units are in reasonably sound condition and should be capable of providing reliable services for another ten years or more. To remedy the cooling system problem, it is recommended that TEC arrange for an experienced mechanical engineer (diesel station/ventilation) to analyze the situation and recommend modification to ensure that the units can produce their full output. The details of the current generating units are shown in Table 3.2.

Table 3.2: TEC GENERATING PLANT /a

	Unit 1	Unit 2	Unit 3	Unit 4
Manufacturer/Type	Cummins/Onan		NT855G/ODFE-515H	
Speed (rpm)	1,500	1,500	1,500	1,500
Capacity (kW)	150	150	150	150
Year installed	1982	1982	1982	1982
Total Operating Hours	24,359	26,680	24,806	24,565

/a As of January 1991.

Source: TEC

3.7 Outside of TEC, the Mechanical Section of the Public Works Division of the MWC is responsible for the daily operation of the generator at the Motufoua

Secondary School, while maintenance is supplied by TEC. The genset at the Tuvalu Maritime School (TMS) is operated and maintained by TMS staff, while major TMS maintenance programs are handled by TEC. In addition, there are a few very small private diesel generating units in Tuvalu, but no information on these is available. In Funafuti, apart from the telecoms and broadcasting operations, the installed private diesel capacity is insignificant.

System Losses

3.8 The level of energy losses, including station use and distribution loss, on the TEC system appears to be high, of the order of 18 to 20% of gross generation (Table 3.3), although there are some doubts about the reliability of these estimates On a small, well-run system, the losses should not exceed 8-9%. Based upon data for 1989 and 1990, the station use is about 9%, though typical station use for diesel powered systems is less than 3%. Similarly, the distribution loss is about 10%, though for the small TEC system it should probably not exceed 5-6%. Thus, there appears to be a substantial potential for cost savings through reduction in system losses.

Table 3.3: TEC POWER SYSTEM LOSSES /a

Year	Distribution System MWh	Distribution System %	Station Use MWh	Station Use %	Total Losses %
1986	119.8	11.4	90.2	8.6	19.9
1987	n.a.	11.1	92.5	7.8	18.9
1988	n.a.	n.a.	n.a.	n.a.	17.7
1989	146.7	11.4	112.9	8.8	20.2
1990	147.9	10.5	133.1	9.5	20.1

/a Losses expressed as percentage of gross generation.

Source: TEC and various studies and reports.

3.9 As an initial step towards the reduction of system losses, it is recommended that TEC carry out an investigation to establish the level of system losses and the contribution of each source. This could be done through the accurate metering of (i) the units generated and the units used for station service, (ii) the largest 15-20 consumers, and (iii) a limited number of randomly selected other consumers. Once an accurate figure for the system loss is available, further investigation would be necessary to establish the sources (e.g., transformers, 11 kV cable, low voltage cables, non-technical loss, etc.). Based upon these findings, appropriate measures can be identified and taken to reduce the losses to an economically and technically satisfactory level to say, 8-9%.

3.10 As an example of the likely causes or sources of the high losses, spot readings taken by the mission indicate that the loading on the three phases of both the main supply transformer and the station auxiliary supply was quite unbalanced. This condition creates additional power losses as well as poor voltage conditions, and it should be corrected by reconnecting appropriate loads. Based upon a brief perusal of station log sheets, the system power factor is low, with an average value of 0.8, and a range of 0.70 to 0.84. Measures, such as adding capacitors, to improve the system power factor to at least 0.9 will certainly be economically justifiable in reducing system energy losses.

Funafuti System Expansion

3.11 Generation. Given the investment in the existing system and the size and density of the electric load, diesel powered generation is the only economically and technically viable source of electricity for Funafuti. However, solar photovoltaics is economically more appropriate for most outer island electrification than diesel systems, and this situation is not expected to change over the next ten years, while the household loads are limited to very small loads (lighting, radios) and larger loads such as refrigerators.

3.12 Since TEC has no formal system development plan, a preliminary least cost development plan has been prepared (Table 3.4 and Annex 4). This plan is based on the projected average annual growth rates of 4.4% for energy sales and 5.6% for peak demand. The reserve capacity criterion is that the installed capacity should be sufficient to meet peak demand in the absence of the two largest units, which is similar to the criterion in use now. This criterion is appropriate for Tuvalu, given its distance from suppliers of parts, equipment, and technical services. Further, under normal operating conditions, the capacity of the diesel units is considered to be 85% of their nameplate rating. Diesel units are designed typically to achieve maximum technical efficiency (lowest fuel consumption per kWh) at 80-85% of their nameplate rating. Further, operation at this level, rather than at the nameplate level, is less stressful on the units, which leads to more reliable operations and longer operating lives.

3.13 On this basis, the 1992 projected peak demand of 343 kW exceeds the firm capacity (255 kW) available with the existing units. In other words, three of the four units will have to operated at the time of peak demand. When a unit is down for maintenance or on fault, there will be inadequate capacity to meet the peak demand if another unit should be unavailable for whatever reason. Thus, the installation of additional generating capacity in 1991/92 is essential to maintain reliable service security.

3.14 To meet the increase in demand, the least cost option is to install another 150 kW unit in the remaining spare bay of the existing station. This should suffice to meet the projected demand until about 1996. To meet the growing demand beyond that date, TEC would have to install a new station and consider the alternatives of continuing with the 150 kW units or beginning a new series of 250 kW units. In view of the uncertainties associated with the long term forecast, it is recommended that TEC review this question with updated information in 1993, when a decision on the new plant would have to be made.

3.15 Transformers. The capacity of the two existing main transformers, which step up the generated power to 11 kV, to distribute power in the system is rated at 350 kVA, which has been adequate to provide security of supply in the past in the event of the failure of one of the transformers. However, in the future, based upon the projected peak demand and the poor system power factor, it is estimated that one transformer will no longer be able to carry the full load. Thus, if one of the two transformers failed, selective load shedding will be necessary at peak demand time during the many months it could take for a replacement transformer to reach remote Tuvalu. Hence, it is desirable to add a third 350 kVA main transformer (including 11 kV circuit breakers, relay protection and control) within the next two years, even though the probability of transformer failure is low. Apart from increasing the security of supply, this additional transformer will also bring the loading on the transformers closer to the level that would minimize system losses.

3.16 Distribution. The ring-main 11 kV underground cable distribution system appears adequate to meet the foreseeable requirements. As shown in Table 3.4 additional substations and transformers can be integrated into the system to provide adequate capacity to supply major new consumers or cater for heavy load growth.6/

3.17 Investments. In the 1991-1995 period, the main capital expenditures envisaged are for additional generating capacity, an additional main transformer, and additional transformer substations (Table 3.4). Some capital expenses, which will depend upon the recommendations of the proposed System Loss study (paragraph 3.9), will also be likely necessary to improve the system power factor. For the sake of completeness, notional sums related to system power factor improvement have been included in the Plan, which is shown in Annex 4. On this basis, the total investment requirements for the period are estimated to be about US$135,000 in 1991 prices.7/

6/ Information on a proposed extension of the 11 kV spur distribution feeder from the wharf northwards was not available to the mission in February 1991. However, a study "Asset Revaluation and tariff Study for the Tuvalu Electricity Authority," April 1991 indicates that extension will serve about 50 households, 6 chicken farms, a piggery, a guest house, a Catholic center, and a large, two-storey boarding secondary school.

7/ According to the "Asset Revaluation and Tariff Study for the Tuvalu Electricity Authority," the cost of the proposed northwards extension will be A$743,000. Given this high cost, and the limited number of customers this extension will serve, it is recommended that GOT consider alternative means of serving these customers.

Table 3.4: POWER DEVELOPMENT PLAN SUMMARY

Year	Project	Cost US$ '000, Constant 1991 Foreign Component	Local Component	Total
1992	Install and commission 1 x 150 kW diesel generator and associated auxiliary equipment, elec. switchgear and controls.	61	3	64
	Spare parts (incl. in main contract).	7	0	7
1992	Install 11 kV - 415/240 v 160 kVA substation to meet additional demand (Telecoms, new hotel).	11	1	12
1993	Install 350 kVA main transformer including associated cabling, circuit breakers, protection and control, modify existing substation.	27	3	30
1993	Capital projects for loss reduction as recommended in study to be made in 1992.	8.5	1.5	10
1994	Install 11 kV - 415/240 kW substation.	11	1	12
1992-95	Total	125.5	9.5	135

Source: Mission projections and estimates.

3.18 To implement the recommended Power Development Plan, TEC should arrange for the necessary studies and investigations as well as for the financing for the additional 150 kW generating unit. The work should be scheduled to achieve an in-service date for this generating unit to be no later than the end of 1992, and earlier, if possible.

Solar Energy

3.19 The solar resource appears good on all the islands, with few long cloudy periods and high levels of radiation on clear days due to the clean air. The chief agency responsible for developing the energy potential of this resource is TSECS. The initial funds for TSECS came from USAID, and this allowed the installation of 170 single-panel PV systems for minimal lighting purposes. Unfortunately, the systems were installed without charge/discharge controllers for the storage batteries. Consequently, battery failures began occurring within six months after installation. In 1985, a European Community (EC) project provided an additional 150 units. These also encountered problems due to a poor design of the charge/discharge controller. Also, the battery chosen by the EC later proved to be unsatisfactory. The design flaws of these initial systems were overcome through a French Government grant, which provided 200 replacement batteries and controllers, thereby making all the systems operational.

3.20 The customers frequently complained that the single-panel systems were inadequate, and a study by the Energy Studies Unit of the University of the South Pacific confirmed this. Following this, the EC agreed to upgrade 170 systems to two panels, and to provide replacements for the poor quality controllers, lights, and batteries received under the 1985 scheme. When the upgrade project is complete, nearly all the systems will have two panels, a reliable battery, and a controller that has been well proven in the Pacific environment.

Biomass

3.21 The biomass available for energy use consists almost exclusively of products of the coconut trees. Though the primary fuel from the coconut tree is coconut husks and shells, fronds and stems are also used as fuel. Pandanus and breadfruit trees are present in quantity but their use results in little biomass waste useful for energy purposes. Mangrove areas also common in most of the islands, but their ecological significance for fish breeding, etc., precludes their use for fuelwood other than on a minor, household basis.

3.22 The present rate of production of copra does not provide sufficient husk and shell waste to meet more than normal household fuel needs. Should the price of coconut products rise dramatically and copra production increase several fold (which is a remote possibility), sufficient waste might become available for a small steam power plant, but it is not recommended that investment in such systems be made without assurance of fuel supply for at least ten years.

3.23 The replacement of senile coconut trees for plantation rejuvenation could provide sufficient biomass for energy use beyond the household fuel level. On some of the larger islands, senile coconut tree cutting could provide as much as a ten year supply of wood fuel for a village steam electricity system. Since the long term storage of cut coconut trees is impractical, it would be necessary to carefully schedule tree cutting to directly meet wood fuel demand. With tree ownership spread over hundreds of households, this is a very difficult task. Before any investment is made, the potential modest energy benefits need to be carefully weighed against the social and administrative problems that could result.

IV. POLICY AND INSTITUTIONAL ISSUES

Petroleum Subsector

Petroleum Product Prices

4.1 Petroleum product prices are set by the supplier (BP) on the basis of its own landed costs plus customs duties and sales taxes, which are set by the GOT. The sales tax is charged as 5% of the FOB value plus local customs duty. The duty for motor spirit is A$0.06/liter, and for ADO, A$0.005/liter, while aviation gas and kerosene/jet A1 are free of local customs duty. These rates of taxation are extremely low in comparison with other countries; for example, for motor spirit, which is the most heavily taxed petroleum product, the customs duty and sales tax are less than 10% of the retail price.

4.2 Price Monitoring. There is no system of petroleum product price control or even monitoring in Tuvalu. The detailed price build-up for the Tuvalu landed cost appears to be unknown to local authorities, including the local BP manager. The Tuvalu BP manager changes the wholesale ex-depot prices only on specific instructions from the finance manager BP Fiji. In the absence of any such instructions, the prices were not changed from April, 1990, to November, 1990, even though changes in the Singapore price indicate a possible downward adjustment in August or September, 1990. This is indicative of the need to monitor prices to ensure that Tuvalu pays the lowest possible price of imported petroleum products.

4.3 To keep the GOT informed of the oil companies practices in this regard, and to assist it in identifying and addressing problems as they arise, it is recommended that GOT acquire from BP detailed price build-up information on a regular basis. However, at present, GOT does not have the capability of assessing the reasonableness of price levels and adjustments from such information. To overcome this shortcoming, it is recommended that GOT arrange for additional support from a regional energy agency in the form of the standard sets of international petroleum product price and freight information required to analyze each line on the BP landed product cost build-up. About one year ago, on the basis of talks with BP, the Tuvalu energy planner prepared a draft "Guidelines" paper on petroleum pricing in Tuvalu, and how GOT could monitor prices. It is recommended that GOT request some regional experts to critique and update this study, and to train a Tuvaluan to monitor prices with the assistance of some spreadsheet templates. These experts should also assist in running through a few test calculations on past price adjustments.8/

4.4 There are several retail outlets on Funafuti, which sell the three fuels supplied by BP. The main outlet is the Fusi Co-op. Near the Fusi, there are several other small shops, which also sell these three products from drums. Again, there is no control or monitoring of the retail prices set by the Fusi or the smaller outlets. A survey on February 12, 1991 showed that on that day Fusi

8/ By December 1991, BP was supplying GOT with a detailed price build-up for the Tuvalu landed cost of petroleum. GOT assesses the reasonableness of this information with the assistance of FSED.

and two other shops charged the same price for kerosene (A$0.90/liter), but Fusi charged more for motor spirit than the two shops. Only one of the two shops sold ADO, and its price of A$0.82/liter was more than Fusi's price of A$0.65/liter.

Petroleum Products and Regulatory Concerns

4.5 There is an important environmental concern related to the marine terminal used in the import of petroleum products. While the general condition of the BP terminal yard and facilities appears to be acceptable, there is a lack of an oily water collection system and separator, which would prevent oil spillage from inside tank firewalls and the general yard area from finding its way into the lagoon. To control this environmental hazard, it is recommended that GOT seek the assistance of experts from a regional energy agency, or other sources, as appropriate.

4.6 The Fusi Co-op has two above-ground horizontal tanks for motor spirit and kerosene, as well as drums of ADO, outside its store in built-up area of the town. This operation has many potential hazards:

(a) a high risk of fire/explosion because of poor equipment and substandard filling procedures. The tanks appear to be poorly maintained, the vents are pouring out volatile fumes, the customers' containers are splash-filled, and the ground around the ADO drum area is saturated with oil.

(b) a high likelihood of the spread of any fire/explosion to the surrounding population. The clearances are practically non-existent; there is a school building within 6 meters of the tanks; there are no firewalls (bunding) to contain the contents of the tank in the event of rupture.

(c) the pollution arising from the very obvious volatile, lead-containing fumes escaping from the gasoline tank, and from the spillage around the filling area.

The smaller shops near Fusi are also unsafe, since the drum storage/dispensing areas are generally indoors, and there is evidence of spillage on the floors.

4.7 There is a clear need to control these potential hazards. It is recommended that GOT seek the assistance of specialized experts from a regional energy agency.

Possible Reduction in LPG Price

4.8 One of the reasons for the current relatively high price of LPG of $2.40/kg is high transportation costs associated with low levels of LPG imports. Therefore, one issue is the extent to which LPG price would fall if the scale of the market increased. Taking into account heat value and efficiency differentials, at this LPG price, for most consumers it would be worthwhile to switch from kerosene to LPG only if the kerosene price is more than A$1.10 - 1.20/liter. Since kerosene currently sells for A$0.90/liter, it is not surprising that LPG has made few inroads into the household cooking market. In the long term, however, kerosene prices should decline to about A$0.70/liter, based on present international prices. At this lower price of kerosene, for most consumers it would be worthwhile to switch to LPG only if the LPG price is A$1.50/kg or less.

4.9 Provided the LPG price is A$1.50/kg or less, the total penetration of the Funafuti household cooking market would imply a total annual consumption of approximately 100 tonnes of LPG. At this scale of the market, which is approximately twelve times the current scale of 7.6 tonnes, one possible way of reducing the LPG supply cost and associated burner-tip price is the bulk supply of LPG via tanks on the deck of the vessels of a regular shipping line (e.g., Pacific Forum Line) into a small receiving terminal at Funafuti. A preliminary analysis (Table 4.1) indicates that it worthwhile undertaking a more detailed pre-feasibility study to analyze the economic potential of replacing kerosene by LPG in cooking. Another possible way of reducing LPG costs would be the supply of LPG in larger containers or cylinders, combined with local decanting into 13 kg bottles. It should be noted that an entrepreneur in Tarawa, Kiribati, who currently imports 50 kg LPG cylinders and decants to smaller sizes, is anticipating a switch to bulk importation, based on offloading from on-deck tanks of a Pacific Forum line freighter loaded in Fiji. There is the possibility of integrating a drop-off in Funafuti with this supply movement to Tarawa.

Table 4.1: POTENTIAL COST OF BULK LPG SUPPLY, FUNAFUTI

Element of Cost	Cost /a
	A$/tonne
LPG, FOB Australia/Singapore	200
Freight to Fiji	350
Fiji Depot Costs	50
Freight to Funafuti	500
Funafuti Depot/Distribution Costs	300
Total Costs	1,400
Equivalent to	A$1.40/kg

/a Preliminary estimates.

Source: Mission estimates.

4.10 In view of the above, it is recommended that a pre-feasibility study be conducted to determine the benefits of importing LPG in bulk or large containers, combined with local decanting. This study should compare four options: (i) the base case, which is the current system, (ii) import of filled 50 kg cylinders from Fiji, with local decanting to smaller sizes, (iii) import of standard containers (about one tonne each) from Fiji, with local decanting to smaller sizes, (iv) bulk import from Fiji, with offloading of LPG from on-deck pressurized tanks of the freighter into a small receiving depot, with local decanting to smaller sizes. This study will require two work-months, with a cost of approximately $30,000.9/

Electricity Subsector

Power Tariff

4.11 For all consumers, TEC's present tariff is A$0.30/kWh for the first 100 kWh per month and A$0.38/kWh for the consumption in excess of 100 kWh per month. This tariff has remained unchanged since 1982.

4.12 Although TEC's financial figures for 1989, the latest year for which accounts are available, show a surplus of revenue over expenditures, these expenditures exclude capital charges or insurance expenses. If capital charges are included in expenditures on an annuitized basis, then TEC makes a loss, with an implied subsidy on electric consumption of A$0.04/kWh. TEC's capital assets (including engines, generators, power house, transmission and distribution system) were largely provided through overseas aid. Since TEC's tariff makes no allowance for fluctuations in fuel prices, the extent to which TEC's revenues cover expenditures varies with the price of fuel.

4.13 TEC is presently undertaking a review of its tariffs, and it is recommended that this study address:

(a) the desirability of incorporating an automatic fuel price adjustment clause within the published tariff.

(b) the desirability of different tariffs for residential and non-residential consumers, reflecting the variances in electricity consumption patterns between these consumer groups.

(c) the need for the tariffs to recover the full costs of electricity, including capital charges and insurance costs, in order to ensure the financial viability of the utility.10/

Strengthening TEC

4.14 The Tuvalu Electric Authority Corporation Act of 1990 changed TEC's status from a Government agency to a corporation, but has left unresolved a number of issues. Thus, there still remains an urgent need to strengthen TEC.

9/ In December 1991, the GOT was considering shifting the responsibility for LPG imports either to a privately-owned and operated company or the Tuvalu Cooperative Wholesale Society.

10/ The study, completed in April 1991, recommended that an automatic fuel price adjustment clause be incorporated in the tariff. By December 1991, this clause has already been incorporated. The study recommended against different tariffs for residential and non-residential consumers, but proposed peak/off-peak pricing for major consumers, and different fixed charges for single-phase and three-phase supply. The study recommended that tariffs recover the full costs of electricity supply.

4.15 Corporate Accounting. At present, from a financial viewpoint, TEC is still treated as a Government department rather than as a corporation or a statutory authority. In particular, TEC's annual budget is allocated by the Treasury from Government revenues based solely on TEC's expected operating expenditures, which are mainly fuel costs and wages. However, TEC's actual costs also include depreciation charges, calculated on revalued fixed assets. As a result of the failure to take account of depreciation charges, there is no real connection between the budget allocations and TEC's actual costs. Further, under the present accounting system, TEC's management is unable to assess the effectiveness of potential engineering innovations or even of improvements in O&M, much less the relative worth of future capital investments. If the full benefits of TEC's change in status are to be realized, then the necessary first step towards the commercialization of TEC is the establishment of a proper corporate accounting system.

4.16 Adequacy of Records. In addition, at present TEC lacks an adequate system of records for operating data, including power station and distribution system loading information, fuel consumption, energy generated, peak load, energy sold, and revenues. TEC cannot operate efficiently without this information. To remedy this shortcoming, it is recommended that TEC implement a simple, but comprehensive, system of records designed to assist management in identifying the areas of operations that need improvement, determining plant and equipment expansion needs, and assessing TEC's financial condition. TEC should establish such a management information system on an urgent basis, and maintain the records on a routine basis. This would not be expensive, as it could be done on two AT-class PCs (one PC as a back-up) with standard spreadsheet software.

4.17 Staffing and Organization. TEC's organization chart shows separate positions for an Accountant and an Accounts Clerk, but the Accountant position is vacant. This position may be difficult to fill because, at present, Tuvalu does not have a single certified accountant. However, at TEC's present level of operations, the Accountant and Accounts Clerk positions could be combined into one. One possible option is that GOT recruit one accountant immediately, whose services would be shared by a number of government agencies, including TEC and TSECS. As an interim measure, which would also be useful to train a qualified Tuvaluan, the GOT should consider the use of UN volunteers as accountants.

4.18 Corporate Objectives. TEC's status change has resulted in much greater responsibility for the General Manager and other senior staff members. It is necessary for the Board of Directors, in consultation with the General Manager, as appropriate, to determine TEC's objectives, to establish clear policies, and to determine the responsibilities and authority of the General Manager. Further, the Board should set targets or goals to be reached in a given time period.

4.19 Organizational Structure. TEC's generating and distribution system can be efficiently operated by a small organization using straightforward procedures and systems. The present organizational structure (Annex 5) and manning level are appropriate in general arrangement, but would benefit from some modifications. While present staff level of 24 is reasonable, the role of the Inspection Division could probably be filled by one person instead of the current two persons, and the meter reading duties, currently under the Inspection Division, could be moved to the Finance Division. One secretary should be adequate for all of TEC.

4.20 Training. The future effectiveness of TEC's operations will depend more upon the competence of the staff than on the number of employees. There is a need for additional training of TEC staff at all levels. In the absence of training facilities in Tuvalu, the training can take place in neighboring Fiji, where a training school is operated by the Fiji Electric Authority.

4.21 Maintenance. As a general practice, but particularly at present, as plant reserve margins decline with increasing system demand, it is essential that the maintenance of the generating units and all auxiliary units be carefully planned and programmed. Further, in view of Tuvalu's distance from major suppliers and long delivery times, above average stocks of materials and parts should be on hand for both planned maintenance and unexpected breakdowns, based on the experience at the station.

4.22 Regulatory Issues. TEC's change of status has also raised a number of other issues that need to be resolved. These include:

(a) the value at which the fixed assets are to be transferred to TEC.

(b) the appropriate financial (debt:equity ratio) and shareholder structure for TEC.

(c) whether or not TEC is required to pay corporate income tax.

(d) the general nature of the relationship between GOT and TEC, and in particular, the extent of the autonomy to be granted to TEC to determine its own capital expenditure and revenue (tariff) policy.

Solar Energy

4.23 Role of TSECS. Over the years, TSECS has evolved to the point where it is able to properly administer and maintain nearly 300 outer island solar installations. After some teething problems, TSECS has now proven itself capable of operating and maintaining the systems, and maintaining general customer satisfaction. It is working well, and no change in its structure or mode of operation is recommended. In particular, no attempt should be made to merge TSECS and TEC. Though the general competence of TSECS is good, technical assistance to TSECS in the form of periodic expert visits would be valuable to solve specific problems, to identify trends, to assist in budgeting and planning, and to assist in upgrading the quality of accounting and businesses practices. TSECS staff in Funafuti would benefit from short courses in management, accounting, computer use, and solar technology. For the field staff, there are already some courses, based on materials provided by PEDP and SPIRE, but the training quality could be improved by the provision of specialized training equipment, training videos, and text material in the Tuvaluan language.

4.24 To achieve better utilization of its resources, it is recommended that TSECS attempt to secure maintenance contracts for GOT solar installations in the outer islands, notably in communications and health. However, because TSECS operational costs are a significant part of the TSECS tariff, TSECS should not attempt to increase its staff or facilities, particularly office and workshop space, which would increase operational costs, unless near term financial returns will clearly result.

4.25 Pricing. At the present time, membership in TSECS costs A$50, with a monthly fee of A$6.25 for a single-panel system, and A$7.60 for a two-panel system. At present, TSECS earns roughly A$1.00 per month (out of the single-panel A$6.25 charge). The break-even point for TSECS operations is roughly 300 members, not including replacement costs. Thus, the present level of tariffs provides for operation and maintenance costs, but is inadequate for the expansion or the replacement of the solar panels at the end of their useful life (10-15 years). It is recognized that the existing level of service is insufficient to warrant full charges to customers. However, a general upgrading of installations to a uniformly adequate level of service is underway, and as services improve, TSECS should strive to bring its tariff structure to a level that provides for full capital replacement costs, which should be determined by open market tender. It is estimated that, given the membership fee and TSECS current reserves, a monthly charge of A$10.00 per month would be sufficient to ensure the long term financial viability of TSECS, assuming a membership base of 500, and the awarding of all solar power-related government contracts to TSECS. While this cost is considerably above TEC's current tariff on Funafuti (on a per kWh basis), it is estimated that solar energy will remain the least cost alternative for lighting on the outer islands until such time as the load densities increase significantly.

4.26 Investments. Funding for the general increase in the capacity of solar systems for those customers able to pay will be needed after 1993. Though aid will be sought, these systems will be provided to wealthier customers, and their ability to pay may be sufficient to allow initial capital investment to be from loans rather than grants. New capital investment of about A$150,000 per year for five years is expected to be needed for this purpose.

4.27 Environmental Concern. For solar PV systems, a system for reclaiming lead from spent lead acid batteries should be developed to prevent possible environmental damage.

Biomass, Wind and Ocean Energy Development

4.28 Biomass. The adverse environmental effects of biomass based energy development could be significant, and caution is urged in the development of this resource. Only development that is based on sustainable agricultural waste should be contemplated. Fuel wood plantations are not appropriate in the limited space and fragile ecosystems of the atoll environment. The use of senile coconut trees for biomass must also be viewed with caution, due to the requirement for vehicular access and resulting environmental damage.

4.29 Wind Energy. Wind measurements are available from all the islands. Winds are very seasonal with consistent energy quality winds from about November to March, but for the rest of the year, the winds are weak and variable. Winds are similar throughout the country. Since the islands are uniformly low, with no topographic features, few wind microclimates exist, and the location of a wind machine is not critical so long as it is high enough to be clear of the turbulence from trees. Since trees are typically 30 meters high, the machine would have to 40-50 meters high. This problem and the combination of a poor wind regime and the difficulty of maintaining rotating mechanical and electrical equipment in the corrosive atoll environment precludes the use of wind-power for anything more than the non-critical task of water pumping. Therefore, it is recommended that no efforts be made to develop wind energy in a major way.

4.30 OTEC. There is some OTEC potential in Tuvalu, but given the very limited land areas of the country and its fragile ecosystem, it is recommended that OTEC development not be considered until commercially operated systems have been in operation long enough to judge their economics and their effect on the environment.

4.31 Tidal Energy. The enclosed lagoon at Vaitupu has a small entrance way which could be the site of a tidal energy system, but it is recommended that such development not take place because partially isolating the lagoon could have adverse effects on the ecology of the lagoon. The use of the lagoon as a food resource appears much more appropriate than as an energy resource.

4.32 Wave energy is limited, though it appears to be a significant energy resource. In the absence of any coastal features other than low-lying reefs, wave energy is expected to be difficult and expensive to tap even when commercially proven equipment is generally available in the future. At present, it is recommended that wave energy not be considered until commercially operated systems have been in operation long enough to judge their economics and their effect on the environment. However, it is worthwhile for GOT to request an agency such as SOPAC to measure and monitor the wave energy potential, assuming there are no opportunity costs of doing so.

V. INVESTMENT AND TECHNICAL ASSISTANCE PRIORITIES

Sectoral Development Priorities

5.1 According to the Tuvalu National Development Plan, 1988-1991, the overall aim of the GOT is to ensure that the supply of energy is consistent with its development objectives - that is, increased rural production, support for the growth in commercial activities, and support for the social and economic development of the outer islands. The specific aims are to:

(a) reduce the cost of energy by improving the efficiency of its use, and where possible, by reducing the supply price of primary fuels;

(b) ensure that the cost of the different forms of energy being provided are affordable and are equitably shared by all sections of the population;

(c) develop forms of energy production that are appropriate to the climate, conditions and technological status of the country.

5.2 Over the next ten years, Tuvalu's energy sector will continue to depend upon imported petroleum products, which will be used throughout Tuvalu, and solar energy, which will be used on the outer islands. The main themes for the next decade will be better use of existing assets and resource' and cautious expansion. Apart from solar energy, the other known indigenous resources in Tuvalu are biomass, ocean energy and wind energy. Since these two resources have not yet had any technical or economic success in the Pacific region, it is recommended that GOT take advantage of any programs that exist for data gathering related to wind and ocean energy, but the physical development of these resources be postponed until they are proven commercially in the Pacific island environment.

5.3 While biomass will continue to be used by households for cooking and lighting, the use of solar power for lighting and LPG/kerosene for cooking will increase. The adverse environmental effects of biomass based energy development could be significant, and it is recommended that caution be used in considering the development of this resource. Only development that is based on sustainable agricultural waste should be contemplated. Fuel wood plantations are not appropriate in the limited space and fragile ecosystems of the atoll environment. The use of senile coconut trees for biomass must also be viewed with caution, due to the requirement for vehicular access and resulting environmental damage.

Petroleum Subsector

5.4 Price Monitoring There is no system of petroleum product price control or even monitoring in Tuvalu, and the detailed price build-up for the Tuvalu landed cost appears to be unknown to local authorities. It is recommended that GOT acquire from BP detailed price build-up information on a regular basis, and assess the reasonableness of price levels and adjustments with the assistance of regional experts. (See paragraphs 4.2-4.3)

5.5 Regulatory Concerns There is an important environmental concern related to the marine terminal used in the import of petroleum products. The BP marine terminal lacks an oily water collection system and separator, which would prevent oil spillage from finding its way into the lagoon. It is recommended that GOT seek the assistance of regional experts to control this environmental hazard. (See paragraph 4.5.)

5.6 The Fusi Co-op and the smaller nearby shops have many potential hazards, such as a high risk of fire/explosion, a high likelihood of the spread of any fire/explosion to the surrounding population, and the pollution from the fumes escaping from the gasoline tanks and from the spillage around the filling areas. It is recommended that GOT seek the assistance of specialized technical experts from a regional energy agency, or other sources, as appropriate. Further, it is recommended that the Director of Works, GOT, with assistance from regional experts, prepare and maintain a complete file on these facilities and document their deficiencies. Later, the elimination of these deficiencies could be pursued, again with external support from regional experts, in a continuous and sustained way. (See paragraphs 4.6 and 4.7)

5.7 LPG. It is recommended that a pre-feasibility study be conducted to determine of the potential reduction in LPG costs by importing LPG in bulk or large containers, combined with local decanting. (See paragraph 4.10)

Power Subsector

Strengthening TEC

5.8 While TEC's status has changed from a Government department to a corporation, there remain a number of unresolved issues related to this change. First, TEC's annual budget should take account of depreciation charges, calculated on revalued fixed assets. Since a proper corporate accounting system is needed to take full advantage of TEC's corporate status, it is recommended that TEC take the necessary steps to implement such a system. For this purpose, TEC may combine the Accounts Clerk and the Accountant position, and use one accountant whose services would be shared by a number of government agencies. Another option is to try to get a UN volunteer accountant. (See paragraphs 4.15 and 4.17.)

5.9 Second, it is recommended that the GOT determine TEC's financial status and the extent of TEC's autonomy to determine its own capital expenditure and tariff policy. (See paragraph 4.22.)

5.10 Third, it is recommended that TEC's Board of Directors, in consultation with the General Manager, determine TEC's overall objectives and policies, the role of the General Manager, and set targets to be reached in a given time period. (See paragraph 4.18.)

5.11 At present TEC lacks an adequate system of records for operating data, without which it cannot operate efficiently. It is recommended that TEC urgently implement a simple, but comprehensive, system of records designed to assist management in identifying the areas of operations that need improvement, determining plant and equipment expansion needs, and assessing TEC's financial condition. (See paragraph 4.16.)

5.12 While TEC's organizational structure and manning level are generally appropriate, the present staff level of 24 may be increased to 29-30, but not to the full authorized level of 34 staff. There is a need for additional training of TEC staff at all levels, which could take place in Fiji. (See paragraph 4.17 and 4.19.)

Power Tariffs

5.13 It is recommended that TEC's forthcoming study of tariffs address (i) the desirability of incorporating an automatic fuel price adjustment clause, (ii) the desirability of different tariffs for residential and non-residential consumers, and (iii) the need for the tariffs to recover the full costs of electricity, including capital charges and insurance costs. (See paragraph 4.13)

Operational Issues

5.14 TEC's Cooling System. TEC's output from two of its is generators is limited by inadequacies in the cooling system. It is recommended that TEC arrange for an experienced engineer to analyze this problem and recommend steps to ensure that the generating units can produce their full output. (See paragraph 3.6.)

5.15 Loss Reduction Study. TEC should reduce its relatively high system losses (20%). As an initial step, it is recommended that TEC should carry out an investigation to establish the level of system losses and the contribution of each source. Based upon these findings, appropriate measures can be identified and taken to reduce the losses to an economically and technically satisfactory level. Spot readings taken by the mission indicate that the loading on the three phases of both the main supply transformer and the station auxiliary supply was quite unbalanced. This condition creates additional power losses as well as poor voltage conditions, and it is recommended that this problem should be corrected by reconnecting appropriate loads. (See paragraphs 3.8-3.10.)

5.16 Power Factor Improvement. TEC's system power factor is low, with an average value of 0.8, and a range of 0.70 to 0.84. It is recommended that measures be taken to improve the system power factor to at least 0.9, as this will reduce system energy losses. (See paragraph 3.10.)

5.17 Maintenance Planning. The maintenance of the generating units and all auxiliary units be carefully planned and programmed. In view of Tuvalu's distance from major suppliers, it is recommended that TEC maintain above average stocks of materials and parts. (See paragraph 4.21)

Expansion Plan for TEC

5.18 Given the existing system and the size and density of the electric load, expansion of diesel powered generation is appropriate for Funafuti, but not for the outer islands, where it is appropriate to expand solar photovoltaics. To meet the increase in demand on Funafuti, the least cost option is to install another 150 kW unit in the remaining spare bay of the existing station. This should suffice to meet the projected demand until 1996. To meet the growth in demand after 1996, TEC should review its options with updated information in

1993, when a decision on the new plant would have to be made. (See paragraphs 3.11-3.14.)

5.19 It is desirable to add a 350 kVA main transformer (including 11 kV circuit breakers, relay protection and control) within the next two years. Apart from increasing the security of supply, this additional transformer will also bring the loading on the transformers closer to the level that would minimize system losses. (See paragraph 3.15.)

5.20 In the 1991-1995 period, the total investment requirements for the period are tentatively estimated to be about US$135,000 in 1991 prices. (See paragraph 3.17.)

5.21 TEC should immediately arrange for the studies and the financing associated with the additional 150 kW generating unit. (See paragraph 3.18.)

Solar Energy

5.22 Role of TSECS. TSECS is working well, and it is recommended that there be no change in its structure or mode of operation. In particular, no attempt should be made to merge TSECS and TEC. TSECS needs technical assistance in the form of periodic expert visits, and TSECS staff in Funafuti and the field need further training. To achieve better utilization of its resources, it is recommended that TSECS attempt to secure maintenance contracts for GOT solar installations in the outer islands. However, TSECS should not attempt to increase its staff or facilities unless near term financial returns will clearly result. (See paragraphs 4.23 and 4.24.)

5.23 Pricing. The present level of TSECS tariffs is inadequate for the expansion or the replacement of the solar panels at the end of their useful life. It is recommended that, over time, TSECS raise its tariff so that it recovers full capital replacement costs. (See paragraph 4.25.)

5.24 Investments. Investments of about A$150,000 per year for five years are expected to be needed for the expansion of solar capacity after 1993. Though aid will be sought, these systems will be provided to wealthier customers, and their ability to pay may be sufficient to allow initial capital investment to be from loans rather than grants. (See paragraph 4.26.)

5.25 Environmental Concern. It is recommended that TSECS develop a system for reclaiming lead from spent batteries to prevent possible environmental damage. (See paragraph 4.26.)

Biomass, Wind and Ocean Energy Development

5.26 It is recommended that, at present, no efforts be made to develop these forms of energy in Tuvalu. (See paragraphs 4.28-4.32)

TUVALU

COUNTRY ENERGY ASSESSMENT

Tuvalu - TEC Historical Electrical Statistics (1985-90)

Year	Energy sales (MWh)	Sales growth (%)	Distribution losses (MWh)	Distribution losses (%)/a	Station Use (MWh)	Station Use (%)/a	Total loses (%)/a	Energy generation (MWh)	Load factor (%)	Peak demand (kW)	No. of consumers	No. of electric households
1986	842.7	n.a.	n.a.	11.3	90.2	8.6	19.9	1,052.7	58.6	205	381	292
1987	962.2	14.2	n.a.	11.1	92.5	7.8	18.9	1,186.1	64.5	210	423	354
1988	1,025.3	6.6	n.a.	n.a.	n.a.	-	17.7	1,245.5	66.1	215	n.a.	361
1989	1,025.1	0.0	146.7	11.4	112.9	8.8	20.2	1,284.8	63.8	230	n.a.	370
1990	1,120.3	9.3	115.4	8.5	129.9	9.5	18.0	1,365.6	66.3	235	469	401
Av. annual growth (%)												
1986-90	7.4							6.7		3.5	7.2	6.6
1988-90	4.5							4.4		4.5		5.5

/a Losses expressed as a percent of gross generation.

Source: TEC, MFCP and various studies and reports.

ANNEX 2

TUVALU

COUNTRY ENERGY ASSESSMENT

Projected Electricity Generation, Peak Demand and Sales (1990-2000)

Year	Energy sales (MWh)	Energy losses /a (MWh)	Energy generation (MWh)	Peak demand (kW)	Load factor (%)
1990 (Actual)	1,120	246	1,366	235	66.4
1991	1,185	261	1,446	273	60.4
1992	1,376	303	1,679	343	55.8
1993	1,530	337	1,867	365	58.4
1994	1,556	342	1,898	371	58.4
1995	1,577	347	1,924	376	58.4
1996	1,609	354	1,963	383	58.5
1997	1,634	359	1,993	389	58.5
1998	1,655	364	2,019	394	58.5
1999	1,687	371	2,058	400	58.7
2000	1,718	378	2,096	407	58.8
Av. annual growth (%)					
1990-1995			7.1	9.9	
1995-2000			1.3	1.6	
1990-2000			4.4	5.6	

/a Losses assumed to remain at the 1990 level of 18% of gross generation. Losses include distribution losses and station use.

Source: Mission projections.

ANNEX 3

TUVALU

COUNTRY ENERGY ASSESSMENT

Projected Electricity Sales by Consumer Classification
(1990-2000)

Year	Government	Commercial & large residential	Domestic	Total sales
	(MWh)			
1990 (Actual)	412	424	284	1,120
1991	448	433	304	1,185
1992	554	497	315	1,376
1993	587	622	321	1,530
1994	595	634	327	1,556
1995	602	643	332	1,577
1996	613	658	338	1,609
1997	619	670	345	1,634
1998	626	679	350	1,655
1999	638	693	356	1,687
2000	647	709	362	1,718
Av. annual growth (%)				
1990-1995	7.9	8.7	3.2	7.1
1995-2000	1.5	2.0	1.7	1.6
1990-2000	4.6	5.3	2.5	4.4

Source: Mission projections.

TUVALU

COUNTRY ENERGY ASSESSMENT

Power Development Plan

Alternative generating options were compared for a period from 1991 to 2005. This end date provided a reasonably equivalent basis for the comparison of the schemes. The capital costs, fuel cost, and operation and maintenance costs were included in the least cost analysis.

COST ESTIMATES

Diesel generator	US$ (1991)
Landed price Funafuti cif of 1 x 150 kW air-cooled (radiator) diesel powered, generating at 415 v 3-phase 50 hz, complete with all accessories	35,000
Local transportation and handling	900
Electrical panel, controls, cabling etc.	13,000
Installation, testing and commissioning	15,500
Subtotal	64,400
Contingencies	9,500
Total, excluding taxes and duties	70,900
of which	
Foreign exchange component	68,000
Local cost component	2,900

Power Station Building

A prefabricated structure of relatively simple construction and arrangement is assumed. It would be erected on a concrete slab, designed to accommodate the loadings of the diesel units and other equipment. No overhead crane is envisaged.

	US$ (1991)
Prefabricated building landed in Funafuti cif	37,000
Civil works	10,000
Fuel storage, piping etc.	6,000
Mechanical, electrical and other building services	3,000
Subtotal	56,000
Contingencies	4,000
Total	60,000
of which	
Foreign exchange component	52,800
Local cost component	7,200

POWER DEVELOPMENT PLAN - TEC FUNAFUTI SYSTEM

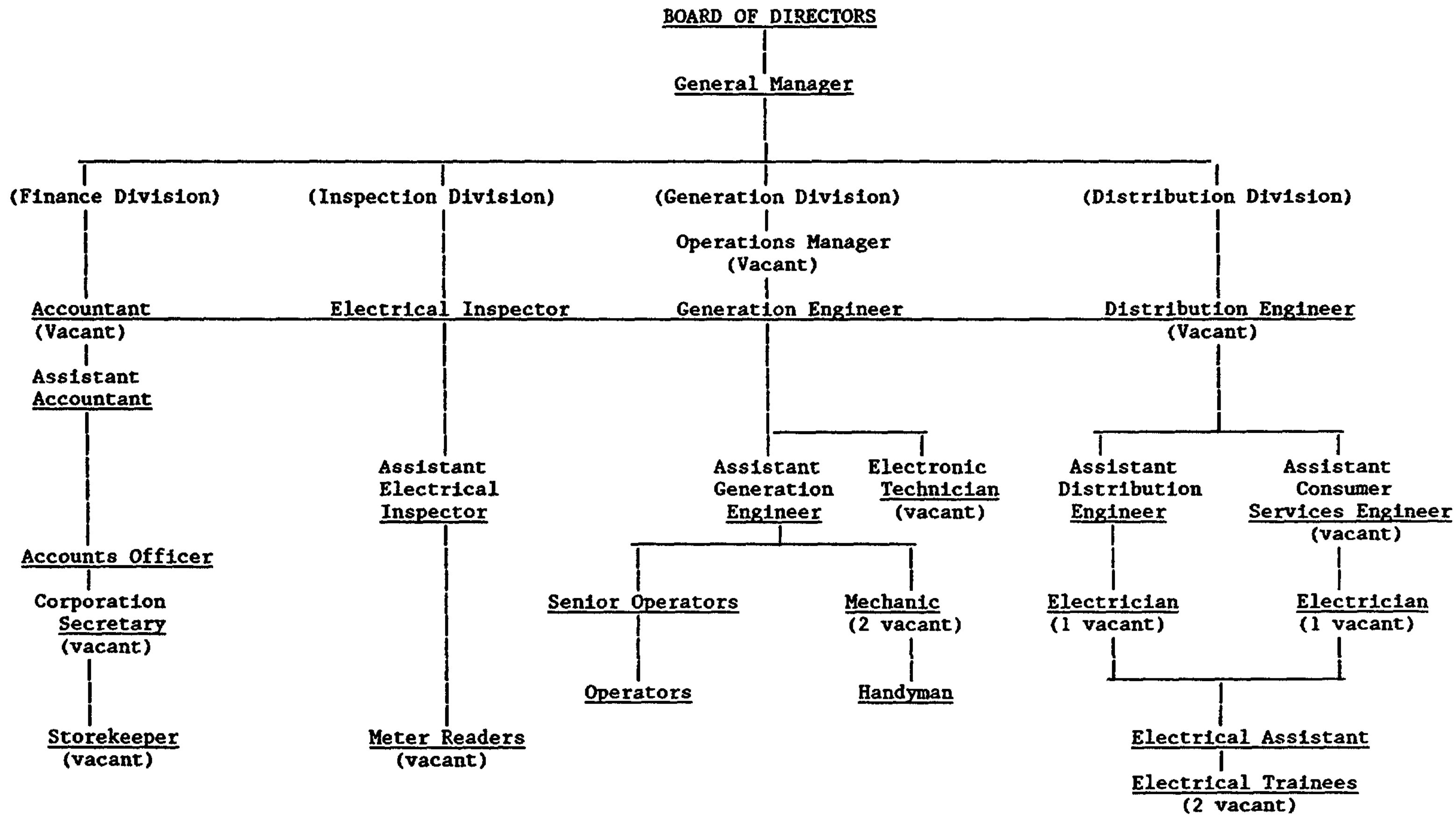
		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Projected generation	(MWh)	1,446	1,679	1,867	1,898	1,924	1,963	1,993	2,019	2,058	2,096
Projected peak demand	(kW)	273	343	365	371	376	383	389	394	400	407
Installed capacity (start of year)		600	600	750	750	750	750	900	900	900	900
New capacity added	(kW)	-	150	-	-	-	150	-	-	-	-
Total Capacity		600	750	750	750	750	900	900	900	900	900
Normal capacity		510	638	638	638	638	765	765	765	765	765
System firm capacity		255	383	383	383	383	510	510	510	510	510
INVESTMENT STREAMS											
		------------------------------US$ '000 (1991 prices)------------------------------									
Generation Investments											
New power station building		0	0	0	0	0	60	0	0	0	0
Diesel generator 1 x 150 kW complete incl. spares		0	71	0	0	0	71	0	0	0	0
Subtotal - Generation		0	71	0	0	0	131	0	0	0	0
Distribution System Investments											
Additional main transformer and associate gear		0	0	30	0	0	0	0	0	0	0
Capital expenditure for loss reduction		0	0	10	0	0	0	0	0	0	0
Miscellaneous reinforcement		0	12	0	12	0	0	12	0	0	0
Subtotal - Distribution		0	12	40	12	0	0	12	0	0	0
Total Investment		0	83	40	12	0	131	12	0	0	0

Source: Mission projections.

TUVALU

ISSUES AND OPTIONS IN THE ENERGY SECTOR

Tuvalu Electricity Corporation



Note: All the positions indicated on this chart are not meant to be filled at the same time. For example, either the Accountant position or the Assistant Accountant position will be filled at any given time.

Source: TEC.

TUVALU

COUNTRY ENERGY ASSESSMENT

Study of System Losses

Introduction

Electrical power on the island of Funafuti, Tuvalu, is generated and distributed by the Tuvalu Electricity Corporation (TEC). The generating station has four 150 kW diesel generating units and power is distributed by an underground 11 kV ring-main system. Power is distributed to consumers from five substation by underground low voltage (415/240 volt 3-phase, 50 hz) cables. The peak demand is about 260 kW (January 1991).

Based upon the data available the system losses are about 18-20 percent, which is excessive, particularly for such a small system. These losses include station use and losses in the distribution system. No information is available on the source of losses in the distribution system. The indicated station use is 8-9 percent of gross generation, compared to typical levels of 2 percent or less.

It has been observed that the loading of the phases, based upon spot readings, is quite unbalanced, and that the system power factor, from a perusal of station logs, ranges between 0.7 and 0.84, with a typical value of 0.8. Both of these conditions will increase system losses unnecessarily, but do not begin to explain the high level of losses. The absence of information on transformer and circuit loadings precludes even an initial assessment of the situation.

In order to improve the operating efficiency and to plan for the future development, it is essential that the actual losses and their source be established. Appropriate measures must then be implemented to reduce the system losses to a level that can be achieved technically and justified economically. The proposed study will involve the checking of the generating station metering accuracy, obtaining operating information throughout the distribution system, the analysis of the data obtained to determine the level and source of system losses, and to make specific recommendations aimed at reducing the level of system losses to appropriate levels based upon sound technical and economic considerations.

Work to be done

1. Determine the source and level of distribution system losses and the actual station use.

2. Check all station metering and associated instrument transformers if any to ensure that the indicated readings are accurate.

3. Obtain all necessary distribution system operating data for carrying out the study. This will include the use of appropriate instrumentation, metering and recording devices to determine loadings and losses in various parts of the system. The necessary instrumentation is not available in Tuvalu.

4. Check the accuracy of the billing meters of the 10-15 largest consumers and also the meters of a random selection of other consumers to ascertain the general condition and accuracy of the billing meters.

5. Obtain whatever other information may be required to complete an adequate assessment of the source and magnitude of the system losses, and to enable recommendations to be made for improving the situation.

6. Prepare a report of the findings regarding the level and source of the system losses and make recommendations to reduce the level of losses, based upon sound technical and economic criteria. The report shall including the following:

   (a) description of the condition and accuracy of the station metering, and recommendations for improvements, if any. Comment on the provision of metering to record system peak demand, and other quantities that might be desirable.

   (b) discussion of the findings on consumer meters, and make any recommendations considered appropriate.

   (c) provide information on the present level of station auxiliary use and distribution system losses, and their source.

   (d) make specific recommendations for reducing the level of system losses to an economically justified level. Indicate the sequence in which the various measures should be implemented, and the overall effect on system losses of each step.

   (e) make any further recommendations, considered appropriate, to improve the overall efficiency of system operation.

Requirements

The study will require an engineer with practical experience in power system metering, and with experience in the analysis of system data to determine appropriate measures to reduce losses, and to rank the measures in terms of their cost effectiveness.

It is estimated that the complete study will require approximately 2-2½ work-months, of which about one work-month will be in the field.

STATISTICAL APPENDIX

TABLE 1
TUVALU: SELECTED DEVELOPMENT INDICATORS

		1985	1986	1987	1988	1989	1990
GDP ('000 AU$)[1]		5,034	6,257	7,033	8,616	8,036	8,357
Per capita (AU$)		612	747	832	973	862	884
Total Imports[2] ('000 AU$)		4,126	4,577	5,337	7,529	5,626	na
Total Exports[3] ('000 AU$)		597	486	232	311	212	na
Inflation Rate[4] (%)		3.8	8.6	9.1	7.4	2.9	na
Exchange Rate[5] (AU$/US$)		1.43	1.49	1.43	1.27	1.26	1.28
Sea Area (sq. km)	900,000						
Land Area (sq. km)	24						
Wage & Salary Employment[6]		1,166	na	na	na	na	na
Average Wage (AU$/hr)		na	na	na	na	na	na
Total Population[7]		8,229	8,372	8,458	8,854	9,325	9,450
% urban		35	32	32	32	32	32

Overseas Development Assistance

	1985	1986	1987	1988	1989	1990
Annual ODA (thousands AU$)[8]	na	na	20,096	10,100	6,352	na
Mulitlateral (thousands AU$)	na	na	896	710	834	na
Bilateral (thousands AU$)	na	na	19,200	9,390	5,518	na
ODA as % of GDP	na	na	286	117	79	na
ODA as % Current Government Income	na	na	na	na	na	na
ODA per Capita (AU$)	na	na	2,376	1,141	681	na

Sources: Preliminary Abstract of Tuvalu Energy Statistics (1991 draft).
An Abstract of Agricultural Statistics (1980–1990).
UNDP Development Co–operation Reports.
Mission Estimates (February 1991).

Notes:
(1) Current prices at Factor Cost. 1990 figure estimated using growth of 4%.
(2) CIF actual figures.
(3) FOB actual figures.
(4) Adapted from 1980–1989 Agricultural Statistics.
(5) Average throughout the year.
(6) 1985 data from 1985 census.
(7) Mid–year estimates. Includes overseas seamen, overseas students, and Tuvaluans abroad. 1989 from 1989 census. 1990 figure estimated from Agricultural Statistics. Urban percentage estimated as population on Funafuti.
(8) UNDP Development Co–operation Reports for 1987, 1988, 1989. Multilaterals Include UNDP, but do not include NGO's assistantce. Bilaterals include: Australia, Canada, Malaysia, Japan, S. Korea, France, W. Germany, New Zealand, United Kingdom and USA.

TABLE 2

TUVALU: SELECTED PROJECTIONS

	1990	1995	2000
Population[1]:			
urban	3,024	3,455	3,947
rural	6,426	7,342	8,388
Total	9,450	10,797	12,335
GDP ('000 AU$)[2]:			
high growth at 5%	8,357	10,666	13,613
med growth at 4%	8,357	10,168	12,977
low growth at 3%	8,357	9,688	12,365
GDP/Capita[3]:	884	942	1,052
Electricity Generation (kWh)[4]:	1,366	1,924	2,096
Peak demand (kW)	235	376	407
Fuel Consumption (kl)[5]:			
Gasoline	*386*	488	594
Kerosene	*150*	169	187
ADO	*904*	1,275	1,464
Lubes	*6*	8	9
Avgas	*107*	95	87
Solvent	*2*	2	2
LPG	*11*	12	14
Total Inland	*1,566*	2,050	2,357
Total Av/Bunkers	*549*	695	845
Total Trade	*2,115*	2,744	3,202
Rural electricity consumers[6]:			
grid	na	na	na
isolated	300	500	700

Sources: Abstract of Agricultural Statistics (1980–1990).
Mission Estimates.

Notes:
(1) 1990 from Agricultural Abstract. 1995 & 2000 values estimated at growth rate of 2.7%.
(2) 1990 figure estimated from 1989 actual data at 4% growth.
(3) Medium growth scenario.
(4) TEC grid on Funafuti.
(5) Actual data from 1989 rather than 1990. TEC fuel consumption for 1995/2000 calculated by multiplying estimated generation data by a factor of .31/.315 litres per kWh.
(6) Isolated consumers are all members of the Solar Co–op.

TABLE 3a

TUVALU: ENERGY BALANCE, 1989
(Original units)

	Fuelwood (tonnes)	Coconut Residues (tonnes)	Total Biomass (tonnes)	Electricity (MWh)	Gasoline (kl)	Jet A1 (kl)	Kerosene (kl)	ADO (kl)	Avgas (kl)	LPG (kl)	Total Petroleum[5] (kl)
Primary Supplies:											
Production	1,106	4,714	5,820								
Imports					386	549	150	904	107	11	2,107
Bunkering/Exports[1]						(549)			(107)		(656)
GROSS AVAILABLE	**1,106**	**4,714**	**5,820**	**0**	**386**	**0**	**150**	**904**	**0**	**11**	**1,451**
Conversion:											
Power Generation[2]				1,285				(375)			(375)
Station use				(113)							
Transmission/Distribution Losses				(147)							
NET SUPPLIED	**1,106**	**4,714**	**5,820**	**1,025**	**386**	**0**	**150**	**529**	**0**	**11**	**1,076**
Final Consumption:											
Households[3]	1,106	4,714	5,820	260			150			11	161
Transport					386			529			915
Government				377							
Commercial				388							
Agro-industries[4]											
Others											
TOTAL	**1,106**	**4,714**	**5,820**	**1,025**	**386**	**0**	**150**	**529**	**0**	**11**	**1,076**

Source: Mission estimates.

Notes:
(1) Avgas used by Fiji Air flights to Funafuti which were discontinued in May 1990.
(2) Private power generation is considered negligible.
(3) Population data estimated from figures in Agriculttural Statistics (9,450). 32% urban estimated as population of Funafuti. Biomass consumption is based on Vaitupu/Funafuti cooking patterns. Assume 7.2 persons/urban HH with 93% urban population using biomass and 6.4 persons/urban HH with 100% rural population using biomass. Urban consumption is estimated at 2858 kg/HH/year (1.1 kg/cap/day), rural consumption is estimated at 4800 kg/HH/year (2.0 kg/cap/day). Biomass consumption is estimated as follows:
Urban: 9,450 people x 32% x 1.1 kg/cap/day x 93% x 365 days/year/1000 kg/tonne = 1,129 tonnes
Rural: 9,450 people x 68% x 2.0 kg/cap/day x 100% x 365 days/year/1000/kg/tonne = 4,691 tonnes
Total household consumption (assumed to be 81% coconut waste and 19% fuelwood) = **5,820 tonnes**
(4) Copra production estimated at 35 tonnes. Biomass consumption is negligible.
(5) Energy Balance does not include consumption of Lubes (6kl) and Solvents (2kl).

TABLE 3b

TUVALU: ENERGY BALANCE, 1989
(TOE)

	Fuelwood	Coconut Residues	Total Biomass	Electricity	Gasoline	Jet A1	Kerosene	ADO	Avgas	LPG	Total Petroleum[5]	Total Energy
Primary Supplies:												
Production	464	1,593	2,058									2,058
Imports					312	474	130	813	84	7	1,820	1,820
Bunkering/Exports[1]						(474)			(84)		(558)	(558)
GROSS AVAILABLE	**464**	**1,593**	**2,058**	**0**	**312**	**0**	**130**	**813**	**0**	**7**	**1,261**	**3,319**
Conversion:												
Public Power Generation[2]				337				(337)			(337)	(0)
Transformation Losses				(228)								(228)
Station use				(10)								(10)
Transmission/Distribution Losses				(12)								(12)
NET SUPPLIED	**464**	**1,593**	**2,058**	**87**	**312**	**0**	**130**	**476**	**0**	**7**	**924**	**3,069**
Final Consumption:												
Households[3]	464	1,593	2,058	22			130			7	137	2,217
Transport					312			476			787	787
Government				32								32
Commercial				33								33
Agro-industries[4]												0
Others												0
TOTAL	**464**	**1,593**	**2,058**	**87**	**312**	**0**	**130**	**476**	**0**	**7**	**924**	**3,069**

Source: Mission estimates.

Notes:
(1) Avgas used by Fiji Air flights to Funafuti which were discontinued in May 1990.
(2) Private power generation is considered negligible.
(3) Population data estimated from figures in Agriculttural Statistics (9,450), 32% urban estimated as population of Funafuti. Biomass consumption is based on Vaitupu/Funafuti cooking patterns. Assume 7.2 persons/urban HH with 93% urban population using biomass and 6.4 persons/urban HH with 100% rural population using biomass. Urban consumption is estimated at 2858 kg/HH/year (1.1 kg/cap/day), rural consumption is estimated at 4800 kg/HH/year (2.0 kg/cap/day). Biomass consumption is estimated as follows:
Urban: 9,450 people x 32% x 1.1 kg/cap/day x 93% x 365 days/year/1000 kg/tonne = 1,129 tonnes
Rural: 9,450 people x 68% x 2.0 kg/cap/day x 100% x 365 days/year/1000/kg/tonne = 4,691 tonnes
Total household consumption (assumed to be 81% coconut waste and 19% fuelwood) = **5,820 tonnes**
(4) Copra production estimated at 35 tonnes. Biomass consumption is negligible.
(5) Energy Balance does not include consumption of Lubes (6kl) and Solvents (2kl).

TABLE 4a

TUVALU: ENERGY BALANCE, 2000
(Original units)

	Fuelwood (tonnes)	Coconut Residues (tonnes)	Total Biomass (tonnes)	Electricity (MWh)	Gasoline (kl)	Jet A1 (kl)	Kerosene (kl)	ADO (kl)	Avgas (kl)	LPG (kl)	Total Petroleum[5] (kl)
Primary Supplies:											
Production	1,433	6,110	7,543								
Imports					594	845	187	1,464	87	14	3,191
Bunkering/Exports[1]						(845)			(87)		(932)
GROSS AVAILABLE	**1,433**	**6,110**	**7,543**	**0**	**594**	**0**	**187**	**1,464**	**0**	**14**	**2,259**
Conversion:											
Power Generation[2]				2,096				(650)			(650)
Station use				(199)							
Transmission/Distribution Losses				(178)							
NET SUPPLIED	**1,433**	**6,110**	**7,543**	**1,719**	**594**	**0**	**187**	**814**	**0**	**14**	**1,609**
Final Consumption:											
Households[3]	1,433	6,110	7,543	362			187			14	201
Transport					594			814			1,408
Government				647							
Commercial				709							
Agro-industries[4]											
Others											
TOTAL	**1,433**	**6,110**	**7,543**	**1,718**	**594**	**0**	**187**	**814**	**0**	**14**	**1,609**

Source: Mission estimates.

Notes:
(1) Avgas used by Fiji Air flights to Funafuti which were discontinued in May 1990.
(2) Private power generation is considered negligible.
(3) Population estimated at 12324 (32% urban). Biomass consumption is based on Vaitupu/Funafuti cooking patterns. Assume 7.2 persons/urban HH with 90% urban population using biomass and 6.4 persons/urban HH with 100% rural population using biomass. Urban consumption is estimated at 2858 kg/HH/year (1.1 kg/cap/day), rural consumption is estimated at 4800 kg/HH/year (2.0 kg/cap/day). Biomass consumption is estimated as follows:
Urban: 12,324 people x 32% x 1.1 kg/cap/day x 90% x 365 days/year/1000 kg/tonne = 1,425 tonnes
Rural: 12,324 people x 68% x 2.0 kg/cap/day x 100% x 365 days/year/1000/kg/tonne = 6,118 tonnes
Total household consumption (assumed to be 81% coconut waste and 19% fuelwood) = **7,543 tonnes**
(4) Copra production estimated at 35 tonnes. Biomass consumption is negligible.
(5) Energy Balance does not include consumption of Lubes and Solvents.

TABLE 4b

TUVALU: ENERGY BALANCE, 2000
(TOE)

	Fuelwood	Coconut Residues	Total Biomass	Electricity	Gasoline	Jet A1	Kerosene	ADO	Avgas	LPG	Total Petroleum[5]	Total Energy
Primary Supplies:												
Production	602	2,065	2,667									2,667
Imports					480	730	162	1,316	68	9	2,765	2,765
Bunkering/Exports[1]						(730)			(68)		(798)	(798)
GROSS AVAILABLE	**602**	**2,065**	**2,667**	**0**	**480**	**0**	**162**	**1,316**	**0**	**9**	**1,967**	**4,634**
Conversion:												
Public Power Generation[2]				584				(584)			(584)	(0)
Transformation Losses				(407)								(407)
Station use				(17)								(17)
Transmission/Distribution Losses				(15)								(15)
NET SUPPLIED	**602**	**2,065**	**2,667**	**145**	**480**	**0**	**162**	**732**	**0**	**9**	**1,382**	**4,195**
Final Consumption:												
Households[3]	602	2,065	2,667	31			162			9	171	2,868
Transport					480			732			1,212	1,212
Government				55								55
Commercial				60								60
Agro-industries[4]												0
Others												0
TOTAL	**602**	**2,065**	**2,667**	**145**	**480**	**0**	**162**	**732**	**0**	**9**	**1,382**	**4,195**

Source: Mission estimates.

Notes:
(1) Avgas used by Fiji Air flights to Funafuti which were discontinued in May 1990.
(2) Private power generation is considered negligible.
(3) Population estimated at 12324 (32% urban). Biomass consumption is based on Vaitupu/Funafuti cooking patterns. Assume 7.2 persons/urban HH with 90% urban population using biomass and 6.4 persons/urban HH with 100% rural population using biomass. Urban consumption is estimated at 2858 kg/HH/year (1.1 kg/cap/day), rural consumption is estimated at 4800 kg/HH/year (2.0 kg/cap/day). Biomass consumption is estimated as follows:
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Rural: 12,324 people x 68% x 2.0 kg/cap/day x 100% x 365 days/year/1000/kg/tonne = 6,118 tonnes
Total household consumption (assumed to be 81% coconut waste and 19% fuelwood) = **7,543 tonnes**
(4) Copra production estimated at 35 tonnes. Biomass consumption is negligible.
(5) Energy Balance does not include consumption of Lubes and Solvents.

TABLE 5

TUVALU: PETROLEUM MARKET PRODUCTS CONSUMPTION, 1985-1989 (kl)

	1985	1986	1987	1988	1989
Product:					
Gasoline	225	351	348	386	386
Kerosene	138	141	144	147	150
ADO	544	576	745	641	904
Lubes	1	1	16	23	6
Solvents	0	0	0	2	2
LPG	11	14	14	17	11
Total Inland Trade	919	1,083	1,267	1,216	1,459
Bunkers:					
Jet A1	84	59	287	318	549
Avgas	163	184	141	138	107
Total Trade	1,166	1,326	1,695	1,672	2,115

Sources: BP statistics
Mission Estimates.

TABLE 6

TUVALU: NATIONAL PUBLIC ELECTRIFICATION SYSTEM

	1985	1986	1987	1988	1989	1990
Consumers[1]:						
Household Consumers	na	292	354	361	370	402
Total Consumers	na	381	423	na	na	429
Capacity (kW):						
Installed Diesel[2]	600	600	600	600	600	600
Available Diesel[3]	510	510	510	510	510	510
Max Demand	185	205	210	215	230	235
Output (MWh):						
TEC Generation	920	1,053	1,186	1,246	1,285	1,367
Station usage	89	90	93	na	113	130
Total sent out	831	963	1,094	1,147	1,182	1,237
Distribution losses	na	120	na	na	147	115
Net Consumption	660	843	962	1,025	1,035	1,122

Source: Mission Estimates.
TEA: Considerations for Planned Commercialisation (PEDP 1990).
Country Paper prepared for Regional Power Meeting (PEDP 1990).
Electrification Study of Tuvalu Electricity Authority (1988).
Tuvalu Electricity Coporation Statistics (1991).

Notes:
(1) TEC does not classify customers by type.
(2) Manufacturer nameplate rating for all 4 units.
(3) "De-rated" to 85% of nameplate rating assuming all units operational.

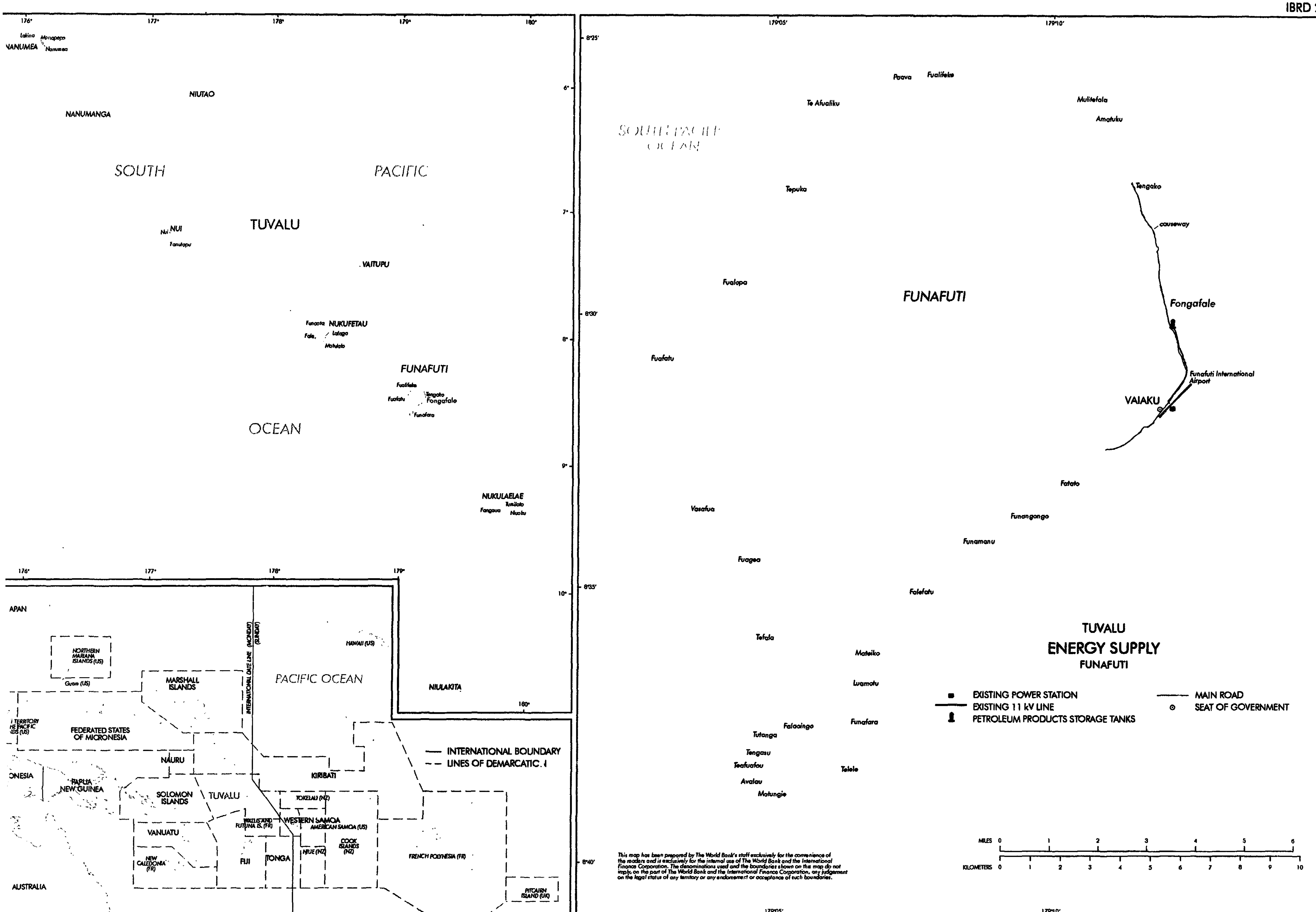
TABLE 7

TUVALU: ELECTRIFICATION PERFORMANCE INDICATORS, 1990
TUVALU ELECTRICITY COPORATION (TEC)

Fixed Assets (million US$)	na
Average Revenue (US¢/KWh)	na
Average Cost (US¢/KWh)	
Capital	na
Fuel	na
Other operating	na
Estimated ROI (%)	na
Fuel Consumption (l/kWh)	0.315
Households Electrified[1] (%)	90.0
kWh/year/consumer[2]	3,186
kWh/year/employee[3]	42,719
Employees/MW installed	19
Outages	
Number	na
Ave. duration (hrs)	na
Customers affected (%)	na
Voltage drop/increase	na

Source: Mission Estimates.

Notes: (1) Households on Funafuti only.
(2) Total Generation.
(3) 32 total TEC employees.


TUVALU
ENERGY SUPPLY
FUNAFUTI
EXISTING POWER STATION
EXISTING 11 kV LINE
PETROLEUM PRODUCTS STORAGE TANKS
MAIN ROAD
SEAT OF GOVERNMENT
SOUTH PACIFIC OCEAN
TUVALU
NANUMEA
NANUMANGA
NIUTAO
NUI
VAITUPU
NUKUFETAU
FUNAFUTI
NUKULAELAE
NIULAKITA
Fongafale
VAIAKU
Funafuti International Airport
causeway
Tengako
Tepuka
Fualopa
Fuafatu
Vasafua
Fuagea
Falefatu
Funamanu
Funangongo
Fatato
Tefala
Mateiko
Luamotu
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WALLIS AND FUTUNA IS. (FR)
VANUATU
NEW CALEDONIA (FR)
FIJI
TONGA
NIUE (NZ)
COOK ISLANDS (NZ)
FRENCH POLYNESIA (FR)
PITCAIRN ISLAND (UK)
HAWAII (US)
AUSTRALIA
INTERNATIONAL DATE LINE (MONDAY) (SUNDAY)
INTERNATIONAL BOUNDARY
LINES OF DEMARCATION
MILES 0 1 2 3 4 5 6
KILOMETERS 0 1 2 3 4 5 6 7 8 9 10
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