ESM0021

Joint UNDP/World Bank Energy Sector Management Assistance Program

Activity Completion Report

No. 021/84

Country: SEYCHELLES

Activity: ELECTRIC POWER SYSTEM EFFICIENCY STUDY

AUGUST 1984

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ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

The joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP), started in April 1983, assists countries in implementing the main investment and policy recommendations of the Energy Sector Assessment Reports produced under another joint UNDP/World Bank program. ESMAP provides staff and consultant assistance in formulating and justifying priority pre-investment and investment projects and in providing management, institutional and policy support. The reports produced under this Program provide governments, donors and potential investors with the information needed to speed up project preparation and implementation. ESMAP activities may be classified broadly into three groups:

- Energy Assessment Status Reports: these evaluate achievements in the year following issuance of the original assessment report and point out where urgent action is still needed;

- Project Formulation and Justification: work designed to accelerate the preparation and implementation of investment projects; and

- Institutional and Policy Support: this work also frequently leads to the identification of technical assistance packages.

The Program aims to supplement, advance and strengthen the impact of bilateral and multilateral resources already available for technical assistance in the energy sector.

FUNDING OF THE PROGRAM

The Program is a major international effort and, while core finance has been provided by the UNDP and the World Bank, important financial contributions to the Program have also been made by a number of bilateral agencies. Countries which have now made or pledged initial contributions to the program through the UNDP Energy Account, or through other cost-sharing arrangements with UNDP, are the Netherlands, Sweden, Australia, Switzerland, Finland, United Kingdom, Denmark, Norway, and New Zealand.

FURTHER INFORMATION

For further information on the Program or to obtain copies of completed ESMAP reports, which are listed at the end of this document, please contact:

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OR

SEYCHELLES

ELECTRIC POWER SYSTEM EFFICIENCY STUDY

AUGUST, 1984

ABBREVIATIONS

GWH	gigawatt hour
km	kilometer
kV	kilovolt
kW	kilowatt
kWh	kilowatt hour
LRMC	long run marginal cost
MVAR	megavolt amperes of reactive power
MW	megawatt
toe	tonne of oil equivalent
TOR	terms of reference

ACRONYMS

GOS	Government of Seychelles
SEC	Seychelles Electricity Corporation

CURRENCY EQUIVALENTS

1 US dollar = 6.6 Seychelles rupees (SR)

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FIGURE

SUMMARY

1. This report is based on the findings of a mission financed under the joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) which visited the Seychelles during March 19-30, 1984. The mission was organized in response to a request by the Government of Seychelles (GOS) for technical assistance identified in the joint UNDP/World Bank Energy Assessment Report Seychelles: Issues and Options in the Energy Sector (January, 1984). The Assessment Report noted significant scope for improving the efficiency of the electricity system and recommended the following projects:

(a) a power factor improvement program;

(b) a diesel power plant maintenance program;

(c) a training program for supervisors and operators of diesel generating equipment.

2. The purpose of the mission was to briefly review the efficiency of the power system and prepare terms of reference for energy savings projects to be financed by bilateral and/or multilateral donors. The mission visited all generating plants and selected sites in the distribution system, held discussions with managers and operators and reviewed statistical information prepared by SEC in order to assess:

(a) the magnitude and source of energy losses in the system;

(b) operating and maintenance procedures for diesel generation;

(c) the adequacy of the existing tariff structure and the need for a study to recommend improvements.

3. The major findings and recommendations of the mission may be summarized briefly as follows:

(a) Generation Losses. At the generation level, there is substantial scope for increasing efficiency through a system-wide program of preventive maintenance, standardized plant operating procedures and training in diesel generator operation. On an individual plant basis, the mission recommends a detailed audit of the Praslin Power Station to investigate and correct the station's apparent high use of electricity (18% of gross electricity generation), and a study of the feasibility of using waste heat for heating fuel oil used in the Mahe Power Station to reduce station use of electricity. Terms of reference for efficiency in diesel power plant operation are found in Annex 2. The total cost of the technical assistance is estimated at US$300,000.

(b) Distribution Losses. The mission found a lack of reliable data on losses in specific parts of the distribution network, a significant share of unexplained or "non-technical" losses, and a low power factor in the Mahe distribution system (0.85) at peak load which, if corrected through capacitor installation, could result in lower distribution losses. The mission recommends a technical assistance package to help SEC improve efficiency in its distribution system, including (a) more accurate calculations of distribution losses through the use of a micro-computer and a software package specifically tailored for network analysis, and (b) measures to improve energy efficiency in the distribution system, i.e., changes in design standards, power factor improvement through capacitor installation and administrative regulations, etc. Terms of reference for this assistance are found in Annex 1. The total cost of this project is estimated at US$150,000, including funds for microcomputer hardware/software and capacitors.

(c) Tariffs. The mission compared electricity tariffs with estimated long-run marginal costs of electricity supply (LRMC) and found the LRMC of supplying small domestic consumers to be nearly double the tariff they pay. On the contrary, large efficient consumers with high load factors pay a rate which is much higher than the LRMC of servicing them. The mission proposes a tariff study to establish a demand/cost related tariff structure. Details on the current tariff structure, some preliminary observations on possible changes, and terms of reference for a tariff study are found in Annex 3. The total cost of the tariff study is estimated at US$70,000, including metering equipment.

Next Steps

4. Based on the above findings, the mission recommends a total technical assistance package of US$520,000 to improve the efficiency of the Seychelles electricity system, including consulting services and equipment. The terms of reference for the three projects identified are given in Annexes 1, 2 and 3. The components, duration and cost of each project are summarized below:

Table 2.5: TECHNICAL ASSISTANCE FOR POWER SYSTEM EFFICIENCY IMPROVEMENTS

Project	Consulting Services		Equipment		Total
	Man-months	Cost (US$)	Type	Cost (US$)	Cost (US$)
Efficiency Improvements in the Distribution System	2.0	30,000		120,000	150,000
Efficiency Improvements in Diesel Power Plant Operation and Maintenance	21.0	300,000			300,000
Electricity Tariff Study	4.0	60,000		10,000	70,000
Total	27.0	390,000		130,000	520,000

I. BACKGROUND

Country Situation

1.1 The .Republic of Seychelles includes 100 islands off the coast of East Africa with a total land area of 400 square kilometers and a population of 65,000. About 88% of the population live on the island of Mahe. The Seychelles' economy is very small, open and highly dependent on tourism from Western Europe. During 1976-79, the country's real GDP increased on average by about 10% annually. However, between 1979 and 1982, GDP declined by about 11%, due in large measure to a reduction in tourism. At the same time, prices for major export products (copra and fish) also declined. The subsequent drop in merchandise exports and tourism receipts, coupled with imports amounting to nearly three-quarters of GDP, resulted in an increase in the trade deficit from SR 420 million in 1979 to SR 500 million in 1982 (current prices). The Government of Seychelles (GOS) now has a strategy to increase tourist activity and fish exports in order to stimulate economic growth and improve its trade balance.

Energy Demand

1.2 Imported petroleum products account for more than 90% of total energy consumption in Seychelles, the rest of which is fuelwood and small amounts of other biomass. Total inland demand for petroleum products increased from 17,962 tonnes of oil equivalent (toe) in 1975 to 27,773 toe in 1979, or at an average annual rate of 11.5%. However, growth between 1979 and 1982 was only marginal, about 343 toe. During 1976-79, the cost of petroleum imports grew rapidly, from SR 54 million to SR 130 million, and despite the decline in tourism and the lower growth of petroleum imports since 1979, the cost of oil remained nearly unchanged in 1982, at SR 129 million. In 1982, the cost of these imports far exceeded total merchandise exports, amounting to 42% of combined tourism and merchandise export earnings. GOS is very concerned about the growing burden of these costs on the country's narrow export base. There appears to be significant scope for reducing these costs through fuel substitution and conservation measures in various sectors, and through pooling the procurement of petroleum products with other countries.

Electric Power Sector

1.3 Electricity is generated and sold by the Seychelles Electricity Corporation (SEC), a parastatal company created in 1980. Current electricity supply covers two islands, Mahe and Praslin, which accounts for 95% of the country's population. Nearly two-thirds of all households in Seychelles are connected to electric power supplies. Mahe has two power stations with a total installed capacity of 17.4 MW. Peak demand currently is 9.3 MW and the firm capacity of the system (9.0 MW) is inadequate for the demand level. Praslin, which includes about 7% of the Seychelles' population, has a total installed capacity of 2.1 MW, a peak demand of about 400 kW, and an annual energy use of 1.4 GWh.

1.4 Electricity sales increased rapidly during 1976-79, by about 14% per year, but this rate recently declined to about 2% because of lower economic growth. Table 1.1 summarizes power generation and sales data for the period 1976-82. Currently, commerce and industry (mostly hotels) account for the largest share of electricity sales (54%), followed by the domestic sector (31%), and government/street lighting (15%). In 1982, total power generation amounted to 52.2 GWh, of which 45.4 GWh were sold and the remainder taken up by losses in generation, transmission and distribution and non-technical losses.

Table 1.1: SEC - POWER GENERATION AND SALES, 1976-82

	1976		1979		1982		Average Annual Growth Rate 1976-79	1979-82
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(percent)	
Generation	34.5		48.3		52.2		11.9	2.6
Total Sales	28.9	100.0	42.8	100.0	45.4	100.0	14.0	2.0
Domestic	8.1	28.0	12.8	30.0	14.1	31.0	16.5	3.3
Commerce & Industry	17.3	59.9	23.5	55.0	24.5 a/	54.0	10.7	1.4
Govt. and Street Lighting	3.5	12.1	6.4	15.0	6.8 a/	15.0	22.9	2.0

a/ Mission estimates.

Source: SEC

1.5 The power sector accounts for the largest share of petroleum demand (44%) and consumed 12,306 toe in 1982. Prior to 1982, all electric power was generated by diesel engines operating on light gas oil but since then much of the equipment has been modified to use fuel oil, a substitution which is estimated to save SEC about SR 2 million (US$300,000) per year in financial terms.

1.6 The technical characteristics of Mahe transmission and distribution system are as follows:

(a) 14 km of 33 kV lines;
(b) 120 km of 11 kV lines and cables;
(c) 170 km of low voltage lines;
(d) transformer capacity of 30 MVA from 33 kV to 11 kV; and
(e) transformer capacity of 34 MVA from 11 kV to low voltage, in 300 substations.

1.7 The current electricity load forecast for the Seychelles is shown in Table 1.2. Maximum demand in Mahe is expected to increase from 9.3 MW in 1982 to 16.1 MW in 1995, with corresponding increases in electricity generated from 50.8 GWh to 84.4 GWh. On Praslin, La Digue and the other islands, maximum demand is projected to increase from 0.4 MW to 0.9 MW, with a concurrent rise in electricity generation from 1.4 GWh to 4.5 GWh.

Table 1.2: ELECTRIC POWER LOAD FORECAST

	---Mahe System--- Base Case Scenario		High Growth Scenario		Praslin, La Digue and Other Islands	
	(MW)	(GWh)	(MW)	(GWh)	(MW)	(GWh)
1982	9.3	50.8	9.3	50.8	0.3	1.4
1986	11.1	58.3	11.8	62.1	0.6	3.0
1990	13.1	68.7	14.7	77.2	0.7	3.5
1995	16.1	84.4	19.3	101.4	0.9	4.5

a/ These projections do not include possible siting of a BBC relay station in 1987/88 which would require about 2-3 MW of power.

Source: Mission estimates based on SEC data.

Long-Run Marginal Costs

1.8 The long-run marginal cost (LRMC) of electricity may be defined as the present value of the economic cost of supplying an incremental unit of electricity demand in a given power system. In this report, it is used as a tool for analyzing the level and structure of electricity tariffs. The LRMC is estimated as a two-part cost: (a) an incremental capacity cost, which corresponds to the minimum capital expenditure to maintain reliable service; and (b) an incremental energy cost, which is the operating cost of the unit best suited to meet additional energy demand. These costs may be summarized for the Seychelles as follows: (a) capacity cost of SR 1,000 (US$151) per kW annually at the generation level; SR 1,100 (US$167) per kW annually at the 11 kV level; and an energy cost of SR 0.58/kWh (US$0.09/kWh). Background information on the calculations of the LRMC is provided in Annex 4.

II. FINDINGS AND RECOMMENDATIONS

Generation Losses

Mahe System

2.1 Statistical data for the Mahe power stations indicate the thermal efficiency of Station A (2.4 MW) to be about 32% with a 30% load factor and that of Station B (15 MW) to be 33.2% with a load factor of 65%. Although these efficiencies are within an acceptable range for the type of equipment used, the mission finds that improvements in maintenance and operating procedures could result in significant increases in thermal efficiency. For example, the mission's review of the maintenance schedule for the generating units indicates that intervals between overhauls often have been much longer than those stipulated by the manufacturer, often due to capacity constraints, especially for the Station's 5 MW unit. This finding was also confirmed in discussions with SEC staff. In addition, judging from the existing skill levels of plant operators, current operating procedures and discussions with SEC staff, diesel units are not always running at optimal load. The mission believes that better plant maintenance and the training of operators to understand the value of running the generating units in an optimal way could significantly improve thermal efficiency. Also, energy use in Station B is 6.6% of electricity generated, compared to 2.7% for Station A. The high figure for Station B results from the predominant use of fuel oil (75-80%), which, though overall less expensive than diesel oil, must be preheated and treated in a separator, a process which requires additional energy.

Praslin System

2.2 At the Praslin Station, there are three units of 0.67 MW, each of which has a thermal efficiency of about 29%. This lower efficiency figure is more due to its low load factor (0.28) than maintenance or operating procedures and thermal efficiency should improve with a growing load. All units operate on diesel oil but station losses are extremely high -- nearly 18% of generation. A major contributing factor to the large share of losses is the station's low load factor, which, given a fixed level of auxiliary equipment required for the station's operation, results in a larger proportion of station use than if the load were higher. The mission also noted that some of the buildings at the plant were highly air-conditioned. However, the mission estimates that, even if the present load factor were doubled and 50,000 kWh were deducted for air-conditioning, station losses would still be on the order of 8.5% -- a level higher than the fuel oil-based plant in Mahe and triple that of Station A. Therefore, the mission and SEC have agreed that a detailed analysis of the major loads within the power station should be made to determine the causes of this excessive energy consumption. Terms of reference for a detailed audit of station use in Praslin are included in Annex 2.

Transmission/Distribution Losses

Technical Losses

2.3 SEC's calculations of technical losses for the main distribution system (1983) amount to 3.1 GWh. The mission studied the available data and arrived at losses of 3.6 GWh. Table 2.1 shows a breakdown of the mission's calculation of these losses. However, a much more thorough analysis is required for planning purposes and for this more data on the loads in various parts of the network is needed. SEC has begun to gather more load information with recently acquired metering equipment. Both the mission and SEC staff agreed that a microcomputer with software for network monitoring would greatly assist SEC in more accurately determining the magnitude and cause of the losses in each part of the system.

Table 2.1: COMPOSITION OF DISTRIBUTION LOSSES IN THE MAHE SYSTEM

	Demand Losses		Energy losses	
	(kW)	(% of peak load)	(GWh)	(%) a/
Transformer Iron Losses	120	1.2	1.1	2.0
Transformer Load Losses	100	1.1	0.4	0.8
33 and 11 kV Line Losses	340	3.6	1.2	2.3
Low Voltage Losses	280	3.0	1.0	1.9
Total	840	8.9	3.6	7.0

a/ Based on share of energy sent out, i.e., excluding generation and station losses.

Source: Mission estimates.

Non-Technical Losses

2.4 The mission's review of the technical losses in the SEC system revealed some "unexplained losses" which result from the difference between energy sent out and available information on technical losses. Its technical loss calculations of 3.6 GWh for Mahe and 0.1 GWh for Praslin compared with the energy production and sales figures (December 1982 to November 1983) results in an unexplained loss of 1.7 GWh for Mahe and .060 GWh for Praslin, or about 3% and 5% of total electricity sent out by each system, respectively.

Table 2.2: ELECTRICITY SENT OUT AND SALES: DECEMBER 1982 TO NOVEMBER 1983

	Mahe	Praslin
	('000 kWh)	
Energy Sent Out	51,496	1,352
Sales	46,209	1,190
Difference	5,287	162
Estimated Technical Losses	3,600	100
Unexplained Residual	1,687	62

2.5 These unexplained losses could result from: (a) uncertainties in loss calculation; (b) consumers connected to the electricity system but not necessarily registered in the billing system; (c) meter tampering; or (d) defective metering equipment or calibration.

Reactive Power in the Mahe System

2.6 The power factor 1/ at peak load (February and March) for the Mahe system is about 0.85, with maximum reactive demand of 4.9 megavolt amperes of reactive power (MVAR). 2/ During low demand periods (June, July and night time), the reactive power in the system is significantly lower, about 2.0 MVAR. There is little available information on exactly how this reactive power is distributed within the network but most probably it comes from cold stores, the brewery and offices with air-conditioners. The majority of these installations are located in the Victoria area. Other significant sources are hotels, which are high consumers of electricity, and overhead transmission lines and transformers. The installation of static and/or switched capacitors in the distribution system to boost the power factor during peak load could result in substantial energy savings. In a number of countries, ESMAP has found investments in capacitors are likely to have quick payback periods (1-2

1/ The power factor is the ratio of the active to the apparent power and therefore will depend on the amount of reactive power present in the system. The objective of power factor correction is to reduce reactive power in the system, which tends to lower voltage levels and increase losses; it therefore is important that the power factor be as close to unity as possible without causing excessive voltage in the system.

2/ The power factor in the Praslin system is 0.98.

years). 3/ The mission's preliminary review indicates that the Seychelles could also benefit from such investments but the details on the types of capacitors required (switched and/or unswitched), their number and location need to be worked out once more information becomes available about reactive loads and losses in various parts of the system.

Recommendations

2.7 The mission recommends a technical assistance package to (a) determine technical losses in various parts of the distribution system, using a specially designed computer program; (b) identify the major reactive power loads; (c) evaluate the potential of various energy saving measures including capacitor installation, changes in the distribution system's construction practices and design of administrative regulations to control the power factor; and (d) assess the magnitude and causes of non-technical losses and recommend measures to reduce them. Annex 1 provides terms of reference for this assistance, which will require a total of US$150,000 for two man-months of consultant work, computer hardware/software and capacitors.

Diesel Generator Operation and Maintenance

2.8 The mission visited power stations on Mahe and Praslin and held discussions with SEC management and operating staff in order to evaluate the maintenance system, operating procedures and skill levels of supervisory and operating staff. The mission found that most of the maintenance work is not systematic and, as mentioned earlier, the period between generator overhauls often is longer than that recommended by the manufacturer, sometimes due to capacity constraints. In Station B, for example, the maintenance work is based on checklists drawn up by the maintenance staff stating what has to be done, but there are no procedural guidelines. The staff have to consult the engine book, which is a time-consuming process, and there is no control mechanism to ensure that the work on the checklist is actually carried out. As for skill levels, many of the staff lack training in basic electricity theory, load management and diesel plant operation which makes it difficult for operators to make the most efficient use of generating equipment to meet demand.

Recommendations

2.9 The mission recommends a comprehensive, documented preventive maintenance plan for diesel generators combined with standardized operating instructions and a training program for shift operators and supervisors to improve the efficiency of generating facilities. After

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3/ Ethiopia, Kenya, Panama, Sri Lanka, Sudan, etc.

observations of the physical plant and discussions with SEC staff, the mission and SEC agreed on a program tailored specifically to the needs of the SEC power system. This program would include:

(a) the design and implementation of a comprehensive preventive maintenance program and specific plant operating instructions. (See Annex 2 for a sample maintenance card, time schedule, reporting system, and operating instructions);

(b) the preparation of standardized operating procedures for the diesel units which would be displayed prominently in the station house;

(c) a training course in Mahe for shift supervisors, operators and maintenance staff covering basic electricity, combustion engine design and operation, and load management and maintenance; and

(d) consulting services to evaluate the potential for using waste heat to heat fuel oil in the Mahe Station, and audit the high amount of station use in the Praslin Station. Terms of Reference for these tasks are attached in Annex 2.

The benefits expected from this program are:

(e) increased availability of generating equipment;

(f) improved efficiency of generating units;

(g) fewer breakdowns and electricity outages;

(h) extended life of present generating equipment and thus fewer expenditures for spare parts and investment in new generating capacity;

(i) reduced maintenance costs over the long-term;

(j) more productive use of available maintenance staff; and

(k) better load management and more efficient use of available capacity.

Electricity Tariffs

2.10 The mission reviewed the current tariff structure for electricity in order to prepare terms of reference for a power tariff study. The study should propose a tariff which reflects, as much as possible, the economic cost of meeting electricity demand, subject to any constraints such as specific revenue requirements or Government programs for providing subsidies to particular categories of consumers. The mission focussed its review on two areas: (a) brief review of the current tariff compared with estimates of the LRMC for various consumers; and (b) preliminary suggestions on how to approach the revision of tariffs based on demand related costs.

2.11 The mission noted, for example, that more than half of all domestic consumers use an average of only 60 kWh per month and that the cost of supplying electricity to them is nearly double the tariff they pay. At the same time, of the large consumers, those which have high load factors(and therefore operate more efficiently) pay a rate which is much higher than the LRMC of supply (See Figure, page 10). The mission and GOS have agreed, therefore, that a small study should be carried out to establish a demand/cost related tariff structure to assist GOS in the economic pricing of electricity.

Recommendations

2.12 The mission has made some preliminary recommendations for demand/cost related tariff changes. These include:

(a) for small consumers up to 100 amps, a two-part tariff consisting of a fixed monthly charge and an energy charge;

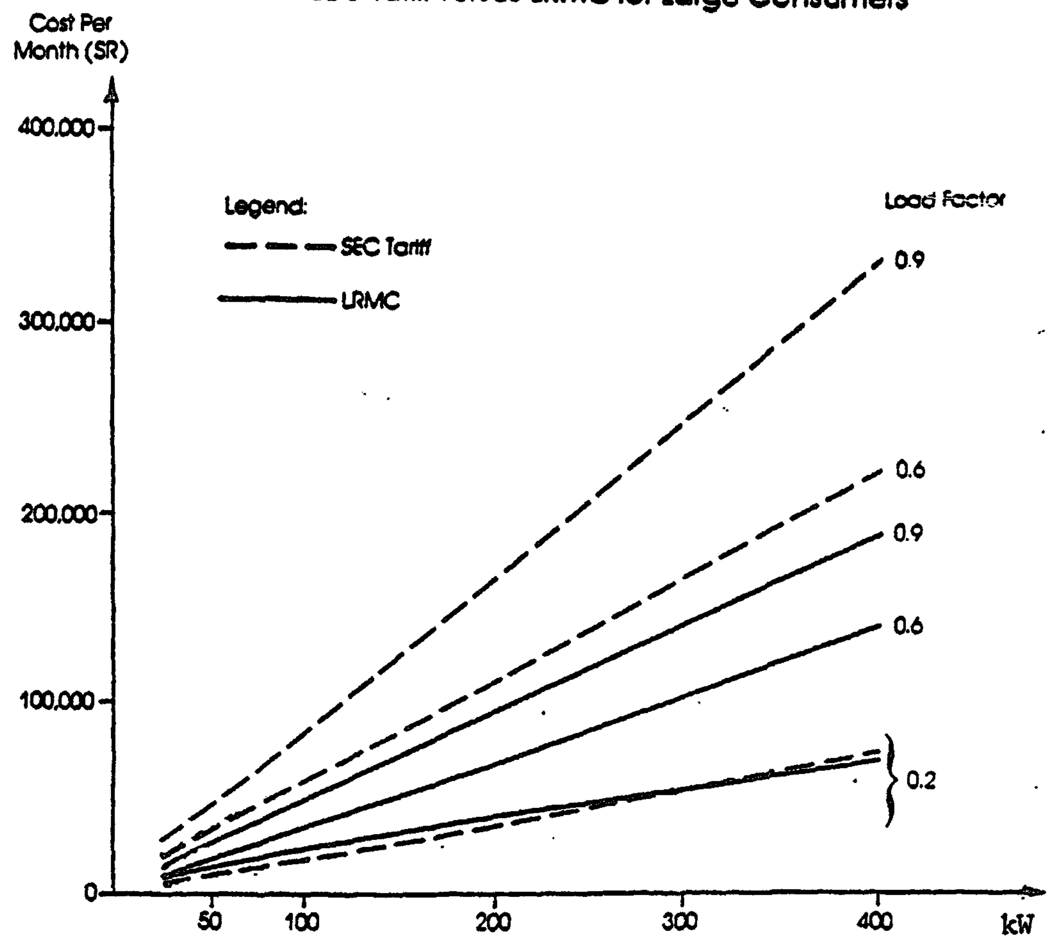
(b) for large consumers, a fixed monthly charge, an energy charge, and a demand charge.

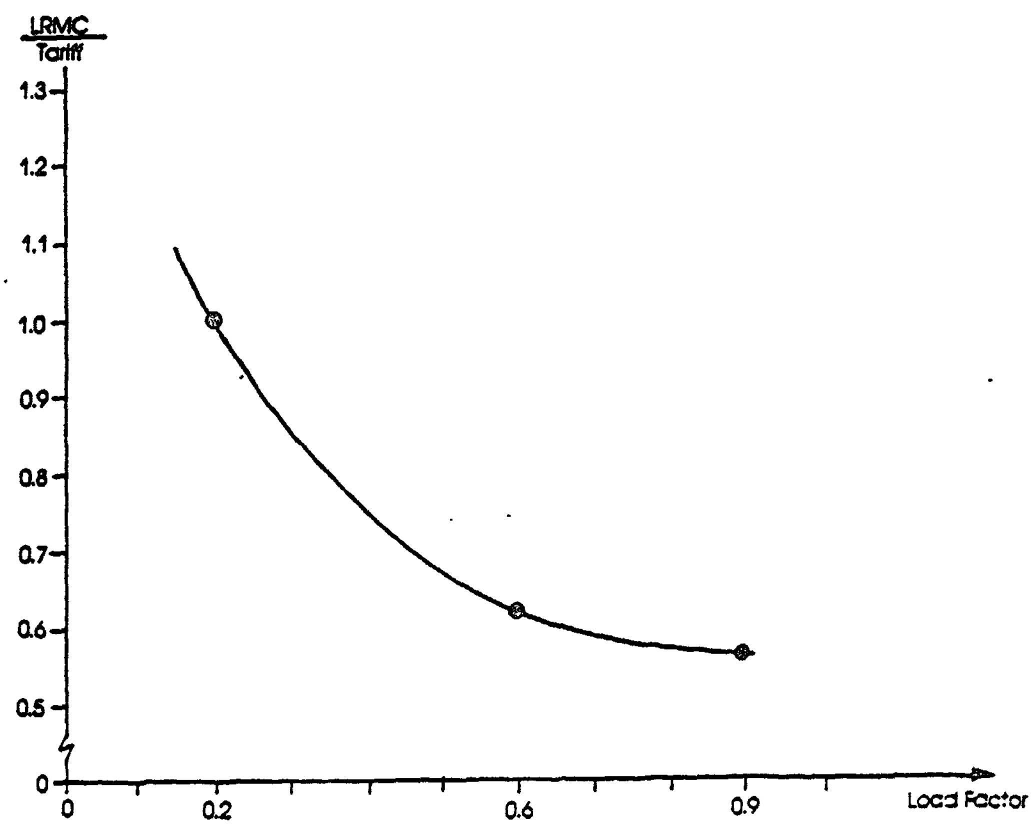
For small consumers, the fixed monthly charge would include non-energy charges related to electricity generation and distribution (capital costs plus operating/maintenance costs) as well as specific consumer-related costs i.e., for connection and metering. The level of the non-energy cost should be proportional to the demand in each principal part of the system. Furthermore, these consumers would also pay an energy-related charge which includes the cost of supply, losses and a safety margin.

2.13 For large consumers, a three-part tariff may be appropriate since a number of them are already metered for both energy use and demand. The demand charge would be based on the maximum demand registered every month and include charges related to capital costs and operating/ maintenance costs of the system. The fixed monthly charge for these consumers would include consumer-related costs such as metering, connection, and administration. The energy charge would include costs of supply (including losses and a safety margin).

2.14 The mission noted that 60% of all consumers in the SEC system are in the 20 amp demand category--the smallest trip switch available at the present time. However, these customers consume an average of only 60 kWh per month which could be met just as well with a much smaller trip switch. Therefore the mission recommends that the tariff study explore the feasibility of installing smaller trip switches.

SEC Tariff versus LRMC for Large Consumers





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Next Steps

2.15 Based on the above findings, the mission recommends a total technical assistance package of US$520,000 to improve the efficiency of the Seychelles electricity system, including consulting services and equipment. The terms of reference for the three projects identified are given in Annexes 1, 2 and 3. The components, duration and cost of each project are summarized below:

Table 2.5: TECHNICAL ASSISTANCE FOR POWER SYSTEM EFFICIENCY IMPROVEMENTS

Project	Consulting Services		Equipment		Total Cost
	Man-months	Cost (US$)	Type	Cost (US$)	(US$)
Efficiency Improvements in the Distribution System	2.0	30,000	Capacitors	100,000	
			microcomputer and software	20,000	
Subtotal	2.0	30,000		120,000	150,000
Efficiency Improvements in Diesel Power Plant Operation and Maintenance:					
1. Praslin Plant Audit	0.5	7,500			
2. Feasibility of Waste Heat Use for Heating Fuel Oil in the Mahe Plant	0.5	7,500			
3. Design of Plant Operating Instructions	3.0	45,000			
4. Design of a Preventive Maintenance Program	11.0	165,000			
5. Training Program	6.0	75,000			
Subtotal	21.0	300,000			300,000
Electricity Tariff Study	4.0	60,000	Metering Equip.	10,000	
Subtotal	4.0	60,000		10,000	70,000
Total	27.0	390,000		130,000	520,000

TERMS OF REFERENCE
EFFICIENCY IMPROVEMENT IN THE FLECTRICITY DISTRIBUTION SYSTEM

Objective

1. This project is designed to reduce losses in the Mahe distribution system and includes consulting services to assist the Seychelles Electricity Corporation (SEC) staff in establishing procedures for determining the location and magnitude of losses in the various parts of the distribution system and evaluate the potential of several energy savings measures. It also includes the provision of a microcomputer and an appropriate software package for network analysis as well as funds for installing capacitors as determined by a detailed network analysis.

Scope of Work

2. Consulting Services. About two man-months of consulting services (specialist in distribution network analysis) will be required to establish power network parameters and a monitoring system. Prior to beginning work in the Seychelles, the consultant will assist the SEC in selecting and installing the appropriate microcomputer and software to be used in SEC headquarters. The consultant will calculate load flows and voltage levels in order to identify losses in various parts of the system as well as identify the major sources of reactive power. Then, the consultant will evaluate the energy savings potential of the following measures:

(a) installation of capacitors in the Mahe distribution system, (selection of size, location, type, etc.);

(b) design of administrative regulations to manage the system's power factor, such as controls on imported equipment uncorrected for reactive power (i.e., air conditioning units, fluorescent lights, etc.) and inclusion of a power factor clause in the tariff structure to encourage power factor correction;

(c) changes in the construction methods of the distribution system including the use of larger conductors, higher voltage levels, selection of optimal transformer sites and their locations, the use of high efficiency transformers, transformer load management, etc.;

(d) evaluation of the magnitude and causes of non-technical losses (after technical losses have been more clearly defined) including review of the billing system and the effective operation of existing metering equipment.

Equipment

3. Microcomputer. A microcomputer and software package would be used for network analyses, evaluation of rehabilitation and extension programs, data recording and reliability assessment of the power system. Calculations would include loss levels, voltage levels, currents, active/reactive loads, fault currents and relay settings. A microcomputer could also be used in other areas of operations and maintenance such as registration of technical data (i.e., fuel consumption, oil temperature, pressure, etc.) for analyzing generating efficiency.

4. Capacitors. The consultants will provide a more detailed analysis of losses in various parts of the distribution network, the number of capacitors required, their types (switched vs. static), location, implementation schedule and an analysis of the costs/benefits of installing them. The mission has estimated US$100,000 for the purchase and installation of capacitors based on its brief review of the likely needs.

Cost

4. The total cost of this project is estimated at $150,000, disaggregated as follows:

	US$
Consulting Services (2 man-months)	30,000
Microcomputer and Software	20,000
Capacitors	100,000
Total	150,000

TERMS OF REFERENCE
EFFICIENCY IMPROVEMENTS IN DIESEL POWER PLANT
OPERATION AND MAINTENANCE

Objective

1. This project includes consulting services and a training program to help the Seychelles Electricity Corporation staff increase the efficiency of energy use in generation through better operation and maintenance procedures. Its specific tasks will be to:

(a) improve plant operations through (i) an audit of the high station use in the Praslin power station, (ii) an evaluation of the potential for using waste heat instead of electricity to heat fuel oil in the Mahe power plants, and (iii) the design and implementation of specific plant instructions for the optimal operation of diesel generating units;

(b) design and implement a preventive maintenance program adapted to local conditions; and

(c) conduct a training course in Mahe for shift supervision, operators and related maintenance staff.

Plant Operations

2. There are two parts to this component. The first consists of consulting services to evaluate the high station use of electricity in Praslin and potential efficiency improvements, i.e. shutting down fans and pumps when not required, checking for air leaks, etc; in addition, the consultant should examine the feasibility of using waste heat rather than electricity to heat fuel oil for the Mahe power stations. This will involve about one man-month of consultant time. The second part consists of consulting services to develop detailed operating instructions to improve the efficiency of operating procedures for power plants in Mahe and Praslin. Sample operating procedures are found in Attachment 1. Consulting services to prepare such instructions will amount to nearly 3.0 man-months.

Maintenance Program

3. The maintenance component of the project will draw up detailed guidelines for preventive maintenance in power stations A and B on Mahe and in the Praslin Power Station. Detailed information on generators and auxiliary equipment to be covered under the maintenance program is given in Attachment 2. Establishing the maintenance program will require about 11 man-months of consultant services. The maintenance guidelines will include: (a) a maintenance card which gives detailed descriptions of how to perform specific maintenance tasks on power generating units and auxiliary equipment; (b) a description of the maintenance time schedule,

which will state when and where each specific maintenance activity should take place; and (c) a description of the maintenance report which will be used as a basis for developing the guidelines. Examples of these items are provided as Attachment 3.

Training Program

4. The participants would number about 40, divided into several groups, and training would take place in the Seychelles. The training would run for three weeks and have to be conducted in three sessions, since the sessions would require full time staff participation and some staff must be available to operate the power plants. The project will cover the following areas:

(a) basic information about electricity;

(b) basic information about combustion engines in general;

(c) specific information regarding the diesel engines installed and their auxiliary equipment;

(d) optimal operating procedures (load management); and

(e) maintenance requirements.

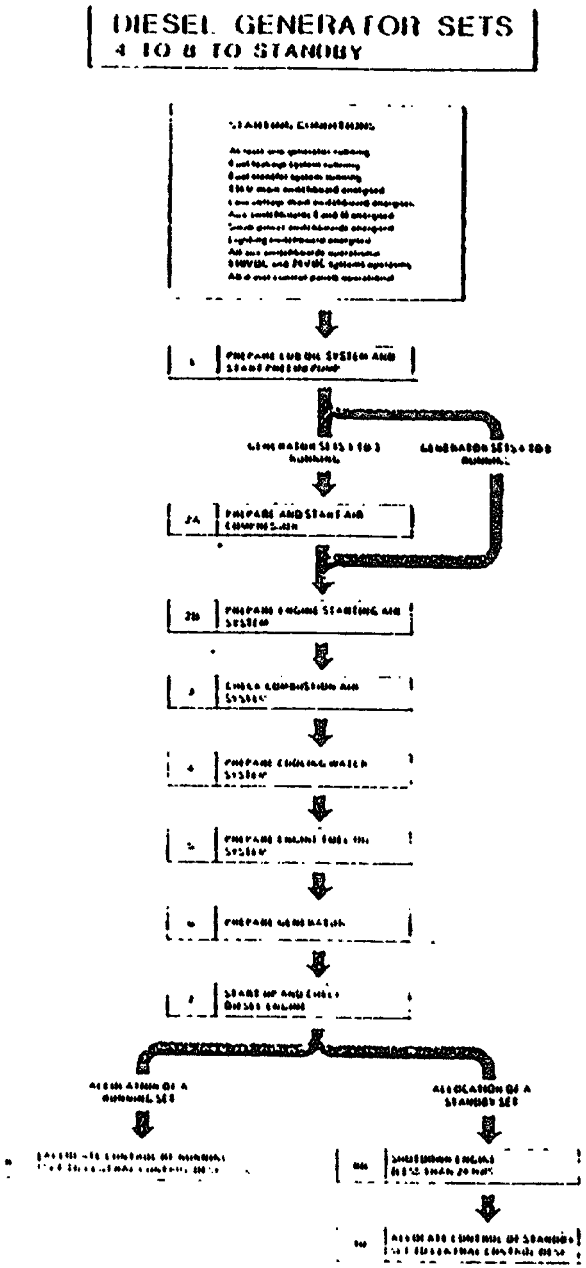
The participants will represent different skill levels but it is still recommended that all participants take part in the entire course. The participating staff will include shift supervisors, operators, and selected maintenance staff. A proposed syllabus of the course is given in Attachment 4. A total of 6.0 man-months would be required for this effort.

Project Cost

5. The total cost of the project would amount to US$300,000 allocated as follows:

Component	US$
Praslin Power Plant Audit	7,500
Mahe Power Plant - Feasibility of Waste Heat Recovery for Fuel Oil Heating	7,500
Design of Plant Operating Instructions	45,000
Design of a Preventative Maintenance Program	165,000
Training Program for Diesel Power Plant Operation	75,000
Total	300,000

SAMPLE DIESEL GENERATOR OPERATING INSTRUCTIONS



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SEYCHELLES POWER EFFICIENCY AUDIT

BASIC DATA ON DIESEL GENERATING EQUIPMENT

			ENGINE SPECIFICATIONS a/					
STATION	UNIT	YEARS SERVICE	Engine No.	MW	kV	RPM	Fuel	Auxiliary Equipment
		15	ESS 16G65C621352-8	1.00	6.6	1,000	Light fuel oil	Oil storage facilities
A	2	17	ERS 8G64C2610420	0.46	6.6	750	Light fuel oil	Engine mounted diesel control panel
	3	16	ERS 8G68D219024	0.46	6.6	750	Light fuel oil	Central control panel switch gear
	4	16	ERS 8G68D2200244	0.46	6.6	750	Light fuel oil	Starting oil compressor (electrically driven)
	5							Starting air compressor diesel driven
B	1	12	K8 major inline con. 6528.1	2.50	11.0	500	Light fuel oil for starting and shutting down; heavy fuel for normal running.	Oil storage facilities
	2	12	K8 major inline con. 6528.1	2.50	11.0	500		Two starting air compressors (oil driven)
	3	8	K8 major inline con. 6528.1	2.50	11.0	500		One starting air compressor (electrically driven)
	4	6	K8 major inline con. 6528.1	2.50	11.0	500		Preheating equipment for heavy fuel oil
	5	3	KV 12 major mk 2 vec type. con. 6822-2	2.50	11.0	500		Separator for heavy fuel oil
								Portable separator for lube oil
								Direct control panel for each engine switchgear (11 kV)
Praslin	1	3	SL 8 con. 13628	0.670	11.0	750	Light fuel oil	Oil storage facilities
	2	3	SL 8 con 13628	0.670	11.0	750		Starting air compressor (electrically driven)
	3	3	SL 8 con 13628	0.670	11.0	750		Starting air compressor (oil driven)
								Direct-control panel for each engine
								Central Control Panel
								Switch gear (11 kV)

a/ Engines manufactured by Mirrlees Blackstone, Ltd, (England) with brushless alternators manufactured by Brush Electrical Machine, Inc.

SAMPLE MAINTENANCE CARD

1. CLEANING AND CHECKING OF PISTON

2. CHECKING OF CRANC BEARING CLEARANCE

3. REPLACING OF PISTON PIN BEARING

1. CLEANING AND CHECKING OF PISTON

Remove the cylinder head as described under instruction No. B5-1 "CYLINDER HEAD".

Dismantling

1.1 Screw an M 12 eyebolt into piston top, pull rope through eyebolt and hang it

Note: If eyebolt cannot be screwed in, clean tap hole with the use of the cleaning tool.

1.2 Cautiously pull piston while guiding the connecting rod by hand to avert damage to the crankpin and the cylinder liner.

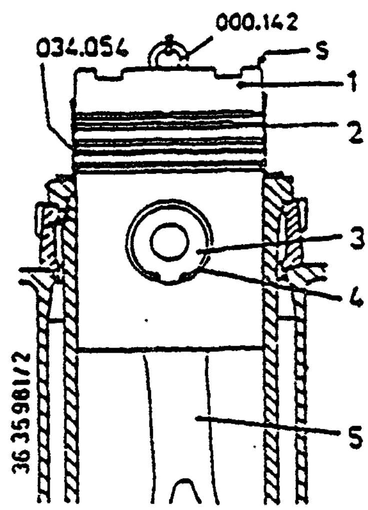
1.3 Piston rings should only be removed by use of the piston ring expander (034.035) to avoid over-stressing of rings.

1.4 Remove lock ring and push out piston pin while lifting the connecting rod to reduce the binding force. Withdraw connecting rod from piston.

1.5 Clean piston, do not scratch or roughen the surface. Flush oil spaces and blow out with an air hose.

1.6 Take measurements of piston, piston rings and piston pin clearance, replace parts as necessary. Table of clearances is to be found on page 4.

Note: Dismantling of a composite piston should only be carried out by one of our service stations or in the piston manufacturer's works.



1 Piston
2 Piston ring
3 Piston pin
4 Lock ring
5 Connecting rod
S Marking (Conrol side)

Fig. 4

SPARE PARTS

1 set of piston rings (5) per cylinder No. ....

SAMPLE MAINTENANCE CARD

Assembling

1.7 Insert connecting rod into piston so far that bore holes in piston and rod are in alignment, oil piston pin and insert it. Fit lock ring which must enter its groove.

Note: The open end of the connecting rod foot should be facing in the direction of the marking S (control side) of the piston.

1.8 Fit piston rings in the correct order, with the ring gaps staggered.
Ring Order: 1st Ring, chromium plated, angle joint, rising on the right or plasma ring
2nd Ring, chromium plated, angle cut, rising on the left
3rd Ring, step-joint ring
4th and 5th Ring, oil-scraper rings

Note: Rings should only be fitted by use of the ring expander (034.035).

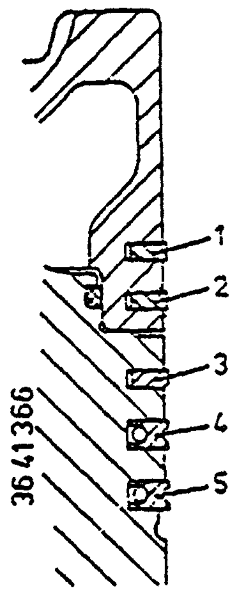


Fig. 5

1.9 Inspect top of liner flange for carbon deposits. Remove deposits, if any.

1.10 Clean ring compressor, check it for damage and oil it on the inside. Place ring compressor over the piston ring set in about mid-position and tighten it until the piston rings are compressed to the inner diameter of the cylinder liner.

1.11 Oil liner running surface and piston liberally and cautiously lower piston into the liner, by use of the lifting gear, until the connecting rod seats on the protecting band on the crankpin if necessary turn crankshaft accordingly. The letter "S" (control side) on the piston, i.e. the open side of the crank bearing must be facing the control side.

1.12 Install crank bearing, instruction No B5-2.

1.13 Screw out eyebolt and remove piston ring compressor.

1.14 Mount cylinder head, instruction no B5-1.

SAMPLE MAINTENANCE CARD

2. CHECKING OF CRANK BEARING CLEARANCE

Remove the crankcase covers and measure the crank bearing clearance by means of a feeler gauge.
Bearing clearance: 0.10-0.20 (Max. 0.27)

3. REPLACING OF PISTON PIN BEARING

In case the clearance between the piston pin and its bearing is found excessive i.e. more than 0.20 mm or the bearing is found scored it has to be renewed.

Dismantling

3.1 The bearing is extracted by means of the extractor (M.030.067) attached as illustrated by tightening the hexagon nut, size 19.

Note: If it is a tight fit, slit bush by sawing to remove the tension. A slit depth from the inner diameter of the bush to a distance of 2 mm from the outside diameter will be sufficient. On no account must the bore hole in the connecting rod be damaged!

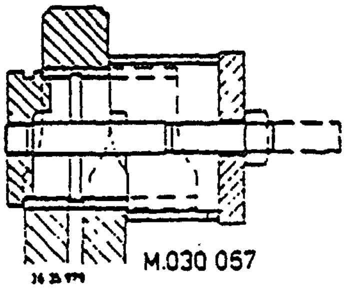


Fig. 6

SPARE PART

One Piston Pin Bearing per cylinder No. ....

Assembling

3.2 Clean bore hole in connecting rod and the outside of the bearing bush, remove any burrs or damage.

3.3 Freeze piston pin bush with liquid air (-194° C) or liquid nitrogen (-195.8° C) to approximately -100° C or heat connecting rod to +120° C.

3.4 Take frozen bush from freezing vessel with suitable hooks.
Caution! Use thick gloves. Danger of freezing!

3.5 Insert bush into connecting rod so that lubricating oil passages are in alignment and the projection is the same on both sides.

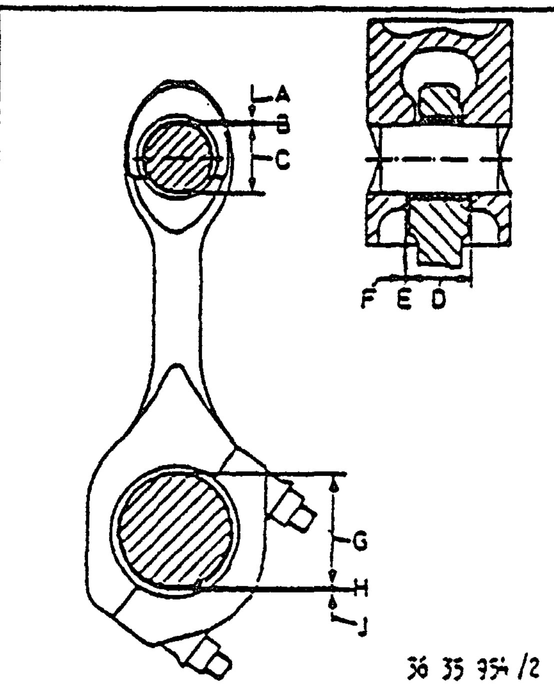
3.6 When connecting rod and bearing bush have reached normal temperature (approximately 20° C), take measurements of bearing bush and enter them in the Engine Record.

Note: It is recommended that this work be carried out by one of our service stations.

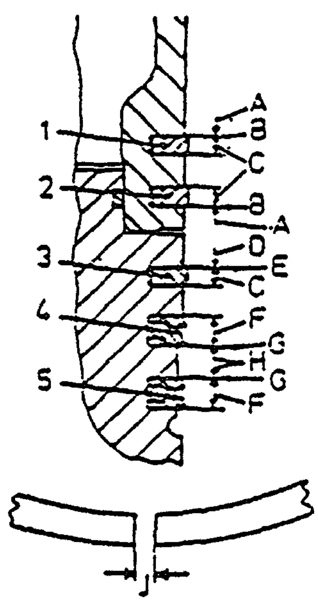
SAMPLE MAINTENANCE CARD

TABLE OF CLEARANCES:

	Dimen-sions	Clearance When new	max.
A	$115^{+0,130}_{+0,090}$	-	-
B	-	0,115-0,170	0,20
C	$115^{-0,025}_{-0,040}$	-	-
D	$103,5^{0}_{-0,20}$	-	-
E	-	0,5-0,9	1,2
F	$104^{+0,2}_{0}$	-	-
G	$195^{0}_{-0,029}$	-	-
H	-	0,135-0,223	0,27
I	$195^{+0,194}_{+0,135}$	-	-
		-	--



A	$5,15^{+0,02}$	-	-
B	-	0,160-0,192	0,40
C	$5^{-0,010}_{-0,022}$	-	-
D	$5,08^{+0,02}$	-	-
E	-	0,090-0,122	0,40
F	$8^{-0,013}_{-0,028}$	-	-
G	-	0,033-0,068	0,15
H	$8,02^{+0,02}$	-	-
J	$1,5^{+0,15}_{-0,10}$ *	-	3,00
J	$0,6^{+0,20}$ ∞	-	2,00



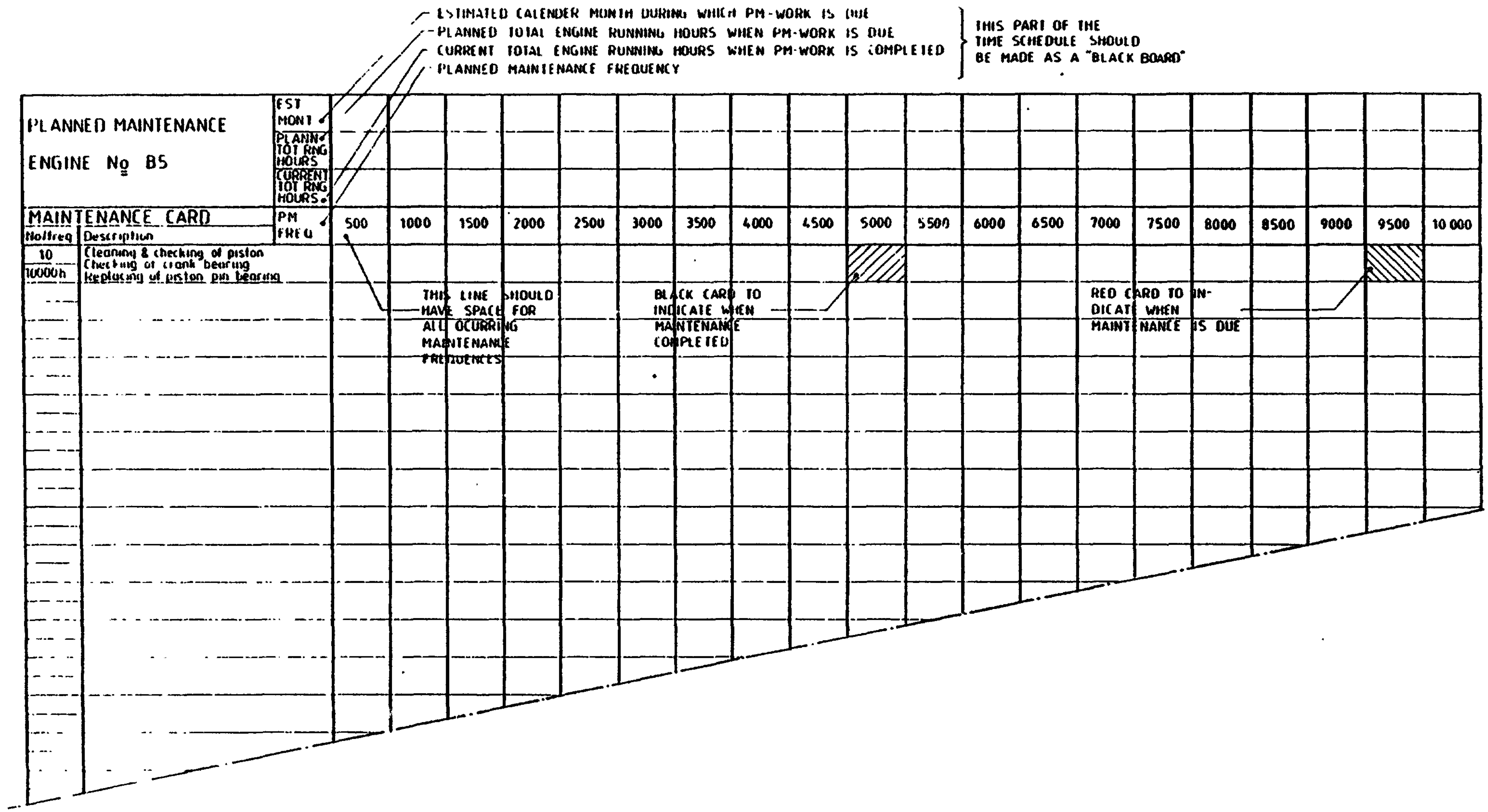
Ring gap

* Ring 1, 2 and 3
∞ Ring 4 and 5

SAMPLE MAINTENANCE REPORT

NOTES TO BE TRANSFERED TO ENGINE HISTORY BOOK			
ENGINE	Type of work	Date	Sign

SAMPLE MAINTENANCE TIME SCHEDULE



THIS WALL MOUNTED MAINTENANCE TIME SCHEDULE, ONE PER ENGINE SHOULD BE OPERATED TOGETHER WITH AN OVERALL SCHEDULE SHOWING CURRENT TOTAL ENGINE RUNNING HOURS PER ENGINE AND WEEK BY WEEK

PROPOSED SYLLABUS FOR TRAINING SEC STAFFING DIESEL GENERATOR OPERATION AND MAINTENANCE

(1) Basic Electricity

(a) Definitions and relations between electrical units
(b) Electricity generating theory
(c) Alternating and direct current
(d) Three-phase system
(e) Measuring methods
(f) Pilot circuits
(g) Measuring circuits
(h) Function of basic electrical equiment including current transformers, voltage transformers, contractors and auxiliary relays, overload relays, voltage and frequency relays, etc.

(2) Combustion Engines

(a) Basic engine types

- the heat cycle - constant volume or constant pressure
- the mechanical cycle - four stroke - two stroke
- single-acting or double-acting
- piston type or piston rod and crosshead

(b) Cooling methods
(c) Cylinder adjustment
(d) Valve adjustment
(e) Methods of firing
(f) Different types of fuels
(g) Methods of injection
(h) High, medium and low speed types
(i) Auxiliary equipment

(3) Diesel Engines in Seychelles

Overall description with references to the points covered above under combustion engines. Description of the functions of following main components: bed plate, frame, crankshaft, connecting rods, pistons, cylinder heads, etc. Additional information on the following systems:

- speed control system
- lubricating system
- fuel oil system and preheating system
- starting air system
- cooling water system
- turbo-charger
- electrical equipment including CCP, CCP and the switchgear.

(4) Efficient Generator Operation

(a) Load management, including sharing and load forecasting;
(b) Analysis of engine data and its impact on the operating efficiency of the unit;
(c) Use of the computer for collection, storage and analysis of engine data;
(d) Use of the computer for load prediction.

(5) Maintenance

Theoretical and practical information regarding the main components (crankshaft, connecting rods, pistons, cylinder heads, etc.).

TERMS OF REFERENCE
ELECTRICITY TARIFF STUDY

Objective

1. The objective of the study is to design a tariff structure which reflects as closely as possible the costs to the economy of meeting the demand for electricity in the Seychelles, subject to other important socio-economic considerations such as the revenue requirements of the utility, subsidization of poor consumers, etc. These terms of reference review the current tariff structure and recommend guidelines for implementing the tariff study.

Profile of the Current Tariff System

2. Rate Structure. The current rate structure distinguishes between small consumers (domestic) and large consumers (commerce, industry, offices, etc.) The small consumers pay a minimum fee of SR 10 and then SR 1.26 (US$.19) per kWh for the first 50 kWh each month. For the larger consumers, a declining block tariff is in effect. Each month, for the first 500 kWh used, they pay SR 1.44 (US$.22), which declines to SR 1.31 (US$.20) per kWh for the next 500 kWh and to SR 1.26/kWh for electricity use above 1,000 kWh.

3. LRMC. The mission made a preliminary analysis of the long-run marginal cost of electricity supply for various categories of consumers and compared it with the current tariff structure. This analysis is discussed in paras. 2.20 to 2.23.

4. Connection. When first connected to the system, the consumer pays a connection fee of SR 25 (US$6) and a deposit which depends on the size of trip switch ordered, available in the following amp sizes: 20, 40, 60 or 100. For a 20 amp switch, which is used by most of the consumers, there is a deposit of SR 100 (US$15). A number of large consumers receive demand meters.

5. Price Level Variations. Adjustments to the tariff for fuel costs are made automatically but the authority to increase tariffs must come from the Government. The current oil price paid by SEC includes a duty which corresponds to SR 0.30 (US$.045) per kWh.

6. Payment Procedures. Consumers receive monthly electricity bills. The time period for payment is 15 days, plus an additional 7 days before a consumer is put on a list for disconnection.

7. The following is an overview of electricity use by domestic consumers according to size of trip switch:

20 amps: There are 6,150 consumers in this category with an average consumption of 60 kWh per month. This level of demand

includes use of lighting, a refrigerator, a fan and an iron. The peak demand of this category is estimated at between 0.2 - 0.3 kW.

40 amps: There are 3,200 consumers with an average consumption of 200 kWh per month. Their demand level includes the same appliances as a 20 amp consumer plus a cooker. Peak demand of this category has been estimated at 1.3 - 1.6 kW.

60 amps: There are 70 consumers with an average consumption of 1,500 kWh per month. These have the same appliances as the 40 amp group plus an air-conditioner. The peak demand in this category has been estimated at 5-5.5 kW.

Scope of Work

8. Analysis of Cost Structure. The relevant costs are the incremental economic costs of electricity supply to the economy. Strictly speaking, therefore, shadow prices (for capital, labor and foreign exchange) rather than actual prices to the utility should be used in measuring costs, and any taxes or subsidies excluded. For the appropriate shadow prices to use, the study team must rely on guidance from the Government. If these are not available, the actual prices of inputs (corrected for taxes and subsidies) should be used. It is suggested that the opportunity cost of capital for discounting future costs be taken at 12%.

9. The first step would be to analyze the marginal costs of generating, transmitting and distributing electricity at different places, times and voltage levels to different consumers over the period to 1986-87, the horizon of the current investment plan. This would require attention to the daily and seasonal variations in forecasting system demand for various consumer categories. Much of the required information for this purpose may have to be specially collected e.g., by taking substation readings, by inquiring about shift-working, seasonal work patterns, etc. and by statistical analysis of available load curves. The basis for the estimates of marginal costs would be the development program for the period to 1986-87 and any additional projects for expansion.

10. For time periods when demand does not come up against the system capacity constraint (allowing for the reserve margins set to maintain security of supply), marginal costs would be simply marginal running costs taking account of losses at the different voltage levels. The relevant losses are incremental losses.

11. During periods when an increase in generation would bring the system up against the security constraint, the marginal cost of meeting demand would be the addition to all system costs resulting from adding to generation capacity or transmission and distribution in order to provide the increased supply with an unchanged probability of failure.

12. Analysis of Existing Tariffs. The existing tariff structure and rates should be examined and compared with the structure of marginal costs of supply derived from the foregoing analysis. A preliminary analysis already has been made by the mission, which points out significant discrepancies between the LRMC and tariff rates of specific consumer groups. Large differences between the LRMC and tariffs charged may be an indication that the existing system is giving the wrong price signals to consumers. Examination of the existing system should pay particular attention to the type of metering equipment in use and the quality of meter maintenance, as well as administration requirements, etc., since this would provide some guidance to the types of tariff structure that would be feasible.

13. New Tariff Proposals. Collection and analysis of the above information should make it possible to develop a first set of proposals for changing the existing tariff system. The mission made several preliminary analyses which should help the study team to tailor the tariff study guidelines to specific aspects of the SEC system. These are as follows:

(a) The SEC tariffs should be more in line with the LRMC of servicing different categories of consumers and, in order to analyze these costs, better data are needed on consumer load curves. This data should not be difficult to gather given the small number of SEC consumers (10,000). In fact, SEC already has begun to monitor some consumers with a recently purchased metering device.

(b) Future changes in the tariff structure for this small system should be as simple as possible to meet energy demand management and cost recovery objectives, i.e., a two or three-part tariff charge. For consumers with a trip switch under 100 amps, a two-part tariff should be considered -- a fixed monthly charge and an energy charge. The fixed monthly fee should include a non-energy charge related to electricity generation and distribution (capital costs plus operating and maintenance costs) as well as certain consumer related costs (i.e., connection and metering). The level of the non-energy cost should be proportional to demand by each specific consumer category on each principal part of the system. In addition to the fixed charge, there also should be an energy related charge which includes the cost of supply, losses and a safety margin.

(c) For larger consumers, some of whom already are metered for both energy use and demand, a three-part charge should be considered. The fixed monthly charge would reflect the same types of costs mentioned above for smaller consumers, but should be considerably larger due to more expensive metering, connection, etc. The energy charge also would reflect the costs mentioned above for small consumers. In addition to the fixed monthly charge and energy charges, a demand charge would be included, based on maximum demand registered, every month. Its value should be proportional to the consumer's use of each major part of the system. In addition, some consideration should be given to the feasibility of time-of-day metering for some categories of large consumers.

(d) Some provision in the tariff setting framework should be made for automatic adjustment due to fuel price increases, to enable SEC management to better control and forecast the Corporation's development.

(e) Nearly 60% of all customers in the SEC system are small consumers in the 20 amp category -- the smallest trip switch available at present. However, these customers consume an average of only 60 kWh per month and it is estimated that the electricity needs of many consumers in this category could be met with a 5-10 amp trip switch. The feasibility of converting these consumers to a smaller amp category should be evaluated.

Cost

14. The tariff study would include four man-months of consultant expertise consisting of an economist, a power engineer, and a financial analyst at a total cost of US$60,000. An additional US$10,000 is estimated for metering equipment, making a total of US$70,000.

NOTE ON THE CALCULATION OF THE LONG-RUN MARGINAL COST OF ELECTRICITY SUPPLY (LRMC)

Capacity Costs

1. Generation Level. The marginal cost of installing new generating capacity was based on the cost of installing a 5 MW diesel unit scheduled to begin operation in 1986-87. There are no further generation investments planned at present. The cost of the five MW diesel unit, including a step-up transformer, is estimated at SR 20 million (US$3 million). Based on this cost, the mission has calculated the LRMC at the generation level using the following assumptions:

(a) availability factor of 0.85;
(b) interest of 20% during the construction period;
(c) depreciation over 15 years;
(d) a 12% annual rate of discount; and
(e) maintenance and operating costs equal to 3% of the total cost.

Therefore, the annual cost per kW of capacity amounts to:

$$\frac{10^3 \text{ kW/MW}}{5 \text{ MW} \times 0.85} \times \text{SR } 20 \text{ million} \times 1.2 \left(\frac{0.12}{(1-1.12)^{-15}} + 0.03\right)$$

This results in an annualized cost of SR 1,000 (US$151) per kW.

2. Distribution Level. Calculations at the distribution level were based on the installation of 11 kV lines. Since it is assumed that most of the new loads are to be installed close to the generating station in Victoria, Mahe, the marginal 11 kV network is comparatively short, about 6 km. This investment is based on the installation of 600 kW at SR 700/kW. Assuming a 15-year depreciation period, operation and maintenance costs equal to 2% of the total cost, and a 12% discount rate, the annualized distribution level capacity investment is about SR 1,100 (US$165).

Energy Costs

3. The marginal energy cost per kWh at the generation and the 11 kV level were calculated to be fairly close. For the purpose of the LRMC calculation in this paper, a figure of SR 0.58/kWh (US$0.09) is used for energy costs system-wide.

ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM

ACTIVITIES COMPLETED

		Date Completed
Energy Assessment Status Report		
Papua New Guinea		July, 1983
Mauritius		October, 1983
Sri Lanka		January, 1984
Malawi		January, 1984
Burundi		February, 1984
Bangladesh		April, 1984
Rwanda		May, 1984
Kenya		June, 1984
Zimbabwe		August, 1984
Uganda		August, 1984
Project Formulation and Justification		
Panama	Power Loss Reduction Study	June, 1983
Zimbabwe	Power Loss Reduction Study	June, 1983
Sri Lanka	Power Loss Reduction Study	July, 1983
Malawi	Technical Assistance to Improve the Efficiency of Fuelwood Use in Tobacco Industry	November, 1983
Kenya	Power Loss Reduction Study	March, 1984
Sudan	Power Loss Reduction Study	June, 1984
Institutional and Policy Support		
Sudan	Management Assistance to the Ministry of Energy & Mining	May, 1983
Burundi	Petroleum Supply Management Study	December, 1983