Joint UNDP/World Bank
Energy Sector Management Assistance Program

Activity Completion Report

No. 014/84

Country: KENYA

Activity: POWER SYSTEM EFFICIENCY REPORT

MARCH 1984

Energy Sector Management Assistance Programme

The Joint UNDP/World Bank Energy Sector Management Assistance Programme (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 programme. 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 Programme provide governments, donors and potential investors with the information needed to speed up project preparation and implementation. ESMAP activities can be classified broadly into three groups:

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KENYA

POWER SYSTEM EFFICIENCY REPORT

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I. SUMMARY

Background and Objectives

1.1 Power system efficiency improvement and loss reduction have been identified as issues in almost all of the country energy assessment reports completed under the joint UNDP/World Bank Energy Assessment Program. 1/ In response to these findings, the UNDP agreed to support a preparatory project to develop a methodology which could be used to identify improvements in electric power systems. Case studies were conducted under the preparatory project and have subsequently been continued under the joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP). This report is one of the studies completed under the ESMAP.

1.2 The principal objective of the study was to identify, through on site inspection of system facilities and operations, a program of specific measures which can be implemented to reduce system losses and to improve the operating efficiency and capacity availability of generating plant. The study was designed to be carried out quickly and at low cost. Accordingly, its findings and recommendations are not intended to be definitive, and further detailed engineering work is required to establish the precise costs and benefits of the various measures. This applies particularly to the analysis of system losses where the absence of detailed circuit data precludes a rigorous circuit-by-circuit analysis which must form the basis of any systematic loss reduction effort. To compensate for this, a relatively conservative approach is adopted in this study in the preliminary estimation of costs and benefits. In particular, the longer term benefits from system improvement measures identified by a detailed engineering study are likely to be significantly greater than indicated here.

1.3 In addition to the discussion of the mission's specific findings and recommendations in Section II, the report also includes detailed terms of reference to initiate the recommended program of improvements. These terms of references are written to provide guidance for either external consultants or in-house staff. However, since it was not possible to assess how much of the work would be carried out by KP&L's own staff, in preparing the cost estimates for the required engineering services it has been assumed that, except where otherwise stated, all of the work will be carried out by external assistance.

1/ The assessment report for Kenya, Kenya: Issues and Options in the Energy Sector, was issued in May 1982.

Main Findings and Recommendations

Transmission and Distribution

1.4 The Kenya Power and Lighting Company operates a generally efficient and well-run electric power system which has been able to meet the country's growing demand for electricity. The company is in the process of diversifying its electricity supply base to hold back the rising cost of electricity production. Nevertheless, as in many other developing countries, the electricity transmission and distribution network has become overextended with the result that system losses (estimated to be 14.6% of generation) are higher than optimal and can be economically reduced. Steps also can be taken to raise the system's power factor (currently estimated at 0.88) through the installation of additional capacitors, and to substitute more efficient methods of power factor correction for the synchronous condensers that are currently used for this purpose.

1.5 Specifically, the analysis in this report suggests that:

(a) System loading may be reduced by as much as 43 MVA (megavolt amperes) by installing 165 MVAr (megavolt amperes reactive) of static capacitors at a cost of $2.3 million. 2/ The result would be to reduce system generation requirements by 5.7 MW with an annual value of $1.28 million and to reduce system losses by 26 GWh per year (9% of current losses) with an annual value of $1.8 million.

(b) The replacement of synchronous condensers by static capacitors would reduce system demand by 2.25 MW (annual value $0.5 million) and consumption by about 20 GWh (annual value $1.38 million). In addition, this should also make available 5 MW of generating capacity at Kipevu and 12 MW at Nairobi South by relieving the need for these units to provide reactive power. The investments required for this task are estimated at $0.7 million.

(c) System losses also can be reduced by reconductoring part of the 11 kV and low voltage distribution network. The precise number and location of the circuits to be reconductored should be determined through a detailed circuit analysis and rehabilitation study which should be initiated immediately.

2/ Costs and benefits in this report are stated in US dollars. Unit cost estimates for equipment are based on manufacturer quotations and include shipping costs to Kenya. Customs duties and sales taxes are not included although an allowance has been made for the shadow price of foreign exchange.

However, it is estimated that approximately 20% of the 11 kV lines and 30% of the low voltage network will need to be reconductored at an estimated cost of $3.3 million. The effect of this would be to reduce losses by approximately 53 GWh per year, valued at $3.76 million per year.

1.6 Based on these findings, the report proposes a package of technical assistance and investments which will reduce losses and raise the efficiency of the transmission and distribution system. The total cost of this package is estimated at $7.7 million, about 90% of which would be in the form of foreign exchange for importing the required materials and engineering services, assuming that the latter were provided through international consultants. The program would be implemented in an 18-24 month period and would require about 100 man-months of engineering services. Detailed terms of reference (TORs) for carrying out the work are included in Annex 2.

1.7 The benefits of the proposed program are estimated to be $8.7 million per year, which exceeds the total investments required. Thus, even allowing for the margin of error associated with the preliminary nature of this analysis, it is clear that these investments are likely to have exceptionally high rates of return and quick paybacks and should, therefore, be accorded a high priority by KP&L and potential financing agencies alike.

Generation

1.8 The mission's findings indicate that KP&L's hydro and geothermal generating plant are in good operating condition and do not require rehabilitation. However, the Kipevu Thermal Power Station at Mombasa needs immediate rehabilitation. At present, it cannot operate at its original rating and has a low level of efficiency and reliability. The underlying problems relate both to the design and operation of certain individual units as well as to station-wide systems such as the condenser/cooling water system and the water treatment system which are all in extremely poor condition and affect the plant's overall operation.

1.9 Based on its findings, the mission has proposed a comprehensive rehabilitation program for the Kipevu Steam Plant. Specifically, the program would:

(a) restore Units 4 and 5 at Kipevu to their full rated capacity of 12 MW each from their present derated level of 8 MW and 10 MW respectively;

(b) restore the combustion turbine unit to 12 MW from the current rating of 5-6 MW;

(c) rehabilitate the condenser/cooling water systems, thereby improving heat rates for the operating units and reducing the need for cooling water pumping;

(d) rehabilitate the Waste Water Treatment Plant;

(e) carry out a series of other minor improvements to specific units and plant facilities.

1.10 The net effect of this program would be to raise the available capacity of the Kipevu Steam Plant by 12 MW and reduce operating costs through improved efficiency and lower auxiliary power requirements.

1.11 Based on the expected future operating requirements of the Kipevu Plant and using the marginal cost of capacity additions and energy production in the KP&L system as a measure of benefits, the benefits from these improvements translate into an annual savings of $1.80 million. Compared with this, the total cost of the proposed rehabilitation package is estimated at $2.85 million, including engineering services of $0.5 million. Thus, as with the proposed distribution improvement package, the proposed Kipevu rehabilitation is also an investment with high economic returns which will be paid off in under two years.

1.12 The proposed improvements to the Kipevu plant could be implemented in about two years. Detailed terms of reference for the engineering services and equipment requirements for the program are presented in Annex 3.

Conclusion

1.13 The overall package of investments recommended by this report amounts to $10.5 million and should result in estimated annual benefits of the same amount, as shown below.

Recommended Improvement Package
(US$'000)

Distribution Rehabilitation Package a/	
Engineering Services	1,400
Equipment-capacitors, conductors, etc.	6,269
Estimated Total Cost	7,669
Estimated Annual Benefit	8,720
Kipevu Rehabilitation Package b/	
Engineering Services	540
Equipment, construction, etc.	2,240
Estimated Total Cost	2,780
Estimated Annual Benefit	1,795

a/ See Table 3 for details.
b/ See Table 5 for details.

II. FINDINGS AND RECOMMENDATIONS

General

2.1 This section of the report reviews the problems of the KP&L transmission and distribution system and the Kipevu Thermal Power Station, and presents recommendations for their improvement and rehabilitation.

2.2 In calculating the value of electricity losses, the economic long run marginal cost (LRMC) is used. The LRMC may be defined as the present value of the economic cost of supplying an incremental unit of demand on the power system. This reflects the economic cost of the incremental supply facilities that would be required to provide an incremental unit of demand.

2.3 For the purposes of valuing technical losses in the electrical network, the LRMC is estimated as a two-part cost: an incremental capacity related cost and an incremental energy cost. Capacity marginal cost is determined by the incremental investment and associated fixed operating and maintenance costs. Long run marginal cost of energy is determined by the marginal fuel and variable operating and maintenance costs of the generating plant required to provide the incremental kilowatt-hour.

2.4 For Kenya, the LRMC of the peak kilowatt (capacity marginal cost) and of the peak kilowatt-hour (energy) is estimated at US$110/kW/year and US¢6.6/kWh, respectively, at the generation level. At the distribution transformer level, the costs are US$225/kW/year and US¢7.0/kWh. The former figures are used to measure the benefits of generating plant rehabilitation and the latter for improved distribution losses. The derivation of the LRMC figures is presented in Annex 1.

Transmission and Distribution

Basic System Characteristics

2.5 The Kenya Power and Light Company is a relatively efficient operator of a medium-sized electric power system, supplying about 170,000 consumers who live mostly in Nairobi and the other urban centers. Between 1977 and 1982, the system's maximum demand grew at about 7% per year to reach 317 MW by the end of this period. Basic statistics for the transmission and distribution network in 1982 are summarized in Table 1 below and set out in more detail in Annex 2.

Table 1: KP&L: Basic System Statistics, 1982

Peak Demand MW		317
MVA		360
MVAR		171
Peak Power Factor (Estimated)		0.88
Load Factor		0.70
Generation (net) GWh		1,946
T&D Lines 220/132 kV - km		1,835
33/40/66 kV - km		2,722
11 kV or less - km		8,719
Transformer Capacity - Generation Substation	MVA	582.5
- Transformer Substation	MVA	390.0
- Distribution Substation	MVA	1,481.5

Source: KP&L

2.6 System losses for 1982 are estimated at 285 GWh, or 14.6% of net generation station output. The absence of adequate and accurate metering equipment makes it difficult to allocate these losses to the various parts of the transmission and distribution network and to differentiate between technical losses and non-technical ones which reflect unmetered usage by final consumers. Nevertheless, a preliminary allocation can be made on the basis of available information. As shown in Table 2 below, the bulk of the losses are incurred in the transmission lines and in the low voltage distribution network. This is partly a result of their high thermal loading and partly their excessive length which, for the transmission lines, reflects the distance between the hydro generating plant and the load centers, and for the low voltage lines reflects their growing over-extension. These factors influence the scope of the priority loss reduction measures that are discussed below.

Table 2: KP&L: Allocation of Estimated System Losses (1982)

Source	Losses, GWh	As a % of Generation
Generation Substation	10.5	0.54
Transmission Lines	101.2	5.20
Transmission Substations	2.3	0.12
Distribution Substations	14.2	0.73
Distribution Primary	41.5	2.13
Distribution Transformers	29.2	1.50
Low Voltage Lines	85.2	4.38
Total	284.1	14.60

2.7 Particular problems in transmission and distribution of the KP&L system in which improvements can be made are:

(a) Power factor improvement.

(b) Inefficient power factor correction methods.

(c) Inadequate system metering.

(d) Unsatisfactory voltage control.

(e) Heavily loaded 11 kV and overextended low voltage lines.

Power Factor Improvement

2.8 The system's power factor could be improved significantly. At present it is estimated to be around 0.88, with 54 MVAR of synchronous condensers at a system peak demand of 317 MW, resulting in a thermal loading of 360 MVA.

2.9 It is estimated that the installation of 165 MVAR of static capactors would reduce the loading to approximately 311 MW at near unity power factor. The required generation capacity would be reduced by 5.7 MW, valued at US$1.28 million per year, and the system losses would be reduced by an estimated 25.8 GWh, valued at US$1.8 million per year. Thus, the total benefits from this measure would be about $3.0 million per year. The direct cost of installing the 165 MVAR of capacitors is estimated at $2.3 million and the work could be completed in about six months. Detailed TORs are provided in Annex 3. Correcting the power factor to near unity would reduce or delay the need for investment in additional generation, assuming that service quality (voltage) is maintained at existing levels.

2.10 The analysis in this report does not, however, take into account the overall system effects of the proposed new transmission lines, which would add substantial capacitive reactance. This leads to the conclusion that a system with optimal losses would likely include both switched reactors in the transmission circuits and fixed and switched capacitors in the distribution system. This would minimize the VAR flow throughout the system with acceptable voltage limits at both generating stations and within the distribution system. Studies of this nature are beyond the scope of this report but will be required as part of more detailed follow-up studies. The terms of reference in Annex 3 include provisions for this work.

Inefficient Power Factor Correction Methods

2.11 Synchronous condensers are in operation at Juja Road, Nairobi South and Kipevu, with a total value of 54 MVAR. This method of power factor correction is inefficient. The condensers operate almost continuously, consuming approximately 19.7 GWh per year with a demand of 2.25 MW to operate.

2.12 It is recommended that the use of synchronous condensers during peak hours be replaced with an equivalent amount of static capacitors, most being located out on the 11-kV distribution lines (not in the substations). The direct cost of these static capacitors is estimated to be about US$650,000. The result will be a savings of $1.38 million per year in energy production and a reduction of 2.25 MW of generation capacity requirement valued at $506,000 per year. The installation work could be completed in six months. Terms of reference and cost estimates are provided in Annex 3.

2.13 In addition to these benefits, the improved method of power factor correction would release 5 MW of capacity at Kipevu and 12 MW of capacity at Nairobi South, for a total of 17 MW of additional available capacity during peak hours.

Inadequate System Metering

2.14 Many substations, control centers and feeders do not have sufficient meters to allow for more than rudimentary system analysis and study. In-house capability does exist for proper testing and adjustment of meters but it is necessary to initiate a program of regular testing and adjustment of meters in all power stations and substations. Consideration should be given to establishing an integrated recording-meter system to supply data for computer-based system analysis.

2.15 A review is recommended of all existing metering to determine adjustment requirements of present installations as well as any required additional metering. A priori, it seems that additional metering (both permanent and portable) is needed. Such a study will require about three man-months at a cost of $32,000 and an initial investment of $30,000 in metering equipment. TORs are found in Annex 3.

Unsatisfactory Voltage Control

2.16 The supply input to the 11-kV primary distribution system is provided by stepdown substations with a total capacity of approximately 610 MVA. Most of these stepdown transformers are equipped with automatic ULTC (underload tap changing) equipment for voltage control. The purpose of the ULTC equipment is to provide automatic and independent voltage control for each 11-kV distribution primary area fed from a 33/11 or 66/11 kV stepdown station.

2.17 Although the ULTC equipment exists, station visits indicated that most of the ULTC unit controls have been disconnected. Distribution system voltage control is therefore dependent, in many cases, on manual operation of the controls or simply on system voltage (generation or transmission voltage).

2.18 A study should be made of this problem and corrective action should be taken to put the ULTC equipment back into service. Such a study is estimated to require about three man-months at a cost of $44,000. Terms of reference are included in Annex 3.

2.19 The benefits of improved voltage control are difficult to estimate but can be quite large, particularly when considering the increased financial revenues to the utility. The objective should be to achieve minimum acceptable voltage to the farthest customer at the time of peak demand, while maintaining maximum acceptable voltage at the nearest customer under light load, thus optimizing energy flow over the system.

Reconductoring of 11 kV Lines

2.20 Losses on the primary distribution lines, after installation of capacitors, are estimated to be 1.9%. At first look this appears to be relatively small. However, this is explained by the relatively low ratio of 11-kV lines in the network and by the fact that several substations are located at large industrial loads where the 11 kV lines are either nonexistent or very short.

2.21 Nevertheless, each major feeder should be studied to determine the optimum conductor size and to reconductor circuits where warranted. It is estimated that approximately 20% of the 11 kV lines will need to be reconductored to improve voltage regulation and reduce losses. An estimated 1.3% reduction in losses on the primary distribution lines may be obtained by this reconductoring, which would cost an estimated $2 million. The savings from reduced losses would have an annual value of $2 million. TORs and a cost estimate are provided in Annex 3.

Reconductoring of Low Voltage Lines

2.22 Although loading information on the low voltage system is very limited, losses are estimated to be 4.4%. A review of distribution maps shows many lines to be overextended and of small cross section. Losses may be halved by setting a target for reducing the length of lines to 300 meters. A satisfactory voltage level can generally be attained only by limiting the length of low voltage lines to 300 meters.

2.23 This area requires special attention, as the losses and the investment to reduce them are both quite large. It is estimated that 30% of the low voltage lines should be reconductored with larger conductors. An increase of one conductor size will reduce losses by an estimated 37 GWh, representing a savings of $2.63 million per year at an estimated cost of $1.3 million. These results also indicate a need for a thorough system-wide study to optimize distribution transformer sizes and low voltage circuit lengths. Under current and future cost conditions, it is likely that the system should include smaller and more numerous distribution transformers and much shorter low voltage lines. TORs and a cost estimate are provided in Annex 3.

2.24 The costs and benefits of the various measures are summarized in the following table.

Table 3: KP&L Transmission and Distribution Rehabilitation Program
(US$ '000)

Item	Estimated Cost a/	Estimated Annual Benefits b/ Capacity	Energy	Total
Engineering Services c/	1,400	-	-	-
Power Factor Correction	2,300	1,280	1,800	3,080
Replacement of Synchronous Condensers	650	500	1,380	1,880
Reconductoring 20% of 11-kV Lines d/	2,010	-	1,130	1,130
Reconductor 30% of Low Voltage Lines d/	1,309	-	2,630	2,630
Totals	7,669	1,780	6,940	8,720

a/ All costs and benefits are in 1983 US$. All figures are indicative only and need to be verified through detailed engineering.

b/ Benefits are based on system LRMC. The figures are for estimated annual benefits of capacity additions or energy savings as approximate. See Annex 1 for derivation of LRMC.

c/ Engineering services include the cost of implementing all the recommended improvements, including detailed design and supervision during implementation. It is assumed that all of this work would be carried out through the use of international consulting engineers. Costs would be lower if suitably trained KP&L staff carried out this work. This item also includes the cost of all proposed studies listed in Annex 3.

d/ Reconductoring costs are based on the differential costs of new conductors and assume that existing lines can be salvaged for use elsewhere in the system.

Source: Mission estimates.

2.25 Approximately $1.4 million of the total cost is accounted for by the engineering services input necessary for the program. It is estimated that approximately 100 man-months of consulting services will be called for, both to implement the specific measures and to carry out a number of other preparatory studies which also are identified in the report. Assuming that external consultants carry out this work, it is expected that they will need to establish a field office in Nairobi for about 18-24 months to complete this work. Inputs of varying lengths will be required from a variety of specialists. Detailed TORs for this work are provided in Annex 3.

2.26 Most of the remaining $6.2 million will be required for purchasing capacitors, conductors and materials, metering and monitoring equipment and other associated goods which are listed in Annex 3. This equipment is readily available from a variety of sources and could be procured with relatively short delivery times. However, it is important that arrangements be made to ensure the delivery of this equipment soon after the engineering services contract is initiated so that these programs can be fully implemented during the 18-24 month stay of the consulting engineers.

2.27 It is important to emphasize that the above figures are indicative estimates only and need to be verified through detailed engineering work. Nevertheless, the figures do suggest that highly profitable investments can be made in improving KP&L's transmission and distribution network. The estimated annual benefits from the proposed improvement package exceed the total investments required. Moreover, these benefits can begin to accrue very soon after the rehabilitation program is begun, as the bulk of the work proposed could be carried out in 18-24 months.

Generation

Hydro-Electric Power Stations

2.28 The KP&L system generating capacity is comprised of hydro, geothermal, and thermal generating units with a total capacity of 540 MW. An additional 30 MW of hydro capacity is purchased from Uganda. The hydro capacity is essentially all on the Tana River (335 MW out of a total of 348.5 MW) with a very large reservoir (1,400 x 10^6 M^3 capacity) at the first dam site (Masinga) which supplies the downstream hydro plants at a controlled flow rate.

2.29 The hydro plants function without operating restrictions. They are all relatively trouble-free installations with a high degree of reliability. Discussions with plant management and inspection of three of the large installations (Masinga, Kamburu and Gitaru) revealed no deterioration in output or efficiency losses due to deterioration.

Olkaria Geothermal Power Station

2.30 A visit was made to the 2 x 15 MW Olkaria geothermal plant. This is a new installation, the first unit having been commissioned in July 1981 and the second in November 1982. The units are fed mainly from 14 of the 26 geothermal wells that have been drilled at the site. The life of the wells is estimated to be more than 25 years.

2.31 These units are in exceptionally good condition and operate as base load units. Inspection of the units and discussions with the plant personnel indicated that there are no major problems at this installation and both the units are operating at or above rated capacity.

Kipevu Thermal Power Station

2.32 Unlike the hydro and geothermal generating plants, the Kipevu oil-fired steam plant at Mombasa is in a state of disrepair and badly requires rehabilitation. This plant is comprised of seven heavy oil-fired steam units and one kerosene-fired combustion turbine with a total original rating of 114 MW which has been downgraded to 96 MW because of the poor condition of some units. The plant also operates below design efficiency levels mainly because of problems in the steam condenser/circulating water system. The present configuration at the plant is as follows:

- One 12-MW combustion turbine with an actual rating of 6 MW;
- Units 1, 2 and 3 at 5 MW each, but unit 1 is no longer operational;
- Units 4 and 5 at 12 MW each, derated to 8 and 10 MW, respectively;
- Unit 6 rated at 30 MW; and
- Unit 7 rated at 33 MW.

2.33 At this time, the Kipevu plant is operated primarily for voltage control reasons at Mombasa. The operating regime is to run one unit at a time, alternating the use of the various units without any order of merit. The combustion turbine operates as a synchronous condenser. In the future, the role of the Kipevu plant will change because the conversion to 220 kV of the 132 kV line to Mombasa from the Tana River hydro station will relieve the voltage problem in the city. The Kipevu plant can then act as a thermal supplement to the overall power system. It will be particularly important as a reliable alternative source of power in the Mombasa area in the event of a breakdown in the 500 km interconnection between Seven Forks and Mombasa. 3/ The future operation of this plant has been forecast by KP&L for an average rainfall year and a very dry year, as follows.

Table 4: Annual Thermal Plant Energy Requirement
(GWh)

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Average
Average Year	185	131	154	210	277	99	134	63	106	79	143.8
Driest Year	696	696	841	837	837	837	777	722	722	722	768.7

Source: KP&L.

3/ For this purpose, it is essential for Kipevu to retain a "black start" capability. This could be provided through the combustion turbine or, if it is to be used as a synchronous condenser, by relocating two or three old diesel sets to Kipevu to act as "black start" generators.

2.34 The average figure for the average year (i.e., 144 GWh/yr) is used to evaluate the benefits of efficiency improvements at the plant. However, as shown in the above figures, plant use is expected to be particularly heavy in the years 1986-88. This is because KP&L expects an overall supply shortfall in this period until the 140 MW Kiambere hydro station is commissioned in the latter half of 1988. This factor makes the rehabilitation of Kipevu particularly urgent and provides further justification for this work.

2.35 The inspection and analysis carried out by the mission have identified a number of measures that can be taken to improve the operating efficiency of the Kipevu plant and to restore its capacity to near original rating. The specific measures are discussed below.

Units 1, 2 and 3

2.36 The Unit 1 steam turbine has been seriously damaged and KP&L has written off the turbine generator as an operating unit. The boiler still operates and supplies steam to the turbines of Units 2 and 3. However, Unit 3 has been out of service for two years awaiting turbine parts from the UK. Efforts to obtain and install these parts should be intensified. These units do not require major rehabilitation. However, one item requiring attention is the absence of fuel oil flow meters on these units which prevents the monitoring of their efficiency and thermal performance. In turn, this prohibits the establishment of an order of merit in the operation of the two turbine units and the three boilers. The benefits of installing these meters, in terms of improved efficiency, cannot be quantified in advance, but they are likley to be well in excess of the estimated $8,000 cost of installation. The detailed TORs for this work are included in Annex 4.

Units 4 and 5

2.37 The breakdown of desuperheating coils in the boilers has caused these units to be derated to 8 MW and 10 MW respectively, from the design rating of 12 MW. The units also operate at low efficiency with high auxiliary power consumption. A package of improvements -- comprising control instrumentation, replacement desuperheating coils, soot blower system additions, etc. -- costing about $70,000 will return these units to their full rated capacity and result in higher operating efficiency. The estimated benefits from restoring capacity alone are $0.66 million per year; additional benefits from efficiency improvements cannot be quantified in advance. The detailed TORs and costing of this work are included in Annex 4.

Units 6 and 7

2.38 These units are 11 and 7 years old, respectively, and in relatively good working condition. However, several basic design shortcomings need to be corrected to increase unit reliability and efficiency. Critical monitoring and metering equipment, which is currently not functioning, also needs to be replaced to avoid the possibility of expensive and extensive repairs to the units in the future. The required package of improvements is outlined in detail in Annex 4 and is estimated to cost $310,000. One immediately quantifiable benefit of these improvements will be to reduce the units' auxiliary power requirements by an average of 650 kWh per year based on the projected operating figures for these units. The value of this improvement alone is $125,000 per year and the investment should be paid back in less than three years. The other benefits, which cannot be quantified in advance, should be at least as great and add to the priority for carrying out this task.

Combustion Turbine Unit

2.39 This 12 MW unit has been derated to 6 MW because of several basic design shortcomings relating to (a) the inadequate size of the lube oil coolers and (b) the wrong location of the lube oil storage tank and the reduction gear in an unventilated area. These problems can be corrected by the addition of a forced-air-finned cooler system and forced ventilation systems in both the lube oil storage tank and reduction gear enclosures. The cost of these improvements would be about $15,000 as shown in Annex 4. The benefits would be to restore the capacity of this unit back to 12 MW, which translates into an annual savings of $660,000 in terms of incremental system capacity output.

Condenser/Cooling Water System

2.40 The condensers and sea water cooling systems are in a severe state of disrepair, mostly due to corrosion and lack of proper maintenance. The system's entire cathodic protection system has not functioned for many years. Corrosion has reached an extent where the cooling water pump and condenser isolating valves cannot be used to facilitate maintaining the equipment. The lack of a chlorination system has resulted in severe pluggage of the cooling water lines and condensers with clams, algea, worms and other marine life, with a resulting effect on condenser vacuums and unit heat rates. Rehabilitation of this aspect of the Kipevu plant is of high priority because, if left untreated, this could result in extensive plant-wide damage. The work required is described in Annex 4 and is estimated to cost $1.4 million. Specific benefits are difficult to quantify, but two of the benefits are an improvement in the heat rate of the operating units, and the reduced usage of cooling water pumps. The estimated value of these benefits alone is $350,000 per year.

Waste Water Treatment Plant

2.41 This equipment is also in a very poor state due to the failure of the acid and caustic waste drainage system. In addition, the drains from the treating plant are fed directly into the Units 1 and 2 station drainage system and discharge into Mombasa Bay in an untreated state. Leakage in the plant area has caused an erosion of foundations and additional overhead steel supports are required. In short, the water drainage system needs to be rehabilitated completely including the station drains, blowdown tank and new sump and sump pumps and a waste treatment system. The work required is estimated to cost $360,000 and is detailed in Annex 4. It is not practical to quantify the benefits from this, except to note that without an adequate water treatment system, the Kipevu plant cannot function.

Storage Warehouse

2.42 An acute shortage of storage capacity has resulted in inefficient storage of materials outdoors and in the turbine hall equipment laydown area. While this is not as urgent a task as the other measures listed above, it is recommended that an adequate storage warehouse be constructed to meet the requirements of this station. The estimated cost of such a warehouse is $75,000 and the work required is outlined in Annex 4.

Table 5: Kipevu Steam Plant Rehabilitation :rogram

	Item	Cost a/ (US$'000)	Annual Benefits b/ (US$'000)
(a)	Engineering Services	540	-
(b)	Units 2 and 3 Fuel Oil Meters	8	-
(c)	Units 4 & 5 Rehabilitation	70	660
(d)	Units 6 & 7 Rehabilitation	310	125
(e)	Combustion Turbine Rehabilitation	15	660
(f)	Condenser/Cooling Water System Rehabilitation	1,400	350
(g)	Water Treatment System Rehabilitation	360	-
(h)	Warehouse for Storage	75	-
Total		2,778	1,795

a/ All costs are in 1983 US$. They include physical contingencies. The Engineering Services estimate is based on the assumption that all of this work will be carried out using outside, international engineering firms. Costs are not based on detailed design.

b/ The estimated annual benefits are based on system LRMC. The benefits of items (c) and (e) are based on restoring the capacity of these units at an LRMC of $110/kW/year. The benefits of items (d) and (f) are based on improvements in operating efficiency or in lower energy usage at an LRMC of US¢6.6 per kWh.

Source: Mission estimates.

2.43 The cost of the total package, including contingencies and the cost of engineering services is estimated at $2,780,000. Implementation would take about two years. The benefits in terms of incremental capacity additions or of energy (kWh) savings as appropriate, are estimated at $1,795,000 per year. These figures, while subject to a margin of error given that they are not based on detailed engineering, nevertheless provide compelling grounds for undertaking this work as a measure of high priority.

Load Growth

2.44 At the time of the mission, studies made by KPC projected load growth at 6% per annum during 1983-88 with a demand shortfall in 1986 to be met by the installation of a 30 MW gas turbine. However KPC now projects electricity demand growth at 5.5% between 1984 and 1988, with a possible demand shortfall of 10 MW in 1977/88. This shortfall, according to KPC is within the capacity of the load management system and therefore it is anticipated that additional gas turbine capacity will not be required. Moreover, the proposed improvements to the power plant at Kipevu and to the distribution system should further reduce the need for gas turbines.

Long-Run Marginal Costs

The Long Run Marginal Cost (LRMC) may be defined as the present value of the economic cost of supplying an incremental unit of demand on the power system. For the purposes of valuing technical losses in the electrical network, the LRMC is estimated as a two-part cost, an incremental capacity related cost and an incremental energy cost at the generation level and at the distribution level.

The capacity cost corresponds to the minimum expenditure system planners are ready to accept to maintain reliable service, disregarding fuel cost at peak and during energy shortfalls in any year. The marginal fuel cost (energy cost) is the incremental operating cost of the unit best suited to meet demand increments.

The marginal cost of generation for Kenya is derived from combustion turbine unit costs based on annual fixed charges for a 15 year life at a 12% discount rate and an 80% availability at peak. At a unit investment cost of $550/kW and 16% (14.5% carrying charge plus 1.5% operating and maintenance costs) equates to $88/kW. For 80% availability this becomes $110/kW/year.

The cost of capacity at the transmission voltage level increases with increased losses (7.5%). The average incremental cost for the transmission and distribution program is therefore 1.075 times $110/kW plus $107 for the cost of the transmission line equating to $225/kW/year.

The marginal energy cost for the period under consideration is the fuel cost at the Kipevu steam plant which, at an economic fuel cost of $200/tonne, is $0.066/kWh at the plant and $0.07/kWh with the transmission losses.

KP&L: Basic System Statistics

KP&L Estimated System Load, 1982

MW, Peak demand	317
MVAR	171
MVA	360.2
Peak Power Factor	0.88
Load Factor	0.70
GWh Net	1,946

KP&L T&D Network (1983)

Voltage kV	Length Kilometers	
220	217	
132	1,618	
66	374	
40	113	
33 OH	2,234	(Includes single wire earth return)
33 UG	1	(Includes submarine cable at Mombasa)
11 OH	5,876	
11 UG	195	
0.415 OH	2,502	
0.415 UG	146	

KP&L Installed Capacity, 1983

Type	Voltage	MVA
Generation Substation	11/132	396
Generation Substation	11/66	30
Generation Substation	11/33	137
Generation Substation	11/40	5
Generation Substation	3.3/11/40	8
Generation Substation	3.3/40	4
Generation Substation	3.3/33	2.5
Transmission Substation	132/66	195
Transmission Substation	132/33	180
Transmission Substation	66/40	15
Distribution Substations	66/11	323
Distribution Substations	40/11	15.5
Distribution Substations	33/11	272
Distribution Transformers	11/0.415 and 33/0.415	871

Consultant's Terms of Reference

Transmission and Distribution System Improvement

General Note

The Kenya Power and Lighting Co., Ltd. (KP&L) is soliciting proposals to organize and implement the rehabilitation of the KP&L transmission and distribution system.

Terms of Reference

These Terms of Reference cover the consulting services required to study, evaluate, recommend, specify and assist the KP&L in the improvement of the transmission and distribution system to reduce losses and improve the efficiency of the system. For the distribution system work, the consultants shall provide sufficient resources to carry out investigations, detailed design work, preparation of work schedules and supervision of work execution. The program for these services will be integrated with the construction program so that the engineering and construction of distribution works may be carried out as parallel activities. It is estimated that about 101 man-months of service will be required in Kenya.

The Consultant will do the following:

(a) establish an office and perform all work in Nairobi, Kenya;

(b) review all available studies and research as well as the present transmission and distribution system;

(c) make a field inspection of the transmission and distribution system and make an offer to undertake the work described in these terms of reference;

(d) prepare engineering designs and job descriptions, where required, for specific tasks;

(e) issue specifications for the supply, delivery and installation of equipment, material and system required for the Project;

(f) assist KP&L in the evaluation of proposals as required;

(g) undertake on KP&L's behalf the procurement, transport, expediting and scheduling of work including the fabrication and timely delivery of the equipment, material and/or systems required to complete the specified tasks, and

(h) supervise the installation of all work elements specified herein.

A World Bank/UNDP System Efficiency Report dated November 1983, is the first phase of this rehabilitation program indicating the remedial actions required to reduce losses to an acceptable level. The report is based upon an accelerated field survey. The basis of the report is the result of discussions and observations made during the mission's visit to Kenya. The estimating data is based upon order of magnitude values only. The Engineer is to perform an indepth investigation of the work elements outlined herein and shall also recommend additional rehabilitation work elements which become evident as a result of his investigation. These recommended additional tasks should demonstrate that improved operation, reduced power losses, efficiency, performance and/or reliability will result from the proposed improvements. The Engineer shall include in his proposal a suggested procedure to be used to handle additions and deletions to his contractual scope of services. This shall include but not be limited to work time estimates with backup data and hourly or daily rates for the work performed. These rates shall be included in the contract.

An overall program schedule from the time of award of contract to completion of the program shall be included in the proposal. The priority work elements are to be completed by the fourth calendar quarter of 1985 at the latest. These are identified in the Terms of Reference.

The following lists the work elements to be included in the Engineer's scope of services. The Annexes attached to these Terms of Reference give more detailed descriptions of the work to be done and form a part of this document.

The KP&L engineers shall assist and continue the work after gaining additional experience working with consulting engineers.

The Consultant will perform a review of Generation Station Logs and observe loadings to verify that the system power factor is 0.88. It is noted here for reference that the 1982 peak demand was 360.2 MVA, delivering 317 MW to the system with 54 MVAR of synchronous condensers operating. The reduction of the MVAR requirement to bring about a near unity power factor should result in the release of generating capacity by approximately 43 MVA as well as reduce the system demand loss by approximately 5.7 MW.

The Consultant will make an overall indepth economic evaluation study, on location in Kenya, to determine the MVAR requirement of each part of the system. This will necessitate the review of all metering at generation stations, substations and feeder positions. The study will require the installation of additional substation and feeder meters as well as the use of portable meters on numerous lines.

The Consultant will establish the most advantageous and economic location for static capacitors near the load requiring VARs. Most of these will be installed on the 11 kV lines at some distance from the substations. The need for bulk installations in substations will be established by the Consultant.

The Consultant shall engineer the use of static capacitors specifically addressing but not limited to, the following technical aspects of the work:

(a) Release of system capacity.

(b) The reduction of system losses.

(c) The raising of the system voltage level.

The Consultant will specify for purchase by KP&L one-fourth of the estimated supply of capacitors together with controls while the engineering is under way so that KP&L can begin installation as soon as locations and methods of application are determined by the Consultant.

The engineering study is to be made on a substation area basis, utilizing KP&L engineers so that they may learn and understand the method of engineering and application principals.

Since technical capability does exist within the KP&L system, KP&L will participate in the system stability studies and system analysis so that the KP&L will gain the additional experience and capability to continue the engineering studies on an annual basis.

The Consultant should recommend computers and programs for use in making studies and provide training.

It is estimated that the shipping time on the original capacitor order will be about three months. By that time the initial locations and quantities should have been determined so that initial installations can begin. An additional order should be placed as soon as additional quantities and locations are determined.

The KP&L system presently operates a 3 x 8 MVAR of synchronous condensers at the Juja Road Control Center, 1 x 18 MVAR at Nairobi South and 1 x 12 MVAR at Kipevu in Mombasa. These machines require approximately 2.25 MW of power for operation and consume approximately 19.7 GWH of energy per year.

It is expected that 20 units of 1,170 kVAR will be required in the Juja Road area, 15 in the Nairobi South area and 12 in the Kipevu area.

The supply input to the 11 kV distribution system on the KP&L system is provided by many substations equipped with automatic under load tap-changers (ULTC) equipment for voltage control. Station visits indicate that many of the ULTC unit controls have been disconnected or are inoperable. Distribution system voltage control is therefore dependent on manual operation of controls or on system voltage.

The Consultant will inspect all ULTC equipment in the substations and determine if parts or work is required to place the mechanism in operation. He will prepare a specification of needed parts or work descriptions for the use of KP&L.

The Consultant will instruct the KP&L engineers in required inspection and maintenance work as well as in-service operation and adjustment of the ULTC equipment, including specifying optimum voltage control profiles.

The Consultant will determine the economic loading of the 11 kV conductors and prepare charts and tables for the future use of KP&L in selecting economic conductor sizing and for recommending reconductoring when required.

The following information will assist the Consultant in further identifying and defining his scope of consulting services. This information can be augmented upon request with KP&L.

(a) The primary distribution operates at 11 kV, 50 cycles. The KP&L primary losses are estimated to be 1.9% of system losses after the installation of capacitors.

(b) It is estimated that the losses in (a) can be reduced to approximately 1.33% by a study and reconductoring approximately 930 km of the 11 kV system.

(c) The largest load is in the Nairobi area with a large amount of underground primary cables serving the metropolitan area. Many industries are taking service directly at the 11-kV level or have distribution transformers immediately at the service entrance.

(d) Many industrial and commercial feeders are heavily loaded and will require reconductoring to reduce losses as well as to improve voltage.

The KP&L field crews are to do the reconductoring. The Consultant shall review the KP&L construction equipment and specify compression tools, connectors and other line equipment required for general distribution construction.

The Consultant will determine the economic loading of the low voltage conductors and prepare charts and tables for the future use of KP&L in selecting economic conductor sizing and for recommending reconductoring when required. The reconductoring of feeders which will provide economic benefits and the rerouting or switching where justified will be the basis of the preparation of the charts and tables.

The following information will assist the Consultant in further identifying and defining his scope of consulting services. This information can be augmented upon request with KP&L.

(a) The low voltage distribution operates at 240/415 volts, 50 cycles. The losses are estimated to be 4.4% of system losses.

(b) It is estimated that the losses in (a) can be reduced to 3% or less by a study and reconductoring approximately 600 km of the low voltage system.

(c) The largest load is in the Nairobi area with a large amount of underground cables serving the metropolitan area.

(d) Many feeders are heavily loaded and will require reconductoring to reduce losses as well as to improve voltage.

The Consultant will prepare construction and engineering standards for KP&L. The standards shall include economic loading and change out charts for distribution transformers.

The Consultant will study the transmission system and determine the requirement for future transmission lines. He shall study the existing lines to determine the economic advantage for replacement, paralleling and/or changing operation to bring about the optimum economic operation of the lines. He shall prepare a report indicating economies to be gained, the benefits and payback periods of the recommendations.

The Consultant will review and prepare a report with recommendations on the various levels of voltage in use in the KP&L system with a view to reducing the number of transformers. Such study shall especially review the elimination of 40 kV, the conversion and use of 33 kV as a rural distribution system and continued use of 11 kV. Economic benefits shall be considered in all cases.

The Consultant will determine the requirements for the rehabilitation and expansion of the existing distribution system to meet forecasted demands. This shall include, but not be limited to, the interarea transmission, subtransmission systems, the distribution substations, feeders and transformers and methods of providing services. He shall prepare an interim report with recommendations for the interim period of three years for rehabilitation and loss reduction. He shall prepare estimated cost and benefits. This will include project descriptions, cost in foreign and local exchange, construction schedules and benefit with justifications. The purpose would be to correct the worst deficiencies in voltage levels, service quality and loss levels as quickly as possible. All work will be coordinated with and be complimentary to any system expansion and improvements planned by the KP&L. The report shall cover a three year period and be submitted in two parts, a preliminary recommendation in two months and a final report in four months.

Estimated Costs for Transmission and Distribution System Improvement:

Engineering Services

Item	Cost
1. Power Factor Improvement - Annex 2	
12 Man-months	$120,000
Transportation	5,000
Administration	25,000
Contingency	12,000
Total	162,000
2. Replace Synchronous Condensers - Annex 3	
6 Man-months	$60,000
Transportation	5,000
Administration	12,000
Contingency	6,000
Total	83,000
3. Distribution Substation Tap-Changers - Annex 4	
6 Man-months	$60,000
Transporation	5,000
Administration	12,000
Contingency	6,000
Total	83,000

4. Reconductor 11 kV lines - Annex 5

Consulting assistance as required is for two man-years comprised of one man-year of engineering assistance and one man-year of field supervision, both to run concurrently. It is expected that KP&L engineers will continue the engineering and supervision.

24 man-months	$240,000
Transportation	10,000
Administration	48,000
Contingency	24,000
Total	$322,000

5. Reconductor low voltage lines - Annex 6

Consulting assistance is required for two man-years comprising one man-year of engineering assistance and one man-year of field supervision, to run concurrently. It is expected that KP&L engineers will continue the engineering and supervision.

24 man-months	$240,000
Transportation	10,000
Administration	48,000
Contingency	24,000
Total	$322,000

6. Prepare engineering and construction standards

12 man-months	$120,000
Transportation	5,000
Administration	25,000
Contingency	12,000
Total	$162,000

7. Transmission line study and report

3 man-months	$30,000
Transportation	5,000
Administration	6,000
Contingency	3,000
Total	$44,000

8. Study and report on voltage levels

2 man-months	$10,000
Transportation	5,000
Administration	2,000
Contingency	1,000
Total	$18,000

9. Transmission and distribution rehabilitation and expansion study

12 man-months	$120,000
Transportation	5,000
Administration	24,000
Contingency	12,000
Total	$161,000

Engineering Services:	$1,357,000
Telephone, car rental, office supplies, etc.	43,000
Total	$1,400,000

Total man-months - 101

Note: Local cost of accommodations and subsistance are not included in

Power Factor Improvement

Costs

Materials and erection cost estimate is based on units of 1,170 KVAR. 140 units will be required.

Items Per Unit	US$ Foreign Exchange
Capacitors	6,300
Frames, fuses, arresters, etc.	5,100
Controls	600
Packing and shipping	600
Structures	800
Erection	
Contingency	400
Subtotal	13,800
Total Foreign Cost 1/	15,456
Local cost of erection	800
Total Cost per unit of 1,170 KVAR	16,256
Total for 140 Units	2,275,840
Supply additional required metering	30,000
Total	$2,305,840

Benefits

5.7 MW reduced demand at $225 per kW	= 1,282,000
25.8 GWh reduced kWh losses at $0.07/kWh	= 1,806,000
	$3,088,000 per year

$$\text{Payback } \frac{\$2,305,840}{\$3,088,000/\text{yr.}} = 0.7 \text{ years}$$

1/ Includes a 12% foreign exchange premium.

Replace Synchronous Condensers

Estimated Costs/Benefits

Costs

Materials and erection cost estimate is based on units of 1,170 KVAR. Forty-seven units will be required.

Items Per Unit	$ Foreign Exchange
Capacitors	6,300
Frames, fuses, arresters, etc.	5,100
Controls	600
Packing and shipping	600
Structures	800
Contingency	400
Subtotal	13,800
Total foreign cost 1/	15,456
Local cost of erection	800
Total Cost per unit of 1,170 KVAR	16,256
Total for 47 units:	$650,240

Benefits

2.25 MW reduced demand at $225 per kW	=	506,250
19.71 GWh reduced energy consumption at $0.07	=	1,379,000
		$1,885,950

$$\text{Payback } \frac{\$650,240}{\$1,885,950/\text{yr.}} = 0.3 \text{ years}$$

1/ Includes a 12% foreign exchange premium.

Reconductoring 11 kV Lines

Estimated Costs/Benefits

Costs

The cost estimate is based on the salvage and reuse of removed conductors.

Reconductoring of 930 km of 11 kV lines. Estimate is based on differential cost of the cable for a change out of the conductor.

Items Per Unit	$ Foreign Exchange
Conductor	1,580,000
Tie wire, compression tools and miscellaneous items	10,000
Erection	
Subtotal	$1,590,000
Total foreign exchange cost 1/	$1,780,800
Local cost of erection	230,000
Total Cost	$2,010,800

Benefits

16.2 GWh reduced losses at $0.07/kWh = $1,130,000

$$\text{Payback } \frac{\$2{,}010{,}800}{\$1{,}130{,}000/\text{yr}} = 1.8 \text{ years}$$

1/ Includes a 12% foreign exchange premium.

Reconductor Low Voltage Lines

Costs

Cost estimate is based on salvage and reuse of removed conductor.

Reconductor of 600 km, cost is based on differential cost supplied by KP&L for change out of conductor.

Items Per Unit	$ Foreign Exchange
Conductor	1,020,000
Tie wire and miscellaneous items	15,000
Subtotal	1,035,000
Total foreign exchange cost 1/	1,159,200
Local cost of erection	150,000
	$1,309,200

Benefits

37.2 GWh reduction of losses at $0.07/kWh - $2,630,000

$$\text{Payback } \frac{\$1{,}309{,}200}{\$2{,}630{,}000/\text{yr}} = 0.5 \text{ years}$$

1/ Includes a 12% foreign exchange premium.

Consulting Engineering and Project and Construction Management Services: Terms of Reference

The Kenya Power and Lighting Co., Ltd. (KP&L) is soliciting proposals to organize and implement the rehabilitation of the Kipevu Thermal Power Station which consists of the following units:

2 x 5 MW steam unit numbers 2 and 3
2 x 12.5 MW steam unit numbers 4 and 5
1 x 30 MW steam unit number 6
1 x 33 MW steam unit number 7

The present KP&L retirement plan for the Kipevu units is as follows:

Units 2 and 3	- 1989	
Units 4 and 5	- 1992	
Gas Turbine	- 1992	
Unit 6	- 2000	- estimated at ± 30 year life
Unit 7	- 2005	- estimated at ± 30 year life

The rehabilitation program is to restore these units to an acceptable operating condition, a proper heat rate, a reasonable overall plant auxiliary power load, and plant availability and reliability values. Units 4 and 5 are presently derated to 8 MW and 10 MW respectively. The program also includes restoring these units to their rated output. This work is to be referred to as "The Project" and is estimated to require 26 man months of service in Kenya and 46 man months of home office services. The firm performing these services shall be referred to as the Engineer, and Kenya Power and Lighting Company, Ltd. is to be referred to as KP&L.

Terms of Reference

The following are the terms of reference for the consulting engineer and project manager:

(a) Make a field inspection of the Kipevu Thermal Plant in Mombasa and make an offer to undertake the work described in these terms of reference.

(b) Prepare engineering designs and job descriptions, where required, for specific tasks.

(c) Issue specifications for the supply, delivery and installation of equipment, material and systems required for the Project.

(d) Assist KP&L in the evaluation of proposals as required.

(e) Undertake on KP&L's behalf the procurement, transport, expediting and scheduling of work including the fabrication and timely delivery of the equipment, material and/or systems required to complete the specified tasks.

(f) Manage and supervise the installation of all the work elements specified herein.

A World Bank/UNDP System Efficiency Report dated November 1983, is the first phase of this rehabilitation program indicating the remedial actions required to restore this plant to an acceptable operating condition. The report is based upon an accelerated field survey. The basis of the report is the result of discussions and observations made during the mission's visit to Kenya. The estimating data is based upon order of magnitude values only. The Engineer is to perform an indepth investigation of the work elements outlined herein and shall also recommend additional rehabilitation work elements which become evident as a result of his investigation. These recommended additional tasks should demonstrate that improved operation, reduced auxiliary power, efficiency, unit performance and/or unit reliability will result from the proposed improvements. The engineer will include in his proposal a suggested procedure to be used to handle additions and deletions to his contractual scope of services. This shall include but not be limited to work time estimates with backup data and hourly rates for the work performed. These rates shall be included in the contract.

An overall program schedule from the time of award of contract to completion of the program shall be included in the proposal. The priority work elements are to be completed by the fourth calendar quarter of 1985 at the latest. These are identified in the Terms of Reference.

The following lists the work elements to be included in the Engineer's scope of services. The Annexes attached to this Terms of Reference give more detailed descriptions of the work to be done and form a part of this document.

The Engineer will perform indepth investigations of the existing conditions of the circulating water (CW) system and condensers and shall engineer, design, specify, procure and implement the necessary steps to rehabilitate these systems into good operating condition. He will have qualified parties inspect and chemically clean the systems and shall implement the installation of units 6 and 7 traveling screens, chlorination units, CW pump motor ventilation duct work, and either have repaired or installed a complete cathodic protection system.

The Engineer will provide as soon as possible after the award of contract, comprehensive procedures for placing the plant in cold standby. These procedures shall include the shutting down of the plant in its entirety and the recommissioning of the plant after a period of six months to possible several years time. A nitrogen blanketing system shall be included.

The Engineer will inspect and have the Kipevu water treating plant rehabilitated to good operating condition. He will also carry out through his contract the commissioning of the water pretreatment plant using the services of the original supplier to accomplish this work.

The Engineer will redesign and have installed new oil burner units with steam in lieu of air atomization, including the steam supply system. A soot blower steam system moisture separator installation will be included plus the installation of blowers in the economizer and air heater sections of units 6 and 7.

The Engineer will evaluate, and if justified, implement the installation of variable speed drives for the units 6 and 7 forced draught fans.

He will also have spare parts purchased for the repair of the units 6 and 7 turbine supervisory instruments. The repair of these devices will be done under the Engineer's supervision.

The Engineer will study and implement the steps necessary to restore units 4 and 5 to full rating including the installation of desuperheaters in the boiler mud drums. Additionally he will have unit fuel oil meters and excess air instruments and recorders purchased and installed in these units. Steam moisture separators and air heater soot blowers shall be added to the boiler soot blower systems.

The Engineer will have the units 4 and 5 stack inspected by qualified inspectors to determine the condition and need for repairs. If repairs are required, the Engineer will implement this work.

The Engineer will assist KP&L, as requested, in making arrangements for modifications to the combustion turbine unit at Kipevu. It is assumed the actual work would be undertaken by the turbine manufacturer.

The Engineer will design and then specify, evaluate, procure and supervise the installation of a storage warehouse for the Kipevu Station. The storage area will be specified by KP&L.

The Engineer will furnish KP&L spare parts lists based upon the forecast operation of the Kipevu units and the criticality of the part itself on unit operation and/or delivery time required.

A benefit-to-cost calculation will be submitted by the Engineer for each of the work elements specified herein. The evaluation factors such as fuel cost and operating regimen are furnished by KP&L as an attachment to this request for proposal. Cost estimates and benefits derived for each task will be submitted by the Engineer for review and approval by KP&L prior to implementing the work.

The Engineer will include in his proposal the number of head office and field engineering technical staff he proposes to employ for this work. The time required at the plant site to perform inspections and to research records will be given, including rates and expenses.

The Engineer will include the services of a construction manager who will manage the work and liaise with KP&L. The field labor is to be provided by KP&L except for foreign specialized service personnel or special skilled craftsmen. The latter will be furnished by the Engineer as required and will be for KP&L's account. Field supervision, administration and accounting personnel will be furnished by KP&L for the Engineer's management.

The Engineer will plan and schedule the work. The schedule will reflect the normal operating regimen of the KP&L system whereby the thermal unit repair work is to be performed. The tender document will give a first estimate of the overall time required to complete the specified work.

Resumes of the key personnel being offered to perform this work will be included in the proposal document.

As an order of Priority, the following work elements are to be given First Priority in having this program implemented:

Condenser/Cooling Water System
Water Treating and Pretreating Plant Work
The rehabilitation of Units 4 and 5 desuperheaters
The rehabilitation of Units 4 and 5 stack
Cold standby procedures and systems

This work is to be completed by the fourth quarter, 1985.

Second Priority work elements include:

Units 4, 5, 6 and 7 soot blower system revisions
Spare parts list

This work is to be completed by the second quarter, 1986.

Third Priority work elements include:

Boiler Units 6 and 7 burner revisions
Boiler Units 6 and 7 variable speed forced draught fan drives
Turbine Units 6 and 7 turbine supervisory instruments
Boiler Units 4 and 5 fuel oil meters and flue gas analyzers

This work is to be completed by the second quarter, 1986.

Fourth Priority element:

Storage warehouse

Cost Estimate

The following cost estimates cover the project and construction management services for the Kipevu rehabilitation project:

Home Office Project Management		
12 man-months (MM) @ $8,000/mo.	=	$ 96,000
Project Administration 2 MM @ $4,500/mo.	=	7,500
Project Scheduling 3 MM @ $4,500/ mo.	=	7,500
Project Management Expenses, 10 1 week trips @ $3,500/trip	=	35,000
Field Manager, two years @ $67,500/year	=	135,000
Living expenses @ $1,000/mo	=	25,000
Condenser/Cooling Water System		
Project Services, 16 MM	=	90,000
Field Engineers, 0.5 MM	=	5,000
Travel	=	2,500
Water Plant		
Project Services, 2 MM	=	16,000
Field Engineering, 2 M days	=	5,000
Travel	=	2,500
Units 6 and 7		
Project Services, 2.5 MM	=	14,500
Field Engineering, 0.25 MM	=	2,000
Travel	=	2,500
Units 4 and 5		
Project Services, 2.5 MM	=	14,500
Field Engineering, .25 MM	=	2,000
Travel	=	2,500
Warehouse		
Project Services, 6 MM	=	35,000
Field Engineering, 0 MM	=	-
Travel	=	-
Subtotal	=	490,500
Contingency	=	49,500
Total	=	$540,000

Rehabilitation of the Kipevu Power Station Units 2 and 3 Fuel Oil Meters

Fuel Oil Meters

The limited forecast use of Units 2 and 3 plus the facts that these units have (a) a spare boiler unit; (b) the condensers installed above sea level; and (c) the units designed for hand operation; all go together to minimize the need for major rehabilitation of these units with one exception.

The lack of fuel oil flow meters on these units prohibits monitoring the unit heat rate in order to check unit efficiency and thermal performance. It also prohibits establishing an order of merit in the operation of not only the two turbine units but also the three boilers. Three fuel oil meters should be installed to permit the plant efficiency engineer to establish the most economic loading of these turbines and boilers.

Cost Estimate

This can be carried out by the plant personnel and will require no outside assistance. Based on these needs, outside consulting services will not be required. It is estimated the three meters would cost a total of $8,000 in place.

Consultant's Terms of Reference: Rehabilitation of the Kipevu Station, Units 4 and 5

General

The following outlines the existing conditions and rehabilitation requirements of the Kipevu Units 4 and 5. The Engineer's scope of services is to perform all the work necessary to correct the conditions described as requiring rehabilitation or add systems as specified herein in accordance with his contractual Terms of Reference. Where necessary, the Engineer will subcontract special engineering services with the approval of KP&L.

In cases where the repair of a unit of equipment or a system would be best accomplished through the services or replacement parts from the original supplier, the Engineer will submit to KP&L, a check estimate of the value of the service or item(s) being offered.

These 12 MW each units were originally installed in 1962 and in 1966 in the days of low fuel oil costs. Efficiency of operation was not of major concern as reflected by the unit designers not furnishing unit fuel oil meters or excess air indication. They also did not concern themselves with the amount of auxiliary power required to operate these earlier units, as no meters exist to monitor this parasitic power consumption. It is estimated to be in the 10% range on these units. These conditions are to be investigated to effect more efficient and safer unit operation.

Instruments and Controls

In order to achieve more efficient operation and monitor unit performance even for the relatively few hours these units will be in operation, individual unit fuel oil meters and flue gas oxygen analyzers are to be installed. The analyzers will permit the operator to better control boiler excess air losses which would quickly pay for itself and increased efficiency and safety of operation. The oil meters will permit monitoring of the boiler and turbine units' performance.

Soot Blower System

Analogous to Units 6 and 7, these boilers do not have soot blowers in the air heaters nor do they have moisture separators. The installation of the blowers and separators will reduce flue gas losses by reducing the exit gas temperature by an estimated 12 to 15°F.

Boiler Desuperheaters

Both Units 4 and 5 boilers have desuperheating coils in their mud drums to control steam temperatures to the turbine. The coils are no longer functioning and this has caused these units to be derated to 6 MW instead of the design 12 MW. The replacement of the coils will bring these units back to full rating again. (This is not possible however, without the earlier referenced repairs to the condenser and CW system.). The coils are to be replaced in both units.

Stack Inspection

The single stack serving Units 4 and 5 is reported to be deteriorating badly. An inspection is to be made to determine the extent of damage and the amount of repair required. (A budget figure has been included in the estimate to cover this possibility.)

Costs/Benefits

The cost estimates and benefits to rehabilitate Units 4 and 5 are as follows:

Item	Cost $	Benefit ($/Yr.) 2/
Controls and Instruments		
Oxygen Analyzers (2)	15,250	
Miscellaneous materials and supports	150 (Kenya)	
Panel instruments (2)	3,000	
Fuel Oil Meters (2) In Place	5,150 -	
Miscellaneous valves, pipe w/supports, etc.	500 (Kenya)	
Soot Blower System Addition	10,200	
Stack 1/	25,000	
Kenya labor and miscellaneous materials	6,000	
Contingency	4,750	
Replacement Capacity Cost		660,000
Total	70,000	660,000

Cost to Benefit Payout = Two Months

1/ Please note that nominal funds have been allowed for the stack repair as it is not known if this work will be necessary. In any event, a major repair effort should not exceed an expenditure of $50,000. A nominal cost of $25,000 is included in the estimate.

2/ The forecast operation of Units 4 and 5 is essentially nil. However, the restoration of these units to full rating is equivalent to installing new 6 MW of capacity at a long range marginal cost

Consultant's Terms of Reference:
Rehabilitation of the Kipevu Power Station, Units 6 and 7

General

The following outlines the existing conditions and rehabilitation requirements of the Kipevu Units 6 and 7. The Engineer's scope of services is to perform all the work necessary to correct the conditions described as requiring rehabilitation or add systems as specified herein in accordance with his contractual Terms of Reference. Where necessary, the Engineer will subcontract special engineering services with the approval of KP&L.

In cases where the repair of a unit of equipment or a system would be best accomplished through the services or replacement parts from the original supplier, the Engineer will submit to KP&L, a check estimate of the value of the service or item(s) being offered.

These units are respectively 11 and 7 years old and in relatively good operating condition; however, several basic design shortcomings should be corrected to increase the unit reliability and efficiency. Additionally, since the future operation of these units will be at varying unit loads, the application of variable speed boiler fan drives is also to be evaluated.

Boiler Fuel Oil Burners

The original boiler burner design on these units called for air atomization of the fuel oil and piston operators to position the combustion air vanes to direct the air flow into the burner combustion zone. The air atomization system has never been successful and inefficiencies in combustion are being experienced as a result of this. In addition, the design of the burner itself creates a very hot area which burns out the piston rings and seals on a frequent basis. The piston drives have been removed from the Number 6 boiler and the dampers are now operated by hand.

The burners are to be revised to atomize with steam in lieu of air and to replace the damper pistons with a new design unit capable of operating in a hot zone. The revised system is to include new oil-steam burner tips and steam supply system suitable for continuous operation at loads varying from 30 to 100% without the aid of ignitors.

Soot Blower System Revisions

These two boilers have been installed without soot blowers in the economizer and tubular air heater sections which build up with oil and ash deposits, thus reducing heat transfer efficiency. In addition, moisture laden saturated steam is used as the blowing medium and this has created steam cutting problems in the superheater area. This is common to all operating boiler units at Kipevu.

In order to increase boiler efficiency by reducing the air heater exit gas temperature, blowers are to be installed in the economizer and air heater sections and a moisture separator with a drain line to the blowdown tank, is to be installed downstream of the steam shutoff and/or pressure control valve(s). This will eliminate moisture carryover from the steam which is formed with a reduction in pressure.

Variable Speed Fan Drives and Auxiliary Power

Since these units will operate at widely varying load factors over their remaining life (15-20 years), it is justified to install variable speed drives on the boiler fans. The average forecast generation on these units over the next seven years, it is estimated, will justify reducing the unit auxiliary power requirements for the two units by 650 kW per hour. Auxiliary power is estimated to be in the range of 8% of these units. This is also to be investigated by the consultants and suitable action taken to reduce this figure. Based on the average forecast thermal plant loading for the next ten years, these units are each forecast to operate 750 hours at full load; 1,000 hours at 70% load; and either the two units operating at 50% load (spinning reserve) for 1,750 hours or as an altenative, operate one unit at full load. However, the 1,000 hours at 70% load is used to justify the conversion to variable speed drives.

Turbine Supervisory Instrumentation

Units 6 and 7 turbines were originally installed with supervisory instruments and recorders to monitor turbine differential expansion, vibration, metal temperature differentials and other very critical measurements. Because of the lack of spare parts, this equipment is no longer functional and thereby exposes the turbine units to stresses and vibrations which, if left undetected and uncorrected, could lead to extensive and expensive damage to the equipment. The instruments are to be repaired using KP&L furnished labor.

Kipevu Power Stations
Costs/Benefits of Rehabilitating Units 6 and 7

Estimated Costs/Benefits

The following cost estimates and benefits indicate that this corrective work is justified with the forecasted remaining service life of these units.

Item	Cost ($)	Benefits ($/yr.)
Boiler/burner upgrading	35,000	20,000
Boiler soot blower system revisions 1/	45,000	60,000
Boiler fan variable speed drives 2/	145,000	45,000
Turbine supervisory instrument repairs	20,000	-
Kenya labor and miscellaneous materials	25,000	-
Contingencies	40,000	-
Total	$310,000	$125,000

Cost to benefit payout = 2.6 years

1/ Kenya material: $10,000
2/ Long Run Marginal Cost = $0.066/kWh @ 650 kW for 1,000 hours/year.

Manufacturer's Terms of Reference: Rehabilitation of the Kipevu Power Station Combustion Turbine Unit

General

This 12.0 MW unit is presently derated to 5 MW due to several basic design shortcomings which can be corrected through consultation and corrections made with the services of the manufacturer. These shortcomings deal with: (1) the apparent undersizing of the lube oil coolers, especially as it pertains to the tropical climate germaine to the Mombasa area; (2) the location of the lube oil storage tank in an unventilated area which also encloses the gas generator combustor, and (3) the lack of ventilation in the reduction gear enclosure which also houses the combustion turbine exhaust duct. The manufacturer, in consort with KP&L engineers, is to review these shortcomings and any other problems which are creating the derating of this unit.

Lube Oil Coolers

The lack of sufficient oil cooling can be resolved by augmenting the existing forced-air-finned lube oil coolers to further reduce the oil to its proper inlet temperature. This would result in increasing unit output towards the base unit rating.

Enclosure Ventilation Systems

In addition to the above limitations the addition of a forced-air ventilation system in both the lube oil storage tank and reduction gear enclosures would eliminate the capacity restrictions presently being experienced.

Estimated Costs/Benefits

The cost of these changes is estimated to be in the range of $15,000. The addition of a forced-air-finned cooler and the two vent systems in the referenced enclosures should return these units to rated capacity. There is no need to hire consultants to address these shortcomings but it is necessary to work with the manufacturer to determine the exact additions to be made in each of the above applications. The benefits equate a new 6 MW of capacity @ $110/kW/yr. Benefits are $660,000.

Consultant's Terms of Reference: Rehabilitation of the Kipevu Power Station Condenser/Cooling Water System

General

The following outlines the existing conditions and rehabilitation requirements of the Kipevu condenser/cooling water system. The Engineer's scope of serivces is to perform all the work necessary to correct the conditions described as requiring rehabilitation or add to the systems as specified herein in accordance with his contractual Terms of Reference. Where necessary, the Engineer will subcontract special engineering services after obtaining KP&L's approval.

In cases where the repair of a unit of equipment or a system would be best accomplished through the services or replacement parts from the original supplier, the Engineer will submit to KP&L, a check estimate of the value of the service or item(s) being offered.

Condenser and CW System Leaks

The condensers and sea water cooling water (CW) systems are in a severe state of disrepair mostly due to corrosion and a lack of proper maintenance. The system's entire cathodic protection system has not functioned for many years. The CW system has corroded to such an extent that the CW pump and condenser isolating valves cannot be used to facilitate maintaining the equipment. Units 4, 5, 6 and 7 condensers are below sea level and cannot be maintained while any of the six functional units are in service. Because of this condition, it is necessary to operate several CW pumps to maintain an adequate flow to the operating unit(s) which contributes materially to auxiliary power consumption. Units 4 and 5 condenser water boxes have corroded to such an extent that water streams out of all the bolt holes and other connections onto the floor of the plant. These boxes, plus 14 isolating valves, are no longer repairable and must be replaced.

Unit Condenser Inspection

Although Unit 3 has been out of service for over two years because of a delay in the delivery of a turbine bearing and turbine blade shrouds, the condenser remains full of salt water due to the lack of capability to isolate and drain the condenser unit. The same is true of the other non-operating units. It is not possible to assess the damage to the condensers without isolating the unit. This should be done by a professionally qualified firm specializing in this type of service. The work will be done through the consulting engineer's contract for services.

Chemical Cleaning Condenser/CW System and Chlorination System Installation

The lack of never having a chlorination system on any part of the CW system has resulted in the severe pluggage of the CW lines and condensers with clams, algea, worms and other marine life. This has materially impacted on condenser vacuums and unit heat rates. The CW system and condensers are to be chemically cleaned and then, after flushing, manually cleared of the remaining debris. The chemical cleaning is to be performed by a qualified company, professionally skilled in this type of service through the consulting firm's contract for services.

The two 35,000 igpm CW pump intakes and CW lines shall be revised to accommodate the installation for two oversize chlorinators to chlorinate the entire CW system flow with all pumps in service. The work scope includes the complete installation of the chlorinators with chlorine bottles and racks and a chlorine injection system in the two pump inlets.

Unit 7 Auxiliary Cooling Water Strainer Replacement

Unit 7 has a CW strainer which filters the cooling water to the generator air cooler and generator lube oil cooler. The strainer has experienced serious corrosion and is to be replaced.

CW System Intake Traveling Screens

The CW pump house is composed of two large CW pumps and four smaller pump units. All the pumps discharge into a common loop system which furnishes water to all the condensers. However, with the present and forecast operation of the Kipevu plant, the operation of these pumps will be essentially limited to the two large pumps.

None of these pumps have a traveling screen unit in place. Hand installed and hand cleaned screens are used instead. Debris buildup on the screens is abnormal during the rainy season and a continual problem is experienced with garbage from the ships anchored nearby in the Mombasa harbor.

In order to increase the reliability of the cooling water system, the two large pumps should be upgraded with traveling screens and a high pressure water screen cleaning and sluicing system.

Cathodic Protection System

The cathodic protection system will be either rehabilitated or replaced with a new system. The work here involves inspecting the system in its present condition and in repairing and augmenting the system or installing a complete new system on the condensers, CW system pipe, pumps, etc.

CW Pump Motor Ventilation System

In addition to the CW system problems, the two motor drives for the large CW pumps are in a deep, narrow pit with a downward directed air cooling
system which recirculates the hot air discharged at the bottom of the motor back into the top air inlet of the motor. A closed duct system is required to direct cool outdoor air into the motor, thus preventing the recirculation of hot air back into the motor.

Cold Standby

Since the Kipevu units will be used essentially for cold standby service for relatively long periods of time, it will be necessary for the consultant to prepare procedures for cold standby or layup during the storage and cold standby periods in order to prevent deterioration of the equipment and to ensure that it is maintained in good working order. This is especially the case with the boiler and condenser which are susceptible to severe damage if not stored properly in this tropical, sea air atmosphere.

Other areas requiring protection are the internal parts of the equipment, systems and materials which use steam, water, air gas and other liquids. The procedures should call for nitrogen blanketing and/or dry storing with unit heaters of desiccants for the internal presure parts of the boiler, condenser, turbine, generator, switchgear, motors, the feedwater heater cycle (including the bleed steam lines), feedwater and condensate pipes, pumps, controls, etc. The lubricating and fuel oil systems and water treating plant system also require a lay-up and storage procedure to be sure that corrosion or oxidation of the systems is minimized. Detailed discussions and procedural reviews should be held by the consultant with the various suppliers on the best means of protecting their equipment and systems.

Estimated Costs/Benefits

The repair work cost estimates and benefits are as follows:

Item	Cost ($)	Benefits ($/yr.)
14 new condenser and CW pump isolating valves 1/	292,000	
2 new condenser water boxes	110,000	
Condenser/CW system chemical cleaning	288,000	
Chlorination system	55,000	
Cathode protection system	123,000	
Traveling screens (316 stainless steel)	280,000	
Kenya labor and miscellaneous materials	142,000	
Contingency	110,000	
Average annual savings with heat rate improvement		285,000 2/
Average annual savings with one CW pump in service		65,000 3/
	$1,400,000	$350,000

$$\text{Payout} = \frac{\text{Cost}}{\text{Benefit}} = \frac{1,400}{350} = 3.8 \text{ years}$$

1/ The valves, water boxes and traveling screens cost figures are estimated based upon discussion with suppliers of these types of equipment.

2/ Based on 3% improvement in heat rate, generating a total average output of 143.8 GWh at a long range marginal cost of $0.066/kWh: savings equal $0.00198/kWh.

3/ The improvement in the reduction of CW flow to units not in service permits KP&L to operate on one CW pump instead of two as is now the case for 1,750 hours/year @ 540 kWh/pump @ $.066/kWh.

Consultant's Terms of Reference:
Rehabilitation of the Kipevu Power Station
Water Treatment Plant

General

The following outlines the existing conditions and rehabilitation requirements of the Kipevu water treating and pretreatment plant. The Engineer's scope of services is to perform all the work necessary to correct the conditions described as requiring rehabilitation in accordance with his contractual Terms of Reference. Where necessary, the Engineer will subcontract special engineering services after obtaining KP&L's approval. In this work element, he is to arrange for the commissioning of the water pretreatment plant by the original supplier.

In cases where the repair of a unit of equipment or a system would be best accomplished through the services or replacement parts from the original supplier, the Engineer will submit to KP&L, a check estimate of the value of the service or the item(s) being offered.

Water Drains System

The Kipevu water treating plant is in a very deteriorated state due to the acid and caustic waste drainage system failure. In addition, the drains from the treating plant are fed directly into the Units 1 and 2 station drainage system via the boiler blowdown tank. The drains discharge into Mobasa Bay in an untreated state.

The Consultant is to inspect and design the rehabilitation water treating plant system to restore the unit to its initial operating condition. He is also to arrange for the commissioning of the water pretreatment plant. The Consultant is to specify, evaluate tenders, procure and to manage the work as described herein. The labor to make these changes shall be furnished by KP&L.

The drain pipe system leaks so badly in the plant area that the foundations have been eaten away and it is now necessary to support the various tanks from overhead steel frames. The drain pipe problem is being temporarily resolved by using plastic pipe. However, this only lasts approximately three months before it is necessary to replace the lines again. The drain system is to be rehabilitated completely, including the station drains, blowdown tank and new sump and sump pumps and a waste treatment system.

Foundations and Building Structure

The treating plant and other equipment foundations shall be repaired to rehabilitate the treating plant foundations and structures to an acceptable condition for continued plant operation for a 20 year life span.

Makeup Water Pretreatment Plant

The present source of makeup water to the plant is from the high quality Mzima Spring. Until now no water pretreatment has been necessary although a pretreatment plant has been installed but never commissioned. There is now a 90% chance that Kipevu will have to switch to a new source of makeup water from Sabaki which is not a good quality water. When this occurs, it will be necessary to commission the pretreatment plant. The commissioning of the plant is to be completed with the replacement of any parts or systems which require rehabilitation.

Estimated Costs/Benefits

The cost estimate to rehabilitate the treatment plant and to commission the pretreatment plant are as follows:

Water Treatment Plant 1/	Local Cost ($)	Foreign Cost ($)	Total $
Reconstruct pipes and pumps (local materials and labor)	16,500		16,500
New waste treatment sump with drains	35,000	25,000	60,000
Repair water treating building and foundations	5,000		5,000
Repair drainage system including manholes	8,500		8,500
Engineering services (6 man-months)		60,000	60,000
Installation, labor and foreign supervision of 6 man-months	70,000	60,000	130,000
Contingency (including travel and lodgings)	5,000	40,000	45,000
Total	140,000	185,000	325,000
Pretreatment Plant			
Service engineer (time 6 weeks)		14,500	14,500
Lodging		5,000	5,000
Air fare return		1,500	1,500
Parts, replacement and installation	3,700	5,300	9,000
Contingency	300	4,700	5,000
Total	4,000	31,000	35,000
Water Treatment System Rehabilitation			$360,000

1/ Although it is clear that the Kipevu plant cannot operate without a water treating system, it is not practical to put a cost benefit to the repair of this vital system except to say without it, Kipevu is unavailable.

Contractor's Terms of Reference: Rehabilitation of the Kipevu Steam Power Station Storage Warehouse

General

There is an acute shortage of storage capacity at the Kipevu station and it is necessary to store materials outdoors and in the turbine hall equipment laydown area. KP&L is soliciting tenders to design, fabricate and erect a storage warehouse 1/ including foundations, lighting and storage racks. The warehouse is to be located inside the property lines of the Kipevu Steam Power Station in Mombasa, Kenya. This work will be referred to as the Project. The contractor will be referred to as the Contractor. The Engineer will design the warehouse and will function as the Construction Manager at the job site.

Scope of Services

The Engineer will have a KP&L approved contracting firm construct a storage warehouse with foundations and other facilities to store various materials, equipment and chemicals to protect them from the corrosive and tropical elements normal to the Kipevu Plant site areas. The design of the building and its foundations shall be performed by the Engineer.

The foundations are to support the building structure and to support a material storage floor loading. A lorry ramp will be installed at the entrance of the building for off and on loading of materials.

The building design will include industrial type lighting at a level suitable for warehouse use in accordance with Kenya standards.

The Contractor will also furnish industrial class storage shelves 1/ suitable for storing (to be described by KP&L). The Engineer will specify a description of the type of shelves to be furnished.

The building will be a structural steel framed unit with galvanized steel siding with proper girts and seals all designed by the Engineer.

A roll-up metal door will be furnished. It will be hand operated by a chain and sprocket device. The door will be at least three (3) meters wide and four (4) meters high.

The entire building, foundation and its appurtenances shall be designed to Kenya's national codes and/or standards or other design criteria as specified by KP&L.

The contractor will erect the storage facility complete on the Kipevu site in an area allocated by KP&L in the contract scheduled time.

1/ The Engineer is to establish area required.

The Engineer will issue specifications for the supply and installation of equipment, material and systems required for the Project.

The Contractor will undertake the procurement, expediting and scheduling of work including the fabrication, delivery and erection of the building materials and systems required to complete the Project.

The Contractor will supervise and supply manpower to construct and erect the installation including all the work elements specified herein.

Proposal Requirements

The Contractor will review the request for proposal (specification) in detail and specify in his proposal any exceptions he may have to the specification.

The Contractor will submit a Project schedule starting with contract award to completion of the Project. Monthly progress reports shall be submitted to the Engineer by the Contractor.

The Engineer will specify a procedure to show how the additional work items are to be processed.

The Contractor will include the services of a construction site manager who will manage the work and liaise with the Engineer's construction manager. The field labor is to be provided by the Contractor.

Estimated Costs/Benefits

	Cost $
3,000 square foot building @ $25/ft	
Local materials 1/	35,000
Foreign materials 2/	30,000
Local labor - 20,000 hours @ 45¢/hr (US)	10,000
Total	75,000

1/ Includes concrete, rebar, structural steel, girts, wiring and lighting materials.
2/ Includes windows, rollup door, siding, and lighting fixtures.

Energy Sector Management Assistance Programme

Activities Completed

Energy Assessment Status Report	Date Completed
Papua New Guinea	July, 1983
Mauritius	October, 1983
Sri Lanka	January, 1984
Malawi	January, 1984
Burundi	February, 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

Institutional and Policy Support

Sudan	Management Assistance to the Ministry of Energy & Mining	May, 1983
Burundi	Petroleum Supply Management Study	December, 1983